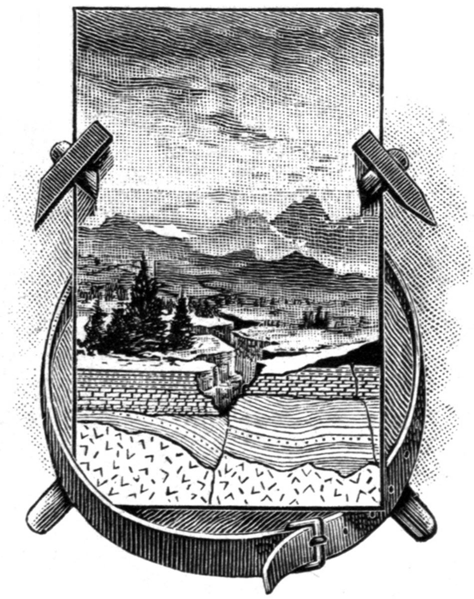
Minerals, Lands, and Geology for the Common Defence and General Welfare

Volume 4, 1939–1961

UNITED STATES
GEOLOGICAL SURVEY



U.S. Department of the Interior
U.S. Geological Survey

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This Douglas C–53D (N19924), crewed and operated by the U.S. Geological Survey (USGS), was photographed while surveying the Painted Desert, southwest of Cameron in northeastern Arizona. The aircraft's magnetic detector is shown deployed at the end of a 100-foot cable. The edge of the Coconino Plateau occupies most of the distant background in the photograph. At the U.S. Atomic Energy Commission's request in 1947, the USGS resumed ground studies and mapping of uranium-bearing sandstones on the Colorado Plateau to extend the work it completed there during 1939–44. USGS and U.S. Navy crews began aeromagnetic surveys in Beechcraft and Catalina aircraft in 1944. The C–53D and its crews commenced aeromagnetic surveys for the USGS in 1949. The U.S. Air Force transferred a Douglas C–47 (N19950) to the USGS in 1955, as the USGS increased its aerial surveys of radioactivity. The C–53D, restored to its original Skytrooper configuration for the Allied invasion of Normandy in 1944, is now in an aircraft museum in Sacramento, California. (From *Scientific Monthly*, v. 78, no. 6, June 1954, cover 1 and caption on p. 364.)

Minerals, Lands, and Geology for the Common Defence and General Welfare, Volume 4, 1939–1961

By Mary C. Rabbitt and Clifford M. Nelson

UNITED STATES GEOLOGICAL SURVEY

A History of Geology in Relation to the Development of Public-Land, Federal Science, and Mapping Policies and the Development of Mineral Resources in the United States From the 60th to the 82d Year of the U.S. Geological Survey

2015

U.S. DEPARTMENT OF THE INTERIOR
SALLY JEWELL, Secretary

U.S. GEOLOGICAL SURVEY
Suzette M. Kimball, Acting Director

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Foreword

Volume Four of the history of the U.S. Geological Survey (USGS) records a pivotal interval of transformation for the United States and the agency. The years from 1939 to 1961 were dominated by the Nation's engagement in major conflicts that included World War II, the Korean war, and the cold war. It was also a time of great national sacrifice, rapid expansion of industrial capacity, spectacular scientific and technological advancement, and international leadership. Mary Rabbitt and Clifford Nelson record and evaluate the important role of the USGS in supporting the Nation's efforts in war and peace at home and abroad. The agency assessed strategic mineral and energy resources, and, in some cases, managed their production from Federal lands. The USGS used improved photogrammetric methods to update and extend its topographic and geologic map coverage and provide critical information for the management of surface-water and groundwater resources. The agency also began using automated methods in recording and storing its data and producing its products. But the national need for the USGS to use its capacity to deliver applied science did not prevent the agency from investing in and delivering wide-ranging advancements in fundamental earth science. The authors also highlight many examples of the USGS' rapid development or adaptation and use of new instrumentation and methods that included airborne magnetometers and radiometers, advanced seismometers, stereoscopic plotters, the Orthophotoscope, and geophysical logging and geological sampling from deep wells.

Through the combination of USGS Pick and Hammer Club "poetry" and quotes from Members of Congress and Department of the Interior and USGS leaders, Mary Rabbitt and Clifford Nelson provide insight into the perspectives of the working scientists, managers, advisers, and politicians on issues ranging from science priorities and organizational structure to the varying degrees of the agency's effectiveness and efficiency. By doing so, the authors have provided current and future generations with a better understanding of the people and the actions that have molded this part of the history of this remarkable institution.

Mark D. Myers
Director, U.S. Geological Survey
2006–2009

Preface

This is the fourth volume in a series about the history of the U.S. Geological Survey (USGS) begun but not finished by Mary Priscilla Collins Rabbitt (1915–2002). Educated at Radcliffe and Berkeley, Mary Collins served as assistant seismologist to Harvard's L. Don Leet before being detailed to the Office of Scientific Research and Development for work at Oak Ridge, Tennessee, on the seismology of nuclear and other explosions. In 1947, she married USGS geologist John C. Rabbitt and, during the next year, joined the U.S. Coast and Geodetic Survey's Seismology Branch in Washington, D.C. Mrs. Rabbitt transferred to the USGS in 1949. There she was responsible for the quarterly publication *Geophysical Abstracts* and then served as Assistant Chief in the Geophysics Branch led by James R. Balsley, Jr. After John Rabbitt died in 1957, she succeeded him as the Geologic Division's Staff Assistant for Publications. In 1966, William T. Pecora, the 8th Director (1965–71) of the USGS, appointed Mary Rabbitt as his staff assistant in the Director's Office. When you have time, Pecora said, also start looking into USGS history. Building on the article the Rabbitts cowrote for *Science* for the agency's 75th anniversary in 1954, her new research led in 1969 to a preliminary analysis of the career of John W. Powell, the second Director (1881–94), and in 1974 to a brief informal history of the agency.

After retiring from the USGS in 1978, Mary Rabbitt wrote the first three volumes of "Minerals, Lands, and Geology," which were published during 1979–86 as USGS special books, an unnumbered and intermittently issued quarto-sized series. Volumes 1–3, long out of print and out of stock, are now available online; see the entries in the Notes and References Cited herein for the Web versions. Two awards honored Mrs. Rabbitt's scholarly contributions to the history of the USGS and of the earth sciences—the History of Geology Award, conferred in 1984 by the History of Geology Division of the Geological Society of America, and the Department of the Interior's Distinguished Service Award, presented in 1988. The History of Geology Award was renamed the Mary C. Rabbitt Award in 2005 by the Geological Society of America's History of Geology Division (now the History and Philosophy of Geology Division) also to acknowledge her posthumous financial contribution to the Division.

This fourth volume about the history of the USGS, like the earlier three, is based primarily on published sources and is intended as a framework for more detailed studies that use the results of extensive searches of unpublished documents. As coauthor, I revised and extended Mary Rabbitt's partial typescript, retained most of her chronological divisions, and added new sections and chapters. Providing coverage of the years between 1939 and 1961 at a level equivalent to the depth presented by Mrs. Rabbitt in her initial three volumes required successively longer chapters that reflect the growth of USGS missions, funds, personnel, and operations during World War II and in the subsequent cold war. Staff increased sixfold and funds increased ninefold during those nearly 22 years. I hope that readers will not be able to distinguish between the parts of this volume written by Mary Rabbitt and those modified or newly written by me.

Many of my colleagues within and outside the USGS aided the preparation of volume 4. USGS seismologist James F. Devine, the former Assistant Director for Engineering Geology and now the Senior Adviser for Science Applications, provided encouragement and moral support in his staff capacity in the Director's Office. Charles C. Groat, the 13th Director of the USGS (1998–2005), and Mark D. Myers, the agency's 14th Director (2006–2009), enabled me to complete volume 4. Maureen A. Booth, Chief Reference Librarian at the Department of the Interior's Library, was my skillful and indefatigable guide to scholarly resources available online. Carmen O'Neill, on the staff of the USGS Library at the National Center in Reston, Virginia, provided access to printed sources via interlibrary loans. Jenny M. Stevens, USGS librarian in Denver, provided links to digital images in the photographic collection after it was relocated. The late Dallas L. Peck, Chief Geologist and subsequently the 11th Director (1981–93) of the USGS; the late Eugene C. Robertson, also a career geologist with the USGS; and the late Hatten S. Yoder, Jr., Director Emeritus of the Carnegie Institution of Washington's Geophysical Laboratory, read and constructively commented on initial versions of several early chapters, as did Ari Hoogenboom, professor emeritus of history at the City University of New York's Brooklyn College. The later versions of each chapter in this volume benefited from critical and constructive reviews by Alan L. Bain, former Archivist of the Smithsonian Institution; Marc Rothenberg, former editor of the Smithsonian's *The Papers of Joseph Henry* and now the National Science Foundation's Historian; and the late E-an Zen, geologist emeritus at the USGS and adjunct professor emeritus at the University of Maryland. Bain and Rothenberg also reviewed the volume's body proof.

Richard L. Huffine, Director, USGS Library Program, and Kevin T. Gallagher, Associate Director, USGS Core Science Systems, authorized the financial support required to publish volume 4 in the style and format of the preceding three volumes. Katharine S. Schindler, supervisory publishing specialist at the USGS National Center in Reston, managed the volume's production by four skilled members of the agency's Science Publishing Network. Elizabeth E. Good (technical editor), benefiting from a review by John R. Keith (scientist emeritus), edited the entire volume. Jeannette M. Foltz (graphics specialist) designed the template and processed the text and illustrations, the latter scanned by Patricia H. Packard (graphics specialist) from images photographed and published before the advent of digital cameras. Angela E. Hall (Web specialist) prepared the files for Web posting. Jenna Nolt and Christine Schorfheide, at the USGS Library in Reston; Holly Reed at the National Archives and Records Administration Still Picture Branch in College Park, Maryland; and Michael J. Brodhead, at the U.S. Army Corps of Engineers' Office of History in Alexandria, Virginia, also provided scanned images. I greatly appreciate all their efforts on behalf of the volume, but my colleagues are not responsible or accountable for its contents.

Some of the USGS employees mentioned in volume 4 played major roles in research and management in the years after 1960. This volume's text, however, does not try to anticipate these and other future developments beyond what those and other persons suggested or the technology promised before 1961. Some captions describe events after that year. Earth science nomenclature and other technical terms in the text are used in the context of the times when they appeared in publication and do not necessarily reflect subsequent or present usage.

Clifford M. Nelson

Chapter 1.
Prologue: U.S. Geological Survey Mandates, 1879–1939

> **[W]hat's past is prologue, what to come**
> **In yours and my discharge.[1]**
>
> **—William Shakespeare**

On March 4, 1939, as President Franklin D. Roosevelt (FDR) asked the 76th Congress for additional funds for national defense, the U.S. Geological Survey (USGS) quietly entered the 61st year of its existence with its name, one of its two original mandates, and most of its subsequent missions intact. In 1878, the 45th Congress and President Rutherford B. Hayes asked the National Academy of Sciences (NAS) to plan for reforming the Federal science and mapping surveys. The NAS ad hoc committee, advised by Clarence King at its chairman's request, prepared the plan. Carl Schurz, the Secretary of the Interior, asked King and Representative Abram S. Hewitt (Democrat of New York, hereinafter D–NY) to turn the plan into draft legislation. As enacted on March 3, 1879, the USGS Organic Act required "the Director of the Geological Survey" to manage the new agency's

> **classification of the public lands and examination of the Geological Structure, mineral resources and products of the national domain.[2]**

The new law provided for a bureau of practical geology, within the Department of the Interior (DoI), principally to aid America's growing mineral industry as the Federal Government had assisted the Nation's agricultural industry since 1862.

Beginning in 1879 and during the remainder of the 19th century, the USGS sought and gained statutory and continuing responsibilities for making topographic maps, collecting mining statistics, conducting water-resources investigations, and surveying forest reserves and Indian lands.[3] The 45th Congress and President Hayes specifically expected USGS investigations and mapping, planned and managed by new Director King, to help locate and develop the new sources of iron needed for construction and precious metals required for currency. In 1879, Congress and Hayes did not agree to establish the separate Federal mapping agency for surveys of measurement and position sought by the founders of the USGS to advance the national geologic compilation and the agency's other work. The Attorney General's interpretation that year of "national domain" as the lands whose title still resided with the Federal Government limited official operations by the USGS to the States and Territories with public lands, areas mostly west of the Mississippi River.

In 1882, the planned official expansion of USGS operations nationwide arrived with the authority, sought by King and his successor John W. Powell from the 46th and 47th Congresses and Presidents James A. Garfield and Chester A. Arthur,

> **to continue the preparation of a geological map of the United States.[4]**

Director Powell's interpretation of the new law enabled the agency to begin the needed national program of topographic mapping, including cooperation with the States beginning in 1884, but at the cost of deemphasizing the mandated efforts in economic geology for which Congress and Hayes established the USGS. To continue work led by Raphael Pumpelly and conducted during 1879–81 in cooperation with the Tenth Census (as arranged and cofunded by King), Congress and Arthur also directed the USGS in 1882 to begin officially "the procuring of statistics in relation to mines and mining other than gold and silver and in making chemical analyses of iron, coal, and oil."[5]

In 1888, responding to pleas for aid from farmers and ranchers devastated by arid summers and harsh winters on the Great Plains, the 50th Congress and President Grover Cleveland gave the USGS authority and $100,000 for

> **investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps[6]**

of the lands west of the 100th meridian. Another clause in the new law reserved from sale, entry, settlement, or occupation "all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes and all the lands made susceptible of irrigation"[7] by those engineering works. Powell established an Irrigation Survey within the USGS to select and map the sites required for the dams, reservoirs, and waterways. Until the USGS did so, however, the Attorney General ruled the statute closed the public lands to all homestead or other entry. The law also denied the gifts of Federal dowry lands promised for education and other public uses in each of the six new States—Idaho, Montana, North Dakota, South Dakota, Washington, and Wyoming—that entered the Union during 1889–90. When the USGS, despite receiving an additional $140,000 for the work, did not promptly designate all the sites, the 51st Congress and President Benjamin Harrison repealed the entry and dowry restrictions and discontinued the Irrigation Survey in 1890. Congress and Harrison then turned to the Agriculture Department for what proved to be a temporary solution. The USGS gained statutory responsibility for continuing national investigations of water resources in 1894, as sought by Charles D. Walcott, whom President Cleveland nominated as Director after Powell resigned. The 53d Congress and Cleveland provided the USGS with an initial $12,500 during fiscal year 1894–95 for

> **gauging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in arid and semiarid sections.[8]**

The USGS received authority and appropriations for surveys of Indian lands and forest reserves during the 1890s. In 1895, the Interior Department's Office of Indian Affairs (OIA) transferred funds to the USGS for

> **the survey of the lands in the Indian Territory * * * under the supervision of the Director of the Geological Survey, by such persons as may be employed by or under him for that purpose[9]**

and continued to provide sums for those surveys of boundaries and topography. In the Forest Management Act of 1897, the 55th Congress and President William McKinley approved draft legislation prepared by Walcott that required Secretary of the Interior Cornelius N. Bliss to arrange to survey the future forest reserves and any of those designated by Harrison and Cleveland since 1891 that were not yet mapped. The USGS received funds in 1898 to support the General Land Office (GLO) by continuing

> **the survey of the public lands that have been or may hereafter be designated as forest reserves.**[10]

The Forest Act of 1905 transferred the administration of the forest reserves from Interior to the Agriculture Department's Bureau of Forestry, an agency founded in 1901, which originated in Agriculture as a Division in 1881. In 1905, USGS responsibilities for classifying forested public lands shifted to the Bureau of Forestry (renamed the Forest Service in 1907), but the USGS retained the topographic (and special) surveys of forest reserves. Those surveys remained funded as a separate line item in the agency's appropriations until 1918, when it was merged with the line item for general topographic surveys nationwide.

After 1900, the USGS gained new missions in reclamation, the testing of fuels and structural materials, and the regulation of mineral resources, but it did not keep all of them. Units established within the USGS or transferred to the agency to carry out those functions that did not develop or retain scientific programs became separate bureaus within the DoI or were transferred outside it. In 1902, the Newlands Act established a reclamation fund, from the proceeds of sales and disposals of public lands in western States and Territories, intended to aid

> **the construction of irrigation works for the reclamation of arid lands.**[11]

The new statute enabled Interior Secretary Ethan A. Hitchcock, at President Theodore Roosevelt's request, to establish promptly a Reclamation Service within the USGS. The Reclamation Service became an independent bureau within Interior in 1907, as Walcott left the USGS to become the Smithsonian Institution's fourth Secretary. The Reclamation Service was renamed the Bureau of Reclamation (USBR) in 1923.

In 1906, the 59th Congress and President Theodore Roosevelt changed the USGS role from scientific classification of the public lands to resource evaluations made by the agency before the GLO sold or otherwise disposed of these lands. Roosevelt ordered the withdrawal of Federal coal lands, nearly 67 million acres, from public entry until the two agencies completed their determinations. The GLO and the USGS agreed to have the USGS finish its examination and classification of the coal lands and to report its findings to the GLO for action. Two years later, the USGS established a Land Classification Board to manage this practical assistance to the GLO that soon would include oil and phosphate lands and waterpower sites. George Otis Smith, Walcott's successor as USGS Director, raised the Board to branch status in 1912, but the Land Classification Branch continued to be funded by assessment on the three program branches until the 65th Congress and President Woodrow Wilson approved in 1917 the agency's budgetary line item for "the examination and classification of lands."[12]

Some of the functions of the U.S. Bureau of Mines (USBM) also originated within the USGS but did not remain there. In 1904, the 58th Congress and President Theodore Roosevelt funded completion by the USGS of a roster of U.S. mines. In the following year, they also approved appropriations for the agency's "analyzing and testing of the coals, lignites, and other fuel substances of the United States, in order to determine their fuel values" by a facility the USGS established at the Louisiana Purchase Exposition in St. Louis, Missouri. The plant began operating on September 1, 1904. They added responsibilities for investigating "the structural materials of the United States (stone, clays, cements, and so forth)."[13] Walcott established a Technologic Branch in 1907 to administer those responsibilities and operations, which continued after the Exposition closed and included from 1909 the inspection of mines and the investigation of the causes of mine explosions. In 1910, the 61st Congress and President William H. Taft agreed to transfer the Technologic Branch's Fuels Division and its Structural Materials Division from the USGS to Interior's newly established USBM. The Structural Materials Division then passed to the National Bureau of Standards (NBS, now the National Institute of Standards and Technology) in the Department of Commerce and Labor.

In 1925, President Calvin Coolidge shifted other functions between the USGS and the USBM. Coolidge's Executive order[14] transferred the USGS Division of Mineral Resources to the USBM, where it later became a unit for Minerals Information that continued the earlier statistical work by the USGS. The same order, as another Federal response to the Teapot Dome scandal,[15] moved the USBM to the Department of Commerce and transferred the USBM's Mineral- and Oil-Leasing Divisions to the USGS. The USGS then combined its two new units with the agency's Land Classification Branch and the Water Resources Branch's Division of Land Classification to form the Conservation Branch. The USBM returned to the Interior Department in 1934. Two years later, the functions, funds, and staff of the USBM's geophysical investigations passed by statute to the USGS; there, the unit formed the Geophysical Prospecting Section in the Geologic Branch.

Earlier in 1925, the 68th Congress and Coolidge also modified USGS cooperative work with the States, efforts that began with topographic mapping in 1884 and expanded to geology in 1899 and to hydrography in 1900. Congress passed and President Coolidge signed in 1925 the Temple Act that provided

> **for the completion of the topographical survey of the United States[16]**

and authorized $950,000 for that purpose during fiscal year 1925–26. The USGS expected that this amount and subsequent equivalent sums would enable its Topographic Branch to complete the work within the statutory requirement of 20 years, but no such money ever was appropriated. The statute also was enacted to raise to a maximum amount the funds provided by the States for this mapping and to allow Federal monies to be used for the remainder of the work rather than just ensure dollar-for-dollar cooperation. In 1926, the 69th Congress and Coolidge agreed to add to the USGS line item for topographic surveys a requirement that no part of the nearly $452,000 provided for that purpose should be expended in cooperation with any State, county, or municipality unless they bore the expenses required beyond those provided by Federal appropriations to the USGS to complete the work,

> **such share of the Geological Survey in no case exceeding 50 per cent.[17]**

They also made $372,000 of the appropriation "only for such cooperation with States and municipalities."[18] The appropriations authorized for water-resources investigations by the USGS during fiscal year 1928–29 applied the same 50-percent restriction to the Water Resources Branch's cooperative work with the States, counties, and municipalities and made available only for that purpose $125,000 of the $247,000 provided to the Branch.[19]

In 1929, USGS Chief Geologist Walter C. Mendenhall emphasized the agency's and the Nation's pressing needs for fundamental work in geology to gain a better understanding of "unknown general relations and natural laws" and thereby contribute to solving "the growing volume of practical problems, which are constantly increasing in complexity." In asking for greater human, institutional, and monetary support, Mendenhall warned that if the country wished to

> **apply science to human needs, there must be science to apply. Research can not be neglected in any field of science, geologic or other, without jeopardizing its usefulness.[20]**

Later that year, President Herbert Hoover, in his State of the Union Message to Congress, requested a reorganization and centralization of Federal efforts in conservation to secure "proper development and adherence to broad national policies."[21] To expand basic studies within the Federal Government, Hoover's initial budget contained increased funding for its scientific agencies. The 71st Congress and Hoover agreed to authorize a new line-item appropriation for the USGS of $100,000 for

> **fundamental research in geologic science[22]**

during fiscal year 1931–32. Mendenhall, who succeeded Smith as Acting Director in 1930 and as Director in 1931, requested the same amount for USGS fundamental research in geologic science in fiscal 1932–33. The 72d Congress and Hoover provided only $40,000 for fiscal 1932–33,[23] and the growing effects of the Great Depression thereafter ended authorizations for this basic work supported by its own line-item funds.

In 1933, Franklin Roosevelt's administration renewed and reorganized Federal activities in resource management and conservation. Interior Secretary Harold L. Ickes transferred to the USGS Conservation Branch the responsibility for receiving and keeping accounts on rents, royalties, and license fees from mineral-resources lands on the public domain before sending the monies to the GLO.[24] In 1934, the 73d Congress and Roosevelt agreed to enact a statute intended "to stop injury to the public grazing lands by preventing overgrazing and soil deterioration, to provide for their orderly use, improvement, and development, and to stabilize the livestock industry"[25] without impinging on mining and water rights but also allowing land exchanges within individual States. The new Taylor Act authorized Secretary Ickes to establish grazing districts, or add to them or modify their boundaries, whose area would not exceed 80 million acres of "vacant, unappropriated, and unreserved lands from any part of the public domain,"[26] except Alaska; national forests, monuments, and parks; and Indian reservations. The new statute also required Ickes to supervise the issuing of grazing permits for these districts and to determine the fees and number of livestock allowed on them. That law, while withdrawing most of the remaining public lands in the conterminous United States, authorized homestead entries in the grazing districts on tracts of less than 320 acres that Ickes determined were "more valuable and suitable for the production of agricultural crops than native grasses and forage plants."[27] The statute also enabled Roosevelt to place under Forest Service administration those unappropriated lands principally valuable for grazing but lying within the watersheds of national forests. In 1935, Ickes ordered the transfer of the USGS Conservation Branch's Agricultural Division (which had been responsible for classifying grazing lands since 1908) to the Department's new Division of Grazing. In 1939, Ickes reorganized the Division of Grazing and renamed it the Grazing Service.

As the world's political situation continued to deteriorate in the late 1930s, Mendenhall warned Congress that it was "futile to wait for an emergency and then expect sound and complete information on essential war materials to be provided immediately."[28] He began diverting some of the agency's activities to preparations for a greater role in the defense effort. In April 1938, the 75th Congress and President Franklin Roosevelt agreed to direct $500,000 of the Navy Department appropriations for fiscal year 1938–39 to the specific procurement and transportation of materials determined to be strategic and critical by the Secretary of the Navy. The 76th Congress and Roosevelt added in May 1939 another $500,000 to Navy funds for this purpose. In June, they provided separately for the common defense by authorizing the Secretaries of War, Navy, and Interior, acting through the Army and Navy Munitions Board (ANMB), to acquire

> **stocks of strategic and critical materials essential to the needs of industry for the manufacture of supplies for the armed forces and the civilian population in time of national emergency, and to encourage * * * the further development of strategic and critical materials within the United States for the common defense.[29]**

This act supplied $500,000 more in each of fiscal years 1939–40 through 1942–43, of which $350,000 in the individual years would go to the USBM and $150,000 to the USGS for "scientific, technologic, and economic investigations"[30] of domestic strategic and critical minerals.

Major changes in American science occurred in the 19th century before the founding of the USGS in 1879. By the beginning of the Civil War in 1861, earth scientists and other specialists (both civilian and military) had organized collective research and secured financial and other support for their endeavors from the States or the Federal Government. They planned and conducted mapping and science surveys of boundaries, coasts, land districts, and transportation routes within and across the United States. Federal mapping and science surveys of large areas of the public domain west of the 96th meridian began in 1867. Science in the United States continued to develop from the avocation of individuals to a professional occupation and from a lack of interest in abstract science and a preoccupation with practical or applied science to a greater emphasis on basic or fundamental research. The interval between 1846 and 1876, as Robert V. Bruce suggested in "The Launching of Modern American Science," saw the establishment of national patterns and institutions in science and technology that gradually transformed 19th-century science into its 20th-century avatar. During those years, science increasingly came to resemble a group and businesslike activity.[31] The increasingly professionalized approach, Bruce emphasized, required capital, labor, and management, and the careful evaluation of markets to gain significant support for research. Those key elements for transforming science were in place when the USGS began operations in 1879.

The establishment of the USGS marked the last stage in the progression, from State and Territory, to region, and then to Nation, of the collective researchers' efforts to gain financial support for their work. Science in general could not make a similar transition to the modern era without one additional important change. It required abandoning the widely held view that science was finite, representing a body of knowledge that could in time be determined completely, in favor of the concept of its limitlessness. When that substitution occurred in the 1890s, the scope of scientific problems increased, special fields of investigation, including those on the borders between them, began to proliferate, the importance of basic, or fundamental, research was recognized more generally, and the necessity of organized effort became clearer.

USGS managers, like their predecessors in the Federal Government, knew the path to continuity, growth, and prosperity for the agency in serving the American people and their elected representatives lay in gaining new functions that provided increased funds, staff, and operations. In the 60 years after 1879, the USGS actively sought or derived some of its new missions based on internal decisions. Other and safer mandates arrived via statutory changes or orders by higher management in the executive branch in response to the demands of emergencies in times of peace and war. On June 30, 1939, at the end of the fiscal year, the USGS retained unchanged one of its original twin mandates—geological surveys—although the other—classification of the public lands—was changed in 1906 from a scientific classification to an assessment made before the sale or disposition of these lands. Of the newer and mostly statutory missions assigned between 1882 and 1925, the USGS kept topographic surveys; cooperation with States, counties, and municipalities; the continuous study of water resources; and mineral-resources regulation. Restrictions imposed on USGS funds available for matching-fund cooperative work with the States and smaller government entities in 1926 and 1928, respectively, in topography and water resources also remained in place. After the turn of the century, the USGS spun off to other Interior Department organizations its functions, funds, and staffs in reclamation in 1907, fuels and structural materials testing and mine inspection and safety in 1910, and agricultural- and grazing-land classification in 1935. Funds for USGS investigations of critical and strategic minerals (1939) renewed studies last significantly increased during the Great War of 1914–18, later known as World War I.

During the years between 1879 and 1939, the Nation's attitude toward and its need for science and its products also affected USGS plans and operations. The responses by the five Directors—King, Powell, Walcott, Smith, and Mendenhall—to the pressing national problems of their times also governed the agency's efforts to varying degrees and produced both successes and failures. The USGS, from its outset, actively supported the modernization of science in America, even after the growth of graduate programs in research at Johns Hopkins and other universities before 1900 and the advent of private-grant organizations like the Carnegie Institution of Washington in 1902. In the subsequent years, USGS funds, staff, and operations grew slowly but intermittently, until they reached the largest levels and widest scope yet attained during fiscal year 1938–39. In that year, the USGS remained one of the smaller Federal bureaus when assessed by its total funds of less than $8 million and staff of about 1,300 employees. Mendenhall and the USGS, however, were about to face a new challenge to the Nation and the agency, one far beyond those posed by World War I and the Great Depression of the 1930s.

Chapter 2.
Pursuing Simultaneous Courses, 1939–1941

> **In our American unity, we will pursue two obvious and simultaneous courses; we will extend to the opponents of force the material resources of this nation; and, at the same time, we will harness and speed up the use of these resources in order that we ourselves in the Americas may have equipment and training equal to the task of any emergency and every defense.[1]**
>
> **—Franklin D. Roosevelt**

On September 1, 1939, at 4:45 a.m. (local time), units of Germany's armed forces attacked Poland.[2] The Wehrmacht's invasion, following a Polish incident staged by Germans on German soil, came without a declaration of war. Two days later, after the German Government refused to end its aggression, the Governments of France and Great Britain declared war on the Third Reich to honor their recently signed agreements to defend Poland. The conflict surprised and shocked many people in the United States, including Members of Congress, who, after they adjourned on August 5, remained confident that war would not begin in Europe that year. Many Americans considered the new war a strictly European affair and believed that Britain and France would defeat Germany. Those who regretted U.S. participation in World War I hoped the Nation would not repeat that "mistake." They wished to continue to avoid all foreign entanglements and, perhaps especially, U.S. cooperation with any collective-security effort such as the League of Nations.

Americans less surprised by the outbreak of war included several geologists. Recalling the scientific contributions that helped the Allied Powers to win World War I, they joined those during the 1930s who urged greater preparedness as dictators and militarists in Germany, Italy, and Japan increasingly threatened world peace. Walter Mendenhall, Director of the U.S. Geological Survey (USGS), raised this issue while testifying in December 1935 before the Subcommittee on Interior Department of the House Committee on Appropriations. Mendenhall observed that

> **[o]bviously much more concentrated attention than is possible should be given to strategic and deficiency minerals. There is great unrest in the world, and all that it is possible to do should be done to make this country self-sufficient in the mineral field.[3]**

U.S. self-sufficiency in minerals became more important during 1935–37. Benito Mussolini's Italy conquered and annexed Ethiopia. Italy's success again exposed the League of Nations' impotence; the League's limited military and economic sanctions, which did not include oil,[4] proved ineffective. Japan joined the Anti-Comintern Pact and began its second war against China. Germany, led by Adolf Hitler, occupied the Rhineland.[5]

When Congress still failed to act to remedy U.S. mineral deficiencies, Mendenhall again cautioned in January 1938 that

[i]t is futile to wait for an emergency and then expect sound and complete information on essential war materials to be provided immediately. Such information should be systematically collected during periods of peace to be available when emergencies arise.[6]

Geologist Walter Curran Mendenhall (1871–1957) joined the USGS full time in 1895. He served with the Geologic and Hydrologic (later Water Resources) Branches in the Eastern and Western United States and in Alaska, led the Land Classification Board (later Branch) during 1911–22, and then succeeded C. David White as the USGS' Chief Geologist. Mendenhall was named Acting Director of the USGS in 1930, after President Herbert Hoover appointed George Otis Smith to the Federal Power Commission. Mendenhall, as Director (1931), guided the USGS through the Great Depression of the 1930s and the initial years of World War II. In 1943, Secretary Ickes, convinced that the Nation and he needed an oil geologist as USGS Director, recommended to President Franklin Roosevelt that Mendenhall not be given a third year's extension beyond the (then) mandatory retirement age of 70. Mendenhall, like White, enthusiastically supported fundamental research in the geological sciences and secured (if briefly) funds devoted solely to it. Mendenhall's directorate was a major watershed in USGS history. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0006, https://www.sciencebase.gov/catalog/item/51dda1e6e4b0f72b4471def7.)

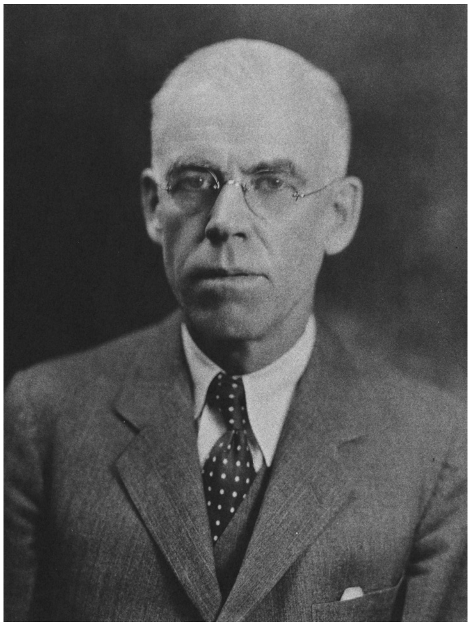
Mendenhall's warnings did not convince Congress to authorize and to fund strategic-mineral investigations, but Interior Secretary Harold Ickes, also head of the Public Works Administration (PWA), allotted PWA funds[7] to enable the USGS to initiate some studies during the fiscal year beginning on July 1, 1938.

In December 1938, the Geological Society of America (GSAm) and the Mining and Metallurgical Society of America focused their attention on strategic minerals. The Mining and Metallurgical Society adopted a resolution recommending to the Roosevelt administration and to Congress the accumulation of emergency stocks of specific minerals for war preparedness.[8] Charles K. Leith, professor of geology at the University of Wisconsin, addressed those concerns in New York City at the GSAm's 51st annual meeting. Leith had advised the Shipping and War Industries Boards about minerals during World War I, accompanied the American Commission to Versailles in 1919, and spent much of the next two decades in a vain effort to establish a national mineral policy. Earlier in the 1930s, he also served on President Franklin D. Roosevelt's (FDR's) Science Advisory Board with physicist Karl T. Compton, president of the Massachusetts Institute of Technology (MIT); astronomer William W. Campbell, director of Lick Observatory and president of the National Academy of Sciences; geographer Isaiah Bowman, president of Johns Hopkins University (JHU) and chairman of the National Research Council (NRC); electrical engineer Frank B. Jewett, president of Bell Telephone Laboratories; and four other distinguished colleagues.

Leith, in one of nine papers presented on December 30, 1938, to mark the GSAm's first half-century, discussed the role of minerals in the present international situation. He reminded his audience that mineral resources could affect not only future standards of living but also the issues of peace and war. Control of the larger part of the world's mineral wealth, Leith again pointed out, centered in nations that bordered the North Atlantic, those where the Industrial Revolution began. Britain and the United States now controlled, in about equal proportions, three-fourths of the world production of minerals, but less privileged nations seriously challenged the position of the nations that dominated the mineral trade. Efforts by the have-not nations to find and develop domestic supplies, to devise processes to make available domestic low-grade supplies, and to use synthetics or substitutes for minerals in deficient supply did not provide adequate resources. Consequently, these countries sought to achieve economic self-sufficiency by acquiring new territory and obtaining commercial control of minerals by barter, exchange, or bilateral treaties. As prime examples, Leith cited Germany, Italy, and Japan. Germany depended heavily on Swedish iron ore and also obtained 62 percent of its oil and 82 percent of its copper abroad. Italy needed foreign sources for 75 percent of its iron and steel, 92 percent of its coal, 96 percent of its oil and copper, and almost all of its antimony, chromium, manganese, nickel, and tungsten. Japan imported 65 percent of its iron ore and coal and 93 percent of its oil, most of it from the United States. Although Japan looked forward to capturing more of China's coal and metal resources, it still relied on foreign sources for a dozen other minerals.[9]

The nations rich in mineral resources, Leith asserted, needed to address this looming problem. He concluded, prophetically, that efforts to resolve the international situation would fail. The mineral-rich nations then would have to defend their economic and geographical positions, the bastions of their democratic institutions. Military preparation for defense already was well underway, although protection against economic penetration was "still sadly in arrears"[10] and likely would be achieved only by the force of events. Leith thought that the mineral-rich nations would not cooperate for mutual defense until further inroads were made on their mineral domains. He believed that "the ultimate problem of finding some way to administer the world's mineral resources from the standpoint of world welfare and peace remains for the future."[11] Leith added that

> **[g]eologists cannot settle these questions, so vital to world peace, but, knowing as they do their physical background, they are in a position to make highly significant contributions to both the immediate problem and the long-range problem of using our mineral power in trust for world welfare. The responsibility should not be avoided.[12]**



Geologist, professor, and minerals adviser Charles Kenneth Leith (1875–1956) was educated at the University of Wisconsin and served on its faculty in 1902–45. During World Wars I and II, and the years between them, Leith also advised the Federal Government about the vital roles of minerals and the need for a national mineral policy. He also planned the geologic and economic survey of the Boulder Dam region, served on Franklin Roosevelt's Science Advisory Board from its founding in 1933, chaired the Board's subcommittee on the USGS and the USBM, and proposed a mineral-policy planning committee that later was folded into the National Resources Planning Board. Leith retired from the University of Wisconsin in 1945, but he continued to advise the U.S. Atomic Energy Commission, the national defense establishment, and the National Research Council. (Photograph from Hewett, 1959, unnumbered plate; also published as Lund, 1957, pl. 14.)

Leith then took his case directly to U.S. military authorities, who reacted promptly. The War Department reactivated its Mineral Advisory Committee (MAC) and placed it under the Army and Navy Munitions Board (ANMB). Late in December 1938, Leith became the MAC's chairman. Leith's group included James W. Furness, of the U.S. Bureau of Mines (USBM), and D. Foster Hewett of the USGS, who presented to the Brookings Institution earlier in the 1930s a plan for what he believed were vital investigations of strategic minerals. The War Department directed Leith's MAC to prepare studies about strategic minerals and metals, recommend what domestic supplies the military could use in an emergency, report where domestic supplies were inadequate, and suggest how much of these materials should be purchased and stockpiled before possible hostilities began. The MAC, using the commodity approach successful in the past, picked 17 essential minerals and established to study them subcommittees composed of representatives of industry and government. On January 12, 1939, President Roosevelt, who in his annual message to Congress a week earlier emphasized the growing danger to world peace, continued his requests for additional huge sums for national defense and his budget-based opposition to stockpiling. On the same day, Senator Elbert D. Thomas, Democrat of Utah (D–UT), filed for the Committee on Military Affairs the first of several bills to provide for acquiring additional strategic and critical materials. Roosevelt did not endorse or oppose the legislation Thomas introduced.

As these bills passed through the legislative process, aggression and civil war continued worldwide. Germany, having annexed Austria and occupied the German-speaking Sudetenland of Czechoslovakia, dismembered the remainder of Czechoslovakia by annexing Bohemia and Moravia. Lithuania's Memel Territory, part of East Prussia until 1919, returned to German rule. Italy annexed Albania. Francisco Franco's Nationalist forces, aided by German and Italian contingents, ended 3 years of civil war in Spain by capturing Madrid and Valencia from the Republican Loyalists and their international brigades, supported by the Soviet Union. Japan intensified its war against China and also clashed with the Soviet Union on the Siberian-Manchurian border.[13]

The appropriations committees in the Democratic-controlled 75th Congress addressed some of the mineral-resources issues in 1938. On April 26, 1938, the legislators provided the Secretary of the Navy with $500,000 for "the procurement and transportation of strategic and critical materials," while preventing their "current use in time of peace unless replaced by materials purchased from current appropriations."[14] For these same purposes, Congress supplied an additional $500,000 on May 25, 1939.[15] For fiscal year 1939–40, the Interior Department requested in late January only a moderate increase in USGS appropriations, primarily to strengthen the agency's water-resources investigations, but the Bureau of the Budget (BoB) recommended no raise over the current fiscal year, and Congress made only minor changes. Interior's appropriations bill for fiscal 1939–40, signed by FDR on May 10, 1939, provided the USGS with $3,293,000[16] for salaries for its regular employees and for operating and publishing expenses, but the statute gave the agency little opportunity for new programs.

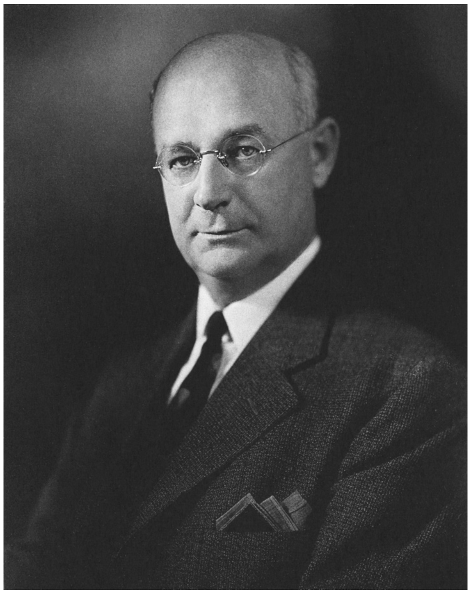
On June 7, 1939, Congress passed the Strategic and Critical Materials Act[17] to provide for acquiring stocks of these materials and to encourage the development of mines and deposits of strategic minerals within the United States. The new law authorized the Secretaries of War, the Navy, and the Interior, acting jointly through the ANMB, to determine which materials were strategic and critical and the quality and quantity of such materials to be purchased. The statute also authorized the Secretaries of War and the Navy, when they deemed it appropriate, to direct the Secretary of the Treasury to purchase such materials. The act further authorized the appropriation of $100 million during the fiscal years ending June 30, 1939, through June 30, 1943, for obtaining stocks of strategic materials, but Congress and the President approved only an initial $10 million.[18] Lastly, this law provided $500,000 to the three Secretaries in each of those fiscal years. Of these annual sums, $150,000 would go to the USGS and $350,000 to the USBM for investigations about

> **the extent and mode of occurrence, the development, mining, preparation, treatment, and utilization of [domestic] ores and other mineral substances * * * essential to the common defense or the industrial needs of the United States.[19]**

Results from the combined studies would be used by agencies and industries to determine and develop these sources, treat and use lower grade reserves, develop substitutes for essential ores and mineral products, and estimate costs of production. On August 9, supplemental appropriations for fiscal 1939–40 gave the USGS the $150,000 for the strategic- and critical-mineral studies authorized on June 7 and an additional $25,000 sought by Director Mendenhall for gaging streams and determining the water supply of the United States.[20] The supplemental appropriations and the funds transferred or repaid from other Federal agencies, States, counties, and municipalities increased USGS total monies available for fiscal 1939–40 to about $7,246,000.[21] Mendenhall thought that the increased funds received for defense-minerals studies remained far short of the sum needed and recommended by the USGS, but the money so far provided for this work also was encouraging as recognizing the principle involved. The USGS funds for fiscal 1939–40 provided salaries and operational expenses for a staff of 1,472 employees in the agency's five Branches—Geologic Branch (176 persons), Alaskan Branch (11), Topographic Branch (345), Water Resources Branch (540), and Conservation Branch (175)—and supporting administrative and publishing units (225).

The renewed strategic-mineral studies by the USGS authorized and funded by Congress and the President were barely underway during the first quarter of fiscal year 1939–40 before Roosevelt called the legislators into special session on September 21 to consider what new or amended legislation would respond best to the changed political and military conditions in Europe. Roosevelt declared on September 3 that "This nation will remain a neutral nation";[22] unlike President Wilson in 1914, however, Roosevelt refused to "ask that every American remain neutral in thought as well."[23] Roosevelt, like Wilson, warned that "When peace has been broken anywhere, the peace of all countries everywhere is in danger."[24] By the time Congress reconvened more than 2 weeks later, the German blitzkrieg, an offensive that combined rapidly moving armored units backed by motorized infantry and close air support, smashed Polish resistance. The Wehrmacht demanded Warsaw's surrender on September 17, the same day that Soviet forces attacked eastern Poland. Roosevelt again asked Congress to reexamine the embargo provisions of the Neutrality Act of 1935, as twice extended, which prevented sales to belligerents by U.S. factories of any completed implements of war but did not prevent the sale of uncompleted ones that could be finished in those nations. Roosevelt applied the act on September 5. Three days later, an Executive order reorganized

Geologist Donnel Foster Hewett (1881–1971) joined the USGS in 1911 and led its Geology of Metalliferous Deposits Section during 1935–44. Hewett, drawing on his experiences during World War I, recognized U.S. needs for strategic and critical minerals. He joined Charles Leith in alerting FDR's administration and the mineral industry about these vital requirements. Hewett then fashioned the USGS response during World War II. USGS geologist James Gilluly recalled that "[b]efore the war ended the nation was producing from many small deposits and a few large ones most of the minerals in short supply." (Quotation from Gilluly, 1974, p. 117; photograph from Fleischer, 1972.)

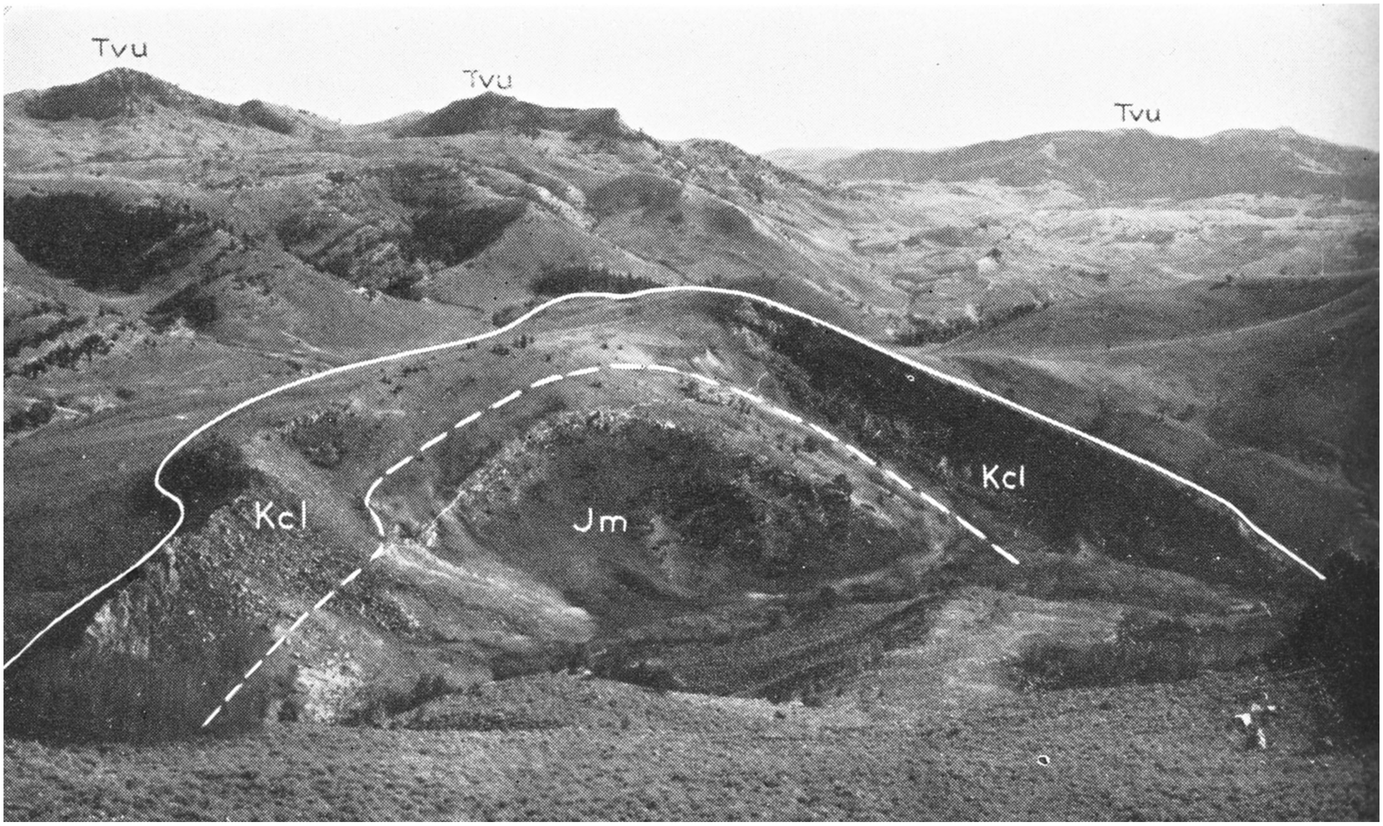


Geologist Gerald Francis Loughlin (1880–1946), after teaching at Yale and Boston College, began working full time for the USGS in 1912. He studied geology and ore deposits in Idaho, the Tintic and other mineral districts in Utah (with Bert S. Butler), and Colorado's Leadville district (with John D. Irving). Loughlin completed the work at Leadville after Irving died in 1918. Loughlin also studied limestones and other building materials. He led the Mineral Resources Division (1920–24) and the Geology of Metalliferous Deposits Section (1924–35), before serving as Chief Geologist (1935–44) and then as a Special Scientist on Director William Wrather's staff. (Photograph from Burchard, 1947, pl. 8.)

the President's Executive Office and established six principal divisions—the White House Office, the Bureau of the Budget (moved from the Treasury Department), the National Resources Planning Board (NRPB), the Liaison Office for Personnel Management, the Office of Government Reports, and an optional office for emergency management to be founded in the event of a national emergency.[25]

Roosevelt, in declaring on September 21 a limited national emergency and urging repeal of the neutrality law's embargo provisions, emphasized that "a belligerent nation often needs wheat and lard and cotton for the survival of its population just as much as it needs anti-aircraft guns and anti-submarine depth-charges." To be consistent, the President believed that those who wanted to retain the existing embargo should "seek new legislation to cut off cotton and cloth and copper and meat and wheat and a thousand other articles from all the nations at war."[26] He also asked Congress to consider legislation to restrict U.S. vessels from entering war zones, prevent U.S. citizens from traveling on belligerent vessels or to dangerous areas, require foreign buyers to take title in the United States to commodities purchased for belligerents, and prevent the extension of war credits to belligerents. On October 3, as Congress continued to debate changing the neutrality legislation, Roosevelt established the Pan-American Neutrality Zone, an unprecedented sea-safety area that extended eastward some 300 to 600 miles from the coasts of the Americas between Nova Scotia and Cape Horn, to be patrolled by the U.S. Navy. The legislators, after weeks of argument, finally voted to repeal the arms-export embargoes and to authorize cash-and-carry exports of arms and munitions to belligerent powers. The President, in signing the new neutrality law on November 4, also established a National Munitions Board (NMB),[27] chaired by the Secretary of State and including the Secretaries of the Treasury, War, the Navy, and Commerce, to formulate rules and regulations for enforcing the statute.

The advent of war in Europe and in the Atlantic brought no marked changes in USGS programs, aside from the increased emphasis on strategic-minerals investigations. For fiscal year 1939–40, the USGS received $542,000[28] for geologic surveys and related chemical and physical research by members of its Geologic Branch, managed by geologist Gerald F. Loughlin since 1935 and now employing 176 persons. In addition to the direct supplemental appropriation of $151,000 for strategic- and critical-minerals studies,[29] funds from other sources raised the Branch's total to $693,000. These funds provided salaries for and enabled operations by its 10 program sections operating since fiscal 1936–37: Chemistry and Physics, Geologic Map Editing, Geology of Areal and Nonmetalliferous Deposits, Geology of Fuels, Geology of Iron and Steel Metals, Geology of Metalliferous Deposits, Geophysical Prospecting, Glacial Geology, Paleontology and Stratigraphy, and Petrology. The Sections of Fuels, Areal and Nonmetalliferous Deposits, Iron and Steel Metals, and Metalliferous Deposits began regular activities at the start of the field season. Loughlin, while visiting regional managers and field parties in the West, also spent 2 weeks looking at gold mines in Montana's Little Rocky Mountains. Geologists in the Metalliferous Deposits Section, Loughlin's former unit and led by Hewett since 1935, continued mapping and mineral investigations in Colorado for the 15th consecutive season in cooperation with organizations in the State. John S. Vhay worked in the Alta and Palmyra Basins; Wilbur S. Burbank, in the Red Mountain area; Albert H. Koschmann, at Cripple Creek; and Edwin N. Goddard and Thomas S. Lovering, at Gold Hill. Henry G. Ferguson and Thomas B. Nolan returned to their fieldwork in Nevada, and Stephen R. Capps (Jr.) went back to west-central Idaho. George R. Mansfield, his study of Florida's phosphate deposits completed, continued to lead the Areal and Nonmetalliferous Deposits Section, formed by the merger of two units in 1927 when Hugh D. Miser transferred to lead the Fuels Section. Mansfield also examined bentonite deposits in Mississippi's Monroe County. Ernest F. Burchard continued serving, as he had since 1917, as Chief of the Iron and Steel Metals Section.



This cross-sectional view of the South Sunshine anticline looks south across Gooseberry Creek, south of Meeteetse, Wyoming. The Morrison Formation (Jurassic, Jm) is the oldest unit exposed in the structure. Scarps formed by the Cloverly Formation (Cretaceous, Kcl) outline the anticline and its more than 800 feet of closure. Tertiary volcanic rocks (Tvu) form the peaks on the skyline. In the late 1930s, USGS geologists continued studies of the geologic framework and economic resources of large areas in the Western United States. William Pierce and David Andrews mapped the geology of about 385 square miles in the southwestern part of the Bighorn Basin and examined in detail its occurrences of Cretaceous subbituminous coal and bentonite deposits. (Photograph from Pierce, W.G., and Andrews, 1941, pl. 20*B*; a higher resolution image is available in the USGS Denver Library Photographic Collection as Pierce, W.G., pwg00381, https://www.sciencebase.gov/catalog/item/51dda14ae4b0f72b4471de79.)

After Polish resistance ceased on October 5, Germany and the Soviet Union divided the country between them. Germany's use of aircraft and motorized vehicles in swiftly conquering western Poland indicated that petroleum would be even more important in the new conflict than in World War I. In November 1939, the House Committee on Interstate and Foreign Commerce held hearings on a bill to promote the conservation of petroleum and to create an Office of Petroleum Conservation. Clarence F. Lea (D–CA), who chaired the committee, filed the bill in July after President Roosevelt suggested to Congress that it quickly enact legislation to provide a coordinated national policy on oil conservation. Hugh Miser and geologist Hale B. Soyster, Chief of the Oil and Gas Leasing Division in the USGS Conservation Branch since 1932, were among the persons who testified at the hearings, but the legislators took no further action. The American Petroleum Institute's estimate of proved reserves in 1939 totaled nearly 18.5 billion barrels of oil, an increase of about 5.3 billion barrels since 1936, despite the production of nearly 4.9 billion barrels during the same interval.[30] The United States still produced some 60 percent of the world's output; even with the expected rising demands for defense, the American petroleum industry anticipated no difficulty in meeting domestic requirements and hoped to increase exports.

In Miser's Fuels Section, Thomas A. Hendricks and Paul Averitt investigated the geology and oil possibilities in the western part of the Ouachita Mountains of Oklahoma, and Wendell P. Woodring continued his work in California's Santa Maria district. Arthur A. Baker appraised the phosphate resources, as well as the coal, gas, and oil potential, of the southern Wasatch Mountains in Utah. David A. Andrews and William G. Pierce continued a study of the stratigraphy, structure, economic geology, and geomorphology along the northeast flank of the Bighorn Basin in Wyoming and Montana. Walter C. Warren, aided by aerial photographs, mapped about 1,150 square miles of coal lands in southeastern Montana. Other members of the Fuels Section completed revising the coal map of the United States, the national oil and gas map, and the oil and gas maps for Kansas, Louisiana, Oklahoma, and Texas. They also prepared reports on the geology and development of oil fields during 1934–39 for the Petroleum Investigation Subcommittee of Representative Lea's Committee on Interstate and Foreign Commerce.

Elsewhere in the Geologic Branch, the mapping program also continued; as before, many projects were done in cooperation with or for other Federal agencies. Charles B. Hunt completed the fifth and final year of his study of Utah's Henry Mountains and also examined gold placers on the Colorado River between Hite and Lees Ferry. In collaboration with the USBM, scientists in the Geologic Branch investigated seismic vibrations caused by quarry blasts, examined tunnel and dam sites for the U.S. Bureau of Reclamation (USBR), studied mining claims, mineral deposits, and geological features for the National Park Service (NPS), evaluated erosion and deposition along shorelines for the U.S. Army Corps of Engineers (Army Engineers), and noted for the Public Health Service geologic factors that might affect the death rate for tuberculosis. Branch members also lent their expertise to the ANMB and the NMB, the Advisory Commission to the Council of National Defense (CND), and Congress' Joint Committee to Investigate the Adequacy and Use of Phosphate Resources in the United States.

When the USGS received the new funds for strategic-minerals investigations, members of the Geology of Metalliferous Deposits Section began field studies under Nolan's immediate supervision while Hewett concentrated on the cooperative work with the USBM. By the end of August 1939, the Mineral Advisory Committee completed reports on all but 1 of the 17 minerals and submitted them to the NMB and recommended acquiring stockpiles of several minerals in sufficient quantities to last for a 3-year emergency at a cost they estimated between $360 million and $363 million. The deficiency and supplemental appropriations act of August 9, 1939, however, included only $10 million for procuring these stockpiles. The MAC recommended that priority be given to gaining stocks of tin, manganese, and chromium. It further suggested that when sufficient supplies of these three minerals had been obtained, the Government should collect stocks of tungsten, mica, mercury, graphite, and vanadium, in that order.

USGS field parties faced a formidable task in investigating possible sources of the first six minerals listed (tin, manganese, chromium, tungsten, mica, and mercury) plus antimony. The United States led the world in using tin but, having virtually no known sources of its own, obtained most of its supplies from British Malaya; smaller quantities came from elsewhere in the British Commonwealth, China, and The Netherlands and its colonies. Less than 10 percent of the United States' requirements for manganese, used mostly in the steel industry, could be obtained from domestic sources; the remainder was imported from the Gold Coast (now Ghana), the Soviet Union, Cuba, India, Brazil, and Chile. Domestic production of chromium, also used in the steel industry, had remained negligible since the end of World War I; chromite-ore imports came from Southern Rhodesia (Zimbabwe), Turkey, the Soviet Union, French New Caledonia, Cuba, the Philippines, and Greece. Tungsten produced in the United States, also used in steelmaking, supplied only about 40 percent of the needed amount; the remainder came primarily from China, French Indochina, Burma, and Portugal. As the world's largest consumer of mica, the United States depended for its supplies almost entirely on imports from India, Brazil, Argentina, Madagascar (Malagasy Republic), and Canada. Quicksilver (mercury) deposits occurred in some U.S. Western States, chiefly in California, Oregon, and Washington, but, as the annual domestic production rarely exceeded the demand, mercury was imported from Spain, Italy, and a few other countries. The domestic production of antimony, used to add hardness and strength to lead, never yielded more than a fraction of U.S. needs. China supplied the United States with most of its antimony before Japanese aggression expanded there in 1937; thereafter, Mexico and Bolivia provided most of U.S. imports.

To conduct the expanded strategic-minerals investigations by the USGS, several experienced geologists recessed their ongoing field projects and were joined in the new field studies by a group of younger geologists, some as seasonal employees and others as full-time members of the staff. Thomas Nolan spent a month looking at tungsten districts in Nevada, California, and Arizona. In the fall, Dwight M. Lemmon, John V.N. Dorr 2d, and Mackenzie Gordon, Jr., also began to investigate the California deposits, especially those near Bishop, and Ward C. Smith and Philip W. Guild examined Nevada's Nightingale district. Initially, Dorr had mapped at Eureka, examined coal deposits in Wyoming and Montana, and then studied a wide range of strategic minerals elsewhere in the West. Earlier, Guild had looked at chromite deposits in Oregon's John Day Basin.

Other USGS geologists reexamined known deposits and searched for new occurrences of additional strategic minerals. Charles F. Park, Jr., continued his study, begun the previous year with PWA funds, of manganese deposits in Washington's Olympic Peninsula, and Edwin Goddard left Colorado to start an investigation of the Philipsburg district in Montana. Clyde P. Ross resumed his study of mercury deposits in central California, and Edwin B. Eckel led a party investigating occurrences in southern California; Eckel was the oldest son of Edwin C. Eckel, who served full time with the USGS during 1902–06 and then as a consultant before joining the Tennessee Valley Authority (TVA) as its Chief Geologist in 1933. Ralph J. Roberts, fresh from graduate studies with Chester R. Longwell at Yale, examined mercury and tungsten deposits in central Nevada. Roberts drew on his earlier part-time minerals-mapping work with John B. Mertie, Jr., in Alaska, with Stephen Capps in Idaho, with Samuel G. Lasky in Arizona, with Charles Park and others in Washington, and in Nevada with Henry Ferguson and Stanford's Siemon W. Muller. Roberts' geologic mapping in Humboldt County's Bottle Creek district pointed the way to inexpensive exploration by the USBM that uncovered a mercury-ore body and also disclosed a large area of similar ground that justified an additional search. Lincoln R. Page, newly employed by the USGS, and Harold L. James, a graduate student at the University of Washington, aided Francis G. Wells in investigating chromite in Oregon and California. Joe W. Peoples and Arthur L. Howland assessed the chromite resources of the Stillwater Complex in Montana, while Thomas P. Thayer examined those in Oregon. Thomas L. Kesler investigated the Carolinas' tin-spodumene belt, and he and Jerry C. Olson studied the muscovite-mica deposits in North Carolina's Spruce Pine district. Ward Smith, Lincoln Page, and Russell G. Wayland examined tin in the Black Hills of South Dakota, while Carl Fries, Jr., looked at tin in southwestern New Mexico's Black Range. Wayland mapped the geology of Alaska's Juneau region for his just-completed dissertation at Minnesota before aiding Charles Park's examination of manganese deposits in Montana's Butte district. A party of three, led by Donald E. White, a newly minted Ph.D. from Princeton, was sent out to examine quickly western districts where antimony might be found and spent most of its time in Idaho's Yellow Pine district. Richard P. Fischer and Arthur P. Butler, Jr., began a comprehensive survey of vanadium deposits in the Triassic and Jurassic clastic formations of adjacent parts of Colorado and Utah. Fischer earned his doctorate at Princeton in 1936, a year before he joined the USGS, with a study of the origin, nature, and distribution of sedimentary deposits of copper, silver, uranium, and vanadium in the Southwest.

The USGS Pick and Hammer Club's players marked the major and welcome infusion of cash and people to strategic-minerals studies by portraying in their annual show during March 1940 the search by "Don Fostero Hew It, Duke of the Mental Section,"[31] for "That Wonderful Wizard of Ours."[32] In "Cackle Hymn,"[33] sung to the tune of Julia Ward Howe's "Battle Hymn of the Republic" of 1862, Hew It crowed that

Geologist John Beaver Mertie, Jr. (1888–1980), worked part time with the USGS in Colorado for three summers before becoming a full-time employee in 1911. He spent 30 of the next 32 field seasons with or leading combined topographic and geologic parties in mapping and studying various parts of Alaska, including the Territory's lode and placer mineral deposits. Geologists Mertie and Philip Smith and two topographers and their assistants conducted a reconnaissance in 1924 of the newly established Naval Petroleum Reserve No. 4 north of the Brooks Range. In 1943, Mertie shifted (at his own request) to the Geologic Branch for studies of gold, monazite, quartz crystals, and zircon, principally in the Southeastern United States, investigations that continued part time (past his mandatory retirement at age 70) through 1975. (Photograph from Overstreet and Chapman, 1982.)

The Survey has more money than it's had for many years,
So it's hired some young geologists not dry behind the ears.
To write reports on minerals for Fergie's frightful shears —
Just watch him cut them down!

*** * * * ***

We sent them to Nevada and forgot to give them cars,
And they mapped the rich deposits that will win our future wars;
Though they spent strategic metals in Reno's gilded bars,
Where the slots gulp nickels down![34]

The Alaskan Branch, the smallest of the agency's five major program units and a mini-USGS for the Territory since 1903, managed for fiscal year 1939–40 less than 1 percent of the agency's funds and a staff of 11 people, but its geologists undertook some strategic-minerals investigations. Alaska miners had already produced more than $800 million in mineral wealth, and they were adding $25 million more each year, especially by extracting antimony, coal, copper, gold, lead, platinum, silver, and tin. Philip S. Smith, head of the Alaskan Branch since 1925, estimated in 1939 that the unit directed 35 percent of its fieldwork to exploration and 60 percent to reconnaissance studies but only 5 percent to detailed studies that included mapping for the War Department. Smith now controlled $65,500 for investigating Alaska's mineral resources and related work in topographic mapping and water-resources studies. He also represented the USGS on Interior's Committee on Alaska, established by Secretarial order on August 16, 1939.[35] Smith personally inspected gold mines in central Alaska to gain information on new developments. John Mertie, Jr., began looking at the tin deposits of the extreme western part of the Seward Peninsula. John C. Reed (Sr.) and Robert R. Coats mapped on Chichagof Island,[36] west of Juneau, to obtain detailed information on its gold mines and to trace the geology northward to an area of reported nickel-bearing ores. Fred H. Moffit continued his examination of the mineral resources on the northern flanks of the Alaska Range, mapping chiefly the country between the Delta and Johnson Rivers.

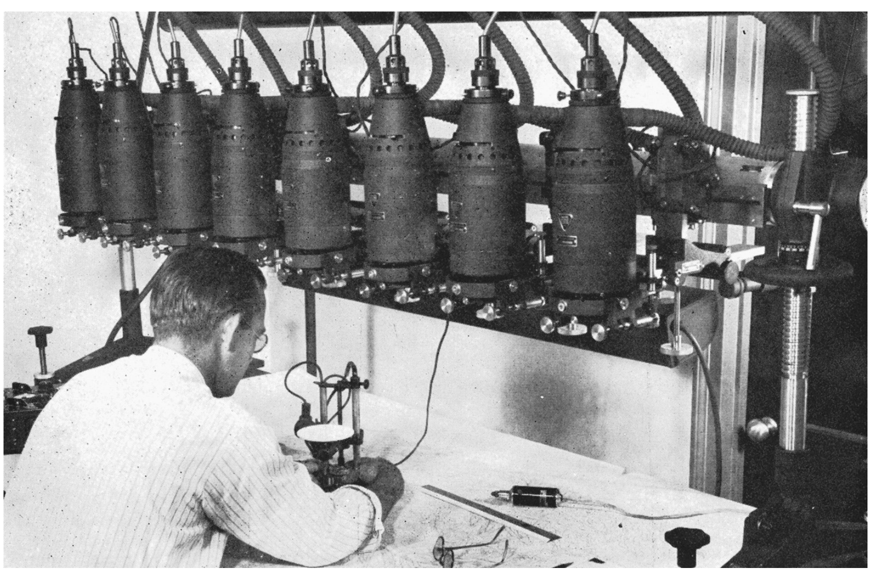
Gerald A. FitzGerald continued to direct all topographic work in Alaska, as he had done since 1937 when he succeeded R. Harvey Sargent after Sargent took over the Topographic Branch's Section of Inspection and Editing following the death of William A. Beaman. FitzGerald's topographers concentrated on eastern Alaska, where Toivo W. Ranta's group revised much of the early exploratory mapping of the country between the Nabesna and Chisana Rivers near the headwaters of the Tanana. FitzGerald's own party completed extensive surveys near the Porcupine River from Fort Yukon to the U.S.-Canadian boundary. From the beginning of continuous work in 1898 to the end of the field season in 1940, USGS topographers mapped, at reconnaissance and larger scales, some 210,000 square miles in Alaska, or about 46 percent of the Territory.

The Topographic Branch, managed by John G. Staack since fiscal year 1929–30, formed the second-largest program unit in the USGS in 1939. For fiscal year 1939–40, the Branch received $2,020,000 for topographic mapping. The appropriations law continued to limit Branch expenditures to no more than 50 percent of the cost of cooperative surveys with the States and municipalities and made $280,500 of the direct Federal appropriation available only for this purpose. The Branch's funds included money from emergency relief and public-works allotments plus repayments, adjustments, and transfers from the Army Engineers, the TVA, and the Public Roads Administration (PRA).[37] Fourteen States, Puerto Rico, and several municipalities provided cooperative funds of more than $297,000. Mapping continued in 46 States, the District of Columbia, and Puerto Rico, most of it by conventional field methods.

The Topographic Branch employed 345 persons in fiscal year 1939–40. The Engineers in Charge of the Branch's three regional Divisions—Albert Pike (Atlantic), Glenn S. Smith (Central), and Herbert H. Hodgeson (Pacific)—supervised topographers in the field. Headquarters for both the Atlantic and Central Divisions continued to be located in Washington, D.C.; the Pacific Division's headquarters remained in Sacramento, California. The Branch also maintained regional Section offices in Chattanooga, Tennessee; Denver, Colorado; Detroit, Michigan; and Rolla, Missouri. Ronald M. Wilson, Harvey Sargent, and Acheson F. Hassan served as Chiefs, respectively, of the Computing, Inspection and Editing, and Cartographic Sections. Joseph H. Wheat's Map Information Office and Photographic Mapping Section was divided, and the resulting units were placed under Acting Chiefs—William H. Gill (Map Information Office) and Samuel P. Floore (Photographic Mapping Section).

Topographic Branch personnel increasingly used photogrammetric methods,[38] principally to prepare topographic maps within the Tennessee River Basin for the TVA. More than 23,700 square miles nationwide were mapped, resurveyed, or revised during fiscal year 1939–40, including 3,600 square miles by the newer stereoscopic Multiplex aeroprojector, the Wild A5 Autograph plotter of 1937, or the decade-older and more limited radial-line photogrammetric method. After Zeiss Aerotopograph introduced the Multiplex machine in 1930 and a second model in 1935, the U.S. firm of Bausch and Lomb, in cooperation with the USGS and the TVA, produced an improved version for use in 1938. Combined with the slotted-templet method of map control introduced in 1933 and developed in 1936 by the Soil Conservation Service (SCS, now the Natural Resources Conservation Service) of the U.S. Department of Agriculture (USDA), the Multiplex system increased accuracy and yielded mass-produced photogrammetric maps at high speed and low cost. In a marked change in map reproduction, in 1939–40, 102 maps were prepared for multicolor photolithography and only 27 for engraving. Staack and his staff estimated that the USGS now provided topographic-map coverage for nearly 46 percent of the United States' total area.

Branch topographers continued work on other projects in fiscal year 1939–40. For the Work Projects Administration (WPA), they prepared maps at a scale of 200 feet to 1 inch in two urban areas. Frank W. Hughes managed the project in St. Louis begun in 1933. The project in Denver, started in 1936, continued with Fred Graff, Jr., the Chief of the Central Division's Rocky Mountain Section, as project director. The topographers intended to reduce the finished products by photography and



This Multiplex stereoscopic projection equipment includes improvements made during the early 1940s. In 1936, the USGS began Multiplex photogrammetry at Chattanooga for the Tennessee Valley Authority (TVA; see the Zeiss-USGS Multiplex equipment of 1937 shown in Rabbitt, M.C., 1986, p. 396). Photogrammetrists used stereotriangulation, planimetric compilation, and stereomodeling of adjacent photo strips, with ground control, to produce planimetric maps used as bases for field plotting of contours. The resulting topographic maps, with plotter-produced contour lines, were prepared mostly at 1:24,000 for the TVA. During World War II, Russell Bean's group, in cooperation with Bausch and Lomb, improved USGS Multiplex equipment to increase its ability to produce strategic-scale maps. They fabricated "diapositive printers with built-in distortion correction," improved projector illumination, and increased the range of tables to read "directly in feet at the desired scale." (Quotations from Thompson, 1958, p. 15; photograph from Rabbitt, M.C., 1954, p. 356, and also published in FitzGerald, 1979, fig. 6.)

Hydrologist Glenn Lane Parker (1884–1946) was educated at the University of Kansas and worked a year for the U.S. Coast and Geodetic Survey before transferring to the USGS in 1909. He studied water resources in the Columbia River Basin and on Alaska's Seward Peninsula and in the Territory's Yukon-Tanana region before becoming District Engineer for Washington State in 1913. In that role, he continued work on the control, quantity, and uses of the Columbia River and its tributaries. Parker, while Chief of the Water Resources Branch from 1939 until his death in 1946, also advised the International Joint Commission about the Columbia River Basin and other water bodies along the U.S.-Canadian boundary. (Photograph from National Archives and Records Administration, Still Picture Branch, as 57–GP–541.)

photolithography to the newer standard-scale coverage of 1:24,000, or 2,000 feet to the inch.[39] Branch personnel also continued efforts toward completing the Chesapeake Bay and Chicago sheets, each covering 4 degrees of latitude by 6 degrees of longitude, for the 1:1,000,000-scale International Map of the World; the U.S. transportation map for the Public Roads Administration; and river surveys for the USGS Conservation Branch.

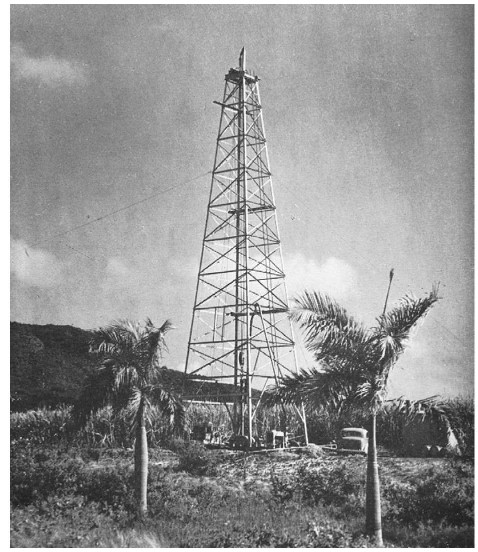
The Water Resources Branch in the fall of 1939 continued its recent 8 years as the largest program unit of the USGS, employing some 540 persons. For fiscal year 1939–40, the Branch received $3,168,000. Of this sum, Congress made $900,000 available only for cooperative surveys with the States, counties, and municipalities and also continued to limit, by statutes since 1926, Branch expenditures to no more than 50 percent of the total cost of this work. The legislators supplied another $25,000 specifically for repairs of monitoring systems and other special work in connection with the hurricane of September 4, 1938, that devastated New England and caused more than 460 deaths. The Army Engineers supplied most of the USGS water-resources funds transferred from Federal agencies. Branch investigations were underway in all States (except Delaware), the District of Columbia, and the Territory of Hawaii.

On October 17, 1939, Glenn L. Parker became Chief Hydraulic Engineer, replacing Nathan C. Grover, who had retired on January 31. Carl G. Paulsen, who temporarily replaced Grover while continuing, since 1931, as Chief of the Surface Water Division, moved into the newly created post of Assistant Chief Hydraulic Engineer, a position made necessary by the Branch's greatly expanded work. While leading the Surface Water Division, Paulsen continued his predecessor's efforts to improve cooperation with the States and the Army Engineers. Gaging stations established by Paulsen's Division increased from 4,165 to 4,761 during fiscal year 1939–40, continuing the decade's trend, and 3,534, or about 74 percent, of them now included water-stage recorders. Division members carried out an expanded program of constructing and operating river-measurement stations in cooperation with the Army Engineers as part of its flood-control investigations. They also continued programs in cooperation with the Department of Agriculture's Flood Control Coordinating Committee and tested, at the National Hydraulic Laboratory of the National Bureau of Standards (NBS), equipment for measuring stage-discharge relations at gaging stations.

Members of the Water Resources Branch's Ground Water Division, led by Oscar E. Meinzer since 1912, began or continued investigations in 38 States, the District of Columbia, and Hawaii, nearly all of them in cooperation with other Federal, State, territorial, or local government agencies. In several States, this work solely continued the observation-well program inaugurated in the mid-1930s, but periodic measurements were made in 5,500 wells in all parts of the country although only 265, or nearly 5 percent, of them contained recording gages. In the East-Central, or "old-rock," groundwater region, as defined by Meinzer in his 1939 description of groundwater conditions, resources, and utilization in the United States, studies were continued in Massachusetts and Connecticut, on New York's Long Island, in the Indianapolis area in Indiana, and in Ohio. Fred H. Klaer, Jr., and David G. Thompson investigated the buried valleys of preglacial streams that provided the chief source of groundwater in Butler and Hamilton Counties, Ohio. In the Atlantic and Gulf Coastal Plain, studies continued in southern New Jersey, Virginia, North and South Carolina, Georgia, Florida, Mississippi, Louisiana, and Texas. New work undertaken in the region included Moultrie A. Warren's study of the Savannah area in Georgia, where groundwater levels below sea level generated concern about possible encroachment by saltwater. Hilton H. Cooper, Jr., and Charles E. Jacob worked in the Pensacola area of Florida, to investigate whether new industries north of the city might adversely affect its water supply.

Groundwater investigations also continued or began in States west of the Mississippi River and in Hawaii. In the plains east of the Rocky Mountains, work continued in Iowa, Nebraska, Kansas, Oklahoma, and eastern New Mexico. Division engineers completed the High Plains project in Texas. The Pecos River Joint Investigation, modeled on that for the Rio Grande, began obtaining information on water supply and quality in order to support a compact between Texas and New Mexico negotiated in 1925 but never ratified. Salinity, erosion, silting of reservoirs and channels, and flood damage were parts of the overall problem. In the Western Mountain region, groundwater studies continued in Colorado, Utah, western New Mexico, and Oregon. Samuel F. Turner led the work in Arizona, where the State, the Interior Department's Office of Indian Affairs (OIA), and the Army Engineers all supplied funds for cooperative projects. Extensive development of Arizona's groundwater by private interests during the drought years of the 1930s exhausted the supply because of a lack of information on recharge. The OIA financed part of the Gila River Basin investigation because that agency needed data on the effect of upstream pumping of groundwater on the water flowing into the San Carlos Reservation. The Army Engineers, then studying flood control on the Gila and other streams, provided additional funds to learn about the potential effect of floodwater storage on the replenishment of groundwater. The Army Engineers suggested that two smaller precursor investigations in the Queen Creek area and the Santa Cruz River Basin should be used as experimental projects to test methods and train personnel. In January 1940, George A. La Rocque, Jr., began a new cooperative study in the coastal area of Orange and Los Angeles Counties in California. A dry interval between 1918 and 1936, combined with increased pumping for irrigation, so lowered the water levels in these counties that saltwater was being drawn into groundwater, which also was contaminated by oil-refinery brines and other industrial wastes. In Hawaii, District Geologist Harold T. Stearns and Gordon A. Macdonald continued their studies of the islands' geology, groundwater resources, and volcanoes. They focused their efforts, in cooperation with the Territory's Division of Hydrography, on Maui.

Work also continued during 1939 in the Water Resources Branch's three smaller program units that investigated water quality, water use, and waterpower resources. Researchers in the Quality of Water Division, led by chemist William D. Collins since 1920, concentrated on chemical analyses and studies of suspended and dissolved matter in 2,255 samples of surface and underground water, particularly in the Pecos River Basin, the Colorado River, and Idaho's Boise River Basin. The Division of Water Utilization, headed by hydraulic engineer Royal W. Davenport since 1931, emphasized flood studies, some of them supported by the PWA and the WPA. Managers in Davenport's Division also supervised projects that gathered data about the topographic characteristics of drainage basins possibly related to determining flood flows. Members of the Division of Power Resources, directed by Albert H. Horton since 1919, cooperated with the Bureau of Foreign and Domestic Commerce of the Department of State (DoS) in compiling a report on the construction of waterpower plants in other countries.



Data from this test well near the Jealousy Estate, about 5 miles east-northeast of Fredericksted, St. Croix, U.S. Virgin Islands, aided investigations by USGS geohydrologist D. John Cederstrom of the island's geology and groundwater resources during 1938–39. The well, which produced brackish water above 90 feet, tailed out in Upper Cretaceous volcanic rocks at a depth of 470 feet. (Photograph by Paul Schweitzer, from Cederstrom, 1950, pl. 6*B*.)

Herman Stabler, the Chief of the Conservation Branch since its establishment in 1925, directed four operating Divisions in 1939 and continued to supervise the Branch's work in land classification and lease supervision. Geologist John D. Northrop, who became Stabler's Assistant Branch Chief in 1925, also led the Mineral Classification Division. Hydraulic engineer Benjamin E. Jones managed the Water and Power Division. Mining engineer Howard I. Smith, who directed the Mining Division's lease work from 6 field offices, and Hale Soyster, who supervised the Oil and Gas Leasing Division and its 16 field offices and suboffices, both came to the USGS from the USBM during the transfer of staff, funds, and functions in 1925.

For fiscal year 1939–40, the Conservation Branch, now with 175 employees, received $594,000 to classify the public lands and to carry out its mineral-leasing responsibilities on public and Indian (now known as Native American tribal) lands and naval petroleum reserves. This sum included $100,000 from the OIA and $40,000 from the Navy. Members of the Mineral Classification Division disposed of more than 7,100 cases, restored from coal-land withdrawals about 128,000 acres in Utah, revised the definitions of the geologic structure of 12 oil and gas fields, and prepared the initial definitions of 12 new fields. At year's end, the completed definitions described nearly 1.4 million acres in California, Colorado, Montana, New Mexico, North Dakota, Oklahoma, and Wyoming. The Water and Power Division's staff made river-utilization surveys of 165 miles and detailed surveys of 11 dam sites.[40] Their work added some 18,500 acres to and eliminated more than 23,500 acres from waterpower reserves that now totaled almost 6.7 million acres in 22 States and the Alaska Territory. The Conservation Branch, in conjunction with the Water Resources Branch, also supervised 160 power projects for the Federal Power Commission (FPC) and 216 others for the Interior Department. Members of the Mining Division and the Oil and Gas Leasing Division, operating from 22 field offices in the States and Alaska, provided technical supervision of the mineral production from 925 mining properties and more than 11,000 oil and gas properties on the public and Indian lands. Interior Secretary Ickes approved 9 new field-unit agreements, bringing the total sanctioned to 120. Only 6 of the 1,680 agreements submitted since the program began in 1930 remained pending after the rejection, withdrawal, or suspension of the others.

Mineral and fuel commodities produced during fiscal year 1939–40 from properties under USGS supervision were worth an estimated $80 million and provided $8 million in royalties and related revenue. The fuels included the 3.8 million barrels of oil (each barrel equivalent in volume to 42 gallons) and 2.3 billion cubic feet of natural gas from 286 wells in California's Naval Petroleum Reserve No. 1 (NPR–1) and its NPR–2.[41] The Federal Government's revenue of $8 million represented more than twice the entire amount directly appropriated for the whole USGS (about $3,625,000) and over 25 times the sum provided by direct appropriation for supervising mineral leasing ($315,000).

When the USGS passed into the second half of fiscal year 1939–40, and the 76th Congress convened its third session on January 3, 1940, active hostilities in Europe were confined to Finland, which the Soviet Union attacked on November 30, 1939, without declaring war and shortly after occupying Estonia, Latvia, and Lithuania.[42] President Roosevelt nonetheless devoted much of his State of the

The site for a dam on the Kootenai River, Idaho and Montana, was relocated after USGS structural geologist Charles E. Erdmann and his colleagues in the Conservation Branch found a shattered-rock zone at the crest of a fold at the initial site downstream. The dam's new axis passed just above the head of the river rapid in the foreground toward the left-abutment site on the canyon wall. (Photograph from Erdmann, 1941, pl. 7*A*.)

Union Message to foreign affairs, emphasizing that although many citizens insisted on avoiding meddling and remaining neutral, there was "a vast difference between keeping out of war and pretending that this war is none of our business."[43] The truth Americans accepted in home affairs, of allowing low standards of living to persist in local units to pull down the entire Nation's level of civilization, Roosevelt believed, also applied to world affairs. He made no direct reference to Japan, which, unable to force a military decision in China, began to attack indirectly the positions of other foreign powers in China to cut their trade. The President did speak at some length about trade restrictions that had been "one of the contributing causes of existing wars."[44] Roosevelt urged that "when the time comes, the United States must use its influence to open up the trade channels of the world in order that no one nation need feel compelled in later days to seek by force of arms what it can well gain by peaceful conference."[45] Secretary of State Cordell Hull notified the Japanese Government on July 26, 1939, that the United States would not renew the American-Japanese commercial treaty of 1911, scheduled to expire on January 26, 1940. The United States would continue trade with Japan only on an ad hoc basis.

The Federal budget for fiscal year 1940–41 that the Roosevelt administration presented to Congress in January 1940 included a request for \$1.8 billion for national defense, but the total sum sought proved slightly less than that for the current fiscal year due to cuts in domestic programs. Overall funds for the Interior Department were about \$38 million less than the sum appropriated for fiscal 1939–40. The USGS sought an increase of about \$1.3 million—\$1,245,700 more for topographic surveys, including strategic mapping, and an additional \$81,500 for water-resources investigations. The budget also contained \$150,000 for strategic- and critical-minerals studies, the same amount appropriated in the supplemental funding in August 1939. On January 4, 1940, 1 day after the 76th Congress began its third session, Secretary Ickes formally changed the administrative assignments of several of Interior's agencies and other units in effect since September 1938. Under the new arrangement, four organizations—the General Land Office (GLO), the USGS, the USBM, and the Petroleum Conservation Division—reported to Assistant Secretary Oscar L. Chapman rather than to Under Secretary Alvin J. Wirtz.

Edward T. Taylor (D–CO), who sponsored the Grazing Act in 1934, chaired both the House Committee on Appropriations and its subcommittee responsible for assessing the Interior Department's requests for appropriations. Funds for USGS strategic-minerals investigations in fiscal year 1940–41 went unquestioned by the subcommittee on February 9, 1940, the day after Secretary Ickes testified, as did the increase for water-resources studies by the agency. On the eve of the subcommittee's hearings, the USGS released a statement on the effect on streams of the continuing drought. Subcommittee member Charles H. Leavy (D–WA) placed the assessment in the *Congressional Record* and said:

> **the alarming situation presented by this report of the Geological Survey is the fact that we are going into the crop season of 1940 threatened with even a greater water shortage than existed in 1939. How important, therefore, it is that we expand rather than contract the activities of the Federal Government in the field of water conservation and utilization.[46]**

The USGS appropriation urged for topographic surveys, however, excited considerable congressional interest. Secretary Ickes, who strongly supported the amount requested, told the subcommittee on February 8 that the record of the United States in topographic mapping should not be viewed complacently. He noted that only 50 percent of the Nation was mapped and that half of that total was "covered by old maps that are no longer adequate for modern needs." "In contrast," Ickes continued, "all of the great nations of Europe long ago completed maps of this character covering their homelands and many of their dependencies."

Britain, with an area less than one-thirtieth of the U.S. area and "her tremendous tax burden, has recently been expending 3 times as much for revision alone as has been directly appropriated in the United States for new mapping." Ickes called the Representatives' attention to the report, dated March 23, 1939, on topographic mapping that he prepared in conjunction with Secretary of War Harry H. Woodring and Secretary of Commerce Harry L. Hopkins in response to a Senate Resolution. The funds being proposed in the Interior bill would make available to the USGS only about half the amount the three Secretaries believed to be a very moderate start toward correcting past neglect. Ickes thought that figure "to be the very least that responsible officials, executive or legislative, can properly consider for this work."[47]

Director Mendenhall, Administrative Geologist Julian D. Sears, Loughlin, Hewett, Philip Smith, Staack, Grover, Stabler, and D. Otis Beasley, Chief of the Accounts Division, met with the subcommittee on February 9. In Taylor's absence, Jed J. Johnson (Sr., D–OK) acted as chairman and James G. Scrugham (D–NV), a former mechanical engineer, conducted the examination of the agency's budget, as he had often done since joining the subcommittee in 1935 and receiving responsibility for analyzing the USGS requests. Mendenhall found some of the Representatives scandalized by the amount for topographic mapping. When Johnson called the new sum "a tremendous increase,"[48] Mendenhall termed it only $320,000 more than the previous year's direct and emergency total and "not a large increase in view of our past neglect of this work."[49] Scrugham reminded his colleagues that Secretary Ickes and the Secretaries of War and Commerce agreed in their joint report to recommend a 3-year program of accelerated mapping that would provide $5 million, then $6 million, and lastly $7 million. The USGS was to receive $4 million of the program's first-year funds, with the balance going to the U.S. Coast and Geodetic Survey (USCGS). As half of the nearly $1,971,000 now requested for USGS topographic work during fiscal year 1940–41 would be spent on mapping strategic areas, based on War Department priorities, the question became a philosophical one. Should the War Department transfer money to the USGS to make the maps or supply its needs by looking to the agency as the Federal Government's prime mapmaker?

The House subcommittee and the full Committee on Appropriations decided that mapping strategic areas was primarily a military function, to be provided for in the military appropriations bill; therefore, the legislators recommended for the USGS a total of about $3.5 million, an increase of nearly $118,000, that included $760,000 for topographic mapping. In so deciding, they doubtless knew that Senator Carl T. Hayden (D–AZ) proposed on January 16 an amendment to a bill providing supplemental military appropriations that stated that as much as $5 million[50] might be expended for topographic surveys and mapping during fiscal year 1939–40, as recommended in the report received from the three Secretaries.

The Senate subcommittee on Interior's appropriations heard testimony on March 25 from Secretary Ickes and on April 4 from Director Mendenhall, Sears, and Beasley. Carl Hayden, the subcommittee's chairman since 1933, continued his interests and efforts in irrigation, reclamation, flood control, Indian affairs, public lands, and mining and water rights. The Senators, asked to restore the full sum for topographic work, shared the reluctance of their House colleagues to appropriate these funds to a civilian agency. Senator Kenneth D. McKellar (D–TN) even expressed great surprise that such a large sum could be spent on mapping when maps could be obtained free at any gas station "and for the life of me I cannot see where there is very much difference between the two."[51] Mendenhall supplied the principal differences. "A great more detail,"[52] he explained, and the accuracy and completeness of the topography, represented on USGS maps by contour lines, facilitated the compilation of geologic, resource, and other data and the construction of roads, tunnels, and other engineering works. Chairman Hayden introduced a statement that Major General Julian L. Schley, Chief of Army Engineers since 1937, made a few days earlier before another of Hayden's subcommittees that supported the accelerated mapping proposed in 1939 by Secretaries Hopkins, Ickes, and Woodring. Schley suggested that plan should be framed and hung "as an objective to be reached as soon as it can possibly be done," especially for its value to the defense of a nation "least advanced in topographic mapping of its own terrain"[53] compared to all other civilized countries. Hayden did not press the matter further. The committee added $1,210,350, available until June 30, 1942, "for topographic surveys and mapping"[54] to the bill making appropriations for the civil functions of the War Department; the money was to be transferred to the USGS. The civil-functions bill, ahead of Interior's legislation on the Senate's calendar, was passed and signed into law by President Roosevelt on June 24, 1940. Interior's appropriations bill, already enacted on June 18, provided the USGS with nearly $3,587,000 in direct monies[55] for the new fiscal year, but, including transfer and repay funds, the agency actually deployed a total of a little more than $7.8 million in 1940–41. The two bills gave the USGS a little more than $1,969,000 for topographic surveys, very close to the full amount requested by the agency.

By the time those bills became law, the international situation again changed dramatically. Soviet forces regrouped after their repulse in Finland; they attacked and overwhelmed Finnish defenses, while Britain and France stood aside and Germany's Adolf Hitler misread Soviet military capabilities. Finland's Government surrendered on March 12, 1940, and ceded key territory to the Soviet Union. On April 9, again without declaring war, German forces occupied Denmark and invaded Norway. Iceland declared itself independent on the next day, and British forces occupied the Faroe Islands (Føroyar). The Wehrmacht intended its attacks in Scandinavia principally to guarantee full access to iron ore from the Kiruna district in northern Sweden, vital to Germany's war economy. In summer, Kiruna ore shipments went south to Luleå on the Gulf of Bothnia for transit across the Baltic Sea. In winter, the ore was shipped west to ice-free Narvik and then south along the Norwegian coast. Only about 40 percent of the iron ore imported by Germany in 1938 came from Sweden, but the Anglo-French blockade cut off most other sources. British and French forces intervened but failed to save central and northern Norway. Although the numbers of British and German warships sunk or damaged during the campaign were about equal, the much smaller Kriegsmarine could ill afford its losses.[56] By the conquest, Germany gained control of Norway's titanium and molybdenum deposits, hydroelectric power, and heavy water (deuterium oxide) production for use as a neutron moderator in atomic-fission experiments. The Third Reich also gained air and naval bases on the North Atlantic and a second common frontier with the Soviet Union. The Soviets remained neutral and continued to exchange oil and other raw materials in return for German technological plans and products under their mutual pact of August 23, 1939.

On May 10, 1940, German air and ground forces invaded Belgium, Luxembourg, and The Netherlands. Winston S. Churchill, First Lord of the Admiralty in A. Neville Chamberlain's British Government since 1939, succeeded Chamberlain as Prime Minister and also assumed the Ministry of Defense. Churchill asked Roosevelt on May 15 for U.S. destroyers, antiaircraft guns, ammunition, steel, and other aid. In the first of a series of memorable speeches, Churchill promised Britons nothing but "blood, toil, tears and sweat"[57] in an at-all-costs struggle for ultimate victory. Defeats quickly tested Churchill's and Britons' resolve. German forces rapidly drove deep into northern France and reached the English Channel on May 20. By June 4, the Royal Navy and a hodgepodge of civilian vessels, well supported by the Royal Air Force (RAF), rescued from the Dunkerque (Dunkirk) beaches some 337,000 British and French troops but not most of their equipment. Hitler then offered the British Government peace in return for noninterference in Europe and indemnifications elsewhere. Churchill defiantly replied on June 4 that Britain would fight on, and Roosevelt promised U.S. support 6 days later.

The Wehrmacht launched a wide attack against the remaining French forces on June 5 and broke through their lines a week later. The Germans entered Paris on June 14, and 3 days later the French Government sued for peace. Henri Philippe Pétain became France's new Prime Minister, and Brigadier General Charles de Gaulle,[58] briefly Under Secretary of State for Defense and War, fled to Britain and began to organize the Free French. Under an armistice signed on June 21, all French forces in France were disarmed, and three-fifths of the country passed to German control. Pétain's government relocated to Vichy. Japan, reacting swiftly to France's collapse, demanded on June 25 the right to land forces in French Indochina, hoping to close the remaining supply routes to China. Churchill demonstrated his never-surrender resolve by ordering the Royal Navy to prevent Vichy French warships from collaborating with Axis forces in the Mediterranean. On July 3, after the French squadron at Mers-el-Kébir, near Oran, refused all peaceful options, the Royal Navy's Force H sank or heavily damaged three capital ships, but a fourth escaped to Toulon. The Vichy French Government promptly broke diplomatic relations with Britain and sent aircraft to strike Gibraltar.

The swiftness of these politico-military changes in Europe again astonished many Americans, but they galvanized official Washington. On May 16 and 31, 1940, Roosevelt asked for a total of $2.5 billion more for national defense to extend the sums already requested. On May 28, the President reactivated the Advisory Commission of World War I's CND, now composed of the Secretaries of War, Navy, Interior, Agriculture, Commerce, and Labor. The CND's Advisory Commission included Chairman William S. Knudsen, president of General Motors; Edward R. Stettinius, Jr., U.S. Steel Corporation's chairman; and five other members. Commission members managed investigations, research, and coordination in their designated fields—industrial production (Knudsen); industrial materials (Stettinius); employment; agriculture; transportation; price stabilization; and consumer protection. When Charles Leith offered Stettinius the services of his Mineral Advisory Committee, inactive since submitting its reports to the ANMB, Stettinius promptly appointed Leith a special consultant on strategic minerals. Leith arranged a series of confidential meetings among industry and government representatives and Advisory Commission members. They revised the procurement plans based on a new premise—increased authority and availability of additional funds for stockpiling but limited sources of supply. Meanwhile, the Interior Department requested more monies for strategic-mineral investigations. On October 9, Congress appropriated for these studies an additional $100,000 for the USGS and $215,000 for the USBM. With these supplemental appropriations, Leith reported in mid-March 1941, the USBM experimented on the recovery of low-grade strategic ores, as the National Academy of Sciences (NAS) recommended to the CND, and, with the USGS, also searched for more promising sources. Some specifications for quality, Leith noted, were lowered to make available certain supplies, but he cautioned that substantial domestic production would take at least a year and cost far more than could be borne in peacetime.

The bills Congress passed in June 1940 to expedite strengthening national defense included provisions for regulating the export of mineral raw materials. On June 25, the legislators authorized the Reconstruction Finance Corporation (RFC) to provide loans to corporations for the purpose of "producing, acquiring, and carrying strategic and critical materials as defined by the President."[59] Congress also authorized the RFC to create corporations of its own to produce, acquire, and carry such materials and to make payments against the purchase price. Under this authority, the RFC established the Rubber Reserve Company, the Metals Reserve Company, the Defense Plant Corporation, and the Defense Supplies Corporation.

The War Department provided funds for the USBM to erect, equip, and operate pilot plants for the beneficiation of manganese and the production of metallic manganese.

On July 2, Congress authorized the President to prohibit or curtail exportation of war materiel, including "machinery, tools, or materials, or supplies necessary for the manufacturing, servicing, or operation thereof,"[60] whenever he determined that national defense required it. On the same day, Roosevelt issued a proclamation prohibiting unlicensed exports of war materials and strategic raw products. The proclamation listed aircraft engines and parts, chemicals, and other items that could be exported only when authorized by the Secretary of State. The list's "basic materials and products containing the same"[61] included aluminum, antimony, asbestos, chromium, graphite, industrial diamonds, magnesium, manganese, mercury, mica, molybdenum, platinum-group metals, quartz crystals, tin, tungsten, and vanadium. Between July 26 and 31, additional Presidential proclamations restricted the export of petroleum products, tetraethyl lead, and certain types of iron and steel scrap. The restriction on exporting petroleum products was aimed, at least in part, at curtailing the Japanese war machine beyond the hoped-for impacts of the embargo placed in December 1939 on information about and plans and equipment for making aviation gasoline and the transfer in April 1940 of the Pacific Fleet from California to Hawaii. Although U.S. petroleum production in 1940 exceeded that reached in 1939, rearmament plans, especially the two-ocean navy[62] and the 50,000 aircraft per year requested by the President, indicated a major increase in domestic consumption as well.

The United States also strove to strengthen hemispheric solidarity, building on the Declaration of Lima announced in December 1938, and to deny Latin America's resources to Germany, Italy, and Japan. On June 16, 1940, Congress authorized sales of munitions to the governments of Republics in the Western Hemisphere, and the Roosevelt administration notified Germany and Italy that it would refuse to recognize transfers between nonhemispheric powers of titles to national areas in the Americas. Some of the defensive measures Congress passed also were intended, at least in part, to aid Latin American countries that recently lost markets in Europe or whose maritime commerce was threatened by German warships. Officials in London and Washington also remained concerned that some of the Latin American countries might attempt to make bilateral commercial agreements with Axis Nations, or that German and Japanese colonists in the hemisphere might be tempted to try to overthrow existing governments. At the Inter-American Conference on July 30, 1940, representatives of 21 Republics of the Pan-American Union signed the Act of Havana to provide, as a measure of defense, that any or all of these countries might occupy and administer any European possessions threatened by external aggression.

U.S. efforts to increase hemispheric cooperation also drew in the geological sciences. President Roosevelt, in a radio address before the Eighth Pan-American Scientific Congress in Washington on May 10, 1940, remarked that the Western Hemisphere was now almost the only place on Earth where such a gathering could take place for "Elsewhere war or politics in its worst sense has compelled teachers and scholars to leave their great callings and to become the agents of destruction."[63] Roosevelt predicted that, if it became necessary, "you and I, in the long run and if it be necessary, will act together to protect and defend by every means at our command our science, our culture, our American freedom, and our civilization."[64] The State Department, trying to emphasize science's creative rather than its destructive aspects, continued to receive statutory funds for the President's Interdepartmental Committee on Scientific and Cultural Cooperation (established in 1938), from which the USGS now was allotted $25,000 for geologic investigations in cooperation with other American Republics.[65] During the Pan-American Scientific Congress, USGS geologists discussed strategic-minerals investigations with their

Latin American colleagues; the USGS chose to use its new funds for these studies and began them in November. On July 30, 1941, another Executive order established the Office of Inter-American Affairs to promote further the good-neighbor policy the President announced in his first inaugural address in 1933.

Mobilizing geology and the other sciences as an integral part of U.S. defense efforts in 1940 drew in part on the experience gained during World War I. Several scientists and engineers associated with the NRC's Committee on Scientific Aids to Learning and concerned with the trend of international affairs began the new coordination. While engaged in Committee business in 1939 and early 1940, these persons frequently discussed their belief that the war would be a highly technical struggle and that the United States should be prepared to make full use of science. As their predecessors did in 1916, they took the initiative in attempting to organize science for national defense. Electrical engineer Vannevar Bush, former dean of engineering and vice president at MIT, president of the Carnegie Institution of Washington (CIW), chairman of the National Advisory Committee for Aeronautics (NACA), and a National Capital resident, led the effort. Bush's experiences with science in government during World War I also convinced him that he needed access to the President, initially through Roosevelt's adviser and confidant Harry Hopkins, and greater personal authority. Bush and his colleagues planned to organize a national research committee modeled on the NACA. Congress and President Wilson created the aeronautics committee in 1915 on the basis of a proposal by Smithsonian Secretary Charles Walcott and Franklin Roosevelt, then Assistant Secretary of the Navy. Rather than turn to Congress to provide for research on scientific and medical problems related to national defense, President Roosevelt chose to have the CND and its Advisory Commission establish the new committee.

Roosevelt's letter of appointment authorized the National Defense Research Committee (NDRC) on June 27, 1940. FDR met with Vannevar Bush and approved his request on June 12 and appointed the NDRC's other members on June 15; they met informally on June 18 at the CIW. Bush's NDRC included chemist James B. Conant, Harvard's president; Karl Compton, MIT's president and Bush's mentor; chemist Richard C. Tolman, dean of the California Institute of Technology's (Caltech's) Graduate School, who also served as Bush's vice chairman; lawyer Frank Jewett, now NAS president; Commissioner of Patents Conway P. Coe; Brigadier General George V. Strong, Chief of the Army's War Plans Division; and Rear Admiral Harold G. Bowen, Director of the Naval Research Laboratory (NRL). Most of the NDRC's members knew each other personally as well as professionally. Bush, Compton, Conant, Jewett, and Tolman also were in the NAS, and Bush, Compton, Jewett, and Tolman were members of Washington's Cosmos Club, where Conant would join them in 1942 and Coe in 1945.

Roosevelt asked the NDRC to develop broad and coordinated plans for the conduct of scientific research in the defense program in collaboration with the War and Navy Departments, to review existing programs formulated by these departments and other Federal agencies, and to initiate and support scientific research on the mechanisms and devices of warfare, except for those in aeronautics. The defense committee in 1916 emphasized that "true preparedness would best result from the encouragement of every form of investigation, whether for military and industrial application, or for the advancement of knowledge without regard to its immediate practical bearing."[66] In 1940, FDR restricted the NDRC's work to research on war devices and mechanisms, except those in aeronautics. The NDRC remained completely independent of the military; its Army and Navy officers provided liaison rather than directing research.

Roosevelt asked his Advisory Committee on Uranium to report to Vannevar Bush, as the NDRC's chairman requested. The President established the uranium committee on October 12, 1939, the day after his discussion with Alexander Sachs, his Lithuanian-American economic adviser. In "The Making of the Atomic Bomb," Richard Rhodes described how Sachs read his own summation of October 11.[67] Sachs emphasized the value of recent experimental work in the United States by two émigré physicists, Italian Enrico Fermi and Hungarian Leo Szilard, that suggested applications in power production, in medicine, and in weaponry. Sachs also passed to Roosevelt a letter prepared by Szilard and physicists Eugene P. Wigner (Princeton) and Edward Teller (George Washington University) and signed by Albert Einstein (Princeton) on August 2, an explanatory memorandum Szilard prepared at Sachs' request, and two articles coauthored by Szilard earlier in 1939.

Sachs and the physicists warned Roosevelt that recent work by Frédéric Joliot-Curie in France, as well as Fermi and Szilard, indicated "that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. * * * This new phenomenon would also lead to the construction of * * * extremely powerful bombs of a new type." Shipborne, such a bomb might destroy a port and its surrounding area but it would likely "prove to be too heavy for transportation by air." A permanent contact, they recommended, should be established between the administration and "the group of physicists working on chain reactions in America," a liaison should be appointed to Federal departments to help in securing higher quality uranium ore, from the Belgian Congo or Canada, than available from U.S. sources, and sufficient funds should be provided to accelerate the experimental work. Germany recently had banned exports of uranium from the extensive deposits at the former Czechoslovakia's Joachimsthal mines (now Jáchymov, in the eastern Czech Republic). "Some of the American work on uranium is now being repeated"[68] by the physicists in Berlin, one of whom was Carl F. von Weizsäcker. He was the son of the Nazi's Under-Secretary of State, had been a student of Niels H.D. Bohr in Copenhagen, and now worked in Leipzig with physicist Werner K. Heisenberg, also one of Bohr's younger colleagues.

Soon there would be more definite reasons for the concern expressed by Sachs and the other U.S. physicists. Heisenberg joined von Weizsäcker and other scientists in establishing in Berlin in mid-September a uranium club directed by Army Ordnance physicist Kurt Diebner. Heisenberg began classified reports on the possibilities of and technical problems involved in using uranium fission as a source of energy for engines and bombs. Heisenberg asked Diebner for significant supplies of uranium oxide and heavy water; until the latter became available, Heisenberg planned to continue neutron-moderator experiments with nonisotopic water and paraffin. Beginning in 1940, Germany received the yearly production of heavy water, produced as a fertilizer byproduct, from the Norsk Hydro-Elektrisk plant at Vermork, some 75 miles west of Oslo.

Soil physicist Lyman J. Briggs, Director of the National Bureau of Standards since 1932, and a NAS, NACA, and Cosmos Club member, led Roosevelt's Advisory Committee on Uranium (ACU), which included Briggs' assistant, one field-grade ordnance expert each from the Army and Navy, and a White House representative. The ACU met on October 21, 1939, with Sachs, Szilard, Teller, and Wigner as guests. Briggs' ACU was more interested in using atomic power for submarines than in using it for bombs according to their report of November 1 to Roosevelt, who decided to have the document placed in the White House files. Urged on by Sachs and the three physicists, the ACU secured $6,000, about one-fifth of the necessary sum, in Army-Navy funds mostly to buy purified graphite for fission-absorption experiments by Fermi and Szilard at Columbia. Their work emphasized the fission reaction produced by neutrons in uranium-238 and in the rarer isotope uranium-235.

The NAS and the NRC, as long urged by Szilard, combined to organize an Advisory Committee on Scientific Publication and obtained the cooperation of more than 200 journals in withholding from issue information about any research related to national defense. In June, that Committee announced a clearinghouse for authors of scientific papers to separate defense-related research from other investigations and provided dates of priority for the former for articles withheld from publication. Nothing could be done, however, about the significant papers on uranium fission and transuranic elements already in print or in press. After July, the U.S. blackout proved effective. In March 1941, Edwin H. McMillan, Glenn T. Seaborg, and two of their colleagues at the University of California at Berkeley confirmed their discovery of a second transuranic element (number 94), formed by bombardment by deuterons (nuclei of deuterium) and the decay of a second isotope of neptunium (number 93, discovered by McMillan and Philip H. Abelson in May 1940). The quartet named the newest element, an alpha-particle emitter with a half-life of 50 years, plutonium (Pu). McMillan and his associates found plutonium-239, another alpha emitter having a much longer half-life of about 24,000 years. Plutonium-239 was highly fissionable by slow neutrons, they noted, and easier and cheaper to produce than uranium-235 as the basis for a nuclear weapon.

The organization of the NDRC and the Office of Scientific Research and Development (OSRD), which became the umbrella agency a year later,[69] proved highly important during coming years and in the development of postwar science. The NDRC, in its early meetings, decided on a pyramidal organization that would broadly delegate downward and provide full facility for programs to move up. The NDRC also agreed to put all business and governmental relations in a separate office, leaving its subunits free to work without being burdened with administrative details, and to make contracts for research with universities, research institutes, and industrial laboratories rather than expand research in government laboratories. Initially, the NDRC comprised five lettered Divisions, each with subordinate Sections. Tolman led Division A, armor and ordnance. Conant directed B, bombs, fuels, gases, and chemical problems. Division B included Briggs' ACU, reorganized, enlivened, and renamed the Section on Uranium. Bush, Briggs, University of Chicago physicist Arthur H. Compton (Karl's younger brother and also a NAS and Cosmos Club member), Jewett, and Berkeley physicist and NAS member Ernest Lawrence formed the Section's review group. Jewett headed Division C, communication and transportation. Karl Compton led D, detection, controls, and instruments. Bush gave E, patents and inventions, to Coe. Unlike World War I's research council, the NDRC demonstrated no formal interest in the geological sciences; although geologists were involved in some of NDRC's activities, its operations did not directly influence the USGS.

Vannevar Bush believed that victory in war depended on developing new weapons. He welcomed Churchill's and Roosevelt's agreement in July 1940 to exchange scientific and technological information. Henry T. Tizard, who chaired the British Defense Research Policy Committee, led to the United States a British Scientific and Technical Mission of military and civilian experts.[70] Tizard's mission included physicist John D. Cockcroft, who, like Bohr, had worked with Ernest Rutherford at Cambridge. Tizard arrived in Washington on August 22, after Roosevelt and William L. Mackenzie King, Canada's Prime Minister, established an American-Canadian Permanent Joint Board on Defense to improve mutual preparedness. Tizard met Roosevelt and Secretary of War Henry L. Stimson on the 26th and 2 days later began discussions with Bush. Tizard's own group reached the United States by sea in September. In Washington on the 29th, they displayed the secrets from their black traveling trunk. The black box contained plans for and data about new antisubmarine weapons; the jet engine, developed independently from the Germans, who led that contest; the design for a radar-guided proximity fuse; the German Enigma codes,[71] from the British "Ultra" decrypts; and a working example of the resonant cavity magnetron that provided power sufficient for effective surface and airborne microwave radar of 10-centimeter and shorter wavelengths. When Tizard left the United States to return to Britain on October 2, Cockcroft replaced him as head of the mission.

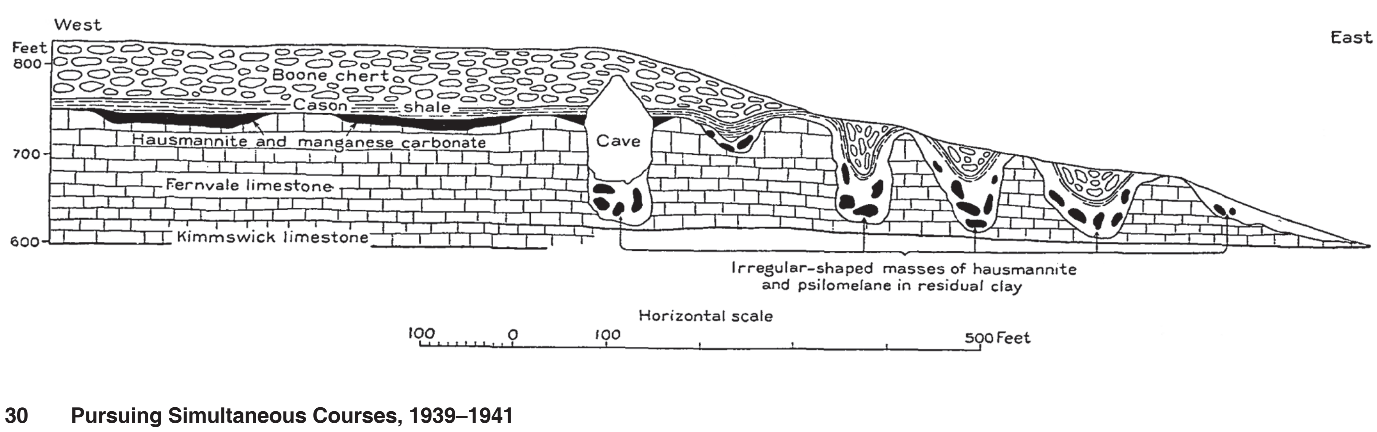
While the British and American scientists exchanged information in Washington, USGS work during fiscal year 1940–41 increasingly reflected the Nation's growing emphasis on national defense. The USGS continued and expanded its studies of minerals needed for defense production, mapped strategic areas, and solved problems of water supply. The nearly $3,587,000 directly appropriated to the USGS[72] for salaries and operations by its nearly 1,770 employees, the funds transferred or repaid from other Federal agencies, and those from State and local governments combined to provide the USGS in fiscal 1940–41 with almost $7,824,000, more than $577,000 above the total for fiscal 1939–40.

The Geologic Branch received nearly $807,000 during fiscal year 1940–41. Strategic-minerals investigations by the Branch drew on the $145,000 directly appropriated for this work, an additional $100,000 supplied as a deficiency[73] on October 9, 1940, the $26,000 received from the PWA and the State Department, and about $75,000 from the direct appropriation of $500,000 for geologic surveys. Members of Loughlin's Geologic Branch participated in work directly related to field projects on strategic minerals; researchers included many in its Metallic Deposits, Areal and Nonmetallic Deposits, and Iron and Steel Metals Sections and almost all those in the Sections of Chemistry and Physics and of Petrology. Many specialists in the Sections of Fuels, Geophysics, and Paleontology and Stratigraphy also took part in field and laboratory investigations of strategic minerals. Branch scientists continued cooperative studies in the mining districts of Colorado, Idaho, and Oregon, but they closely coordinated their work with the general defense-minerals program; after completing more than 150 assessments, they recommended to the USBM that it test-drill some of these sites.

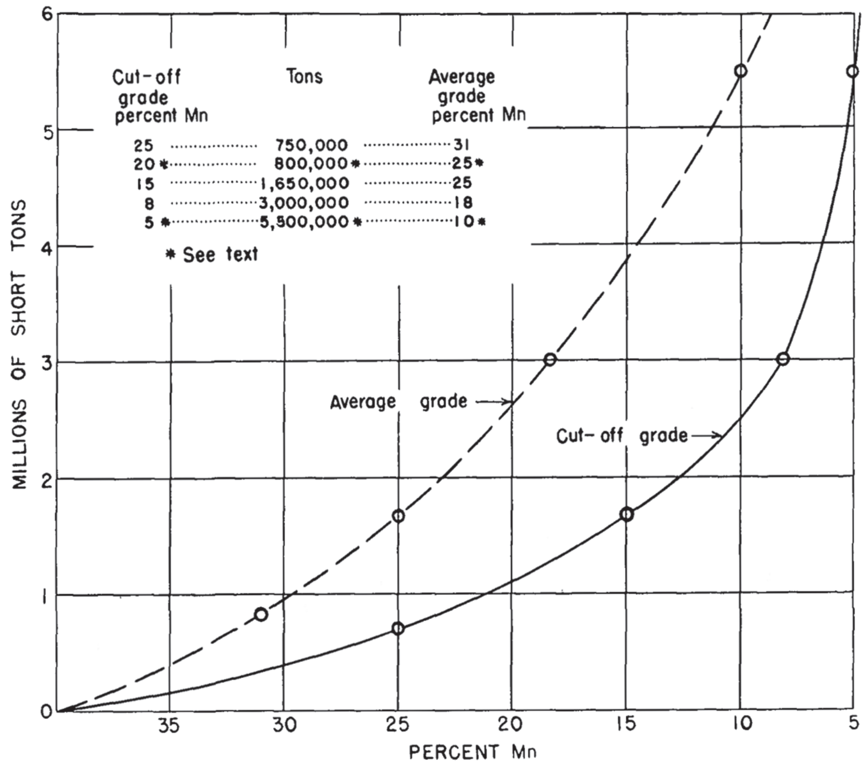
The USGS strategic-minerals program emphasized searches, by another mix of old and new full- and part-time personnel, for manganese and other vital metals and nonmetals. Agency geologists examined manganese deposits in 17 States, including Arkansas, Nevada, Tennessee, Virginia, and Washington. Charles Park, aided by James R. Balsley, Jr., Wallace M. Cady, Harold James, Ralph Roberts, and other geologists, continued to study manganese occurrences in Washington's Olympic Peninsula during the field seasons of 1939 and 1940. As part of investigations east of the Mississippi, the USBM confirmed large tonnages of manganese ore in the Batesville district of Arkansas in areas selected by USGS geologists. Philip B. King, John Rodgers, and Lawrence C. Craig examined manganese prospects in northeastern Tennessee. In Virginia, King also looked at Blue Ridge manganese deposits near Elkton, Harry S. Ladd studied similar ores in the Sweet Springs, Flat Top, and Round Mountain districts, and Watson H. Monroe looked at the Cedar Creek area. As part of the manganese investigations, Walter S. White and newly joined Preston E. Cloud, Jr., studied occurrences in Maine's Aroostook County.

The USGS strategic-minerals program also continued to focus on studies of sources of antimony, chromium, mercury, mica pegmatites, nickel, phosphate, tin, and tungsten. Microscope-based studies of drill cores from the Yellow Pine

This cross section, by Hugh Miser and Foster Hewett, depicts strata at the Club House Mine in the Batesville mineral district of Arkansas. There, manganese occurred in lenticular carbonate bodies in the Fernvale Limestone (Ordovician) and in oxide masses (as hausmannite and psilomelane) in residual clays. The USGS strategic-minerals program especially sought new deposits of bauxite, manganese, mercury, mica, quartz crystals, and tungsten. (From Miser, 1941, fig. 6.)



This graph shows the grades of manganese reserves at the Three Kids deposit, Nevada. USGS searches for manganese in the Western States included examinations of the Boulder City and Three Kids deposits in southern Nevada. C.H. Johnson (of the U.S. Bureau of Mines) and Vincent E. McKelvey and Charles B. Hunt (of the USGS) computed the cutoff and average grades of manganese in estimating the Three Kids' reserves from ore samples recovered in diamond drilling by the USBM and the Manganese Ore Company. The largest reserves at Three Kids, 7 miles northwest of Boulder City, had grades between the 5-percent cutoff grade and the 10-percent average grade. The grades were five times those in the equivalent interval in the Boulder City deposit, 3 miles southeast of the city. (From McKelvey, Wiese, and Johnson, V.H., 1949, fig. 10.)

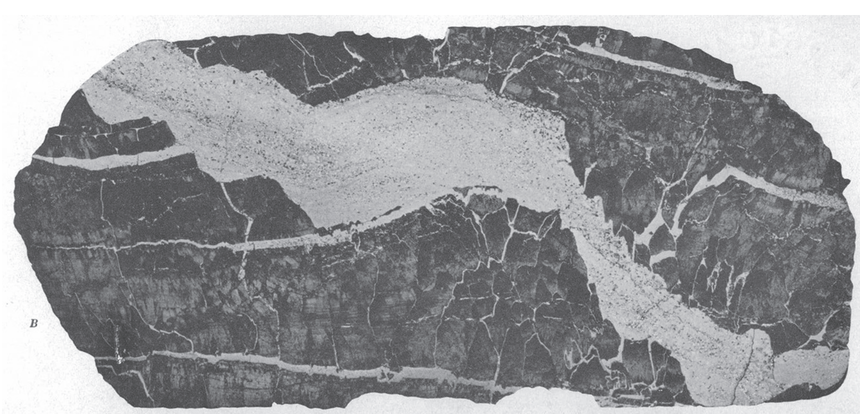


antimony district in Idaho led to recognizing the tungsten-oxide mineral scheelite; further exploration disclosed a large and unusually rich body of tungsten ore closely associated with the antimony deposits. These studies also indicated that antimony could be produced directly in addition to the amount being recovered in antimonal lead as a byproduct of gold mining. Scheelite also was discovered in Idaho's Seven Devils district, and scheelite-bearing quartz veins were found in the Spokane tin area in Washington. Studies by Eugene Callaghan, S. Warren Hobbs, Montis R. Klepper, Dwight Lemmon, Lincoln Page, and Ralph Roberts of tungsten districts in Arizona, Idaho, Nevada, and Washington showed reserves larger than previously supposed and indicated that the United States could supply a considerable part of its demand. Searches by Allan B. Griggs, G. Arthur Rynearson, Clay T. Smith, Francis Wells, and other geologists yielded preliminary estimates of chromite tonnage and grade in 22 districts in California, Montana, Oregon, and Wyoming. Investigations of chromite ore in the State-Line district of Pennsylvania and Maryland included gravity and magnetic surveys. Additional geologic work by the USGS to aid USBM exploration also facilitated the development of chromite mines in Montana's Stillwater district. Geologic studies in California's New Idria mercury-mining district led to recommendations for possible exploration by the USBM in less examined parts of the district. Similar investigations by Clyde Ross in the Steens and Pueblo Mountains in southeastern Oregon indicated deposits with a very low average grade, but they were extensive enough to suggest they could be a source of mercury under emergency conditions. Ross and Carle H. Dane also looked at mercury ores in Nevada's Wild Horse district. Jerry Olson extended his work on mica pegmatites to New Hampshire. Warren Hobbs and William T. Pecora, a petrographer who had just completed doctoral studies with Esper S. Larsen, Jr., at Harvard, looked at nickel ores in Oregon and Washington. Louis S. Gardner and John Rodgers studied phosphate deposits in the Teton Basin of Idaho and Wyoming. Carl Fries, Jr., examined tin deposits in northern Lander County in Nevada.

After the 1940 field season ended in the Northern United States, some USGS geologists joined projects in the Southern States or left to begin cooperative studies of strategic minerals in Latin America. Their work in Brazil, Cuba, and Mexico involved investigations of antimony, chromium, manganese, tin, and tungsten deposits. They also studied the possibilities of conducting strategic-minerals searches in Colombia, Costa Rica, Guatemala, Panama, and Venezuela. In Cuba, between November 1940 and March 1941, Thomas Thayer and William D. Johnston, Jr., examined chromite deposits, and Charles Park and Wendell Woodring studied occurrences of manganese ore. Between mid-December 1940 and March 1941, Johnston aided Stephen Capps' examinations of manganese deposits in the Brazilian States of Mato Grosso and Minas Gerais.[74] In Mexico, William F. Foshag, curator of mineralogy and petrology at the U.S. National Museum (USNM) since 1919, had investigated lead-zinc deposits and other mineral and mining districts since 1926. In January 1941, Foshag and Carl Fries began a 3-month cooperative survey with members of the Instituto Geológico de México of that country's tin deposits.

Although the Geologic Branch suspended several projects in 1940 to provide trained personnel for the national emergency work, the unit continued some of its earlier major activities, including cooperative studies in Colorado, Idaho, Kansas, Massachusetts, Oregon, and Virginia. Mineral-fuels investigations continued in California's Santa Maria Basin, the Powder River coal field in southern Montana and northern Wyoming, Colorado's Yampa coal field, the Jackson area in Mississippi, and Washington's Olympic Peninsula. Parker D. Trask, in cooperation with the American Petroleum Institute, completed for publication by the American Association of Petroleum Geologists (AAPG) a study of source rocks of petroleum that he began in 1931. Trask then shifted to examining manganese deposits in California. Other Sections in the Branch also worked on strategic minerals, but they too continued or began other investigations. The Section of Chemistry, in addition its extensive studies of these minerals, also undertook, in cooperation with the USDA, research on the montmorillonite group of clay minerals that were so critically important in soil problems. Roger C. Wells, Chief Chemist since 1930, completed a report on the distribution of nickel in the Earth's crust and continued his study of the distribution of uranium and thorium. Members of the Section of Geophysics developed a method for locating buried channels in California's gold-placer region and, in cooperation with the city of Rochester, New York, identified the preglacial channel of the Genesee River as a source of groundwater.

The Alaskan Branch's additional investigations of strategic minerals during fiscal year 1940–41, especially those relating to antimony, chromium, nickel, tin, and tungsten, drew on some of its direct appropriation of $60,000 and the $45,000



This specimen of manganese oxide, with tuff veinlets, was collected at the Charco Redondo Mine in Cuba's Oriente Province by USGS geologists during their assessments of mineral resources on the island. USGS geologists also searched for chromite and other strategic-mineral commodities in Cuba and in other Latin American nations. (Photograph from Park, C.F., 1942, pl. 23*B*.)

Topographer John George Staack (1878–1968), joined the USGS full time in 1904 after graduating from the University of Wisconsin. He mapped in the Mississippi Valley and in areas westward to the Pacific Coast before serving as a Captain (1917–19) of Army Engineers. Staack led the Topographic Branch's Great Lakes Section (1924–29) and then the Branch as Chief Topographic Engineer (1929–43). He promoted and oversaw the development and application of Multiplex photogrammetry in the USGS cooperative mapping program with the Tennessee Valley Authority and, from 1941, the expanded program of strategic and domestic mapping principally for the Army Engineers. Staack served as Assistant Chief Topographic Engineer until he retired in 1947. (Photograph from National Archives and Records Administration, Still Picture Branch, as 57–GP–224.)

provided by the War Department. Philip Guild examined chromite deposits near Seldovia in the southwestern part of the Kenai Peninsula. John Reed (Sr.) and John Dorr 2d studied potential nickel deposits in parts of Yakobi Island and Chichagof Island in the southeastern part of the Territory. John Mertie continued to investigate potential sources of tin in the western part of the Seward Peninsula; he concentrated on the Lost River area, where tin minerals had long been known to exist in both lodes and placers, even though they had not been mined in recent years. The results of these and earlier USGS studies aided industry to increase the value of Alaska's mineral production by $3.2 million to $28.3 million in calendar year 1940. In addition to the strategic-mineral studies, Fred Moffit and Russell Wayland continued the USGS investigation of the Alaska Range by doing reconnaissance mapping of the Nutzotin Mountains and their gold deposits from the Nabesna River southeast to the international boundary. James S. Williams began paleontologic studies of specific formations in the Yukon and Copper River Valleys and in southeastern Alaska to aid the correct identification of certain parts of the sequence and accurate correlation with units in other rock groups in Alaska and in the conterminous 48 States.

Alaskan Branch topographers made reconnaissance surveys of part of the valley of the Holitna, one of the largest tributaries of the Kuskokwim, and scattered tracts in the Copper River Valley and near Juneau. For the War Department, these topographers also prepared detailed maps of prospective sites for airfields in southeastern and central-southern Alaska. When the U.S. Army Air Corps (USAAC) Map Chart Division became the Aeronautical Chart Service in 1941, the USAAC's 1st Photographic Group and the Alaskan Branch began cooperating to complete reconnaissance maps of the Territory, principally as aids to aerial navigation. Air photographs were obtained of an extensive area in the central part of Alaska to produce maps by the trimetrogon system. This arrangement enabled project topographers to produce quickly the smaller scale maps required by the USAAC, gain coverage of previously unmapped areas in the Territory, and test and improve the new mapping technique.

During 1940–41, John Staack's Topographic Branch continued to expand its funds and geographic coverage and improve its technology. On June 24, 1940, the Army Engineers transferred more than $1,210,000 for strategic mapping to the Topographic Branch to add to the $759,000 in direct appropriations for topographic mapping during the fiscal year; of the latter amount, $275,000 was available only for State-municipal cooperation. With more than $184,000 from or repaid by other Federal agencies and $315,000 from State and local governments, the Branch managed a total of nearly $2.5 million. Branch members surveyed in 38 States, the District of Columbia, and Puerto Rico, but, as nearly half of the Branch's funds came from the War Department, much of the mapping at scales of 1:24,0000 and 1:62,500 (and at 1:31,680 and 1:63,360 in Alaska) was done in strategic areas and most of that, along the coasts. Cooperative funds from 17 States and Puerto Rico and transfer monies from the TVA, the PRA, and the PWA influenced the choice of other areas mapped. Glenn Smith, Chief of the Central Division, retired on April 30, 1940, and was succeeded by Carl L. Sadler. During fiscal year 1940–41, as Sadler continued to promote photogrammetry at Rolla, the Topographic Branch began in earnest its revolutionary shift from field to photogrammetric methods by installing its improved Multiplex optical-projection equipment in a new office in Arlington, Virginia. The Branch procured aerial photographs of nearly 36,340 square miles as the basis for compiling topographic and planimetric maps of more than 11,500 square miles, 3,640 by Multiplex and the remainder by the older photogrammetric methods. Topographers using conventional field methods surveyed 13,770 square miles for the first time, resurveyed nearly 13,900 square miles, and revised maps covering almost 500 square miles.

This current meter occupied a fixed position above a bed of coarse gravel in a long flume during an experiment by USGS hydrologist Charles Pierce to gage how sediment size influenced the performance of the agency's water-monitoring instruments. He successively placed coarse gravel and sediments of smaller grain sizes on the bottom of the flume, recorded the meter's performance, and transmitted the results for action by the Surface Water Division's managers. (Photograph from Pierce, C.H., 1941a, pl. 2*B*.)

National defense activities brought about fewer changes in the work of the Water Resources Branch, in 1940 still the largest program unit in the USGS. For work during fiscal year 1940–41, the Branch managed nearly $3,174,000, including $1,224,000 in direct appropriations,[75] of which $1 million could be used only for State-municipal cooperation, and $689,000 from the Army Engineers and $968,000 from States and local governments. The Branch received several hundred requests for data on the availability and quality of water to help determine proper locations for sites of industrial plants, military camps, housing units, and airfields. Some answers required special field investigations; for others, information could be obtained from published reports. Rudolph G. Kasel succeeded Carl Paulsen as Acting Chief of the Surface Water Division on April 29, 1940. Under Kasel's direction, the Surface Water Division made cooperative investigations with some 120 agencies in States, counties, and municipalities. Division members also continued their collaborative studies with colleagues in Federal agencies, including the large program of constructing, operating, and maintaining gaging stations in connection with flood-control investigations and river and harbor maintenance and improvement by the Army Engineers.

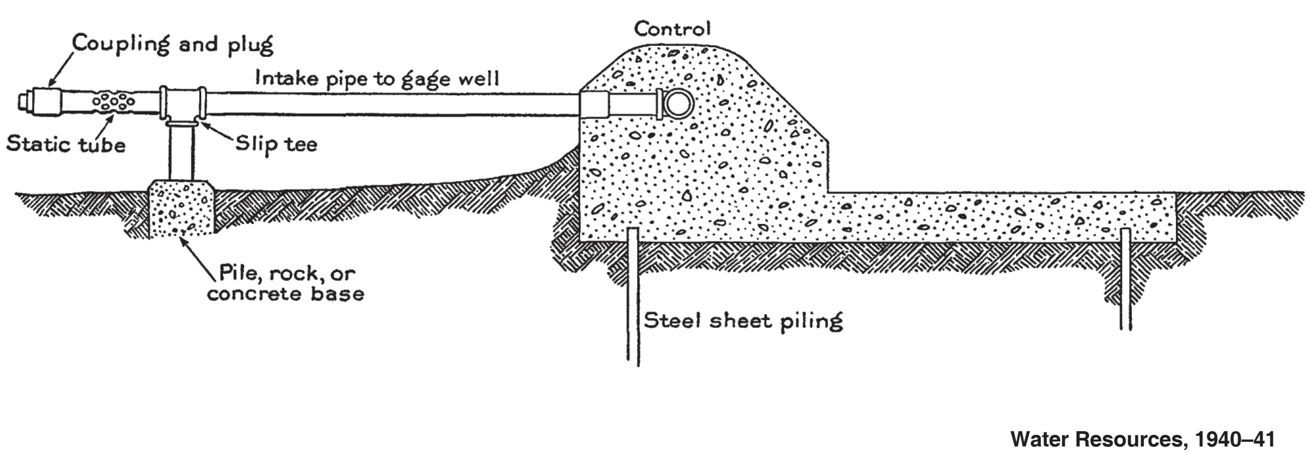
In the Ground Water Division, Oscar Meinzer, recalling the importance of groundwater investigations during World War I, placed David Thompson in charge of the emergency work. Division projects were underway in 41 States, the Territory of Hawaii, Puerto Rico, and the District of Columbia. As in years past, most of this work continued earlier efforts in the observation-well program and other cooperative programs. In the Northeastern United States, groundwater studies kept going in Massachusetts, Connecticut, and New York. On Long Island, Charles Jacob studied sand elasticity and the relation between precipitation and groundwater levels. In 1940, Jacob's analysis of elastic aquifers defined transient-flow equations using flow hydraulic rates from the heat-flow analogy. In the Atlantic and Gulf of Mexico Coastal Plains, investigations continued in New Jersey, Virginia, North and South Carolina, Georgia, Florida, Mississippi, Louisiana, and Texas. Midwestern studies included those in Ohio and Indiana. On the plains east of the Rocky Mountains, fieldwork continued in Iowa, Nebraska, Kansas, Oklahoma, and eastern New Mexico, where efforts for the Pecos River Joint Investigation ended in December. In the Rockies and Pacific Coast States, studies continued in Colorado; Utah; western New Mexico; Arizona, including the Gila River project; California; Oregon; and Washington. In the Hawaiian Islands, Gordon Macdonald completed fieldwork on Maui, and he and Harold Stearns advanced their studies on Hawaii. Stearns continued to serve as a consultant to U.S. armed forces in the Pacific.

Ground Water Division personnel also began several new investigations. In Dade County, Florida, Division hydrologists initiated a comprehensive program of drilling test holes several hundred feet deep to obtain geologic data on water-bearing formations. Charles W. Carlston began a study of groundwater resources in the outcrop area of Alabama's Cretaceous formations. Fred Klaer, Jr., shifted from Ohio to initiate a new cooperative project in the area around Memphis, Tennessee. Another collaborative program started in North Dakota, where test drilling was essential in drift-covered areas. William C. Rasmussen, supervised by Leland K. Wenzel, began a study of glacial Lake Dakota in southeastern North Dakota to determine the capacity of the groundwater reservoir and its annual recharge; a coeval investigation aimed at finding an additional supply for the city of Fargo. Groundwater investigations by Thomas W. Robinson commenced in November in the Pine Bluff area of southeastern Wyoming, where irrigation increasingly drew on such water; Robinson also led similar studies in South Dakota and Iowa. In Utah, Harold E. Thomas started an investigation of the groundwater resources of the Tooele Valley. To the northwest, George C. Taylor, Jr., began a study of the groundwater resources of the USBR's Columbia River Irrigation Project to determine the availability of supplies for farms and communities, ultimate drainage problems, and possible percolation of return flow to areas outside those irrigated.

Members of Royal Davenport's Water Utilization Division, knowing that the water supply in various parts of the country was directly related to its defense, as it was during World War I, began issuing monthly press releases on current streamflow conditions as indicated by selected gaging stations. Such a publication had been considered in connection with conservation activities, but defense requirements made imperative its inauguration. Members of Davenport's Division, aided by personnel from the Army Engineers, the Flood Control Coordinating Committee, the U.S. Forest Service (USFS), and other organizations, also made an extensive study of the major floods in the Southeastern States in August 1940.

Herman Stabler's Conservation Branch operated on about the same scale in fiscal year 1940–41 as in 1939–40. The Branch received the same direct sums—$105,000 for classifying lands and $315,000 for mineral-leasing activities—and contributions from other Federal agencies brought the total funds available to

This diagram shows a design for a coupling, plug, and static-tube connection at the end of an intake pipe to a gage well at a streamflow-measurement station. At the National Hydraulic Laboratory, USGS hydrologist Charles Pierce used a glass-sided flume, 35 feet long by 20 inches wide (with its longitudinal section reduced to 10 inches). He tested some 90 variations of one-eighth-scale models of intake devices to measure their effectiveness in eliminating "drawdown"; in the field, drawdown is the difference in water heights in the gage wells and the rivers at measuring stations. The static tube performed better than baffles, intake boxes, or strainers. Pierce forwarded his results to the Water Resources Branch's district engineers for further design and fabrication. (From Pierce, C.H., 1941b, fig. 6.)



$580,000. Although the work of classifying mineral lands remained at about the same level as in the previous year and the number of mineral properties being supervised increased only slightly, the number of oil and gas properties under supervision decreased by 15 percent. Waterpower projects included a topographic survey of the Nisqually Glacier in Washington. The estimated value of all mineral and fuel production, including the slightly smaller amount of oil and gas derived from the Naval Petroleum Reserves, declined to $71 million, and the Federal revenue it provided fell to about $7 million; Federal supervision cost only $450,000. The 3.5 million barrels of petroleum, nearly 1.9 billion cubic feet of natural gas, and nearly 9.7 million gallons of natural gasoline produced from NPR–1 and NPR–2 yielded royalties totaling more than $798,000.

While USGS scientists and engineers continued their field studies during 1940, national election campaigns at home and political and military developments abroad competed for front-page space in U.S. newspapers. On June 20, a week before the Republican Convention was scheduled to begin in Philadelphia, Roosevelt moved to gain a more efficient and less partisan Cabinet, and support for his policies, by appointing two progressive Republicans to lead the War and Navy Departments. New York's Henry Stimson returned to the War Department on July 10 for a second tour as Secretary, succeeding Harry Woodring. Robert P. Patterson, Stimson's former law-firm colleague, rejoined Stimson as his Assistant Secretary. Stimson now opposed U.S. exports to and aggression by Japan. Frank Knox, a newspaper owner and publisher from Illinois, and the unsuccessful Republican candidate for Vice President in 1936, became Secretary of the Navy, when Knox's predecessor Charles Edison resigned to run for Governor of New Jersey. The Republicans met on June 28, and 4 days later they nominated on the sixth ballot for President the wealthy and conservative lawyer Wendell L. Willkie of New York, the darkhorse candidate, rather than the earlier favorites—Senator Robert A. Taft of Ohio, the President's son, and Thomas E. Dewey, the District Attorney of New York County. Willkie, president of the Commonwealth and Southern Corporation, was a former anti-New Deal Democrat who remained an internationalist. The Democrats convened in Chicago on July 15; 2 days later, they renominated Roosevelt on the first ballot. A majority of the delegates then agreed to nominate Secretary of Agriculture Henry A. Wallace, FDR's choice to succeed John N. Garner as Vice President.

As the Democrats nominated Roosevelt for an unprecedented third term, the Germans continued preparing to invade Britain. To Hitler, the Soviet Union remained Germany's natural enemy and the best source of needed lands and resources, but the Führer planned to turn on his present ally only after securing an arrangement with Britain by political means, blockade, or air and seaborne assault. When the British rejected Hitler's diplomatic offer, he ordered the Wehrmacht on July 16 to begin detailed planning for Operation Sea Lion, the invasion of Britain via the English Channel. On August 8, the Luftwaffe shifted its attacks from the Channel convoys to strikes on British airfields in southeast England, planning to destroy the RAF's Fighter Command on the ground to gain the air supremacy required for peace or a successful invasion. Aerial intercepts based on the radar network[76] developed by Tizard and his British colleagues, ground observers equipped with telephones, and radio-equipped ground controllers significantly aided the outnumbered RAF to inflict heavy losses on a Luftwaffe, now stretched to near the limit of its operational range. The Luftwaffe also lacked strategic bombers, whose development it discontinued in 1937. The Heinkel He-177 Griffin, a relatively long range and four-engine (driving two propellers) aircraft, was still being tested. The Germans, wrongly convinced they had defeated Fighter Command, began attacking London. Their shift to a strategy of terror, aimed at breaking British resolve and also as a response to Bomber Command's increasingly heavy nighttime raids on

Berlin and other German cities, cost them ever-larger numbers of aircraft and their crews and then the battle over Britain. On September 17, 2 days after more dire losses, Hitler postponed Sea Lion.

Just before the Battle of Britain began, the Soviet Union sent troops into the Balkans to occupy Bessarabia (later Moldavia and now Moldova) and the Ukrainian-speaking northern part of Bukovina, part of Romania since 1918. In securing a cession of these territories on June 27, Soviet forces reached positions within 100 miles of the Ploesti oil fields and refineries in Romania that provided the major part of Germany's petroleum imports. Romania turned to Germany for support but was forced to cede southern Dobruja to Bulgaria on August 21 and, after Soviet protests failed, to yield its Transylvanian lands to Hungary on August 30. Italy again decided to expand its holdings in Africa by invading British Somaliland on August 3 and Egypt on September 13.

The RAF's defeat of the Luftwaffe shifted U.S. public opinion about Britain's survival from pessimism in the wake of Dunkirk to a more optimistic outlook. In June and July 1940, the United States shipped old and new artillery and ammunition to Britain. Sending old destroyers proved more difficult, even after Attorney General Robert H. Jackson gave President Roosevelt a legal justification for their transfer. Roosevelt overcame his concern for the lack of congressional approval. He and Churchill agreed on September 3 to exchange 50 U.S. destroyers of World War I vintage for free gifts or 99-year leases of British air and naval bases in Newfoundland, Bermuda, the Bahamas, Jamaica, Antigua, St. Lucia, Trinidad, and British Guiana (Guyana). Wendell Willkie and General John J. Pershing defused the exchange as a campaign issue by approving the deal, and Roosevelt finalized it in an Executive order on September 9. Three days later, Joseph C. Grew, U.S. Ambassador to Japan since 1932, warned Secretary Hull that the Japanese might retaliate in response to additional trade restrictions. On September 26, however, Roosevelt banned all exports of scrap iron and steel to Japan; 11 days later the Japanese Ambassador to the United States formally protested that decision and the embargo on aviation fuel as the acts of an unfriendly nation.

Axis strategy and Allied response to it both changed during the fall of 1940. On September 27, Japan joined Germany and Italy in a 10-year Tripartite Pact. The signatory powers recognized rights to establish a new world order, beginning with Europe and East Asia. The three countries pledged mutual economic, military, and political assistance if one of them was attacked by a nation not involved in the European or Sino-Japanese wars. They specified that their agreement did not affect their political arrangements with the Soviet Union, but its dictator Josef Stalin felt the pact was aimed at his country as much as the United States, especially after Hitler rebuffed Stalin's request in November to join the pact. Earlier in the same month, Japanese forces occupied, with Vichy's agreement, ports, airfields, and railroad lines in northern French Indochina. On January 12, 1941, Hitler again postponed Sea Lion, this time until April. Still looking east, he sent German troops into Romania, ostensibly to train Romanian forces and to protect the oil fields from British attacks but actually to control the country.

Italy, seeking a wider dominion in southeastern Europe, demanded concessions from Greece. When the Greek Government refused these claims, Italian troops based in Albania invaded Greece on October 28, 1940. To aid the Greeks, Britain sent troops from Egypt, and the Soviet Union supplied fighter aircraft. To control the central Mediterranean and to protect Allied convoys, British naval aircraft on the night of November 11–12 attacked with bombs and modified torpedoes an Italian squadron at its shallow-water Taranto base. The British aircraft sank or heavily damaged three of six battleships and damaged harbor installations and oil-storage tanks at the cost of two planes and their two-man crews.[77] Japan's assistant naval attaché in Berlin promptly visited Taranto and then returned home to present his observations. German military intelligence officers also came to

Taranto to make a more detailed assessment of the attack and shared the results with the Japanese, who began planning for a possible attack on the U.S. Pacific Fleet's base at Pearl Harbor on Oahu in the Hawaiian Islands. By mid-November, Greek forces pushed most of the invading Italians back into Albania. On December 9, the remaining British forces in Egypt, reinforced from Britain, attacked the Italian forces, pursued them into Libya, and captured most of them.

While Britain struggled to control the Mediterranean, U.S. voters reelected President Roosevelt on November 5, 1940. Roosevelt's margins of victory, 4.8 million popular votes and 367 electoral votes,[78] were significantly smaller than those in 1936. Roosevelt then rapidly made new efforts to improve U.S. defense and increase American production. On December 20, the President announced that he was establishing an Office of Production Management (OPM) to coordinate the Nation's defense production and speed all material aid to Britain "that we can possibly spare in the judgment of the military experts."[79] Germany promptly labeled the decision a moral aggression. Late in December, Foreign Minister Matsuoka Yosuke, who signed the Tripartite Pact for Japan, told the Roosevelt administration not to interfere in East Asia and the Western Pacific, the area the Japanese felt should be limited to its indigenous peoples. Ambassador Grew, tapping many sources in Tokyo and elsewhere, warned Secretary Hull about new rumors of plans for a Japanese attack on Pearl Harbor. On December 29, the President called for an immense production effort to make the United States "the great arsenal of democracy."[80] Roosevelt, in his State of the Union Message on January 6, 1941, requested "a swift and driving increase in our armament production."[81] He also asked for authority and funds to manufacture additional munitions and war supplies "to be turned over to those nations which are now in actual war with aggressor nations"[82] and to furnish U.S. defense materiel to those countries unable to pay for them in cash; repayments would be made, either in kind or in other goods, "within a reasonable time following the close of hostilities."[83]

President Roosevelt formally established the OPM on January 7, 1941, to "increase production for the national defense through mobilization of material resources and the industrial facilities of the Nation."[84] Roosevelt also intended the OPM to "[s]erve as the liaison and channel of communication between the Advisory Commission to the Council of National Defense and the Departments of War and Navy"[85] regarding matters pertaining to defense purchasing and production. Roosevelt gave the OPM responsibility to "[p]lan and take all lawful steps necessary to assure the provision of an adequate supply of raw materials essential to the production of finished products needed for defense."[86] No change in personnel occurred. William Knudsen became the new agency's Director General and Sidney Hillman, its Associate Director. Edward Stettinius was named Director of OPM's Division of Priorities. The other two operating units were styled the Division of Production, led by John D. Biggers, president of Libby-Owens-Ford Glass, and the Division of Purchases, led by Donald A. Nelson, a Sears, Roebuck executive. Charles Leith became the mineral adviser to the OPM, as he had been to the CND's Advisory Commission.

By the time President Roosevelt established the Office of Production Management, shortages of basic materials were becoming serious. One of the initial problems involved the supply of aluminum. In November 1940, the CND's Advisory Commission estimated that by July 1942, 412,500 short tons of primary metallic aluminum would be required annually. That amount translated into an annual demand for 3.2 million short tons of bauxite, the only aluminum ore then in use. In 1940, however, U.S. production of bauxite for metallic aluminum was only 214,200 tons, and that amount represented a 33-percent increase over the 1939 production. Administration officials, concerned about dealing with the Aluminum Company of America (Alcoa), which held a near monopoly on production but was under indictment for conspiracy to restrain trade, sought to promote competitive companies. Secretary of War Stimson responded by saying that he would "rather have some sinful aluminum now than a lot of virtuous aluminum a year from now."[87] The debaters seemed to assume that an inexhaustible supply of bauxite would be available until a survey of bauxite resources in the spring of 1941 by John R. Thoenen (USBM) and Ernest Burchard (USGS), aided by Watson Monroe (USGS) and Richard W. Smith (USBM), indicated that the estimated U.S. reserves of commercial-grade ore, more than 50 percent alumina, amounted to only a little more than 18 million tons. The Interior Department sought funds for a domestic exploration program, not only for bauxite but for alunite and aluminum clays as well.

Problems also existed in the supplies of other raw and finished materials, including petroleum and petroleum products. On December 10, 1940, Roosevelt added iron and steel,[88] including iron ore, pig iron, ferroalloys, and semifinished and finished products, to the export-restricted list. Abrasives, bromine, cobalt, ethylene, strontium, additional machine tools, and equipment and plans for producing aviation lubricating oil followed on December 20.[89] Brass, bronze, copper, nickel, phosphate, potash, radium, uranium, and zinc joined them on January 10, 1941,[90] as did atropine, belladonna, beryllium, graphite electrodes, leather, and pilot-training machines on February 25.[91] The United States produced petroleum in quantities greater than ever, but transportation facilities to deliver the petroleum products to the Atlantic seaboard, where many defense industries were concentrated, rapidly became inadequate. In a letter dated January 23, Roosevelt called Congress' attention to the need for additional pipeline facilities. By February, problems involving metals and minerals were multiplying so fast that Leith asked the NAS to arrange for a comprehensive organization to advise the OPM. The NAS established an Advisory Committee on Metals, under chemist Clyde E. Williams, who, since 1934, had directed the Battelle Memorial Institute at Columbus, Ohio. Members of the Committee's four main groups were responsible for ferrous minerals and ferroalloys, nonmetallic minerals, tin smelting and reclamation, and metals conservation and substitution.

By now, the failures of the U.S. defense program were so evident that early in February 1941, the Senate authorized a Special Committee to Investigate the National Defense Program and chose as its chairman Harry S. Truman (D–MO). Truman, the junior Senator from his State since 1935, supported Roosevelt's policies while devoting particular interest to interstate commerce and civil aviation. Truman also personally investigated and then pointed out to his legislative colleagues the unsatisfactory conditions at Fort Leonard Wood, southwest of Rolla; introduced a resolution calling for an investigation; and promoted the committee's establishment. The Senate's new Special Committee, quickly termed the Truman committee, included Thomas T. Connally (D–TX), the chairman of the Committee on Foreign Relations; Carl A. Hatch (D–NM), who chaired the Committee on Public Lands and Surveys; and four other Senators, but they received only an initial appropriation of $15,000 for investigating the $13 billion defense budget. Truman held fair hearings and, as the committee's work progressed, its funds grew to $50,000 in the fall as it added three members new to the Senate. The Truman committee examined the awarding and fulfilling of contracts, the utilization of the Nation's economic and manpower resources, and the work of the Federal agencies responsible for the effort. The Truman committee initially concentrated on reviewing the construction of military camps. The Army officers involved in overseeing camp and other construction included Brigadier General Brehon B. Somervell, who, as head of the Quartermaster Corps' Construction Division during 1940–41, helped to design and build the Pentagon. General Somervell later estimated that the Truman committee's work saved the United States $250 million. Truman and his committee soon set their sights on the OPM.[92]

While the U.S. defense production program stuttered and stumbled, and while U.S. and British military officers met in Washington during January 29–March 27, 1941, to coordinate their plans and priorities, the President and the new 77th Congress acted to increase the Federal workforce and provide aid to beleaguered Britain. On February 1, Roosevelt reactivated the U.S. Atlantic Fleet, commanded by Admiral Ernest J. King. FDR authorized the U.S. Civil Service Commission (CSC) on February 16 to approve temporary appointments for the war's duration and no more than 6 months thereafter. A statute signed on March 11 authorized the President to lend an initial $7 billion worth of war material to the nations whose defense he deemed vital to America's defense.[93] Secretary of War Stimson called the new law a declaration of economic war; FDR termed it an end to appeasement. The subsequent Lend-Lease Program gave Britain the additional military aid that Churchill had requested. Early in April, Roosevelt promised to transfer 10 U.S. Coast Guard (USCG) cutters to the Royal Navy and agreed to have damaged British ships refitted in U.S. yards, but he prohibited U.S. warships from escorting convoys. An agreement on April 9 with the Danish minister in Washington allowed the United States to defend Greenland, and its vital supplies of cryolite,[94] against invasion in return for the right to construct air and naval bases on the island. On April 10, three 1917-vintage battleships and a fleet carrier were ordered transferred from the Pacific to the Atlantic to aid the Royal Navy against German surface raiders. In response to Hitler's expansion on March 25 of the German combat zone to the east coast of Greenland, Roosevelt extended on April 11 the U.S. Neutrality (later Defense) Zone in the Atlantic eastward from 60 to 26 degrees west longitude, a line about halfway between Britain and the U.S. East Coast. Germany responded by extending its combat zone in the Atlantic to about 68 degrees west longitude. Hemisphere defense was strengthened when Panama agreed to allow the United States to maintain air-defense installations beyond the Canal Zone's boundaries until the European war ended.

As Roosevelt's policy brought the Nation closer to a real war in the Atlantic, the defense-production program rapidly reached a state of crisis, unable to meet increased demands because of material shortages, labor problems, and a disposition toward doing business as usual. Acquiring sufficient supplies of raw materials remained fundamental to the defense program, but authority for so doing was so dispersed that needs could not be met expeditiously. Increasing numbers of domestic strikes, including the 400,000 miners of bituminous coal out since April 1941, also hampered the U.S. defense program and imperiled some supplies. To keep labor at peace required the combined efforts of the newly established National Defense Mediation Board, Labor Secretary Frances Perkins, and President Roosevelt.

During this time, the British continued to struggle against great difficulties in Africa, the Balkans, the Mediterranean, and the Atlantic. German submarines, striking in multiboat packs, successfully interdicted Allied shipping, especially in the North Atlantic where the merchant ships sunk outpaced twofold the new construction. Additional German surface raiders sortied to threaten the convoys and their escorts. On May 27, 1941, Roosevelt's declaration by radio of an unlimited national emergency emphasized the increased danger posed by these raiders and alleged German plans to extend their dominion to the Indian Ocean and occupy Portugal's Cape Verde Islands, only 7 hours by air from Brazil. National policy, the President emphasized, involved keeping Germany out of the Western Hemisphere, continuing aid to Britain, and ensuring that the United States did all it could to strengthen its own defense.

German forces rescued the faltering Italian campaigns in the Balkans and in North Africa. Bulgaria joined the Axis. The new Yugoslavian Government capitulated after a 12-day struggle and, less than a week later, German forces broke the Greco-British resistance. The Greeks surrendered on April 23, 1941, and the British evacuated the country by the 27th. Some British and Commonwealth troops withdrew to Crete. German airborne forces attacked the island on May 20 to eliminate it as a base for RAF strikes on Ploesti's oil fields and refineries and to increase the Luftwaffe's ability to interdict British convoys in the eastern Mediterranean. The Royal Navy took heavy losses in rescuing some of Crete's garrison during May 28–30. Capturing Crete decimated the German parachute and glider units; although they were reconstituted and expanded, Hitler never used them against Gibraltar or Malta or in any other major airborne assault. In Libya, British forces, weakened by the dispatch of troops to Greece, were forced to retreat late in March by the Luftwaffe units and the Afrika Korps, since February 6 led by Generalleutnant (Major General) Erwin Rommel.

Britain found encouragement only in East Africa and the Middle East. Commonwealth forces drove the Italians out of British Somaliland on March 25 and liberated Ethiopia on May 18, 1941. In Iraq, the British retained large commercial interests in oil fields and airbase rights after their League of Nations mandate ended and the country became an independent nation in 1932. On April 3, 1941, a Pan-Arab clique seized power in Baghdad and blocked the oil pipeline, completed in 1934, from the fields near Kirkuk to the port at Haifa in Palestine. Supported by German advisers and Luftwaffe units flying from Vichy Syria and Mosul, the rebels attacked British troops at Basra and Habbaniyah, the airbase west of Baghdad, on May 2. Within less than a month, the British response forced the rebels to flee to Iran and produced a government friendly to Britain. After British and Free French troops invaded Syria on June 8 and captured Damascus, Vichy units surrendered in July, but only a few of them joined General de Gaulle's forces.

In the Far East, Japan increasingly gained access to French Indochina's rice, rubber, coal, phosphates, and other minerals. In January 1941, Japan arranged an armistice between Thailand and Vichy Indochina. On March 10, Vichy Indochina allowed the Japanese to use the airfield at Saigon (now Hõ Chí Minh City). Hitler told Matsuoka on April 4 that Britain had lost the war but refused to admit it. The Führer advised the Foreign Minister to attack Britain and its allies in Asia; the Wehrmacht would deal with the Americans if they intervened formally in the Atlantic. Japan's 5-year nonaggression pact with the Soviet Union signed on April 13, and the subsequent trade deal on June 11, reflected the German-Soviet agreements. After Foreign Minister Joachim von Ribbentrop suggested to Stalin on October 13, 1940, that Germany, Italy, and the Soviet Union should divide the world, Stalin sent Foreign Minister Vyacheslav M. Molotov to Berlin in mid-November to work out the provisional details. Their new agreement, Stalin told the visiting Matsuoka, left Japan free to straighten out the Far East, while the Soviets and the Germans organized Europe. Thereby, Stalin added, they would control most of the world's natural resources and then take on the United States.

Additional problems for Britain emerged in May 1941. Churchill's government appealed to the United States to help Britain increase available petroleum products, now in short supply due to the loss of nearly 80 tankers and the slowness with which the convoy system operated to replenish supplies. President Roosevelt asked U.S. tanker owners and operators to provide 50 ships to be used to carry petroleum products from Gulf of Mexico Coast and Caribbean refineries to U.S. North Atlantic ports for transfer to British tankers. As the 50 tankers made up about 20 percent of the fleet supplying the U.S. Atlantic seaboard, the transfer would add to the anticipated difficulty in supplying that region. On May 10, the administration issued an export-control order for two plant products having medical uses—hyoscyamine and stramonium—and for more minerals—columbium, cryolite, fluorspar, and tantalum. Roosevelt's decision led U.S. newspapers and Members of Congress to protest the policy that denied henbane (a possible source of hyoscyamine) to Japan but allowed it to obtain oil and gasoline while the East Coast of the United States faced fuel shortages.

The petroleum situation played a role in Roosevelt's subsequent decision to declare an unlimited national emergency on May 27 and, on the following day, to appoint Interior Secretary Ickes as Petroleum Coordinator for National Defense. Roosevelt asked Ickes, now the President's "oil czar," to obtain information about military and civilian needs for petroleum and petroleum products, to determine if any proposed action affected their availability, and to make specific recommendations for necessary or desirable actions to ensure ready and adequate supplies. Ickes, to improve his often uneasy relations with industry, in June chose Ralph K. Davies, vice president of Standard Oil of California since 1935, as Deputy Coordinator. A month later, Everette L. DeGolyer, a wealthy Texas geologist, oil entrepreneur, and bibliophile, also joined Ickes' staff as Director of Interior's Conservation Division. William B. Heroy (Sr.), on leave from Pilgrim Exploration Company of Houston, Tex., served as DeGolyer's deputy.

Major international developments in June produced a vastly different and dangerous set of conditions as the context for U.S. foreign-policy decisions during fiscal year 1941–42. Secretary of War Stimson and Treasury Secretary Henry Morgenthau, Jr., favored a complete embargo on oil to Japan; the State Department continued to object to a total shutoff. Ickes, soon after his appointment as Petroleum Coordinator, stopped oil shipments to Japan from the U.S. East Coast but not those from ports on the Gulf of Mexico or the West Coast. Roosevelt, aware that the Japanese remained undecided about moving north or south in the Pacific, countermanded Ickes' order and reminded him that controlling the Atlantic depended on keeping the Pacific peaceful. Until the new ships were completed and worked up, the President planned to avoid creating situations that would require their use in the Pacific.[95] Roosevelt chose other means to influence the struggle in the Atlantic. He issued an Executive order on June 14 freezing the assets in the United States of certain European countries, including Germany, Italy, and the Soviet Union.[96] Two days later, another order required all German consulates in the United States to be closed by July 10. The German and Italian Governments retaliated by ordering closed by July 15 all U.S. consulates in the parts of Europe under Axis control.

By then, Germany had succeeded in producing significant amounts of synthetic fuels, but the Third Reich still depended heavily on the raw materials it received from the Soviet Union in return for machinery, manufactured goods, and military equipment. Although the Soviets supplied these resources and fulfilled the other economic terms of their 1939 agreement with Germany, Hitler ordered the Wehrmacht to attack the Soviet Union. A successful invasion and occupation would fulfill his long-expressed wish to seize Soviet lands for colonization, and their natural resources and peoples for exploitation, before turning west again to defeat Britain. Stalin ignored warnings from Soviet diplomats and spies, and from the British and other governments, that the Germans were massing troops on Russia's western borders. On June 22, to Stalin's utter surprise and dismay, Germany attacked the Soviet Union along a nearly 2,000-mile front from the Barents Sea to the Black Sea. The Wehrmacht planned to conquer swiftly all the territory and resources, from Petsamo's (Pechenga's) nickel to Baku's oil, west of a line between Archangel and Astrakhan, before expanding into the Middle East and reaching the Indian Ocean. Churchill and Roosevelt quickly pledged their assistance to Stalin. British and Soviet representatives reached an agreement in Moscow on July 12. Roosevelt sent Harry Hopkins to Moscow in late July to promise the Soviets that the United States would provide machine tools and other technological aid. Roosevelt also pledged that U.S. oil would go to the Soviet Union via Vladivostok.

As the German-Soviet conflict began, the U.S. Federal budget for fiscal year 1941–42 totaled $17.5 billion, of which 62 percent was for national defense. The

USGS, now designated a defense agency because of its strategic mapping and minerals investigations, and water-supply studies for defense agencies and installations, received direct appropriations of nearly $4,924,000,[97] only a little more than the total funds gained in the previous year from the Interior and War Departments. After receiving the Thoenen-Burchard report, the OPM on June 27, 1941, nearly doubled its estimate of the aluminum required for the war effort. Although Roosevelt signed Interior's appropriations act on June 28, funds for expanded exploration for aluminum from all potential domestic sources only became available on October 28, when Congress allotted $415,000 to the USBM,[98] of which $70,000 passed to the USGS. The funds the USGS requested for topographic surveys in 1941–42, increased to $1,975,000, again formed the principal source of contention in Congress but the agency also asked for additional sums of $50,000 each for investigations of strategic minerals and water resources, and $40,000 for the salaries of 23 new general administrators (it received $24,000).[99]

Interior's First Assistant Secretary Ebert K. Burlew, Director of Information Michael W. Straus (formerly with the PWA), and the Personnel Director represented Interior when they appeared before the House subcommittee on March 20, 1941, to defend Secretary Ickes' request for an increase of $5.5 million in fiscal year 1941–42, principally for the Bonneville Power Administration, the NPS, and the USGS. Burlew asked for a total of nearly $1,255,000 more for the USGS, a sum that did not include the salaries of its employees reallocated within Interior between July 1939 and December 1940.

Jed Johnson presided and James M. Fitzpatrick (D–NY) examined the estimates when Mendenhall and his managers appeared before Edward Taylor's subcommittee on March 26, 1941, to explain the USGS request for $4,426,500 in direct appropriations, not including the funds the agency expected to receive from Interior for illustrations, engraving, printing, and binding. The House subcommittee recommended a total of $3,911,400 for the USGS for fiscal year 1941–42. The members approved or transferred most, but not all, of the increases. They eliminated the additional funds requested by the USGS for strategic mapping, stating their serious doubt that the work was essential for military purposes; if it was, those funds should be in the War Department's budget.

The Interior and USGS budget requests then passed to the Senate subcommittee, which convened on May 16. Hayden ordered Ickes' letter of the previous day read into the record; in it, the Secretary specifically asked the members to restore the House's cuts in USGS funds for topographic surveys and for salaries in the Director's Office.

Major General Julian Schley, the Chief of Army Engineers, again accompanied Mendenhall and the rest of the USGS delegation when they met with the Senate subcommittee on May 21 for hearings on the bill. General Schley, in supporting the mapping request, bluntly declared that

> **[n]o military man, no man who is well informed about national defense, would say that the map is not the most, or one of the most, essential elements of warfare. Every military man will say that. War is fought on maps. All orders include maps and refer to maps. It is axiomatic that a map is essential to national defense.[100]**

General Schley cared not which Federal department received the appropriation as long as the Army got its maps. If Congress appropriated the money to the War Department, the Department would transfer it to the USGS as it had in 1940. He remained unclear just how the funds could be appropriated to the War Department because Congress had passed the War Department's civil-functions bill. The Senate, therefore, restored the $25,000 for salaries and the $987,500 for topographic mapping that increased the USGS appropriation for the latter purpose to $1,962,500. The Senators added a proviso that not less than half of the amount go to mapping

Strata bearing zinc and other minerals in Washington State included the Metaline Limestone (Cambrian), here thrust over the Ledbetter Slate (Ordovician) in the Pend Oreille River gorge north of Metaline Falls, northeastern Washington. The line of thrust is emphasized by an added black line. A terrace deposit forms the upper right portion of the view. (Photograph from Park and Cannon, R.S., Jr., 1943, pl. 14*C*; a higher resolution image [without the black line] is available in the USGS Denver Library Photographic Collection as Park, C.F., pcf00116, https://www.sciencebase.gov/catalog/item/51dda04de4b0f72b4471dd4d.)

in strategic areas in accordance with priorities determined by the Secretary of War. In the conference between the two legislative bodies, the House yielded to the Senate. The American Congress on Surveying and Mapping (ACSM), organized in June 1941 to advance these activities, followed the approval of funding by stating that one of its aims involved contributing to educating the public in the use of surveys and maps. The new ACSM also planned to encourage the prosecution of basic surveying and mapping programs, especially those paid for, in whole or in part, by the taxpayers. Funds received from all sources for fiscal year 1941–42 raised the USGS total for the year to nearly $9,363,000 for salaries (for its now 1,800 employees) and expenses, an increase of about $1,539,000.

During fiscal year 1941–42, the Geologic Branch managed nearly $958,000. Geologic surveys received nearly $663,000, including $45,000 from States and municipalities, $80,000 from the USBM (principally for investigations of bauxite and other aluminum ores[101]), $30,000 from the Office of the President's National Defense allotment, and $6,000 from miscellaneous repay sources. Branch personnel again concentrated on the search for minerals previously recognized as strategic and critical and expanded their work to search for ores of common metals and minor elements that previously were in adequate supply but for which new sources were needed owing to great increases in demand and the loss of many foreign supplies. Funds for strategic-minerals investigations totaled $295,000, including the $195,000 specifically provided for that purpose in USGS direct appropriations, $50,000 from the Second Supplemental Appropriations Act, and $50,000 from the President's Interdepartmental Committee on Scientific and Cultural Cooperation. USGS funds for all of its geologic work, exclusive of Alaska, increased by 16 percent beyond the sum available in fiscal year 1940–41.

The most extensive of the new USGS investigations involved field studies of iron and aluminum ores. Iron, copper, lead, and zinc were not previously on the list of strategic minerals, but their addition reflected the growing need for these metals. Branch geologists studied iron deposits at Canyon Creek in Arizona, Eagle

This zinc-ore specimen, containing sphalerite (black), jasperoid (gray), and quartz (white), is from the 500-foot level of the Pend Oreille Mine in northeastern Washington. Members of the USGS strategic-minerals program sought commodities both precious and base. (Photograph reduced from Park and Cannon, R.S., Jr., 1943, pl. 25*B* [originally shown at × 1]; a higher resolution image [uncropped] is available in the USGS Denver Library Photographic Collection as Park, C.F., pcf00094, https://www.sciencebase.gov/catalog/item/51dda02fe4b0f72b4471dd2d.)

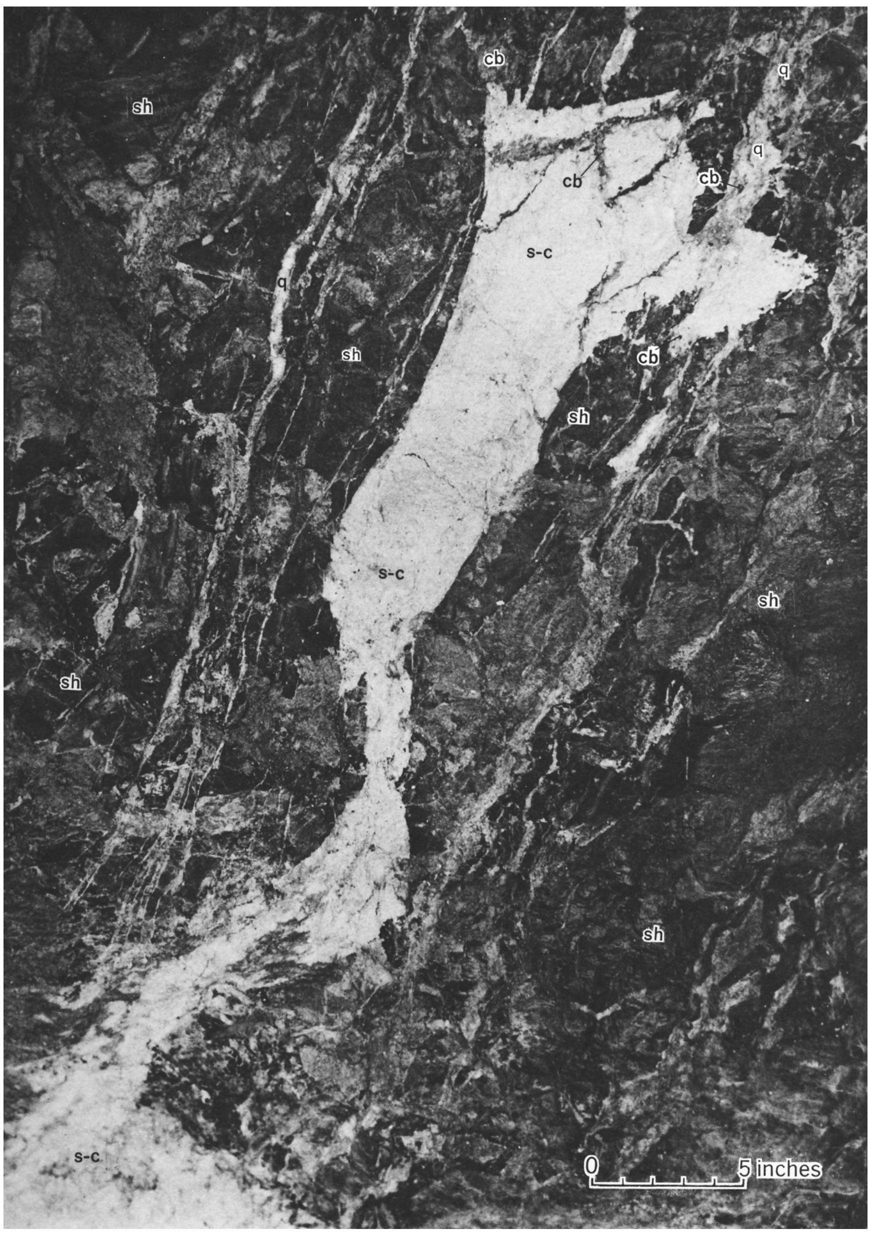
Mountains in California, Dayton in Nevada, Jones Camp in New Mexico, Scappose in Oregon, and Bull Valley in Utah to provide basic data essential to the planning of an iron-and-steel industry in the West. They also looked at other deposits in northeastern Alabama and at Cartersville in Georgia. The aluminum-exploration program, directed by Josiah Bridge, began in November 1941, using the special funds from Congress. Nine field parties initiated searches for bauxite in Alabama (where Preston Cloud served as chief), Arkansas, Georgia, Mississippi, Tennessee, and Virginia; the USBM drilled four deposits recommended by the USGS. Other groups examined high-alumina clays in California, Idaho, Mississippi, South Carolina, and Washington and alunite deposits in several Western States. As a stop-gap protective measure, U.S. forces occupied British Guiana, which supplied 60 percent of its bauxite to the United States.

Magnesium metal proved newly important, and the peculiar properties of the minor metals cobalt and vanadium also made them particularly valuable for the defense effort. Before 1939, the United States produced magnesium at only one domestic plant, where magnesium chloride was recovered by electrolysis from underground brines. USGS geologists now studied magnesite deposits in Washington and estimated the State's reserves. In Utah, appraisals began of the magnesium and potash content of ores and brines from a test well of the Defense Plant Corporation. A search also commenced in the area around Las Vegas, Nevada, for salt, a raw material needed in large quantities by the new plant of Basic Magnesium, Inc. During research on manganese minerals, under X-ray and other refined study methods, some ores displayed cobalt in such quantities as to be considered possible sources of the latter metal. In the search for vanadium, scientists at Harvard University tested spectrographically several hundred titaniferous magnetite specimens. The USGS also cooperated with the USBM in testing vanadium-bearing phosphate rocks in southeastern Idaho and western Wyoming.

The USGS program did not neglect chromium, manganese, mercury, molybdenum, tungsten, and several nonmetallic minerals. Earlier cooperative geologic studies of chromite led to the construction of a chromite-concentrating plant in Montana's Stillwater district that produced 150–175 tons daily, and two other mills were being planned to tap this largest domestic reserve. Prospecting for manganese in the Batesville district of Arkansas, in cooperation with the USBM, continued throughout the field season and into the winter, after which the USGS recommended stockpiling and systematic large-scale development of the ores there to the Metals Reserve Company and the Defense Plant Corporation. Continuing USGS investigations also included detailed mapping of the larger mercury districts of California, Nevada, and Oregon, followed by intensive geologic studies of individual mines. The mercury deposits at Terlingua, Texas, also received detailed district and mine examinations. Joint parties, each composed of one USGS geologist and one USBM engineer, inspected many small and widely scattered mercury properties in the Western States. A simple apparatus was developed for field estimates of the molybdenum content of scheelite concentrates, an important development because excessive molybdenum content subjected these concentrates to a price penalty. Earlier USGS–USBM geologic investigations of tungsten deposits led to large-scale production of the metal from a mine in the Yellow Pine district, Idaho; by the end of fiscal year 1941–42, the mine was the largest single producer of concentrates in the United States. USGS geologists now continued searches for tungsten elsewhere in Idaho and in Arizona (by Warren Hobbs and Montis Klepper), California, Colorado, Nevada, and Utah (by Hobbs). Field and laboratory studies also included examinations of fluorspar in western Kentucky; graphite in Alabama, New York, and Pennsylvania; phosphates in Idaho and Wyoming; sheet mica (with beryllium, lithium, and tantalum) in the New England States and North Carolina; talc in California and Nevada; topaz in South Carolina; and other nonmetallic minerals of immediate or potential value to national defense.

With the State Department funds, the USGS advanced its strategic-minerals investigations in the American Republics during fiscal year 1941–42. John Dorr 2d continued work on iron, manganese, and nickel in Brazil's Mato Grosso. Related work included evaluations of chromium, manganese, and tungsten in Cuba; manganese in Costa Rica; antimony, manganese, and mercury in Honduras; and antimony, chromium, mercury, tin, and vanadium in Mexico. In Cuba, geologic studies by Lincoln Page and James F. McAllister on the Isla de Piños; Charles Park and M. William Cox in the Sierra Maestra; Wendell Woodring and Steven N. Davies in Oriente Province; and others were directly applied to solving the production problems of the operating companies or aimed, in part, to aid increased production. The work in Cuba featured the use of geophysical methods, which gave some promise of success, in prospecting for chromite.

Although the Geologic Branch directed most of its efforts during fiscal year 1941–42 toward the discovery and development of metallic minerals, the few fuels geologists not diverted to strategic-minerals projects continued their coal and oil investigations. They examined occurrences of oil in areas in and adjacent to Naval



This 1942 view taken underground at the Red Devil Mine, Georgetown district, Kuskokwim region, Alaska, shows cinnabar (cb) ore in the centers of quartz veinlets (q) in fractures in both the andesite dike (white) and the surrounding shale (sh); s-c = silica-carbonate rock. USGS geologists expanded prewar strategic-mineral studies in Alaska for mercury and other needed commodities. (Photograph from Cady and others, 1955, pl. 9; a reversed image of pl. 9 bearing a different scale is available in the USGS Denver Library Photographic Collection as Wallace, R.E., wre00026, https://www.sciencebase.gov/catalog/item/51ddcd72e4b0f72b447218fd.)

Topographer Thomas Percy Pendleton (1885–1954) began his career with the USGS in 1909 and mapped with plane table and alidade in the Western United States. During World War I, he served as a 2d Lieutenant of Army Engineers and helped to develop the three-lens camera and radial-line mapping methods. Pendleton led the USGS Photographic Mapping Section during 1921–26. After resigning, he worked for Brock & Weymouth in Philadelphia and then the Aerotopograph Corporation in Washington, D.C., before shifting in 1932 to the U.S. Coast and Geodetic Survey. He returned to the USGS in 1934 to direct the photomapping cooperative with the Tennessee Valley Authority that used improved Multiplex stereoscopic equipment to revolutionize production. Pendleton, as Chief of the Photographic Mapping Section (1941–43) and then Chief Topographic Engineer (1943–47), continued to promote improvements in photogrammetry before retiring after a long illness. (Photograph from Thompson, 1987.)

Petroleum Reserve No. 1 in California. Fuels Section geologists also studied geologic conditions near Mount Pleasant in Utah, where the USBM was drilling a test well in search of coking coal. Another cooperative effort with the USBM surveyed sources of helium gas, valued principally for use in blimps, other lighter-than-air craft, and weather balloons. In Pennsylvania, USGS cooperative work with the State's geological survey led to the drilling of a producing oil well.

The Alaskan Branch's funds ballooned to $365,000, almost 3.5 times the amount available in fiscal year 1940–41, and its staff grew significantly for work on the Territory's mineral resources during fiscal 1941–42. The Branch's total monies included $75,000 in direct appropriations and major infusions from the War Department ($125,000) and the Office for Emergency Management (OEM, established on May 25, 1940; $165,000). Branch geologists sought deposits of antimony, chromium, iron, mercury, molybdenum, nickel, tin, and tungsten during the 1941 field season. Parties examined tin deposits in the York area of the western Seward Peninsula and in the Hot Springs district of the Yukon-Tanana country. Branch geologists studied chromite prospects at Red Bluff Bay on the east coast of Baranof Island, mercury prospects in the Kuskokwim Valley, tungsten deposits in the Hyder and Chichagof districts in the southeastern part of the Territory, and antimony deposits in the Kantishna district and nearby parts of the Bonnifield and Fairbanks districts. With a USBM engineer, they also revisited the mineral deposits at Seldovia. In addition, geological surveys of areas in southeastern Alaska and in the Alaska Range's Delta River district included incidental preliminary investigations of antimony, iron, molybdenum, nickel (by Reed, Dorr, and George O. Gates), and tungsten. Branch topographers also contributed to these investigations. Gerald FitzGerald made a general geologic reconnaissance of the Porcupine River Valley in east-central Alaska. Topographic work in Alaska included additional mapping for aerial navigation and other military use, plus aerial photography of the Yukon-Kuskokwim region (extending westward the work done in 1940), a reconnaissance of the Yentna district, and detailed surveys in the Hot Springs district and in the vicinity of Tanana.

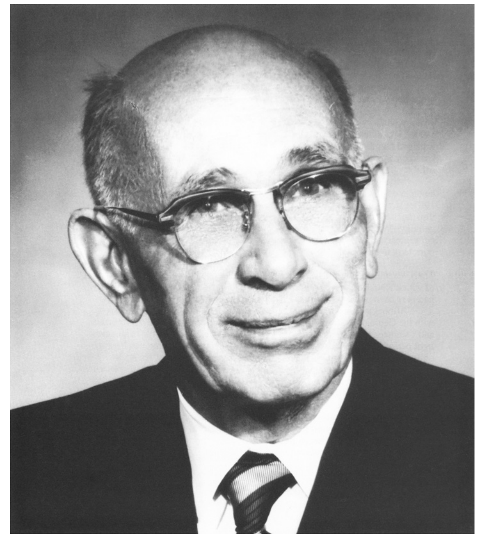
During fiscal year 1941–42, the USGS Topographic Branch drew on about $3,488,000 in total funds (about 1.4 times the sum available in fiscal 1940–41), including the directly appropriated $1,962,500, of which $275,000 was available only for State-municipal cooperation. The States and municipal governments furnished $341,000. Other Federal sources supplied some $1,185,000, including $1,046,000 from the War Department, $53,000 from the TVA, $34,000 from the PRA, and $52,000 from other agencies. Branch topographers mapped for the first time or resurveyed about 16,160 square miles in 38 States (17 of them as cooperative ventures), the District of Columbia, and Puerto Rico. Branch members also continued topographic mapping for the TVA, but most of their fieldwork involved mapping strategic areas. Eighty-six of the 232 quadrangles completed at scales of 1:24,000 and 1:62,500 during the year were mapped for the Army, as were 64 of the 156 quadrangles still underway. Branch topographers mapped planimetrically by photogrammetric methods an additional 3,210 square miles. In preparing aeronautical charts for the USAAC, Branch mappers used Lewis rectoblique plotters, Sketchmasters, and Lucidographs to convert low-oblique air photographs to charts. In August 1941, Thomas P. Pendleton, who directed USGS production of maps for the TVA, became Chief of the Section of Photographic Mapping in Washington, D.C.; Joe K. Bailey replaced Pendleton in Chattanooga, Tennessee. Oscar H. Nelson succeeded Acheson Hassan as Chief of the Cartographic Section. The Branch again expanded its photogrammetric work, this time to Rolla and Sacramento, under the direction of the engineers in charge of the Central and Pacific Divisions. Branch topographers completed a survey of Dinosaur National Monument in

Colorado and Utah. They also made greater use of Ronald Wilson's photoalidade. Wilson, as Chief of the Computing Section since 1933, adopted for its geodetic work electric calculators to aid computing transit-traverse and triangulation surveys. He also received a patent for his photoalidade, which made oblique-angle air photographs usable for vertical map projections. After Claude H. Birdseye, Chief of the Division of Engraving and Printing in the Director's Office since 1932, and the former Chief Topographic Engineer (1919–29), died on May 30, 1941, Fred Graff replaced Birdseye in Washington, effective on August 1.[102]

The USGS Water Resources Branch carried on its normal work as much as possible during fiscal year 1941–42, drawing on total funds of some $3,252,000, including $1,274,500 in direct appropriations, $1 million of which was limited to State-municipal cooperation. States, counties, and municipalities supplied $1,038,000. More than $928,000 came from other Federal sources, including $659,000 from the Army Engineers, $59,000 from the DoS, $55,000 from the TVA, $47,000 from the War Production Board (WPB), and $45,000 from the USDA. Branch hydrologists answered requests for reports on the quality and quantity of surface-water and groundwater supplies at some 1,700 defense installations in the United States and for specific islands of strategic importance. They made special investigations where information remained meager or where possible deficiencies in quantity or the doubtful quality of the water seemed most threatening. Regional surveys determined total pumpage, water-level fluctuations, and possible saltwater encroachment from local depletions of groundwater by heavy pumping for industrial or military purposes. Surveys for the Navy assessed potential emergency supplies from wells to be used in the event of attacks. Other studies summarized water conditions, both at the surface and underground, throughout the United States each month for use by agencies in charge of water-supply and waterpower activities related to preparedness. For this last effort, one that included Lake Roosevelt (above Grand Coulee Dam) in Washington State and Kootenay Lake in British Columbia, Canada, the Branch collaborated with the State Department, the International Joint Commission, and Canada's Dominion Water and Power Bureau so that both countries benefitted from a better knowledge of conditions. The Branch also cooperated with other Federal agencies in completing a new survey of the world's developed and potential waterpower. The assessment of the globe's developed waterpower showed that the United States and Canada controlled 39 percent and Italy and Japan held 18 percent.

The Water Resources Branch's two principal divisions increased their activities during fiscal year 1941–42. The Surface Water Division maintained 45 field offices and cooperated with 140 State, county, and municipal agencies. Division personnel collected records in every State and the Territory of Hawaii of the stages, quantity, or availability of surface waters at some 5,000 gaging stations, 152 more than in fiscal 1940–41, of which about 3,800 were equipped with recorders, an increase of about 90. The Ground Water Division cooperated with State or local agencies in investigations in 32 States and in Hawaii. Division hydrologists periodically measured water levels or artesian pressure in about 7,100 wells, some 1,600 more than in fiscal 1939–40, of which 312 held recorders (an increase of 47), in all parts of the Nation. New investigations in 1941 included statewide cooperative programs in North Carolina, led by Maurice J. Mundorff, and in West Virginia, led by Raymond L. Nace, who began his study in Harrison County, where shifts in population and industrial development for war preparedness caused water-supply problems.

West of the Mississippi, the Ground Water Division added new investigations to its already extensive work in the region. Division members began a study of the underflow in the North Canadian Valley above Oklahoma City, Oklahoma, because the State's Planning and Resources Board, then considering the adjudication of water rights, wished to know if the underflow were large enough to be considered.

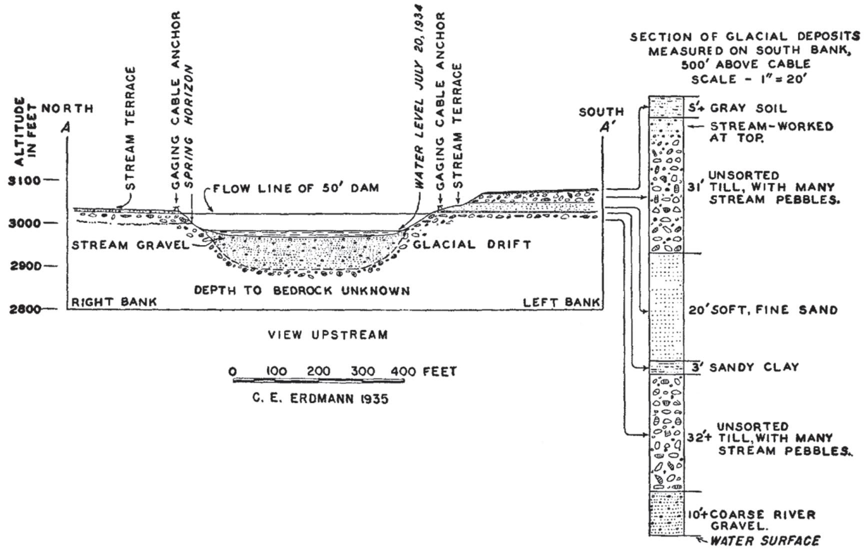


Geohydrologist Charles Vernon Theis (1900–87) spent the summer of 1927 working with USGS geologist Arthur Baker in Utah and then a year with the Army Engineers before joining the USGS Ground Water Division in 1930. His subsequent work, mostly on the High Plains of New Mexico and Texas, led to his continuing analyses of aquifers from well data. In 1935, Theis published his evaluation of nonequilibrium conditions in groundwater flow that included the "Theis equation" as an aid to solving field problems in the geohydrology of aquifers. He served as District Hydrologist in New Mexico in 1936–51 (including work with the Military Geology Unit and the Army Engineers in 1943–44) before coordinating USGS efforts for the U.S. Atomic Energy Commission. Theis continued his research during 1957–65, while on the staff of Luna B. Leopold, Chief of the Water Resources Division, and then in retirement into the 1980s. (Photograph from Clebsch, 1994, frontispiece; also published in White, R.R., 1995.)

In Texas, many small investigations advanced military objectives. In Wyoming, Frank C. Foley began a study requested by Cheyenne's city government to locate additional water for the growing city and its nearby Warren airbase. To the south, Charles V. Theis had led the New Mexico district from Albuquerque since 1936, a year after he published his equation that described nonsteady flow in groundwater whose motion was analogous to heat flow in solids. In additional groundwater papers, issued between 1937 and 1941, Theis described the amount of recharge on the High Plains, the nature and significance of the cone of depression, the essential factors that controlled an aquifer's response to development, and the effect of a well on the flow of a nearby stream.[103] C. Richard Murray supervised the drilling of a test well near Deming, New Mexico, which located additional deeper aquifers in the Mimbres Valley and the possibility of reducing interference between wells in a densely developed section of the valley. At the War Department's request, Lyman C. Huff, supervised by Arthur M. Piper, studied the distribution and character of the water-bearing formations in Washington's Spokane Valley for use by a planned aluminum rolling mill and a magnesium plant, both of which required large volumes of water. George La Rocque began a cooperative investigation of the groundwater resources of Santa Barbara County in California. In December 1940, the Army called hydraulic engineer George H. Taylor to active duty as a Captain assigned to the Office of the Chief of Engineers. While in Washington, Taylor provided liaison with the USGS and also helped to prepare the Army Engineers' technical manual on water supply and water purification.

The Water Resources Branch's smaller Divisions also experienced growing demands for their services and expanded their work. The Quality of Water Division's efforts increased as industrial development created interest in the quality as well as the availability of water. Division hydrologists continued their sedimentation studies and also participated at the University of Iowa's Hydraulic Laboratory in a research investigation of sampling methods. Under the President's reorganization plan of April 11, 1940, planning for the conservation of soil and moisture on lands under Interior's jurisdiction, previously carried on by the USDA, now passed to Interior. Secretary Ickes set up an Office of Land Utilization[104] and designated the USGS as adviser to the active agencies that would conduct the work. The Branch's Water Utilization Division received responsibility for administering the new service; Harold V. Peterson transferred in from the Army Engineers to take charge of the field studies. Peterson worked with W. Glenn Hoyt (younger brother of John C. Hoyt) during the next year on an Army Engineer-USGS survey of the Gila River in Arizona. Peterson principally provided advice about range-water development, erosion, and sedimentation, in part to advise more effectively the GLO, the Grazing Service, and the OIA. He and Walter B. Langbein, who transferred to Washington in 1939, began a reconnaissance of the public domain to obtain first-hand information about conditions. Langbein also increased his investigations, in collaboration with Glenn Hoyt, of the hydrology and impact of floods. Division personnel also continued studies along the Canadian border required by the Joint International Commission.

In fiscal year 1941–42, the Conservation Branch continued its regular work of classifying the public lands and supervising mineral-leasing activities supported by $578,000, including $428,000 in directly appropriated funds and $100,000 from the OIA and $45,000 from the Navy Department. Ickes' Secretarial order, effective January 1, 1941,[105] required the USGS to continue determining the payments due the United States from the production, waste of production, or failure to produce oil and other natural resources on the public lands. Ickes asked the USGS to provide statements to the GLO and to leaseholders, and, if necessary, to defend these reports. The Branch continued to provide requested advice on all lease-accounting matters, but it was not responsible for collections. To carry out all these duties, the



This geologic cross section at the Columbia Falls dam site was drawn along the streamgaging cable across the Flathead River in Flathead County, Montana. The detailed section on the right shows the glacial deposits on the south bank 500 feet above the cable. Charles Erdmann and his colleagues in the Conservation Branch extended their geologic and natural-resource evaluations of dam and reservoir sites on the upper tributaries of the Columbia River in Idaho and Montana. These evaluations included the Hungry Horse site on the South Fork of the Flathead River and the Canyon Creek, Coram Canyon, Fool Hen, and Glacier View sites on the Flathead's North Fork. (From Erdmann, 1947, fig. 10.)

Mining Division now operated 7 field offices in the West and Southwest; the Oil and Gas Leasing Division maintained 16 field offices and suboffices. The Mineral Classification Division's staff handled more than 7,350 cases, concentrating on coal, oil, and potash lands in Kansas, New Mexico, and Wyoming. Members of the Water and Power Division worked in 22 States and Alaska, but insufficient funds forced the closure of its Sacramento office. The number of mineral and oil and gas leases supervised during the year again increased, but the revenue from them decreased, including a reduction of more than $155,000 in the combined revenue from the fewer barrels of oil and the greater volume of natural gas produced from California's NPR–1 and NPR–2.

As the USGS conducted field operations during the summer of 1941, the Axis Powers continued their offensives in the Soviet Union and in the Atlantic. The Germans and their East European allies advanced steadily on the Eastern Front. Wehrmacht forces, moving east from northernmost Norway, captured the former Canadian-owned nickel mines at Petsamo (Pechanga) and then pushed on toward the Soviet port and naval base they briefly shared at Murmansk. To the south, the spearheads of German columns came within sight of the Kremlin's spires on December 1. The Germans got no closer to Moscow because, starting on July 30, Hitler diverted some units to support the drives toward the Ukraine and Leningrad (St. Petersburg), where a partial siege of the city began in early October. The Germans took Kiev and the Romny oil fields in September. Then they struck east and southeast for the Donets Basin's coal, minerals, and industries and south toward the Crimea and its naval base at Sevastopol. Further to the southeast, British and Soviet forces jointly occupied Iran on August 25 to secure the safe transit of British and U.S. arms and supplies to Soviet territory. U.S. and British missions met in Moscow on October 1 to plan for the passage of war materials to the Soviet Union; 1 month later, Congress approved $1 billion in lend-lease credits to the Russians.

The undeclared conflict between the United States and Germany in the Atlantic escalated to a shooting war in September 1941. Iceland accepted the arrival of U.S. Marines, who, from July 7, relieved the Canadian (formerly British) garrison for duty elsewhere. On September 4, a U.S. destroyer en route to Iceland reported a German submarine to a British aircraft, which dropped depth charges on the U-boat. The submarine and destroyer then exchanged torpedoes and depth charges without damage to either ship. A week later, Roosevelt portrayed the submarine's attack as unprovoked and labeled the German U-boats and surface raiders as "the rattlesnakes of the Atlantic"[106] who must be crushed before they struck. He warned German or Italian warships that they now entered the American Defense Zone "at their own peril."[107] In October, 126 U.S. sailors died after U-boat torpedoes damaged a second U.S. destroyer and sank a third. After those attacks, Roosevelt asked for and Congress granted authority to arm U.S. merchant vessels and enabled them to carry arms to anti-Axis belligerents.[108]

In the Far East, tensions also continued to escalate as Japan continued efforts to impose its own new order. On July 21, 1941, the Vichy Government agreed to Japan's demands for bases in southern Indochina and to station Japanese troops within the country to protect it against China, provided French officials retained civil control. Japan quickly occupied Cam Ranh Bay and Saigon and assumed a protectorate over all of Indochina, including its solid fuels, rubber, phosphates, zinc, and other resources. The move also placed Japanese warships and aircraft within easy striking distance of resources and military bases on land in the Philippines, Malaya, and the Netherlands East Indies. On July 26, Roosevelt responded by issuing an Executive order freezing all funds and other assets[109] in the United States held by the Japanese and the Nationalist Chinese (at their request), except for approved special releases for oil and other materials; Britain did the same. The President also warned the Japanese Ambassador that if his country made any further military efforts to dominate Asia, the United States would be forced to act immediately to safeguard U.S. interests and rights. During July 26–27, FDR federalized the armed forces of the Philippine Commonwealth, recalled to active duty retired Major General Douglas MacArthur (the former Army Chief of Staff), and promoted him to Lieutenant (Lt.) General as commander of all U.S. Army Forces in the Far East. The Governments of Britain and The Netherlands then cut their 20 percent of the oil that Japan required to operate its war machine. The Japanese militarists now faced two principal choices. They could give up their plans for attaining their Greater East Asia Co-Prosperity Sphere or move south in the Pacific to achieve that dominion before Japan's oil, metal, and rubber reserves ran out and the new ships of America's two-ocean navy appeared.

On July 30, another Executive order by FDR established the Economic Defense Board (EDB) to develop and coordinate "policies, plans, and programs designed to protect and strengthen the international economic relations of the United States in the interest of national defense."[110] The order defined economic defense as

> **the conduct, in the interest of national defense, of international economic activities including those relating to exports, imports, the acquisition and disposition of materials and commodities from foreign countries including preclusive buying, transactions in foreign exchange and foreign-owned or foreign-controlled property, international investments and extensions of credit, shipping and transportation of goods among countries, the international aspects of patents, international communications pertaining to commerce, and other foreign economic matters.[111]**

The EDB, a Cabinet-level committee chaired by Vice President Henry Wallace, included all members of the Cabinet, except the Interior and Labor Secretaries. Milo R. Perkins, Wallace's close friend, a manager at the USDA beginning in 1935, and administrator of the Surplus Marketing Administration since July 7, became the EDB's Executive Director.

Roosevelt left Washington to confer with Churchill shortly after issuing the Executive order that selectively froze Japanese assets but without making clear how he wished it to be applied.[112] According to Secretary Ickes, the President told the Cabinet that the United States would continue to ship oil and gasoline, but not fuels higher than 86 octane, at 1936 levels to Japan to prevent the Japanese from acquiring additional supplies in Mexico or invading the Netherlands East Indies until the United States readied enough of its Navy to fill all its needs. Roosevelt, Ickes noted, wanted to get Japan's attention by periodically reducing, rather than slowly strangling, U.S. fuel exports to the Empire.[113] Instead, the Executive order meant that Japan could purchase no U.S. goods without a State Department license. Several Federal officials, lacking any definite instructions to the contrary, took the order literally. Secretary Hull, Under Secretary B. Sumner Welles, and Ambassador Grew still opposed the total economic sanctions they thought eased the road to war. Dean G. Acheson, Assistant Secretary of State for Economic Affairs since February 1941, favored embargoes and supported the U.S. military and naval buildup; he helped to provide the legal basis for the bases-for-destroyers deal in 1940. Acheson also chaired the interdepartmental Foreign Funds Control Committee, which remained responsible for implementing the new export freezes. Acheson's Committee could not release dollars to buy export licenses until the Export Control Office (ECO) decided how much oil should go to Japan in exchange for silk and other vital materials. Before accompanying Roosevelt to his meeting with Churchill, Welles, who often substituted for the ailing Hull, asked Acheson to take no action while the freeze was tested.[114] All existing valid licenses were revoked on August 1 and no new ones issued, so Japan never received the fuel authorized later that month by the ECO. At San Pedro in California, two Japanese tankers waiting to be loaded with the approved fuel sailed home empty. After Roosevelt returned to Washington, he accepted the Welles-Acheson decision to avoid appearing weak. Barring a change of policy by the Japanese Government, war in the Pacific thus became inevitable but not yet predictable.

Roosevelt, Churchill, and their military staffs met secretly in the Argentia Conference, held during August 9–12 aboard British and U.S. warships in Placentia Bay off Newfoundland, to discuss war aims, to fashion postwar policies, and to build morale. The attendees developed a joint declaration of "common principles in the national policies of their respective countries on which they base their hopes for a better future for the world."[115] Issued on August 14, the eight-point declaration of postwar aims (the Atlantic Charter) pledged that Britain and the United States sought no territorial aggrandizement, desired no territorial changes unacceptable to the people concerned, respected the right of nations to choose their own form of government, and wished to see sovereign rights and self-government restored to peoples forcibly deprived of them. The Allies also sought to promote friendly collaboration among the peoples of the world, fair labor standards, social security, liberty from fear and want (with freedom of speech and religion, making up the four freedoms Roosevelt announced to Congress on January 6). They also promoted equal access to trade and raw materials, joint economic development, free traverse of the high seas, abandonment of the use of force, and disarmament of aggressor nations. These goals, as part of a permanent peace, would be secured by a grand alliance of united nations. The Atlantic Charter clearly owed much to President Wilson's Fourteen Points of 1917. Ironically, in view of the timing, the new document's fourth principle promised that both countries would "endeavor, with due respect to their existing obligations, to further the enjoyment by all States, great or small, victor or vanquished, of access, on equal terms, to the trade and to the raw materials of the world which are needed for their economic prosperity."[116] That pledge went much further than the third of Wilson's Points, which asked only to remove all economic barriers and establish equal trade conditions among the nations signing the peace treaty and then joining in its maintenance.

By midsummer 1941, although the United States remained officially at peace, American public opinion continued to shift, in part due to a growing understanding of the issues involved in and the course of the ever-widening conflict in the Eastern Hemisphere. As fall approached, President Roosevelt, monitoring the change, made another effort to strengthen the defense-production program. FDR relieved

Harry Hopkins as Lend-Lease Administrator and appointed him Special Assistant to the President, with general supervisory authority that effectively made him, said Secretary Ickes, the assistant president.[117] Edward Stettinius replaced Hopkins and OPM's Donald Nelson succeeded Stettinius. Roosevelt set up on August 28 a new war-oversight group,[118] again chaired by Vice President Wallace. Officially known as the Supply Priorities and Allocations Board (SPAB), the unit also included Secretaries Stimson and Knox; OPM codirectors Knudsen and Hillman; and Leon Henderson, the manager of the Office of Price Administration and Civilian Supply. Nelson became SPAB's Executive Director and assistant to Wallace.

As part of continuing U.S. diplomatic efforts to forestall new hostile actions by Japan, Secretary Hull made it clear to the Japanese Ambassador that his country could have all the goods and credits it wanted if Japanese forces would begin to evacuate China and Indochina. In mid-October, Prince Konoye Fumimaro, the Japanese Prime Minister, asked Lt. General Tojo Hideki, Konoye's War Minister since July 18, to begin at least a token retreat. Tojo refused. When Konoye and his cabinet resigned on October 16, Tojo became the new Prime Minister and acted on the decision to move south made on July 2. Stalin soon learned of this step from his spy ring in Tokyo and, on November 2, Ambassador Grew sent an additional warning to Washington about the volatile situation in Tokyo. Three days later, the Imperial Council agreed that if Japan concluded no satisfactory agreement with the United States by early December, Japan would go to war against the United States, Britain, and The Netherlands to achieve its material and military goals. Certain that Germany would defeat the Soviet Union and wishing to avoid further conflict with the Soviets on the Manchurian border, or with Chinese and Korean guerillas within that country, the Japanese militarists moved to strike south while Japan retained sufficient oil reserves and good weather and while new warships for the United States remained on the slipways, completing in harbor, or working up at sea.

The Japanese Imperial War College began considering a surprise attack on Hawaii in 1936. Using German and Japanese information[119] about the British air raid on Taranto, the Imperial Navy's staff quickly planned to place their six fleet carriers in a single strike force. The joint-force's aircraft would strike Pearl Harbor to protect the flank of the Far East invasions by eliminating the U.S. Pacific Fleet's ability to intervene and, perhaps, also to break American morale. Admiral Yamamoto Isoroku, the Combined Fleet's commander, promised Konoye 6 months to a year of victories. He was not confident of success thereafter against a fully mobilized United States. On November 5, 1941, after the Imperial Council decided for war, the Combined Fleet received a secret operations order to attack U.S. ships at Pearl Harbor and airfields elsewhere on Oahu.

On the same day, a NAS committee recommended that work begin immediately toward developing a U.S. nuclear-fission weapon as a government-academia-industry collaboration. Scientists in Germany and Japan also continued efforts aimed at producing similar devices, but the Soviets decided to shelve their fledgling project. The initial shipment of heavy water from Norway to Germany reached Werner Heisenberg in Berlin during September 1941, the same month Heisenberg (with the younger von Weizsäcker) traveled to lecture at Copenhagen. While there, Heisenberg's informal conversation with Niels Bohr about the morality of using uranium fission for military purposes troubled Bohr with the specter of a Nazi atomic bomb.[120] While Bohr wrestled with his concerns, the Japanese Combined Fleet learned on November 7 that it would strike Oahu on December 8 (Tokyo date).

Richard Rhodes described how Roosevelt's new Top Policy Committee—Wallace, Stimson, General George C. Marshall, Jr. (the Army Chief of Staff since 1939), Bush, and Conant[121]—knew by October 1941 that Britain's Maud Committee decided in July that a nuclear-weapon project was feasible. The Maud Committee's report of July 1941, refining an earlier estimate, indicated that a uranium bomb with about 25 pounds of active material would produce an explosion equivalent to that of 1,800 tons of trinitrotoluene (TNT) and release deadly radiation to add to the blast's effects. A plant costing an estimated £5 million should, the Committee's report continued, produce by gaseous diffusion about 2.5 pounds of uranium-235 per day and 3 bombs each month after the end of 1943. The 1-ton (or less) nuclear bombs, the Committee suggested, could be dropped in free fall or by parachute from any modern bomber, depending on the distance to the target. Using heavy water rather than graphite as a neutron moderator, the panel predicted, would limit German or Allied atomic-energy processes in war use. In summary, the Maud Committee's members thought the uranium bomb practicable and potentially decisive. The Committee recommended giving promptly the highest priority to the project and increasing its resources in Britain and the United States to produce the bomb as soon as possible.

After Vannevar Bush received a pre-release copy of the Maud Committee's report, George B. Kistiakowsky, an émigré Ukrainian chemist, convinced Bush and Conant of the efficacy of producing uranium-235 by gaseous diffusion. On October 9, Bush personally gave Roosevelt and Hopkins a summary of the Maud Committee's report and his preliminary estimates of the amount of uranium required, the cost of a plant for producing uranium-235, and the time required to produce a bomb. Roosevelt asked Bush to determine for himself the project's feasibility and, if it could be done, to return for approval for production. The Top Policy Committee supported the NAS committee's recommendation, and Bush took it to Roosevelt on November 27.

Two days later, Prime Minister Tojo repeated that U.S. and British influence must be eliminated from the Orient to enable Japan to achieve its Greater East Asia Co-Prosperity Sphere. Secretary Ickes reported the administration's decision to maneuver the Japanese, as done with the Germans in the Atlantic, into firing the first shot without excessive risk to U.S. forces. Eventually, Ickes thought, if Germany appeared to be winning its two-front war with Britain and the Soviet Union, Japan would attack the United States. If so, he decided, America should try to influence the place and time of the attack.[122] On December 2, Roosevelt asked for a definition of Japanese aims in Indochina. The Imperial Council, which had decided for war the previous day, issued the attack order on December 3, as German forces remained halted before Moscow. Stalin ordered Soviet forces, led by General Georgy K. Zhukov, west from Siberia in October and November to save the capital. Zhukov's troops, supported by the new T–34 medium tanks, counterattacked on December 5 and drove back the German forces, still not adequately prepared for operating in the deepening sub-Arctic winter.

As the Soviet forces advanced, Roosevelt appealed directly to Emperor Hirohito on December 6 to help preserve the peace, claiming that "a withdrawal of the Japanese forces from Indo-China would result in the assurance of peace throughout the whole of the South Pacific area."[123] FDR also that day approved funds for producing the special bomb and transferring that weapon project to Briggs' uranium unit, now renamed the S–1 Section. Bush, Arthur Compton, and Conant, accompanied by Ernest Lawrence, then convened and reorganized S–1. In the new arrangement, chemist Harold C. Urey, who had isolated deuterium in 1931, would oversee gaseous-diffusion experiments at Columbia. Lawrence would continue to lead electromagnetic-separation trials at Berkeley. Eger V. Murphree, a chemical engineer and vice president of Standard Oil Development, would direct additional work on centrifuges. Arthur Compton, who favored using plutonium rather than uranium-235, would take over reactor experiments and bomb theory and design at Chicago; Glenn Seaborg left Berkeley to join Compton's team.

When Roosevelt's appeal reached Grew in Tokyo, it was already far too late for the President's or any other diplomacy. Beginning on November 11, Imperial Navy warships and Army transports sailed from Japanese and other ports for invasions or attacks on Burma, Guam, Hawaii, Hong Kong, Malaya, Midway Island, the Philippines, and Wake Island, as part of a daring and well-planned campaign to secure the Southern Resources Area and a perimeter to defend it until the United States and Britain sued for peace. U.S. "Magic" diplomatic and British "Ultra" military decrypts, plus direct observations, disclosed that several of the Japanese forces were at sea and headed south but left undetermined the location of the Japanese fleet carriers and their escorts en route, since November 26, from the southern Kurils to attack Hawaii. On the evening of December 6 (Washington date), as the Imperial Navy's strike force neared Oahu, Roosevelt and Hopkins read the first 13 of 14 installments of the Japanese reply to Secretary Hull's note. The President thought that the installments' language meant war but where in the Pacific?

Gordon W. Prange and his coauthors described and analyzed in detail the attack on Oahu and its results. At about 6:00 a.m. on Sunday, December 7 (Hawaiian local time), the Japanese carriers turned into the wind at a point less than 200 miles north of Pearl Harbor to launch aircraft for the first of two huge attack groups totaling more than 350 planes. At 7:53 a.m., the Japanese caught the Americans entirely by surprise, as they did in striking the Chinese in 1894 and the Russians in 1904. Japanese aircraft and a midget submarine sank or heavily damaged the 8 old U.S. battleships (but 6 would fight again) and destroyed or damaged 10 smaller warships and auxiliaries. The raiders also killed or wounded nearly 3,600 persons, nearly all naval and military personnel,[124] and eliminated some 350 of the almost 400 Army and Navy aircraft on Oahu. The Japanese lost fewer than 30 planes, 6 submarines, and about 100 combatants. They did not attack the vital repair facilities and the above-ground fuel-oil supplies of more than 4 million barrels. Nor did the Japanese try to find and destroy the two U.S. fleet carriers then returning to Oahu after delivering reinforcements to Midway and Wake.

Americans initially could not believe the news. Secretary Knox warned Secretary Stimson earlier that year that the Japanese might deliver a Taranto-like attack on Pearl Harbor, but Knox's staff assured him on December 6 that the Japanese would not dare to strike Oahu; only British possessions in the Far East seemed likely targets. Knox thought the Japanese must be assaulting the Philippines; they did but not until more than 9 hours later. Although MacArthur's headquarters in Manila received news of the attack on Pearl Harbor 7 minutes after it began, Japanese aircraft from Formosa (Taiwan) destroyed or damaged on the ground all but 4 of the 100 U.S. aircraft lost, including nearly 20 of the Boeing B–17 Flying Fortresses, the new four-engine strategic bombers.

Roosevelt quickly asked for a declaration of war against Japan, and the Territory of Hawaii went under martial law. At noon (Washington local time) on December 8, Congress convened in joint session at Roosevelt's request. FDR addressed the legislators, and the Nation by radio, at 12:30 p.m. His opening reference to "a date which will live in infamy"[125] proved to be the longest remembered phrase, but the most important one then was "Hostilities exist." Roosevelt promised the Nation that "we will gain the inevitable triumph."[126] After the President departed, the House and Senate quickly reassembled separately. The Senate wasted no time on speeches. Senator Connally introduced a joint resolution. Senator Arthur H. Vandenberg, Republican of Michigan (R–MI), offered just a few words "lest there be any lingering misapprehension in any furtive mind that previous internal disagreements regarding the wisdom of our policies may encourage the despicable hope that we may weaken from within."[127] The Senators unanimously passed a declaration of war and sent it to the House, whose Members concurred with only one dissenting vote.

Churchill, now certain of ultimate victory, kept his promise to aid the United States and declared war on Japan. British Commonwealth nations, The Netherlands, and six countries in Central America and the West Indies also joined the struggle on December 8, as did Nationalist China on the 9th. In the evening, Roosevelt reported to the Nation that “So far, the news has been all bad.”[128] FDR, in Churchill’s style, predicted a hard and long war. He also forecast domestic deprivations, including “a clear and definite shortage of metals of many kinds for civilian use,” including “more than half of that portion of the principal metals which during the past year have gone into articles for civilian use.” Again echoing Churchill, Roosevelt vowed that the United States would accept only “victory, final and complete”[129] and also would “win the peace that follows.”[130]

The Japanese attacks outraged Americans and filled them with a resolve to defeat Japan at any cost, but it left unchanged the undeclared war in the Atlantic. These assaults cut the ground from under some U.S. appeasers and isolationists, but the advent of war there left others still opposed to the Nation’s active participation in the conflict in Europe and Africa as required by the Allied “Germany-first” strategy. The Tripartite Pact of 1940 obliged Germany to aid Japan against the United States, but Hitler, remembering the Japanese-Soviet nonaggression treaty and his own resolve to fight only one major enemy at a time, could have refused active participation. The Führer and von Ribbentrop again encouraged the Japanese to attack Singapore and other British and U.S. possessions in the Pacific, rather than moving north to aid the war against the Soviet Union that Hitler thought the Wehrmacht would win alone. A Germany allied with Japan, Hitler believed, could not be defeated and the Imperial Navy would make up for Germany’s naval deficiencies. On December 11, Germany, Italy, and Japan pledged not to seek a separate peace. The Führer trumpeted the new pact in the Reichstag and declared war on the United States. Mussolini’s Italy immediately joined the conflict with the United States. Congress quickly recognized that a state of war existed with both countries. A little more than 26 months after Poland fell to the Germans and the Soviets, the simultaneous courses on which the United States embarked merged into one; the 20th century’s second major conflict now engulfed the entire world.[131]

Chapter 3.
Washington Madhouse, 1941–1943

> **It is often amusing, and it is sometimes politically profitable, to picture the City of Washington as a madhouse, with the Congress and the Administration disrupted with confusion and indecision and general incompetence. However—what matters most in war is results. And the one pertinent fact is that after only a few years of preparation and only one year of warfare, we are able to engage, spiritually as well as physically, in the total waging of a total war. Washington may be a madhouse—but only in the sense that it is the Capital City of a Nation which is fighting mad.[1]**
>
> **—Franklin D. Roosevelt**

Americans have been prone to consider Washington, almost from the time the city became the Nation's Capital in 1800, as a place of confusion, indecision, and incompetence. The United States' entry into war in December 1941 did not miraculously alter that perception. In some circles, people viewed the two-ocean war as Washington's fault and, for a time, the Capital may well have appeared to be a perfect bedlam as the Government struggled with the manifold problems of global conflict. An equally strong tradition existed in which Americans united behind their Government in times of crisis. Soon after the Japanese attack on Pearl Harbor, the Nation was almost single-mindedly and wholeheartedly engaged in waging total war. On December 13, Congress and the President removed the geographic restriction on the use of U.S. armed forces. A week later, they amended the Selective Training and Service Act of 1940 to extend the ages of males required to register for service to 65 years and of those liable to be called for such service to 45 years.

To describe what went on in Washington during the war, consider Silvio A. Bedini's phrase "Thinkers and Tinkers,"[2] the title of his book about science and technology in early America. Bedini's thinkers were the scientific leaders. His tinkers applied the practical sciences, but not always scientifically, to solve existing problems. The tinkers, undeterred by failure, returned time and time again to the problems until they carried out their tasks. In World War II, the thinkers were the strategists who planned for prosecuting the conflict to victory and winning the peace. The tinkers included scientists, economists, and industrialists in government offices, factories, and laboratories at home and abroad, who persisted until they accomplished their missions. Those tacticians tried to cope with problems involved in rapidly locating raw materials needed for production, fabricating the materials of conflict, and devising new weapons and methods of war. The Japanese successes in the first 6 months of the war made this work even more imperative.

Japan's war plan called for adding to its Greater East Asia Co-Prosperity Sphere the oil and solid fuels, antimony, asphalt, bauxite, chromium, copper, diamonds, gold, iron, lead, manganese, molybdenum, phosphates, rubber, silver, sulfur, tin, tungsten, zinc, and other raw materials of the Southern Resources Area that included Borneo, Burma, Malaya, the Netherlands East Indies, New Guinea, and the Philippine Islands. To protect these and other new acquisitions, Japan's armed forces would establish a wide-ranging defensive perimeter in East Asia and the Pacific and secure it before America could recover from the strike on Pearl Harbor. Japanese strategists estimated that the United States could not mobilize its own forces and mount a meaningful offensive in the Pacific for up to 18 months. By then, sometime in mid-1943, they expected their cordon to be too strong to be breached and the Southern Resources Area to be exploited effectively enough to enable the military and related products of Japanese industry to equal America's. Surely then, the strategists concluded, the United States would sue for peace, as did China in 1895 and Russia in 1905.

As Admiral Yamamoto predicted, additional Japanese successes in the Pacific followed swiftly after the raid on Pearl Harbor. On December 10, 1941, Japanese aircraft operating from Saigon sank at sea the two British capital ships sent to Singapore by Churchill to deter further Japanese aggression. Their loss left the maritime defense of Malaya and the Netherlands East Indies to a handful of Allied cruisers and destroyers. Also on December 10, Japanese troops captured unfortified Guam and landed on Luzon in the Philippines. Imperial Navy forces overwhelmed the U.S. Marines' garrison on Wake on December 23. Two days later, Imperial Army units took Hong Kong from its British and Canadian defenders. Other Japanese forces secured New Britain's Rabaul, and its magnificent harbor. The Japanese occupied the open city of Manila, as General MacArthur and his American-Filipino army retreated to Luzon's Bataan Peninsula. MacArthur and his staff, ordered out by Roosevelt, left Corregidor for Australia on March 11, 1942, but the general promised to return. U.S. Army planners in Washington wrote off the Philippines and diverted reinforcements to Australia. Bataan fell on April 9, Corregidor surrendered on May 6, and formal resistance in the Philippines ceased on May 9.

To the south and west, Japanese forces began occupying the East Indies in January and defeated Allied naval attempts to intervene. The Japanese wrested Malaya and Singapore from their British-Commonwealth garrison by February 15 and completed their conquest of the East Indies on March 9. Burma's Yenangyaung oil fields fell on April 18. Japanese leaders planned that when full production resumed from these newly acquired sources and all shipments reached the home islands, Japan would be self-sufficient in petroleum. After the Japanese overran Mandalay on May 1, British and Commonwealth forces, and a small group of Chinese and Americans, retreated across the Indian frontier, while most of the Kuomintang (Nationalist) units of Generalissimo Chiang Kai-shek (Jiang Jieshi) continued northeast toward Kunming. After raiding Darwin, on Australia's northern coast, aircraft from seven Japanese carriers struck bases and sank more than 30 Allied warships and merchant vessels in the eastern Indian Ocean and the Bay of Bengal early in April. The Imperial Army refused to provide troops, and so the Japanese task force did not invade Ceylon (now Sri Lanka), India, or Madagascar and left for Japan on April 8.

The U.S. Navy planned raids to try to keep the Japanese off balance. U.S. naval aircraft struck islands in the Gilbert (Tungaru in Kiribati) and Marshall groups, Wake, Rabaul, and bases on the north coast of New Guinea in February and March 1942. Two U.S. fleet carriers, commanded by Vice Admiral William F. Halsey, Jr., and carrying 16 B–25 Mitchell medium bombers of the U.S. Army Air Forces (USAAF), sortied from Pearl Harbor to strike Japan. On April 18, Halsey's task force encountered and sank a Japanese far-sea patrol. Although well east of their planned launch point, the B–25s and their 5-man crews, led by Lieutenant (Lt.) Colonel James H. Doolittle, immediately took off for Japan. Doolittle's raiders dropped their 1-ton bomb loads on industrial and military targets in southern Honshu—principally in the Tokyo-Yokohama area, but single planes struck Nagoya, Osaka, and Kobe—before flying on to China and rescue or capture.

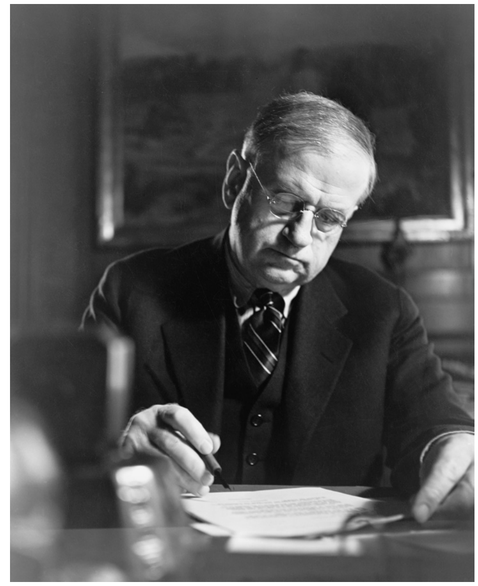
Doolittle's raid, although tactically only another pinprick, lifted American morale and proved far more effective strategically than the shells and aircraft bombs from Japanese submarines that earlier slightly damaged oil facilities and forests on the California and Oregon coasts.[3] The danger of additional direct assaults on Japan and the continuing easy victories elsewhere encouraged the Japanese to try to expand their barrier to include the western Aleutians, Midway Island, the Gilberts, Samoa, Fiji, the Solomons, all of New Guinea, and New Caledonia, whose chromite and nickel ores, and lesser deposits of cobalt, copper, gold, iron, lead, and silver General de Gaulle now controlled. The expansion was aimed at preventing future air attacks on the home islands, interdicting Allied supply lines to Australia and New Zealand, and luring the U.S. Pacific Fleet into the ever-sought decisive battle. Admiral Yamamoto's plan to achieve this victory, now approved, divided the Imperial Combined Fleet, including 8 of its 10 carriers, into 6 components to attack Midway, thought to be the Doolittle raiders' base, and, as a diversion, the Aleutians. The Combined Fleet planned to ambush the U.S. Pacific Fleet as it advanced from Hawaii to rescue Midway.

In the east, Axis forces renewed their assaults on Allied units in the Atlantic and Mediterranean and those on the African and Russian fronts. German submarines, while concentrating on U.S. oil tankers, bauxite freighters, and other new targets in the Western Atlantic, also continued to attack convoys sailing for Britain and northern Russia. U-boats destroyed these ships faster than replacements could be built. General Rommel and his Italo-German troops pushed the British and Commonwealth forces out of Libya and into Egypt. In May 1942, as British forces occupied Cyprus, the Wehrmacht resumed its offensive on the Eastern Front. As the Germans closed on Sevastopol late in June, Hitler ordered major forces shifted southeast to capture Rostov-on-Don and Stalingrad, interdict river transport on the Volga, and then push on to the Caucasus and the oil fields at Maikop and Grozny. Then they planned to continue toward the ultimate prizes, the Caspian oil fields around Baku and those of the Persian Gulf region, possible link-ups with Rommel and the Japanese, and perhaps an increased exchange of resources and technology between Germany and Japan. In July, Hitler ordered armored units transferred from the Caucasus forces to help those nearing Stalingrad.

By May 1942, the Axis Powers had significantly improved their mineral position, strengthened their capacity for war, and increased the Allies' raw-material problems.[4] As fiscal year 1941–42 ended, the U.S. Bureau of Mines (USBM) estimated that the Axis controlled 72 percent of the world's production of tin, 68 percent of its magnesium and mercury, 64 percent of its tungsten, and 54 percent of its aluminum. The USBM also predicted that the Germans, the Italians, the Japanese, and their allies might gain mastery over most of the globe's chromite and manganese ores. Axis control of the world's iron ore rose from 6 to 46 percent; steel capacity increased to 34 percent. Germany's earlier occupation of Czechoslovakia gave the Axis significant reserves of uranium ore, making it more or less independent of those in the Belgian Congo. The Axis Powers also nearly doubled their coal production (to 53 percent of the world's production), but, even with the new sources of petroleum captured by Japan, they only partly alleviated their most serious fuel shortage.

Allied responses included two significant meetings in Washington during the winter of 1941–42. At the Arcadia Conference that began on December 22, Roosevelt, Churchill, and their principal military advisers planned war strategy. On January 1, representatives of the United States, Britain, China, the Soviet Union, and 22 other countries signed the Declaration of the United Nations, based on the Atlantic Charter. The United States and Britain established a Combined Chiefs of Staff to plan and coordinate future operations, agreed that neither country would make a separate peace with the Axis, and declared that they would concentrate on defeating Axis forces in North Africa and Europe. The agreement reached at the secret talks, held in Washington during January 29–March 2, confirmed the "Germany-first" decision. Minimal Allied forces would contain Japan in the Pacific and Far East until military successes in Europe and North Africa, or increased Allied resources, or both, enabled stronger blows against the Empire. Joint boards were set up for munitions, raw materials (including a Combined Minerals Board), and food. They included representatives of the 6 Caribbean and Central American nations that declared war on the Axis after the Japanese attack on Pearl Harbor and the 19 other Latin American countries (but not Argentina and Chile) that broke diplomatic relations with Germany after the Inter-American Conference in Rio de Janeiro in January 1942 .

The U.S. Joint Chiefs of Staff (JCS), established by Roosevelt in February 1942, also aided the President to advance the U.S. war effort. Admiral William D. Leahy, who resigned as ambassador to Vichy France as part of the administration's protest of Vichy policies, chaired the new JCS. Leahy was joined by Army General George Marshall; Admiral Ernest King, Commander in Chief of the U.S. Fleet (COMINCH) and later also Chief of Naval Operations (CNO); and U.S. Army Air Forces' (USAAF) Lt. General Henry H. ("Hap") Arnold. Marshall, who continued to favor a Europe-first strategy, had earlier opposed basing the Pacific Fleet at Pearl Harbor. Roosevelt made the brilliant but irascible King, a former aviator and carrier commander, COMINCH on December 30, 1941. King selected Admiral Chester W. Nimitz, a submariner then Chief of the Bureau of Navigation, to lead the Pacific Fleet. From March 1942, Nimitz also headed the three-part Pacific Ocean Areas, a post equivalent to MacArthur's command of the Southwest Pacific Area. King and Nimitz favored defending an arc of U.S.-held islands from Midway to American Samoa and beginning limited offensives against the Japanese outer perimeter.



Harold LeClaire Ickes (1874–1952), the 32d Secretary of the Interior (1933–46), was educated at the University of Chicago and then practiced law in that city and reported for two of its newspapers. Also active in conservation and politics, he left the Republican Party in 1920 to support the Democrats' ticket of James Cox and Franklin Roosevelt. After backing FDR in the 1932 campaign, Ickes served the new President as Director of the Public Works Administration (1933–39) while he was Secretary of the Interior. Ickes, although a Roosevelt confidant, kept many of the New Dealers at a distance. During World War II, Ickes wore additional hats as head of the Petroleum Administration for War and the Solid Fuels Administration for War. After the war, Ickes strove for civilian management of the Trust Territory of the Pacific Islands. FDR repeatedly refused the self-styled curmudgeon's offers to resign to protest some of the President's policies or decisions. When Ickes tried the same tactic in opposing President Truman's nomination of Edwin Pauley as Under Secretary of the Navy in 1946, Truman quickly accepted Ickes' resignation. (Photograph from the Library of Congress, Prints and Photographs Division, 3c37622.)

Winning the global conflict meant seeing production as the keystone of America's war effort. Roosevelt, in his State of the Union Address to Congress on January 6, 1942, called for greatly increased production of weapons and shipping, "far above present levels, even though it will mean the dislocation of the lives and occupations of millions of our own people." The President noted in his address that

> **[p]roduction for war is based on metals and raw materials—steel, copper, rubber, aluminum, zinc, tin. Greater and greater quantities of them will have to be diverted to war purposes. Civilian use of them will have to be cut further and still further—and, in many cases, completely eliminated.[5]**

In the Interior Department, the USBM and the USGS were involved in searches for strategic and critical minerals as part of the Nation's preparedness program. Meeting production goals required increased efforts to supply the necessary raw materials and energy. Secretary Harold Ickes placed all his bureaus and their employees "on a war-emergency basis"[6] and then ordered a workweek of 44 hours for Interior employees. Ickes established a War Resources Council on January 14, 1942,[7] and appointed to lead it Michael Straus, Ebert Burlew's successor as First Assistant Secretary. Ickes approved a war program to mobilize "the strategic natural resources of this Nation on the scale made necessary by global warfare" and supply the essential raw materials and power to industry "to attain the national war production goals set by the President." The War Resources Council gave priority to "metals for war" and noted that "years of exploration and experiment" prepared the USBM and the USGS "to move the country forward toward production on a victory scale by turning known but unused, low-grade materials into metals." The war program included carrying on "explorations for copper, lead, zinc, iron, chromite, aluminous clays, vanadium, tungsten, and mercury to the point of action,"[8] which involved the USGS but placed greater emphasis on the USBM's metallurgical investigations. Two Executive orders[9] enabled the Civil Service Commission to aid these efforts by making Federal appointments for the war's duration, and a maximum of 6 months thereafter, and approving war-service transfers between and within the departments and their agencies.

The Interior Department remained the major producer of power in areas where the principal undeveloped resources were located. The Boulder (Hoover), Bonneville, and Grand Coulee Dams, completed during 1936–42, produced power annually at the rate of more than 7 billion kilowatt hours of electrical energy. Interior's program on power for war called for constructing new hydroelectric and steam plants to triple 1941's output by 1945. Neither the President, in his State of the Union Address, nor the War Resources Council showed concern about energy sources such as coal and petroleum because, when war began in Europe, shortages of these commodities in the United States seemed unlikely. Secretary Ickes acquired responsibility for petroleum and solid-fuels production before the attack on Pearl Harbor.[10] As Petroleum Coordinator for National Defense, Ickes synchronized Federal activities concerned with the production, refining, transportation, and marketing of petroleum and worked closely with industry in this endeavor. As Solid Fuels Coordinator for National Defense, he stressed orderly production, distribution, marketing, and consumption of coals and cokes to ensure adequate supplies at reasonable prices for military, industrial, and civilian needs. Interior's war program also provided for greater production of helium for use in blimps and weather balloons, increased water supplies for irrigation and military use, a food-drying program to save metals, aid to road building in Alaska, mapping areas of military significance, and clearing withdrawn public lands of mineral and other claims to enable the location and construction of military facilities.

Accomplishing the President's production goals remained a task less organized and more difficult. The first War Powers Act gave Roosevelt authority to redistribute "functions among executive agencies"[11] to enhance defense, prosecute the war successfully, increase support for the armed forces, effectively utilize resources and industries, and operate more efficiently as Commander in Chief. The Truman committee's report, sent to the Senate on January 15, 1942, criticized the Office of Production Management (OPM) as ineffective, making changes imperative. On January 16 and 24, Roosevelt's Executive orders established and amended the responsibilities of the War Production Board (WPB),[12] within the Office for Emergency Management (OEM). The WPB replaced two abolished agencies—the OPM and the Supply Priorities and Allocations Board (SPAB). The President picked Donald Nelson to chair the WPB, with Charles Leith as one of his advisers, but otherwise its seven members represented simply a reshuffling of the persons who comprised the OPM and the SPAB. Additional Executive orders through April 13 defined the WPB's duties to "obtain from foreign sources such materials, supplies, or commodities (other than arms, munitions, or weapons of war) as are necessary for the successful prosecution of the war, and provide for the production, delivery, sale, or other disposition thereof."[13] Roosevelt also gave Nelson the authority, under the National Defense Act of 1916, to place domestic orders, establish priorities for them, and take possession of plants that refused cooperation.

Those changes did not provide the desired result. Embarrassing shortages existed at home; by the summer of 1942, the most critical shortage remained the paucity of rubber. Neither adequate stockpiles nor a synthetic-rubber program existed because Donald Nelson failed to counter the view of Vice President and WPB member Henry Wallace that Latin America could supply all of the needed rubber. A lack of synchronization in producing parts also hampered the production of weapons of war. Even shortages of petroleum developed only a few months after America's entry into the conflict. Nelson also found himself clashing over war-production controls with Brehon Somervell, a Major General since January 1, who became head of the Army's Services of Supply on March 9. Robert Patterson, Under Secretary of War since December 1940 and responsible principally for procurement and production, represented Secretary Henry Stimson and the War Department on the WPB.

Henry Wallace remained as chairman when the Economic Defense Board (EDB) became the Board of Economic Warfare (BEW),[14] and the British ministry's twin, on December 17, 1941, adding yet another acronym to what was called Roosevelt's alphabet soup of agencies. In April 1942, the BEW received responsibility for obtaining the materials and commodities, other than arms, munitions, or weapons of war, needed to be imported either for the war-production effort or for the civilian economy. At the same time, Wallace's BEW also was tasked with carrying out certain duties under the Lend-Lease Act. These new responsibilities imposed difficulties. To procure the needed foreign materials, the BEW received authority to direct the creation, organization, and financing of a corporation or corporations to obtain materials and commodities from foreign sources but no funds of its own for this purpose. The BEW relied for monetary support on the Reconstruction Finance Corporation, headed by Secretary of Commerce Jesse H. Jones, whose fundamental economic philosophy opposed Wallace's views.[15] Jones led the RFC, which funded BEW projects, for some 7 years before succeeding Harry Hopkins as Commerce Secretary in 1940. To complicate matters even further, Jones also administered the Federal Loan Agency and served on the SPAB and the EDB. Duties assigned to the renamed BEW under the Lend-Lease Act also could have incited a conflict with the Department of State.

By June, Wallace's BEW organized a Metals and Minerals Division responsible for the procurement, development, and production of minerals required from countries abroad for war use. Alan M. Bateman, on leave from his position as Silliman Professor of Economic Geology at Yale, led the new Division. Bateman selected as his Associate Chief William E. Wrather, a successful independent petroleum geologist in Texas and, like his friend Everette DeGolyer, a history buff and ardent bibliophile. Bateman's Division, advised by William Heroy (Sr.) and others, initially was composed of six sections, those led by James S. Baker, Herman L. Dauth, Hugh E. McKinstry, Robert H. Ridgway, Paul M. Tyler, and William Warfield. On April 14, the BEW received the WPB's stocks of strategic and critical minerals. The BEW's responsibilities did not include coal or petroleum, still considered in adequate supply in the United States; those resources remained under Ickes' control as Congress considered the USGS budget for the coming fiscal year.

The Roosevelt administration prepared its budget for fiscal year 1942–43 before the Pearl Harbor attack and only hastily and partly revised it before the President sent his annual message to Congress in January 1942. The budget anticipated expenditures of $56 billion during fiscal 1942–43, more than the Nation's estimated annual income, and called for increasing the national debt. The accompanying budget provided for only $13.6 billion; the rest would follow in supplemental requests. For the USGS, Interior originally asked for nearly $7,644,000, an increase of 55 percent above the appropriation approved in June 1941. The Bureau of the Budget trimmed this amount to about $3,753,000, 24 percent less than the sum appropriated in June 1941, and eliminated all funds for strategic mapping because the War Department's allocation of $1.75 million for that purpose would remain available until June 30, 1943.

The initial supplemental request did not reach Congress until March 23, 1942, after the House Committee on Appropriations finished its work on Interior's funding bill. The Senate Committee on Appropriations considered the first supplemental request but received others before it filed its report. The committee recommended, and the Senate passed without debate, significant increases in funding for geologic surveys, studies of strategic and critical minerals, and work on Alaska's mineral resources. The conference committee reduced the total provided by only $36,000. Not until July 2, a day after the new fiscal year began, did Roosevelt sign the bill that provided the USGS with direct funds of some $4,691,000 for its work during fiscal year 1942–43.[16] The new law also gave $498,500 to the USBM, of which $80,000 would be transferred to the USGS.[17] Deficiency and supplemental legislation enacted in 1943 raised the USBM-derived monies to $115,000 and gave the USGS a credit of $400,000, pending reimbursement from cooperating agencies. Funds received from other sources raised the total funds available to the USGS in fiscal 1942–43 to more than $11 million, larger than any single-year sum previously received. For the first time in many years, the Geologic Branch received the greatest share of the new monies and almost doubled those provided in fiscal 1941–42. Major changes in the USGS began as soon as it received those funds. Fiscal 1941–42 was nearly half over when the United States entered the war, and the field season of 1941 was long past. The appropriation of $150,000 for strategic-minerals investigations and the War Department's transfer of funds for strategic mapping made a difference in parts of the Geologic, Alaskan, and Topographic Branches, but otherwise the field season resembled that of 1940.

During fiscal year 1942–43, the Geologic Branch received nearly $1,916,000 from all sources and underwent significant changes in organization, staffing, and operations. Although its personnel maintained their interests in fundamental research through close cooperation with some of the States, professional societies, and the National Research Council, especially on studies that might prove useful to the war program, they were fully committed to supporting the effort to win the conflict. Additional funds enabled the Branch to increase its professional staff from some 150 to more than 280 persons by hiring mostly from academia and industry. Chief Geologist Gerald Loughlin gained the aid, from February 1942, of new Assistant Chief Geologist Stephen Capps, a long-term veteran of work in Alaska and on manganese and other mineral deposits in the Western States and in Brazil. To facilitate cooperation with the USBM, the Geologic Branch established regional offices in College Park, Maryland; Rolla, Missouri; Salt Lake City, Utah; and Spokane, Washington. The Branch's Section of Geophysics, which came to the USGS in 1936, returned to the USBM on October 5, 1942. Secretary Ickes believed the Section's services in the USBM would "locate critical minerals more quickly," "prevent useless drillings," and "speed its exploratory work." USGS funds were "inadequate to do such geophysical work as the Bureau of Mines considers necessary,"[18] and the combined efforts also would increase economy and efficiency. Ickes expected USBM reports to meet USGS needs for geophysical work.

To prepare "terrain intelligence studies" of strategic areas for the Army Engineers, under "wartime priorities,"[19] the Geologic Branch founded an informal and then a formal Military Geology Unit (MGU) in 1942. German and Soviet forces entered their war with large numbers of specialists in terrain intelligence already on their rolls, some of whom served in World War I. In 1937, Ernst Kraus began organizing what became 2 years later the 10th Group, Technical Military Geology, of the German Army Ordnance's Engineer and Fortress Department. Organized by function into six subdivisions and two working subgroups, members of Group 10 used books on military geology by Erich Wasmund (1937) and by Kurd von Bülow, Walter Kranz, and Erich Sonne (1938) as references in training new personnel. They also tested equipment, conducted experiments, deployed field-force teams to the various combat fronts to gather data on the ground, and compiled geologic-tectonic, water-supply, and construction-materials reports and maps at scales from 1:25,000 to 1:100,000. After Kraus retired in December 1941, Bülow took command of the central unit in Berlin.[20] Group 4 of the German Army General Staff's Department of War Maps and Surveys included additional military geologists. Other geologists served in the Kriegsmarine, the Luftwaffe, the Waffen-SS, and the paramilitary construction organization run by Fritz Todt and (later) Albert Speer as ministers of armaments and munitions.

During the interwar years, the USGS failed to build significantly on its own legacy of military geology from World War I. Alfred H. Brooks took leave as head of the Division of Alaskan Mineral Resources to lead a requested effort in military geology for General Pershing's American Expeditionary Force (AEF) in France. In 1917, Major (later Lt. Colonel) Brooks and Captain (later Major) Edwin C. Eckel, who left the USGS in 1906 to become a private consultant,[21] were commissioned in the Engineer Officers Reserve Corps. In September 1917, they established a Section of Geology attached to Pershing's headquarters. Brooks, as the AEF's Chief Geologist, operated within the AEF's Division of Front Line Engineering, then was in the AEF's Division of Engineering Intelligence, and finally reported to the Assistant to the AEF's Chief Engineer. Brooks' unit supplied information and advice about the soils and rocks encountered by the AEF in mining operations and in building and maintaining trench systems and other fortifications, constructing roads and railroads, and seeking supplies of potable water.

In July 1918, the AEF approved Brooks' plan to have six geologist-officers with him at Pershing's headquarters, place five more with each U.S. army, and assign two others for work along the lines of communication. The war ended in November before Brooks could fill all of these slots. At the Armistice, Brooks led a unit that included Eckel and USGS geologist Kirk Bryan, a Yale-trained scientist commissioned as 2d Lieutenant after being relieved from his assignment as a Private of Army Engineers and draftsman in France. Four men served with Brooks at AEF Headquarters, two with the 1st Army, one with the 2d Army, and one with the Water Supply Section.[22] Brooks returned to the United States in August 1919 and promptly published his analysis of how the AEF used geology, but he died in 1924 before recording the details of how he established his geology unit. He recommended that geology be included in military training, suggested peacetime collection of geologic information about potential theaters of war, and proposed organizing a "staff of geologic engineer reserve officers."[23] Thomas Nolan was among the few USGS geologists who held reserve commissions in the Army Engineers between the wars, but his lieutenancy lapsed in 1937 after a 5-year interval of no service.

After the Japanese attacked Pearl Harbor, several USGS geologists quickly sought to revive the agency's earlier efforts in military geology, using existing and new contacts. They and other members of the Geological Society of America convened in Boston, on December 29, 1941, for the GSAm's 54th annual meeting, determined to contribute to the war effort as they had done for aspects of prewar national defense. Existing GSAm pamphlets included Leith's on strategic minerals, Douglas W. Johnson's on geology and strategy in the present war, and Walter H. Bucher's bibliography of military geology and geography.[24] GSAm pamphlets underway involved Sidney Paige's view of engineering geology in war, Johnson's discussion of geology's role in World War I, and William O. Hotchkiss' description of the Army Specialist Corps.[25] Hotchkiss, as a Brigadier General, served as the Army Specialist Corps' Deputy Director during June–December 1942. The GSAm continued contributing to the National Roster of Scientific and Specialized Personnel and asked the Selective Service System to list geology as a critical occupation.

Director Walter Mendenhall led the USGS delegation of full- and part-time employees to the GSAm's meeting in Boston. These participants included Chief Geologist Loughlin, Kirk Bryan and Esper Larsen, Jr. (Harvard), Julia A. Gardner, Chester Longwell (Yale), Thomas Nolan, Clarence S. Ross, William W. Rubey, and Parker Trask. Also attending were the BEW's Alan Bateman and Hugh McKinstry, the Petroleum Administration for Defense's (PAD's) Everette DeGolyer and William Heroy, and Sidney Paige, the principal geologist of the Army Engineers' North Atlantic District since 1935, who previously had worked for the USGS and an energy company (Amerada, later Hess). Longwell was elected one of the GSAm's four vice presidents for 1942. The GSAm's nine-member Council included Bryan, DeGolyer, Hotchkiss, and Rubey. Rubey and DeGolyer also served, respectively, on the GSAm's Committee on Research Program and its Subcommittee on

William Walden Rubey (1898–1974) joined the USGS in 1920 and briefly worked on the geology of oil and gas occurrences before shifting to studies in general geology. Rubey, on a 6-month detail from the strategic-mineral program during part of 1941–42, arranged the USGS effort in military geology, funded by the Army Corps of Engineers. In postwar years, Rubey advised USGS and other administrators while also investigating topics in basic and applied science that included stream hydraulics and sedimentation, the geology of seawater, and (with King Hubbert) overthrust-fault mechanics. (Photograph from Gilluly, 1977.)

Geophysics; the subcommittee also included M. King Hubbert, who left Columbia in 1940, the same year that he published his theory of groundwater motion and its influence on hydrocarbon accumulation. Trask and USGS geologist Harry S. Ladd were members of the GSAm's Subcommittee on Ocean Bottoms.

Reginald A. Daly, Sturgis-Hooper Professor of Geology at Harvard and Penrose Medalist in 1935, welcomed attendees as being "in the front line of National Defense." "In this total war, as in the total peace that must come after it," he emphasized, "geology, the science of raw materials, is at the very root of the matter."

> **The world is hungry for iron, aluminum, copper, chromium, magnesium, beryllium, tungsten, salt, sulphur, potash, phosphate, and petroleum, and therefore hungry for your techniques in finding these things. They are needed both for winning the war and for winning the peace that can only be assured by filling the world's belly.[26]**

On December 30, 1941, the GSAm's Council appointed a Committee on War Effort, comprising Chairman Hotchkiss, former USGS geologist Kenneth C. Heald, Longwell, and Rubey. The new Committee promptly prepared a resolution, adopted unanimously on the following day, requesting the GSAm to "pledge its best efforts, collectively and individually, to meet all calls that may be made upon it and its members for whatever services geology and geologists can provide," especially in research and beyond those activities already underway, and to emphasize studies that "will most effectively contribute to victory."[27] The Committee also asked the Council "to present the resolution to the proper authorities and to offer all possible aid of the Society and its membership to our Government."[28]

Loughlin wished to limit USGS war-related work to the ongoing investigations of strategic minerals, but Mendenhall disagreed and authorized wider participation. Nolan could not be spared from his supervisory work for Hewett's program. On January 2, 1942, Mendenhall and Loughlin relieved Rubey of his own strategic-mineral responsibilities for 6 months so that he could promote a greater use of geology and geologists during the war. Rubey promptly contacted many Army and Navy organizations, 10 of which showed "some degree of serious interest with regard to the services geologists can offer."[29] Members of the Army's General Staff and the staff of Secretary of War Henry Stimson referred Rubey to the Army Engineers.

On January 6, Rubey talked with Colonel William F. Tompkins, who met Brooks in France, served as an Executive Assistant to General Schley in 1940–41, and now worked at the Army War College. After reading Rubey's brief outline of the potential uses of military geology, Tompkins recommended distributing a more formal version to gain approval for two principal geologic activities: "(1) to accompany units such as his own after they had been assigned to specific theaters of operation and (2) to participate at Engineer headquarters in Washington in the compilation and analysis of data for strategic planning."[30] Responding to Tompkins' suggestions, Loughlin appointed USGS geologists Wilmot H. ("Bill") Bradley, Edwin B. Eckel, Charles Hunt, Rubey, and Trask as a special committee to revise Rubey's outline. On January 8, the USGS distributed its special committee's revision to officers in the armed forces and managers in civilian agencies. After additional review by the GSAm's Committee on War Effort, the utilization outline appeared in February; its print run exceeded 10,000 copies by year's end.[31]

On January 12, 1942, Rubey visited Major General Eugene Reybold, General Schley's successor as Chief of Army Engineers since October 1941, to discuss the USGS outline. General Reybold "readily agreed" to approve "any requests for field geologists that came to him from the Chief Engineers of task or expeditionary forces * * * but he emphasized that such requests could not originate in that office." Reybold, briefed by Hotchkiss 2 days earlier, expressed special interest in using "geologists for engineering intelligence and staff planning in the Washington office."[32]

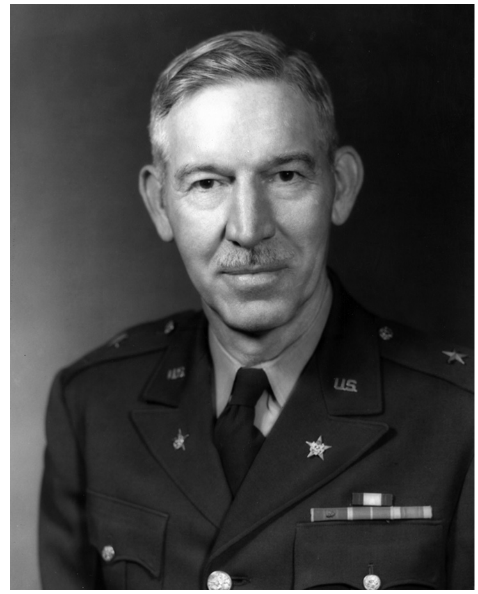
Schley introduced Rubey to Lt. Colonel (later Colonel) Herbert B. Loper, a photogrammetrist and Chief of the Intelligence Division in Reybold's office since July 1940, and asked them to plan to gain this aid.

General Reybold's subsequent letter to Hotchkiss, and Rubey's conference with Lt. Colonel Loper on January 14, revealed the Army Engineers' wishes. They wanted to add the USGS to their strategic-intelligence assets directly and not through the GSAm. The Engineers did not want a uniformed unit like Brooks' Section of Geology in World War I, nor could they find space for any additional geologists in their already crowded offices. Rubey, emphasizing the nationwide scope of the GSAm's resolution, suggested that the best qualified geologists be gathered in Washington as a temporary team of consultants and housed near the USGS Library, where they would have to work. Loper doubted that they could be assembled quickly given the demands of secrecy and time. Engineering intelligence, he thought, could be produced best by "a permanent corps of specially qualified experts who were cleared to work on secret projects under the aegis of some regularly constituted civilian Government agency such as the U.S. Geological Survey." Rubey then agreed to work out "whatever arrangement would best meet the demands of the War Department," and Loper promised to provide "the types of information that geologists would be expected to supply" and a "concrete plan by which this information could be supplied to the Corps of Engineers."[33]

Lt. Colonel Loper asked Major Paul W. Thompson, Chief of the Strategic Intelligence Branch in Loper's Division, to review Rubey's preliminary proposal. While Major Thompson evaluated Rubey's concept, the GSAm Committee on War Effort encouraged Ernst Cloos, a geologist at Johns Hopkins University (JHU), to volunteer to prepare summaries and reviews of recent German publications on military geology. Rubey edited the 20-plus drafts by Cloos and sent them to the Army Engineers, to other Federal agencies, and to the GSAm for distribution to some of its members. Cloos' comments helped to convince Major Thompson that improved engineering intelligence required active participation by geologists. General Reybold's office staff began translating the volumes by Wasmund and by Bülow, Kranz, and Sonne. Thompson, accompanied by two of the Army Engineers' assistants, geologist Mark P. Connaughton and civil engineer John R. Vogler, visited the USGS to work out an agreement between the two agencies.

On February 20, 1942, Thompson, now a Lt. Colonel, asked Director Mendenhall to select USGS geologists to prepare within 1 week a report on the "building materials, soil, water, and fuel supplies of certain parts in northwest Africa,"[34] similar to those the agency completed about strategic minerals earlier that month on equally short notice from the BEW and the Army. At 2 p.m. on February 11, as Paul Averitt and Lincoln Page later recalled, some "big wheel" in the Army asked the USGS to complete by 5 p.m. the next day a report on all of Africa's mineral resources. Told to pick one country, the Army official chose Sierra Leone, because it was a British colony with its own Geological Department quartered near Freetown's growing air and naval bases, and so the report could be checked more easily than one about Vichy Algeria, Morocco, or Senegal.

As Rubey later related, Edwin B. Eckel took command of the operation. Mendenhall was not expected back from the meeting in New York of the American Institute of Mining and Metallurgical Engineers (AIMME) until some 2 hours before the deadline. Eckel asked Ward Smith to get all the reports mentioning Sierra Leone from the Library. Paul Averitt, Bill Bradley, James McAllister, and Lincoln Page gathered in Eckel's and Edwin Goddard's offices and worked from 4 p.m. to 2 a.m. on the 11th and then returned from 8 a.m. to 3 p.m. the next day. Eckel scanned the sources Smith brought and passed them to the person responsible for the specific mineral-commodity group. Each geologist reduced that information to one paragraph, written informally, and gave it to Page, who placed the paragraphs in an outline and drew the preliminary maps. Bradley provided data on surficial and



Herbert Bernard Loper (1896–1989), a photogrammetrist educated at West Point and the Massachusetts Institute of Technology, served in the U.S. Army from 2d Lieutenant (1918) to Major General (1952). In 1942, Lt. Colonel (later Colonel) Loper, then Chief of the Intelligence Division in the Office of the Chief of Engineers, helped the USGS to establish a Military Geology Unit (MGU) and also signed the Loper-Hotine Agreement that divided responsibilities for global mapping between the United States and the United Kingdom. During 1944–45, Brigadier General Loper supervised MGU field teams while serving as Chief Engineer of Army Forces in the Pacific Ocean Areas, then as Chief of Engineer Intelligence in the Southwest Pacific Area, and lastly as Deputy Engineer, Far East Command in Japan. During the war, Loper earned a Legion of Merit and a Distinguished Service Medal. In postwar years (until 1948), he served again as Chief of the Intelligence Division, Office of the Chief of Engineers in Washington, D.C. Loper then filled two staff positions relating to intelligence and atomic energy (1948–51) and led the Armed Forces Special Weapons Project (1951–55) and chaired the Military Liaison Commission to the U.S. Atomic Energy Commission. After retiring in 1955, he joined the group of scientists and engineers who advised USGS Directors Wrather and Nolan. (U.S. Army photograph, December 15, 1950; from the U.S. Army Corps of Engineers, Office of History.)

sedimentary materials, and A. Nelson Sayre contributed information on hydrology. After a typist from one of the mineral deposits sections completed the text, Eckel and Page read it through for the first time in the Director's outer office. All of these specialists drew on their training in report writing from Henry Ferguson and Frank Calkins, and so their report read as though one person wrote it. At 4 p.m. on the 12th, Mendenhall approved unread the 18-page report and its sketch map. Eckel took a cab to deliver the report by 5 p.m. to the Army's waiting plane. Thereafter, Mendenhall spent 2 hours with Eckel's team. The Director thanked the participants for their initiative in recognizing the need for the USGS to do this work for the war effort, discussed their current research, and told tales about his early fieldwork.

The Sierra Leone report proved to be one of many strategic-intelligence studies and related medium- and small-scale reports about other countries worldwide completed for the Army Engineers by a small group of USGS scientists and supporting staff led by Bradley, whose new team included Henry Ferguson and Hunt. Early in March, Lt. Colonel Thompson returned to the USGS with additional requests for: "(1) reports on the physical features and mineral resources (including groundwater) of a half-dozen or so countries in northwestern Africa and (2) a roster of American geologists who were especially well qualified in engineering geology, construction materials, and/or physiography."[35] The Army Engineers planned to commission at least 20 of these men and assign them to field duty, where each geologist-officer would work in a triplet including an Engineer officer and a forestry specialist "under circumstances of great responsibility and danger."[36] On March 28, Mendenhall appointed Bradley, Longwell, Rubey, hydrologist David Thompson, and stratigraphic-paleontologist Wendell Woodring as a special committee to prepare the roster. Although these men completed and later revised the list, the Army Engineers made no formal use of it and dropped the idea of forming the triplet field teams.

Rubey, and then Edwin B. Eckel, led the informal groups of USGS geologists, spared part-time from other urgent war work, in preparing for the Army Engineers the reports they requested about countries in northwestern Africa. By mid-March 1942, additional queries from General Reybold's office increased significantly the total number of reports prepared or underway. Rubey and his colleagues realized that if the Army Engineers did not establish a nationwide corps of geological specialists, the USGS would have to form a unit of full-time geologists to handle the growing demand for engineering intelligence. Loughlin, although still reluctant to transfer members of the Geologic Branch from the ever-increasing work on strategic and critical minerals, agreed late in March to release Bradley from his principal duties to lead the agency's new effort in engineering intelligence.

As Bradley began to select USGS colleagues for these studies, Hunt saw Cloos' review of Erich Sonne's 1936 article on military geological maps. Sonne's six plates included geologic, groundwater and mining, water-supply, and building-materials maps of an unidentified (and hypothetical?) 1:25,000 quadrangle located mostly north of a Glons River. Color-symbol charts provided detailed applied information about each of these four maps. Sonne's text and plates, with a standard stratigraphic section, reappeared in 1938 in the volume by Bülow, Kranz, and Sonne. Using Sonne's method of presentation, Hunt and his USGS colleagues prepared a series of demonstration terrain-intelligence maps of quadrangles in Arizona and Morocco, where Hunt once lived with his parents.[37] Lt. Colonel Thompson looked at their maps, gave them his "enthusiastic approval," authorized a translation of Sonne's text and captions, and asked the USGS to "cast its future reports, so far as possible, into maps following the patterns suggested by Sonne and Hunt." From these original formats and subsequent modifications, the USGS developed the "map-and-tabular-summary type"[38] that the agency used in presenting its military geology reports.

The Geologic Branch then founded an informal unit to supply the Army Engineers with terrain-intelligence studies at scales smaller than 1:100,000. Bradley and Hunt led the way in organizing the Military Geology Unit and proving its worth after Rubey returned to his strategic-minerals investigations. The MGU initially comprised a dozen persons, including geologists Carle Dane, Henry Ferguson, Marcus I. Goldman, and Kenneth E. Lohman, and hydrologist Nelson Sayre. The unit rapidly completed for the Army Engineers a number of intelligence reports, including two on Vichy French Madagascar. The initial report, with maps at several scales, covered that island's construction materials, geology, landslides, minerals, soils, terrain, vegetation, and water supplies. The second report, the first of the MGU's terrain-intelligence folios, also evaluated cross-country movement in and other aspects of the Diégo Suarez area (at 1:200,000) and its air-naval base at Antsirane (Antsiranana) on Madagascar's northern tip. The MGU finished its Madagascar studies just after May 5, 1942. On that day, British forces (in Operation Ironclad) invaded and occupied Diégo Suarez. Subsequent attacks on British ships in the port or at sea by Japanese midget and fleet submarines and auxiliary cruisers convinced the British and South Africans on August 11 to capture the whole island to help clear the vital sea lanes to the Middle and Far East.[39] After July 1, the MGU completed a comprehensive terrain-intelligence folio about Madagascar, Strategic Engineering Study (SES) 40, at 1:3,000,000, which the British reviewed and lauded. The remaining Vichy French forces on Madagascar surrendered on November 5; the island and its high-grade graphite, bauxite, coal, and chromite deposits passed to the Free French on January 8, 1943.

Those reports convinced the Army Engineers that library-based studies could supply useful analyses of terrain, engineering concerns, geology, minerals, and soils. Lt. Colonel Loper requested evaluations of an additional 75 areas, including Denmark, Java, New Caledonia, Guadalcanal and other islands in the Solomons, the New Hebrides (Vanuatu), and the Bismarck Archipelago (especially New Britain). On May 9, 1942, Loper formally asked for a report on terrain, construction materials, and water supply for the West and Northwest African ports of Bathurst (Banjul, Gambia) and Dakar in Senegal, Port-Étienne (Nouâdhibou) in Mauritania, and Agadir in Morocco. The USGS informal military geology unit delivered its summary on June 1. Other reports followed after July 1 for the whole of Morocco (and its Agadir, Chichaoua, Mogador, and Oued Tensift quadrangles), Algeria, Tunisia, and Libya. The Army Engineers sent copies to the headquarters that began planning in August for Operation Torch, the Allied invasion of Morocco and Algeria, led by Lt. General Dwight D. ("Ike") Eisenhower. These analyses were checked against aerial photographs available in September. After Torch's success in November, the U.S. Army forces' chief engineer and General Reybold commended the USGS reports. In May, Loper also signed the Loper-Hotine Agreement, an Anglo-American understanding "to divide mapping responsibility throughout the world. The British [Military Surveys, directed since 1941 by photogrammetrist and Brigadier Martin Hotine, Royal Engineers] agreed to take care of most of Western Europe and the Middle East [and Africa], leaving North and South America, the Far East, and the Pacific to the Americans."[40]

The USGS Military Geology Unit (MGU) began official operations as a formal unit on June 24, 1942, with Bradley as Chief and Hunt as Assistant Chief, and its members began applying their expertise without any additional training. Like the Beach Erosion Board's Foreign Section, the Board of Engineers for Rivers and Harbors' Foreign Ports Section, and the Engineer Research Office of the Army Engineer's North Atlantic Division in New York City, the MGU provided information and analyses to the Army Engineers' Strategic Intelligence Branch, the Joint Army-Navy Intelligence Staff, and the theater commanders. Connaughton, who led terrain studies in Lt. Colonel Thompson's Branch, provided liaison with the MGU.

Wilmot Hyde ("Bill") Bradley (1899–1979) began full-time work with the USGS in 1922 and concentrated on the varved strata, fossils, and paleoenvironments of the Green River Formation (Eocene) in Colorado, Utah, and Wyoming. In 1942, Bradley formed the USGS Military Geology Unit and directed its strategic and tactical engineering studies until he became Chief Geologist in 1944. Bradley, in reorganizing the Geologic Branch (later Division), appointed a new generation of Division (later Branch) Chiefs. Bradley returned in 1959 to full-time research on past and present algal-ooze lakes and their cyclical sediments as freshwater equivalents of the Green River playa-lake strata. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Last Name A–B" folder; published in *The American Journal of Science* Bradley Volume, 1960, portrait facing p. 1, and in Nelson, C.M., and Rose, E.P.F., 2012, fig. 2.)

In September, Mendenhall and the Acting Chief of Engineers signed a cooperative agreement, approved early in October by Interior's Assistant Secretary Oscar Chapman and by Secretary Stimson's representative for the War Department. The agreement, effective October 26,[41] authorized transferring up to $30,000 in Army Engineer funds during fiscal year 1942–43 (and additional monies as required in fiscal 1943–44) to add to USGS funds available to prepare the strategic-intelligence reports of areas specified by the Engineers. The MGU's staff of scientists, engineers, and supporting personnel grew larger and more diverse. Each scientific specialist was required to read effectively at least two foreign languages so the unit could expand coverage of scientific literature that came to include Chinese, Japanese, and Russian sources. Ferguson served as the MGU's "elder statesman and counselor."[42] He also compiled notes on aspects of airfield sites in northern Canada, the Canadian Archipelago, and eastern Greenland. Marie L. Siegrist coordinated work by the unit's librarian-bibliographers, and Kenneth Lohman managed its illustrations group.

For the Army Engineers during 1942, the MGU completed more than 30 unnumbered SES reports on Africa and its countries, colonies, protectorates, and offshore islands (Bonham and Leith, 1997). The unit's more than 20 numbered SES reports included terrain analyses for Alaska, Algeria, Angola, the Aralo-Caspian region, Belgium, the Caucasus, the mineral-rich Belgian Congo, Denmark, Egypt and Sinai, French West Africa, Iran, Iraq, Kamchatka, the Kuril Islands, the Levant countries (Lebanon and Syria), Morocco, Palestine and Transjordan, Italy's Pantelleria Island (in the channel between Sicily and Africa), Río de Oro (southern Spanish Sahara, now in Morocco's Western Sahara), Sardinia, eastern Siberia, and Tunisia. The MGU also prepared miscellaneous papers on coal and coke requirements for producing nickel in Vichy French New Caledonia, causing eruptions by bombing Japanese volcanoes, Sicily (by Marcus Goldman), bauxite reserves in British Guiana (Guyana) and Dutch Guiana (Suriname), and the geology of Vieques, the island east of Puerto Rico used for gunnery training by the Navy (by Eugene Callaghan).[43]

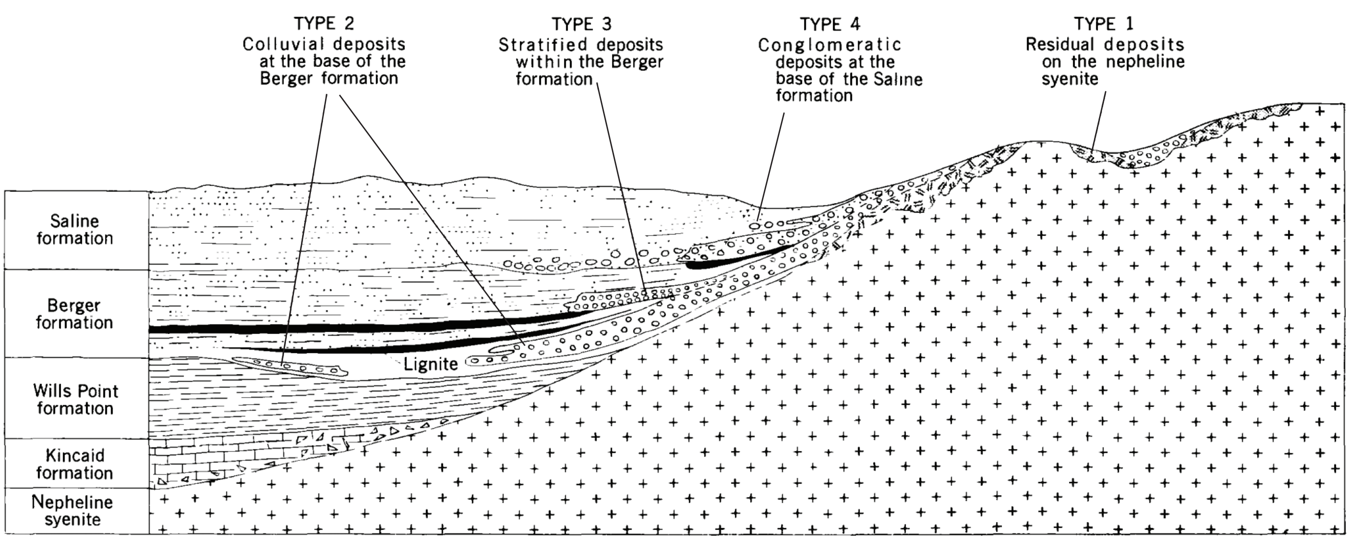
The Geologic Branch's field program in 1942 largely involved the continuing search for minerals needed for war production. Direct appropriations and other funds received for fiscal year 1942–43 raised the sum available for geologic surveys to about $1,175,000, nearly twice the amount the Branch received the previous year. Monies for studies of strategic and critical minerals rose to $741,000, 2.5 times the past year's amount. Chief Geologist Loughlin refined the structure of the war-minerals program on August 29, 1942. He appointed four Regional Geologists—Hugh Miser, later Josiah Bridge, at College Park; Harry Ladd at Rolla; Samuel Lasky at Salt Lake City; and Philip J. Shenon at Spokane—and made each responsible for overseeing operations in four or more States and for facilitating "cooperation between the Geological Survey and Bureau of Mines."[44]

Loughlin also appointed 21 Commodity Geologists. Under the general direction of the Section Chiefs, who would correlate the different commodity programs, each Commodity Geologist would direct the field geologists' work and help the Regional Geologists and the Washington staff "to assemble and make a permanent digest of the records and reports now on file."[45] The Commodity Geologists included Wilbur Burbank for molybdenum, arsenic, and other minor metals; Ralph S. Cannon, Jr., for copper; Edwin B. Eckel for mercury, with Paul Averitt as alternate; Richard Fischer for vanadium; Thomas Hendricks for manganese; Edwin T. McKnight for lead and zinc; Thomas Nolan for tungsten; William Pecora for nickel; Joe Peoples for chromium, with Thomas Thayer as alternate; Ward Smith for tin and pegmatite minerals; John Vhay for cobalt; Donald White for antimony; Arthur Baker for oil, gas, coal, helium, asphalt, and oil shale; Ernest Burchard for bauxite and bauxitic clay, with Watson Monroe as alternate; Edwin Goddard for fluorspar, with James Williams as alternate; Thomas Lovering for iron ore, with Charles Park as alternate; Victor T. Allen for high-alumina clay; Eugene Callaghan for magnesium sources (except saline sources) and alunite; Hoyt S. Gale for saline deposits; Louis W. Currier for graphite and related nonmetals; and George Mansfield for phosphate, potash, and related nonmetals.

The Geologic Branch's scientists concentrated on studies of manganese, chromite, tungsten, and mercury. Branch geologists completed investigations of manganese in California, eastern Tennessee, and the Batesville district of Arkansas, and similar studies continued in 18 other States. Harold James and other geologists examined more than 100 chromite deposits in California, Georgia, Oregon, and Montana, most of them in cooperation with the USBM. In the Western States, Richard H. Jahns and other Branch specialists evaluated more than 100 separate tungsten areas and more than twice that number of individual deposits. Work also continued on domestic deposits of mercury; by the end of the year, most of the important producing areas were mapped in detail. The studies disclosed new ore reserves of mercury, notably at New Idria, California.

Geologic Branch geologists also continued investigations of iron, aluminum, and other minerals begun in 1940. In a project reminiscent of USGS-Tenth Census cooperative studies in 1879–81, as arranged and cofunded by Director Clarence King and led by Raphael Pumpelly, USGS geologists examined iron deposits in 22 States, giving particular attention to finding readily accessible reserves of direct-shipment lump ores of low-phosphorus content. Coworkers, in searching for raw materials from which aluminum and magnesium might be extracted, mapped in detail bauxite deposits in Alabama, Arkansas, Georgia, Mississippi, and Tennessee. Geologists found no large deposits of commercial-grade bauxite in the Appalachian region. Arkansas, once second only to France's Var district in producing bauxite ore, earlier yielded more than the other principal sources in Dutch Guiana (Suriname), western Hungary, British Guiana (Guyana), Yugoslavia's Istria district, France's Herault district, and U.S. localities in Georgia and Alabama. Field parties of the USGS Arkansas Bauxite Project, staffed by Robert P. Bryson, Mackenzie Gordon, Jr., Joshua I. Tracey, Jr., William E. Benson, and other Geologic Branch scientists, discovered many new deposits and recommended the most promising of them to the USBM for surveying and appraisal. The USBM began its Project 1101, an examination of some 1,500 square miles, with magnetic and gravity surveys, late in 1941; core-drill appraisals and developmental drilling followed early in 1942. These efforts located 900,000 tons of commercial aluminum ore in the Gulf of

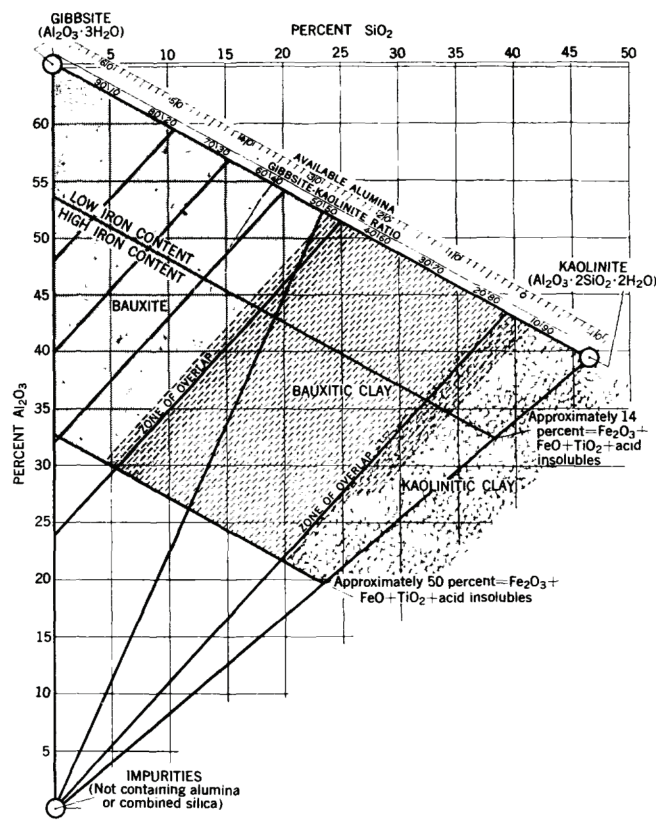
This diagrammatic section shows the four generic types—residual, colluvial, stratified, and conglomeratic—of bauxite deposits in the rocks of the Wilcox Group's Berger and Saline Formations (Eocene) in the Arkansas bauxite district. Wartime searches by USGS geologists located several new domestic sources of bauxite and other aluminum-bearing deposits. (From Gordon, Tracey, and Ellis, 1958, fig. 33.)



Mexico Coastal Plain and more than 3.5 million tons in 20 sites in Arkansas, in addition to the earlier discovered reserves. Greatly expanded studies of copper, lead, and zinc deposits concentrated on districts having large production, but geologists also examined minor deposits that offered possibilities of increased yields.

As the production of steel, aluminum, 100-octane gasoline for military aircraft, and other war material greatly increased the demand for fluorspar, the War Production Board asked the USGS to plan a comprehensive investigation of these deposits in the United States. USGS geologists searched for domestic fluorspar in cooperation with geologists and engineers from other Federal and State agencies and with local producers. Other specialists completed detailed geologic mapping in many localities and recommended the drilling of, or other exploratory work on, the most promising prospects. They found additional reserves in Colorado, New Mexico, Utah, other Western States, and the Kentucky-Illinois field, the supplier for many years before World War II of more than 90 percent of U.S. fluorspar requirements.

Geologic Branch specialists also examined additional mineral resources, including a special survey of possible new sources of cobalt and molybdenum in the Western States, Arkansas, Maine, New Hampshire, North Carolina, and Wisconsin. Their continuing investigations of vanadium centered on deposits on the Colorado Plateau, extending work begun there in 1939, and those in Idaho and Wyoming. In cooperation with the USBM and the war agencies, USGS geologists made substantial progress in estimating reserves of vanadium ore and recommending specific diamond-drilling programs in the geologically favorable areas. Quartz crystals, used in radio-communication equipment, were largely imported before the war; to meet increased demand, the USGS began searches for domestic deposits and located in Arkansas a modest supply of fine-quality crystals. The agency's geologists also examined deposits of arsenic, bismuth, graphite, strontium, and talc. In addition, they made in 16 States general and detailed assessments of pegmatite



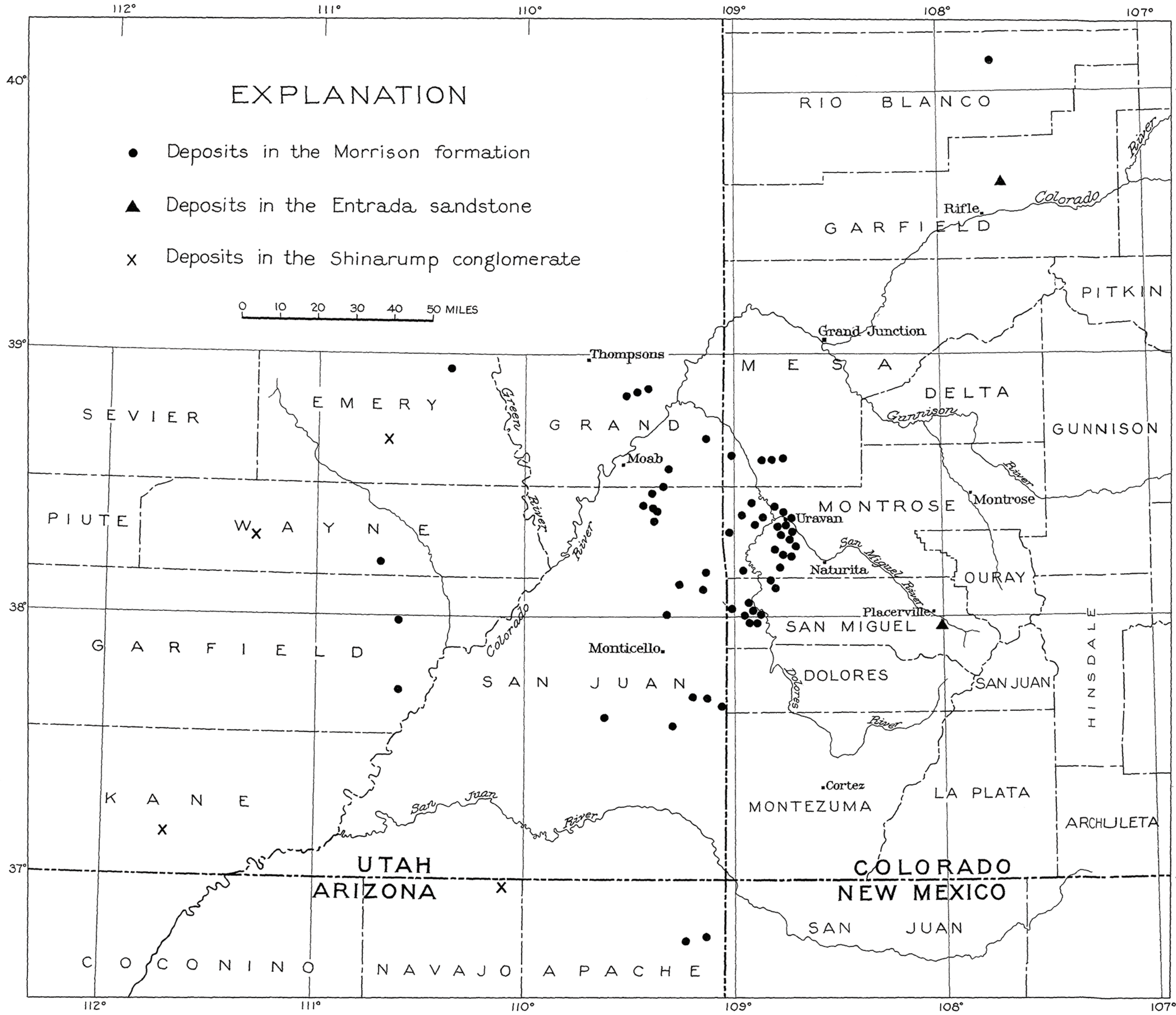
This chemical-mineralogical classification of the bauxite and high-alumina clays in Arkansas shows the percentages of the three principal oxides—aluminum, iron, and silicon—in the State's bauxite, bauxitic clay, and kaolinitic clay. (From Gordon, Tracey, and Ellis, 1958, fig. 30.)

deposits containing beryllium, feldspar, lithium, and sheet mica. Studies of pegmatite deposits in New England and the southern Black Hills were directed toward future composite mining of their minerals.

In October 1942, following discussions between Foster Hewett and Thomas Nolan of the USGS and mining engineer Sydney H. Ball,[46] a Special Assistant to the War Production Board's Deputy Director General for Industry Operations and a USBM consultant, the WPB suggested that the USGS investigate by spectrographic means several strategic elements in products from domestic mills, smelters, and electrolytic refineries. In the resulting Mill Products Program, sources of uranium and other fissionable materials were termed "trace elements" for security purposes. In November, USGS geologists were asked to collect nationwide, from a long and constantly changing list of these elements, samples of concentrates, tailings, slags, flue dusts, residues, and slimes to discover new sources of rare metals that could be developed quickly to meet urgent wartime needs. Particularly sought initially were recoverable amounts of easily reduced alumina, antimony, beryllium, bismuth, cadmium, cobalt, indium, molybdenum, nickel, tantalum, tin, tungsten, and vanadium. In addition to the preliminary spectrographic analyses by the field geologists, and chemical work in Washington, John C. Rabbitt spectrographically analyzed these and other samples at Harvard during 1943 and part of 1944. Rabbitt began his work with semi-quantitative analyses of the vanadium content of the more than 400 samples from the Permian black shales and associated rocks of the Phosphoria Formation obtained from locales in Idaho, Montana, Utah, and Wyoming not yet examined for that element. The USGS, the U.S. National Museum, the Bureau of Plant Industry, and the Tennessee Valley Authority (TVA) sent these samples to Harvard's Esper Larsen, Jr., during January–May 1942.

In May 1942, William Rubey and Vincent E. McKelvey began field investigations of Phosphoria vanadium between Cokeville, Wyoming, and Soda Springs, Idaho. They received John Rabbitt's spectrographic analyses of new samples in June and July; late in July, they completed their USGS report and sent copies to the USBM, the Metals Reserve Company, and the WPB. The geologists intended their field and laboratory studies to yield both applied and basic results, a goal since 1879, by discovering quickly new sources of rare metals to meet urgent war needs and also providing evidence for the origin of particular deposits as a guide to future prospecting. Rubey and McKelvey resumed their reconnaissance in August, aided by USGS geologist J. David Love, USGS chemist Victor North, and two USBM engineers. Measured and indicated reserves discovered in the Paris-Bloomington district, Idaho, totaled some 4.5 million tons, a 15-year supply for a 1,000-ton mill, while the Dry Creek and Swift Creek districts, Wyoming, appeared to have even larger tonnages of vanadium ore. Industry planned to produce 1,000 tons a day from the Sublette Ridge deposit, Wyoming. Significant amounts of uranium and zinc also occurred in some of the Phosphoria samples. Rabbitt also analyzed some 350 magnetite samples from 10 States. Between April and June 1942, USGS geologist James Balsley examined 67 deposits of titaniferous iron ores in California, Colorado, Minnesota, Montana, New Jersey, New York, North Carolina, Rhode Island, Virginia, and Wyoming. Balsley's subsequent detailed investigations of four deposits near Lake Sanford, New York, led to mining titanium from one of them and experimental work on a pilot plant to recover vanadium as a byproduct.

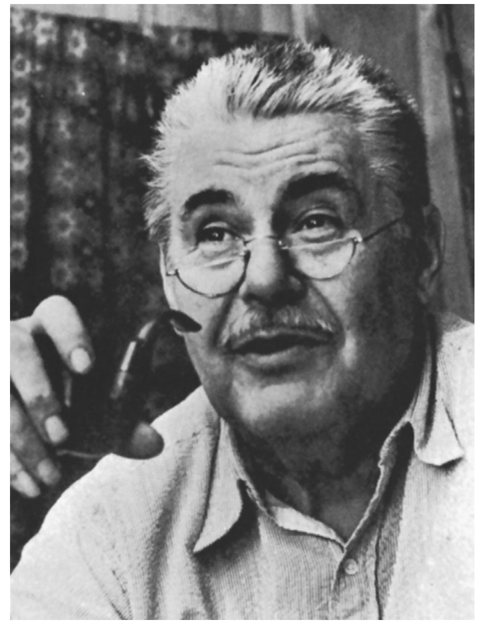
The urgent need for strategic and critical minerals also led the Board of Economic Warfare and the State Department to provide, respectively, $20,000 and more than $96,000 to support USGS investigations in the Caribbean and in Central and South America as part of an expanded effort to promote good relations among the American Republics. The State Department's funds were nearly double the sum it gave for this purpose in fiscal year 1941–42. Wendell Woodring, Steven Davies, and other USGS geologists examined chromite, copper, manganese, and



This map (originally at 1 inch = 20 miles) shows the distribution of vanadium deposits in the Shinarump Conglomerate (Triassic) and the overlying Entrada Sandstone and Morrison Formation (Jurassic) in northeastern Arizona, southwestern Colorado, and southeastern Utah. USGS geologists searching for mineral deposits on the Colorado Plateau concentrated initially on vanadium-bearing units but, beginning in 1944, refocused on the associated uranium. Studies and mapping completed before that year aided the new effort. (From Fischer, R.P., 1942, pl. 53.)

zinc deposits in Cuba and discovered there significant reserves of chromite. Other reconnaissances in the Caribbean sought additional bauxite deposits of grade and size similar to the soil-like occurrences discovered in Jamaica in 1942.[47] Donald White and his coworkers assessed Mexican sources of antimony, fluorspar, manganese, mercury, molybdenum, and tungsten. They located a tungsten district of high-production potential; their work also led to significantly increased production in the country's largest mercury district. Philip Guild evaluated antimony and chromite occurrences in Guatemala. Other USGS geologists studied manganese deposits in Panama; looked at copper, mercury, mica, molybdenum, and quartz in Colombia, where they were led by Quentin D. Singewald; investigated mica, nickel, and quartz in Venezuela; and examined, under William Pecora's leadership, bauxite, mica, and nickel in Brazil. There, William Johnston, Jr., now with the BEW, and others expanded their studies to include searches for piezoelectric quartz; in addition, they assessed beryl, tantalum, and tungsten in Argentina. Singewald's team also looked briefly at mineral deposits in Bolivia and Venezuela.

The Geologic Branch undertook only a few other investigations during fiscal year 1942–43, and they were all war related. At the request of Secretary Ickes, in his continuing capacities as coordinator of petroleum and solid fuels, Branch geologists again revised the oil and gas map of the United States, searched for additional deposits of coking coals suitable for western steel plants, and studied areas that promised to yield additional sources of oil. In cooperation with the USBM, they also looked for additional sources of helium for use in the blimps and other nonrigid aircraft now increasingly employed in antisubmarine patrols.



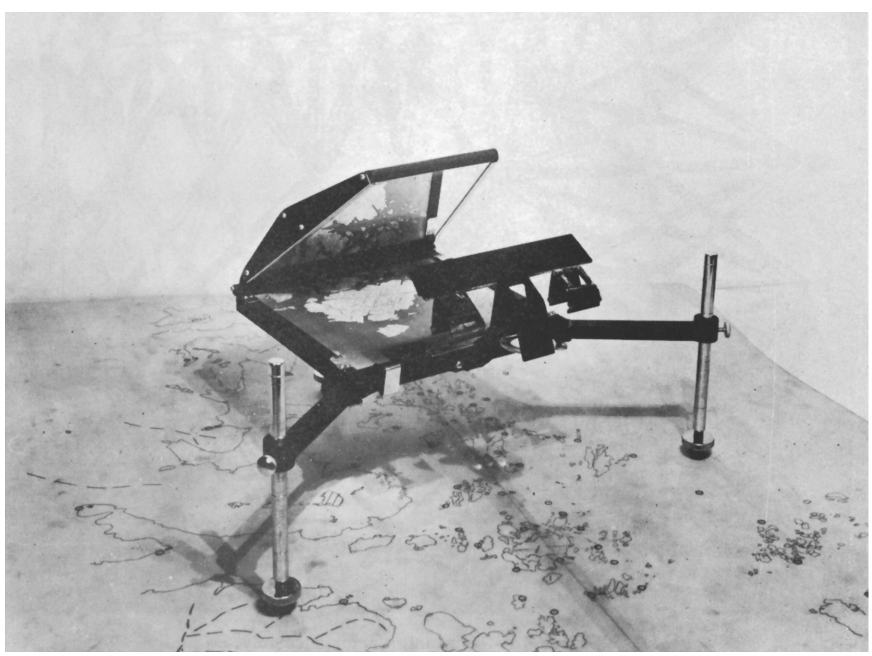
William Drumm Johnston, Jr. (1899–1972), taught in Kentucky, New Mexico, and Ohio before joining the USGS for water-resources studies in 1928 and then investigations of chromite in the Western States and in Cuba. During 1942–46, Johnston managed the Board of Economic Warfare's explorations for iron, piezoelectric quartz, and other strategic-mineral commodities in the Minas Gerais and other areas of Brazil. He returned to the USGS to lead its Foreign Geology Section (later Branch) until 1964, while also working in Thailand and other countries. (Photograph from Dorr, 1975.)

The Roosevelt administration gave increased attention to Alaska during 1942 and 1943 and especially to Federal work in the Territory. On January 16, 1942, Ickes reminded the Cabinet that a land route for conveying lend-lease aid through Alaska and personnel and supplies to Alaska now seemed more dependable than any sea route. Ickes, Frank Knox, Stimson, their staffs, and the Army Engineers collaborated in preparing recommendations for routes to connect Alaska by road to the conterminous States by way of Canada. On February 11, Roosevelt approved plans for constructing the Alaskan-Canadian (Alcan) Highway. Brigadier General Clarence L. Sturdevant, transferred from the Office of the Chief of Engineers, directed the Alcan project. Seven Engineer regiments (including three composed of black enlisted personnel led by white officers) and civilian firms under contract to the Public Roads Administration and the Army Engineers dealt with mosquitoes, mud, muskegs, and permanently frozen ground, or permafrost,[48] in building and then improving sections of the 1,420-mile-long road between Dawson and Fairbanks. The Alcan Highway,[49] completed at an estimated cost of nearly $140 million, opened on November 20, supplemented by an adjacent telephone line. Initial flights to the Soviet Union of lend-lease aircraft, the first of some 8,000 planes by war's end, via airfields from Great Falls, Montana, to Fairbanks, Alaska, began on September 29. The route also facilitated the passage of diplomats, including Foreign Minister Molotov and Andrei A. Gromyko, counselor at the Soviet embassy in Washington and ambassador there in 1943. Army Engineers also constructed the 1,200-mile-long, 4-inch-diameter Canadian Oil (Canol) pipeline, also approved by Roosevelt, to ship crude oil from the field at Norman Wells, on the Mackenzie River in the Northwest Territories, southwest to the refinery at Whitehorse in the Yukon Territory, a project favored by CNO Admiral King but not by Navy Secretary Knox. When Ickes finally learned about the $25 million effort, he termed it useless. General Somervell described Canol to the Truman committee in December 1943, but the committee could not stop the wasteful project, whose costs ballooned to more than $130 million.[50]

Funds directly appropriated for the Alaskan Branch to study the Territory's mineral resources during fiscal year 1942–43 remained virtually the same as in 1941–42, but monies from the War Department and the Office for Emergency Management increased the new total by more than threefold to nearly $1.25 million. Some 40 USGS geologists continued or began studies of chromium, coal, copper, iron, mercury, molybdenum, nickel, tin, tungsten, and zinc in southeastern Alaska, the Prince William Sound-Copper River region, the Cook Inlet-Alaska Railroad area, the Kuskokwim region and nearby portions of southwestern Alaska, and the western Seward Peninsula. As part of this work, Jack Kingston and Don J. Miller spent 5 weeks examining a nickel-copper deposit near Spirit Mountain in the Copper River region.

Alaskan Branch personnel devoted much of their energy to producing urgently needed maps of Alaska for military purposes, especially aeronautical-approach charts, shaded-relief maps, and other aids to aerial navigation. Those maps, many of which were produced by rapid approximate methods to meet immediate needs, did not warrant detailed surveying, but they proved accurate enough for aircraft flying at 200 to 300 miles per hour. Major Minton W. Kaye, who commanded the USAAF's 1st Photographic Squadron, asked the Alaskan Branch to plan for compiling "cartographic data from aerial photographs"[51] to revise the U.S. Coast and Geodetic Survey's Alaskan Aeronautical Charts. Gerald FitzGerald, the Branch's senior topographic engineer, accepted the task of designing and perfecting production methods. To so do, FitzGerald, Charles F. Fuechsel, and David M. Landen used the Wilson photoalidade in developing the trimetrogon method of photogrammetry, which used three aerial cameras; one took vertical photographs and the others recorded oblique images that gave a horizon-to-horizon view at flight-line spacings of as much as 35 miles. As conventional photogrammetry used vertical photography at 3- to 4-mile spacings, the new maps were less accurate but far more rapidly and economically produced. The USAAF made the photographs and supplied the funds for compiling the maps. By the end of the fiscal year, the USGS assigned more than 150 people to this special work. FitzGerald, a USAAF Major since June 2, headed the Map-Chart Division, in the Office of the Director of Photography, now led by Lt. Colonel Kaye, at USAAF Headquarters. In 1943, the USAAF promoted FitzGerald to Lt. Colonel and renamed his unit the Aeronautical Chart Service's Aeronautical Chart Division, whose full Colonel in Charge he became in the following year. Fuechsel succeeded FitzGerald as chief of the Alaskan Branch's topographic mapping section.

The Topographic Branch drew on a total of nearly $3,419,000 in direct, transfer, and repay funds for fiscal year 1942–43, a sum $69,000 less than that available in the previous year. Of the Branch's $689,000 direct appropriation, $270,000 was available only for cooperation with State and municipal governments. The Branch remained concerned primarily with meeting military needs, aided by an Executive order on March 10, 1942, that abolished the Board of Surveys and Maps, established in 1919, and authorized the Director of the Office of Management and Budget to perform the Board's functions, and any others now deemed necessary, "to further coordinate and promote the surveying and mapping activities of the Government."[52] After the threat of Japanese invasion passed, members of the Topographic Branch became deeply involved in the production for the military of maps of foreign areas. Branch topographers mapped nearly 21,500 square miles in 30 States, the District of Columbia, and Puerto Rico; they worked cooperatively in



This 1942 model of the vertical sketchmaster used mirrors to allow the specialist to view details from a vertical photograph and simultaneously transmit them to a plotting sheet; it was an improved version of the portable instrument originally designed by USGS photogrammetrist James L. Buckmaster in 1931. Adjustments to the sketchmaster allowed for "scale changes and approximate tilt correction." The oblique sketchmaster similarly permitted the shift of data from oblique photographs. The universal sketchmaster was used with either type of photograph. Buckmaster also contributed to the development of trimetrogon photogrammetry and the USGS Airborne Control Survey System. (Quotation and photograph from Thompson, 1958, p. 7 and fig. 5; see also Buckmaster, 1946.)

17 States and Puerto Rico and with the TVA. Mapping also continued in Brazil to support USGS strategic-minerals investigations. Most of the Branch's effort abroad involved producing maps of strategic areas, or parts within them, outlined by the War Department, under the Loper-Hotine Agreement of May 1942 that divided Allied mapping responsibilities worldwide. Nearly 67 percent of the Topographic Branch's 241 quadrangles published and the 88 percent of the 684 mapped completely or still in progress at the close of the fiscal year were within the strategic area designated by the War Department.

The Topographic Branch also issued the Chesapeake Bay sheet for the 1:1,000,000-scale International Map of the World. The Photographic Mapping Section produced topographic maps of 5,750 square miles and planimetric maps of 14,250 square miles, in addition to the maps completed at the Chattanooga office, which remained fully engaged in cooperative work for the TVA and the Army Engineers. Two shifts were busy at the Arlington office, now with increased facilities and responsible for maintaining a central laboratory for designing, testing, repairing, and adjusting the special optical equipment needed for stereophotogrammetric work. The number of Secretarial appointees in the Branch peaked at 745 on September 30, 1942, but 59 of those persons were furloughed for military service. Herbert Hodgeson, Pacific Division Engineer, retired on November 30, 1942; on the following day, Conrad A. Ecklund succeeded Hodgeson.[53]

The War and Navy Departments, the War Production Board, industrialists, and engineers employed under war contracts called on the Water Resources Branch for more than 4,000 special reports during fiscal year 1942–43. Branch scientists and engineers drew on total funds of about $3,219,000, a sum $33,000 less than the previous year. Of that amount, the appropriations statute directed that $975,000 could be spent only for cooperative work with the States, counties, and municipalities, whose governments more than matched that amount by providing some $1,038,000. The Army Engineers again led the contributors among the other Federal agencies by furnishing nearly $645,000, a loss of only $14,000 from fiscal 1941–42, but the WPB reduced its transfer funds by $34,500, or more than 70 percent, and the Department of Agriculture halved its transfer funds.

Monies received supported the Water Resources Branch's studies and assessments of water supplies for cantonments, naval stations, military hospitals, training fields, airfields, munitions industries, manufacturing plants, hydraulic and steam powerplants, emergency housing, expanded irrigation for increased production of food, inland-waterway navigation, flood protection, supplements during droughts, and replacements for sources that might be damaged by bombing.[54] Reports covered areas in every State in the Union and in the Territories of Alaska and Hawaii, but most of them centered on the industrial regions of the East, South, and Far West. Branch personnel continued, as much as possible, regular activities to maintain continuity of records. They measured stage, quantity, and availability of surface waters at some 5,000 gaging stations and recorded periodic observations of water level or artesian pressure in some 7,000 wells, numbers representing no significant increase in sites from the previous year. Leland Wenzel published his study of methods for determining permeability in water-bearing materials, especially those for discharging wells. Other continuing activities included the monthly *Water Resources Review* (now including groundwater data), administration of some responsibilities relating to permits and licenses of the Federal Power Commission, investigations of water problems along the U.S.-Canadian boundary, and the laboratory analysis of more than 2,800 water samples.

Of the six water-supply battalions and four water-supply companies (provisional) continued or formed by the Army, five battalions and two of the independent companies served in the Mediterranean and European Theaters; one battalion and the remaining two companies went to the South Pacific Area. The Army

Engineers commissioned 10 USGS groundwater geologists and assigned them to the water-supply battalions or to headquarters' staffs. Among these officers, Richard C. Cady (killed in North Africa in January 1943), R. Maxwell Leggette, and Harold Thomas became Majors. Frank Foley, Raymond Nace, and Reuben C. Newcomb began their service as Captains. Roger C. Baker, Bernard Fisher, William Rasmussen, and Stuart L. Schoff pinned on 1st Lieutenants' bars.

The Conservation Branch's work expanded as the need for raw materials increased the prospecting and development of public-land resources, but, to support this work, the Branch received only $583,000 for fiscal year 1942–43, an increase of just $5,000. Branch members concentrated on increasing the application of these resources to the war program. The Mineral Classification Division acted on 7,900 cases, about 7 percent more than in the preceding year, and made geologic investigations in 8 Western States. The Mining Division supervised operations on 700 public-land properties, 268 Indian properties, and 3 Secretarial authorizations. Substantially increased production of coal, sodium, potassium salts, and phosphate rock from public-land properties yielded correspondingly higher accrued revenues. Searches intensified for potash and associated aluminum and magnesium, especially after a Secretarial order removed restrictions on granting permits and leases.[55] During the fiscal year, the production of coal and vanadium from Indian lands considerably increased, as did prospecting with a view to developing the known deposits of copper, tungsten, uranium, and vanadium; low-grade lead and zinc ores also were worked. The Oil and Gas Leasing Division supervised operations on nearly 4,500 public-land properties, some 4,200 leaseholds on Indian lands, and 18 properties under lease in Naval Petroleum Reserves Nos. 1 and 2 in California. The production of crude oil, natural gas, natural gasoline, and butane from the public lands rose substantially during the fiscal year, but production of these energy resources declined in the NPRs and royalties from them fell by $141,000 to $493,000. Oil and gas production from Indian-land leaseholds also rose a little, owing principally to a substantial increase from Oto tribal lands in Oklahoma. Helium-bearing natural gas was discovered and developed on Navajo lands in New Mexico. Royalties and related revenue from operations on Indian lands rose to slightly above $2.6 million.

Rubber for the war effort remained a problem outside the purview of the USGS. On June 12, 1942, Roosevelt supported a scrap-rubber campaign in a radio address because the war with Japan cut off 92 percent of the America's peacetime supply. In July, with domestic production still lagging, Congress passed a bill to create an independent "rubber czar." Roosevelt vetoed the legislation to prevent it from negating centralized control under the War Production Board, but he appointed a three-person committee to review the problem. To lead the survey, the President tapped financier Bernard M. Baruch, one of his long-term advisers, who served on the Council of National Defense's Advisory Committee and chaired the War Industries Board during World War I. Baruch, joined by Karl Compton and James Conant of the Office of Scientific Research and Development, recommended a complete reorganization and consolidation of the Federal agencies concerned with the rubber program and increased emphasis on conservation and production of synthetic rubber. In September, to resolve the crisis, Roosevelt appointed William R. Jeffers, the Union Pacific's president, to head the rubber program as part of the WPB, with authority to direct the Rubber Reserve Company and other agencies in carrying out some of the program's activities.[56] Secretary Ickes, as Petroleum Coordinator, received specific authorization to conduct or promote developmental research in the production and manufacture, from petroleum and natural gas, of the butadiene needed for producing both aviation gasoline and synthetic rubber. Ickes also supervised the operation of plants that produced synthetic-rubber raw materials from oil and gas.

By August 1942, the lack of synchronization in completing parts for weapons, such as those processes that produced tanks with treads but no armor plate, or carburetors without engines, thoroughly alarmed U.S. military authorities. In mid-September, to solve the weapons problem, the WPB's Donald Nelson invited investment-banker Ferdinand Eberstadt, head of the Joint Army and Navy Munitions Board and Baruch's protégé, to take charge of priorities for the WPB. Eberstadt viewed the production problem as one of controlling the flow of aluminum, copper, and steel. He developed a plan in which orders for finished products figured as the precisely calculated sum of all the parts, components, and materials. The WPB did not adopt Eberstadt's Controlled Materials Plan until November and then did so in a circuitous fashion through a recommendation by the Office of Economic Stabilization (OES). An Executive order established the OES[57] on October 3, immediately after the enactment of the amendment of the Emergency Price Control Act that authorized the President to stabilize prices, wages, and salaries affecting the cost of living. Those powers passed to the OES and its new director James F. Byrnes, who, with Baruch's backing, served South Carolina in Congress for 30 years before Roosevelt appointed Byrnes to the U.S. Supreme Court in June 1941. Byrnes resigned from that bench to become Director of Economic Stabilization and, as one of his initial actions, recommended applying Eberstadt's plan. Only after Roosevelt, Byrnes, and the War and Navy Departments agreed in mid-October to use Eberstadt's design as a means to regulate the war economy did the WPB adopt the plan.

The Nation's oil supply continued to be another nagging problem in 1942. In spite of Ickes' best efforts, the USBM estimated that the demand for all oils reached an all-time peak of 442 million barrels in the last quarter of 1941. That level dropped during the first quarter of 1942, but it remained higher than the corresponding period in 1941. As imports fell somewhat, supply sustained demand only through a reduction of more than 27 million barrels in the stocks of refined oils. In the second quarter of 1942, overall demand declined to almost 3 percent less than in the same interval in 1941; the greatest reduction involved motor fuel, but requests for residual and distillate fuel oils actually increased. Rapidly dwindling stocks and reduced movement of supplies by tankers, in part due to losses to German submarines, produced a serious supply problem on the East Coast. The Roosevelt administration introduced a gasoline-rationing system in May in the Eastern States and encouraged industrial plants using fuel oil to convert to coal. Rationing of heating oil in the main consuming areas began on October 1; nationwide gasoline rationing followed in December. By the fourth quarter of 1942, demand declined only 5 percent from the level in the corresponding peak period of 1941. The increasing military need for petroleum by the United States and its allies indicated additional shortages ahead. The American Petroleum Institute estimated that pools discovered during the fiscal year added only some 260 million barrels to the Nation's crude-oil reserves. Only additional new finds would supply wartime requirements and keep the industry within an efficient rate of production.

An Executive order on October 15, 1942, extended the boundaries of California's Naval Petroleum Reserve No. 1,[58] but now Roosevelt and Ickes looked north to much larger Federal holdings. In April, Secretary and Coordinator Ickes promised the Cabinet that exploration for oil in Alaska would begin immediately, but only in November did Ickes recommend to the President to begin a Federal program to explore for and develop oil in the Territory. The administration issued a public-land order on January 22, 1943, withdrawing from entry potential (but unproved) petroleum-bearing areas in the Territory, including all lands north of the Brooks Range's drainage divide. On March 30, geologist William T. Foran, then on active duty as a Lieutenant in the U.S. Naval Reserve (USNR), suggested to the Bureau of the Budget's oil consultant several reasons for taking a renewed and more careful look at Alaska's Naval Petroleum Reserve No. 4 (NPR–4 or "Pet–4").

The Reserve, established by President Warren G. Harding's Executive order of February 27, 1923, encompassed a large area in northwest Alaska, north of the Brooks Range divide.[59]

USGS geologists began detailed mapping in the future reserve's area in 1901 and reported oil seeps at Cape Simpson in 1919. Foran served two seasons with USGS parties during the 1923–26 reconnaissance of NPR–4 planned by Alfred Brooks and funded by the Navy Department. Geologists Foran, James Gilluly, John Mertie, Jr., Sidney Paige, Philip Smith, and Walter R. Smith and topographers Gerald FitzGerald, E.C. Guerin, R.K. Lynt, James E. Whitaker, and O.L. Wix, sailing in engine-powered small vessels from their principal supply base at Nome, combined to map and assess coals and oil seeps in areas totaling some 2,150 square miles. They also gathered information on an additional 10,000 square miles. These parties, using U.S. Coast and Geodetic Survey charts to fix the coastline, completed in 1924 a 1:500,000-scale map of the northwestern part of NPR–4 from Cape Beaufort to Cape Simpson, based on up-river traverses from the Kukpowruk to the Colville.

On December 2, 1942, Roosevelt's Executive order abolished the Office of the Petroleum Coordinator for War, established on May 28, 1941, and replaced it with the Petroleum Administration for War (PAW), which received on December 17 all of the defunct organization's funds, personnel, property, and records. Secretary Ickes, now Petroleum Administrator, received greater responsibilities and power to "establish basic policies and formulate plans and programs to assure * * * the conservation and most effective development and utilization of petroleum in the United States and its territories and possessions,"[60] provided his directives did not conflict with those issued by the WPB's Nelson. The order authorized Ickes to compile data and make surveys, obtain estimates, make recommendations, effect proper distribution of U.S. petroleum, consult on the movements of tankers and construction of oil and gas pipelines, and collaborate with State governments. Roosevelt also asked Ickes to collaborate with the appropriate Federal departments and agencies required to determine plans and policies with respect to foreign petroleum activities, to issue directives to units of the U.S. petroleum industry directly or indirectly engaged in activities abroad concerning the physical operations of their foreign facilities, and to be the channel of communication on foreign-petroleum matters between the Federal Government and these U.S. petroleum-industry units. The order allowed Ickes to appoint, subject to the President's approval, a formal Deputy Administrator.

By the end of 1942, although the United States still struggled with production problems, its forces won several major victories in the Pacific. Two days after Corregidor fell, U.S. naval fliers turned back a Japanese force en route through the Coral Sea to invade Port Moresby on New Guinea's southern shore. Navy fliers damaged one of the two Japanese fleet carriers, wrecked the other's air group, and sank one light carrier, in return for the loss of one fleet carrier and damage to the other. Meanwhile, in the southern Solomons, other Japanese forces occupied and established a seaplane base on Tulagi Island just north of the much larger Guadalcanal. Decoded messages from Japanese diplomats and the Imperial Navy disclosed the Japanese plan to attack Midway. On June 4, aircraft from four Japanese fleet carriers struck that island. Daring leadership from Rear Admiral Raymond A. Spruance (who replaced a hospitalized Halsey), clever and determined flying, and luck enabled aircraft from three U.S. fleet carriers to ambush the Japanese carriers. They sank all four, but Japanese planes downed only one American carrier. Far to the north, Japanese aircraft from two smaller carriers attacked Dutch Harbor on Unalaska, and other shipborne forces captured Attu and Kiska in the western Aleutians, but those carriers and their escorts came south too late to help the Japanese main fleet reverse the outcome off Midway.[61] On New Guinea, Australian troops defeated Japanese overland efforts to conquer Port Moresby and also successfully defended Milne Bay at the eastern end of New Guinea.

President Roosevelt and Admiral King, changing American plans from hold to attack, encouraged and facilitated an American offensive in the southern Solomons. On August 7, the 1st Marine Division (reinforced) landed on Tulagi, adjacent smaller islands, and Guadalcanal. The Marines quickly captured the lesser islands, but taking Guadalcanal required a long, bitter, and costly struggle against continuing Japanese attacks by air, land, and sea. In a series of furious battles off Guadalcanal, Imperial naval and air forces sank two U.S. fleet carriers, damaged two others, and sank or ruined many cruisers and smaller warships. In October, Nimitz placed Halsey in command of the South Pacific Area. Halsey took hold, American morale rose, and the Japanese continued to suffer severely themselves, losing carriers of their own, two other capital ships, and many other combat vessels. The Japanese failed to interdict the U.S. Navy's supply line to Guadalcanal or break the Marine-Army cordon on the island, lost the battle of attrition, and withdrew their remaining sick and starving troops. Victory on Guadalcanal,[62] and the successful operations by MacArthur's forces between late November 1942 and late January 1943 that took the Buna-Gona positions on New Guinea's northern coast, proved the Japanese were not the invincible jungle fighters that many feared.

Late in 1942, the Allies also reversed the flow of Axis successes in Africa and Russia. In May and June, the Germans renewed their offensive on the Eastern Front, aiming to smash the revived Soviet forces and capture vital Caucasus oil. They captured Maikop and its oil installations in August but only after the Soviets damaged production facilities.[63] After Hitler diverted armored units to Stalingrad, German forces took the Malgobek oil field in October, but they did not reach fields at Grozny or Baku (which produced 10 times more oil than Maikop) or the port and refinery facilities at Batumi. The Russians held the German Sixth Army at Stalingrad and surrounded it there a month after Marshal Zhukov's army groups began a major counteroffensive in November. In North Africa, Field Marshal Rommel's Italo-German army captured Tobruk and reached a point only 60 miles from Alexandria in July. Without additional troops, equipment, ammunition, and especially fuel, Rommel could not advance further; he withdrew his forces to defensive positions early in September. The British 8th Army, under its new commander, Lt. General Bernard L. Montgomery, began a massive counterattack at El Alamein on October 23. Rommel and his surviving Axis troops, forced to retreat on November 4, did not stop until they reached Vichy Tunisia. Roosevelt and Churchill, after discussions with Molotov, agreed in June to have their forces invade western North Africa in Operation Torch and timed it to match Zhukov's offensive. Stalin and Molotov did not see Torch as the true second front, especially as shipments of lend-lease equipment were reduced by 60 percent when Arctic convoys were temporarily suspended.

On November 8, as the Axis troops retreated into Libya, three task forces of mostly American troops, commanded by Lt. General Dwight Eisenhower, Marshall's protégé, landed at Algiers and Oran in Algeria and at and near Casablanca in Morocco, where individual French garrisons either aided or opposed the invasions before being ordered to stand down 3 days later. USGS groundwater geologists Maxwell Leggette and Raymond Nace landed as officers in Operation Torch's water-supply units. The Anglo-American forces then raced east to threaten Rommel's western flank, but they did not arrive in time to prevent his linking up with heavily reinforced German forces in Tunisia. In response to Torch, the Wehrmacht also occupied Vichy France but gained only scuttled warships at Toulon. Italian troops took over Corsica.

As the Allied campaign continued in North Africa, and after the War Production Board adopted Eberstadt's Controlled Materials Plan, Chairman Nelson reorganized the WPB and regrouped its industry and commodity branches. The new Steel Division comprised the old Iron and Steel, Tungsten and Molybdenum, Manganese and Chromite, and Nickel Branches. Nelson placed the new Steel Division and the existing Copper and Aluminum-Magnesium Divisions under the Director General for Operations, who, in turn, reported to Eberstadt as Program Vice Chairman. The Mining, Mica-Graphite, Tin-Lead, Zinc, and Miscellaneous Minerals Branches were linked in a Minerals Bureau, the Chemicals and the Cork-Asbestos Branches merged with other industry branches in a Commodities Bureau, and the Building Materials Branch passed to the Construction and Utilities Bureau. Toward the end of November 1942, the WPB established an Office of Production Research and Development, with physicist Harvey N. Davis, president of Stevens Institute of Technology, as Director and the ubiquitous Charles Leith as Chief of its Metals and Minerals Branch.

When the polls for the American midterm elections opened on November 3, fierce fighting continued unabated in Stalingrad, Operation Torch was a month behind schedule, and Guadalcanal appeared to be a stalemated morass. Only some American voters expressed their concern at the polls; voter turnout for choices for the 78th Congress proved very light. As usual, the party out of power won a larger number of the contested seats. The Democrats lost 50 seats in the House, retaining a majority there of just 10 Members. In the Senate, although the Republicans gained 9 seats, the Democrats still held a 21-seat edge.[64]

When President Roosevelt gave his State of the Union Address to the new Congress on January 7, 1943, some aspects of the war still looked bleak, but none seemed hopeless. Japan now controlled seas, lands and resources that stretched from Burma on the west to the Gilbert and Marshall Islands on the east, and from the western Aleutians on the north to the Netherlands East Indies on the south. The Greater East Asia Co-Prosperity Sphere also included Korea, much of mainland China (including Manchuria), French Indochina, and Thailand. Axis-controlled territory and resources in Europe stretched from Brest eastward to Stalingrad and from the North Cape southward to Mareth in North Africa. In the United States, Federal employees now worked a 48-hour week, with no holidays, but an Executive order deferred them from the draft and the demands and risks of combat.

Roosevelt, after reviewing the previous year's events, goals achieved, and those remaining to be met, suggested that it was "wholly possible that freedom from want—the right of employment, the right of assurance against life's hazards—will loom very large as a task of America during the coming two years."[65] Cracking the Axis defensive perimeters seemed a more daunting mission. After taking Guadalcanal, U.S. forces faced a difficult advance northwest up the rest of the Solomons to join in isolating and reducing the Japanese air-naval base at Rabaul. The German Sixth Army surrendered at Stalingrad on February 2, but the Soviets faced new Axis lines along the Dnieper River. The Germans planned to retake the lands regained by the Soviets and to hold Tunisia, where Hitler finally placed Rommel in overall command on February 23.

Between January 14 and 24, 1943, Roosevelt, Churchill, and their staffs met in Algeria at the Symbol Conference in Casablanca. After the Prime Minister briefed the President on his discussions with General de Gaulle in Marrakech on January 9 about future roles for the Free French, the two leaders agreed to delay the cross-channel invasion of France until 1944. The Allies, after taking Tunisia, would invade Sicily rather than Sardinia. Roosevelt and Churchill named Eisenhower as a four-star supreme commander in the Mediterranean. The two leaders also decided, at Admiral King's continued urging, to increase to 30 percent their allocation of resources to the Pacific. To win the Battle of the Atlantic, where British (Enigma) decrypts gave the Allies a significant edge, they would build more antisubmarine carriers and their escorts, deploy airborne magnetic detectors and high-frequency direction finders, and use "Hedgehog" weapons to supplement improved depth charges. The Allies also would use longer range aircraft, and bomb German targets day and night, giving priority to sites of U-boat construction or repair before striking aircraft plants, ball-bearing factories, and automotive plants. At the final press conference on January 24, Roosevelt announced the Allies' demand for unconditional surrender to give the Axis no World War I-style excuses and to placate a furious Stalin, who might make a separate peace with Hitler. Churchill, remembering his own fight-on declaration in 1940 and also wishing to keep the Soviets in the war, hid his surprise and endorsed Roosevelt's principle. Roosevelt and Churchill confirmed these decisions at the Trident Conference (May 15–25) in Washington, where they reset the invasion of France to May 1, 1944.

The President and the Prime Minister also agreed at Casablanca to resume the highly secret talks on the development of an Anglo-American nuclear weapon. Roosevelt accepted provisionally Vannevar Bush's recommendation of December 16, 1941, to place the U.S. Army in charge of the weapon's construction. The British Maud Committee recommended development, first to Lyman Briggs, the U.S. S–1 Section's Chairman, and then, on January 19, 1942, directly to Bush, Director of the Office of Scientific Research and Development (OSRD). On March 9, Bush summarized for Roosevelt the organization and status of American work on Tube Alloys, the code name for the joint project, and suggested that the special bomb could be completed in 1944 if the President would authorize expediting the effort.[66] Roosevelt so did 2 days later. The Engineering Planning Board, chaired by Eger Murphree, and its Engineering Studies and Pilot Plants group reported directly to Bush. Briggs' S–1 Section and the three contract units—Measurements and Atomistics, led by Arthur Compton; Diffusion, Centrifuges, Chemistry, and Power, led by Harold Urey; and Electromagnetic Methods, led by Ernest Lawrence—all reported to the National Defense Research Committee's (NDRC's) Chairman James Conant. Compton, Lawrence, and Urey also continued to serve on S–1. The project would be sufficiently advanced by the summer, Bush suggested, to pass it to War Department management for completion. In June 1942, when Roosevelt and Churchill met in Washington to discuss a second front and to plan Operation Torch, they also decided to share their atomic research with each other but not with the Soviets. On July 12, Roosevelt ordered Bush to cooperate with the British. When Roosevelt and Churchill agreed that all subsequent work would be done in America, James Chadwick and other British scientists came over to aid the project.

Roosevelt approved on June 17 his Top Policy Group's recommendation to pass all of OSRD's work on the atomic-bomb project to the Army Engineers for full-scale development and manufacture. Two days later, General Reybold's representatives and Bush discussed the new administrative office the Army Engineers intended to establish in New York City within their North Atlantic Division's headquarters. On June 26, Generals Reybold and Somervell agreed on the Laboratory (later District) for Development of Substitute Materials as a cover name for the bomb project. Reybold's general order of August 13, effective on the 16th, changed the Laboratory's name to the Manhattan District, also known as the Manhattan Engineer District (MED).[67] To lead the military and civilian Manhattan Project, Secretary Stimson and Generals Reybold and Somervell selected Colonel Leslie R. Groves, Jr., the Deputy Chief of the Army Engineers' Construction Division, who supervised the War Department's $10 billion construction work (including the new Pentagon Building). Groves was promoted to Brigadier General on September 6 and took over the MED later that month.

Franklin Delano Roosevelt (1882–1945), the 32d President of the United States (1933–45) and Theodore Roosevelt's cousin, was educated at Harvard and Columbia. FDR practiced law in New York before entering politics in 1910 as a State senator. He served as Assistant Secretary of the Navy during 1913–20 before becoming the Democrats' unsuccessful candidate for Vice President. In 1921, poliomyelitis cost him most of his physical mobility. FDR was Governor of New York in 1929–33 until sworn in as President. Roosevelt, a consummate politician, managed the socio-economic New Deal, the U.S. recovery from the Great Depression, and, as Commander in Chief, prewar aid to Britain and America's part in winning World War II. He also contributed significantly to the establishment of the United Nations. Although FDR appointed the conservation-oriented Harold Ickes as Secretary of the Interior, the President was less successful in establishing a national policy for the conservation and use of the Nation's land and water resources. In this photograph, taken during the first week of December 1943, FDR presents a Legion of Merit to General Dwight Eisenhower. (Photograph from the Library of Congress, Prints and Photographs Division, 3c35307.)

Bush feared that General Groves would not work harmoniously with the project's scientists. Groves, as crusty as he was competent, invigorated the bomb project. He held out successfully for a minimal supervisory committee, absorbed $400 million in startup funds, and moved quickly to secure materials and sites. On September 18, Colonel Kenneth D. Nichols, Groves' executive officer, obtained the MED's initial supplies of uranium by purchasing 1,250 tons of high-grade pitchblende, more than 65 percent uranium oxide, from the Shinkolobwe Mine, in the Belgian Congo's Katanga Province, that had been spirited out of Africa 2 years earlier.[68] After Henry Tizard and Frédéric Joliot-Curie warned the Belgian Government in 1939 that the uranium ore at the Olen refining plant, east of Antwerp, should be kept out of German hands, the Union Minière du Haut Katanga's managing director sent the ore stored at Shinkolobwe to safety in New York, but the ore at Olen passed to the Third Reich when the Belgians surrendered in 1940. Additional, but much lower grade ore, less than 1 percent uranium, came from Canada, whose scientists were experimenting with a heavy-water nuclear pile.[69] A USGS–USBM domestic program subsequently supplied more ore, but it was of equally low grade.

Groves also began planning for and organizing construction of facilities at three U.S. locations. Site X at Oak Ridge, west of Knoxville, in Tennessee, would use TVA waterpower to separate fissionable uranium-235 by gaseous diffusion. Site W's plant at Hanford, west of Pasco, in Washington State, would use Columbia River power to produce plutonium. At Site Y at Los Alamos, northwest of Santa Fe in New Mexico, J. Robert Oppenheimer led the bomb-design team, whose members later included Niels Bohr. The MED also encompassed other research and development efforts at academic and industrial sites across the country from Berkeley, California, to New York City and Washington, D.C., where Philip Abelson and others worked at the Naval Research Laboratory and elsewhere on separating uranium-235 from uranium-hexafluoride gas. On December 2, 1942, Enrico Fermi and his colleagues at the University of Chicago's Metallurgical Laboratory (Met Lab), directed by Arthur Compton, used synthetic-graphite control rods free of boron to produce a self-sustaining nuclear reaction in the atomic pile at their laboratory under the stands of Stagg Field. After failing in 1939 to interest the Navy in the potential of nuclear energy for power, Fermi and his earlier team at Columbia, including Leo Szilard, Hans A. Bethe, and Edward Teller, demonstrated during 1940–41 the feasibility of controlled chain reactions.

Earlier in 1942, Glenn Seaborg joined the Met Lab to develop plutonium-separation processes. By late 1942, Allied intelligence suggested the Germans might be ahead of the MED in the race to develop a nuclear weapon. The Allies still feared that the German physicists would succeed in constructing and operating a water-controlled and slow-neutron pile, using uranium from the Czech and Belgian ores, to produce radioisotopes for an explosive weapon, or, at least, a "dirty" bomb. In 1943, the year Bohr escaped from Denmark, Norwegian commandos and then Allied bombers temporarily shut down the heavy-water plant at Vermork and destroyed its stock of heavy water.[70] The Germans removed some of the processing equipment and reassembled it in Hechingen, southwest of Tübingen. Early in 1944, the Norwegians also sank the lake ferry carrying Norsk Hydro's remaining supplies of heavy water. Japan began its own nuclear-weapon program in April 1941; a year later, the Soviet Union resumed its larger effort.

As the nuclear quests continued, President Roosevelt planned coeval changes in the War Production Board. Early in February 1943, the WPB announced plans to coordinate and correlate the mineral programs run by several Federal agencies. WPB Chairman Donald Nelson established a Mineral Resources Coordinating Division, to be aided by a Minerals Resources Operating Committee and a Minerals and Metals Advisory Committee. Alan Bateman (BEW), Foster Hewett (USGS), and Charles Leith (WPB) became members of the Minerals and Metals Advisory

Committee. Roosevelt now planned to replace Nelson with Bernard Baruch and make Ferdinand Eberstadt his chief deputy. In mid-February, however, on the very day that the President intended to announce the change, Nelson forestalled the move by asking for Eberstadt's resignation. Nelson, who wished to prevent military control of production, increasingly worried about Eberstadt's close ties with and support by the military. Rather than endure another controversy by firing Nelson immediately, Roosevelt dropped the matter. Instead, Charles Edward Wilson, president of General Electric since 1940 and manager of the WPB's production schedules since September 1942, became the WPB's Executive Vice Chairman. In March, Julius A. Krug, Director of the Office of War Utilities, was appointed Nelson's Vice Chairman in charge of Materials Distribution and Chairman of the Requirements Committee. In April, Interior Secretary Ickes, in his capacities as Petroleum Administrator for War, Chairman of the War Manpower Commission, and Director of the Office of Defense Transportation, also joined the WPB. Eberstadt's Controlled Materials Plan, once in place, continued to direct the efficient distribution of raw materials and made possible the successful production program of 1943.

During the early spring of 1943, Congress began the postwar planning requested by the President on January 7. The legislators, exhibiting continued opposition both to the New Deal and isolationism, concentrated on economic policy and international cooperation. On February 15, Senator Walter F. George (D–GA) proposed establishing a special committee on postwar economic policy and planning to gather and assess information to prepare Congress to make the principal contribution to "the achievement of a stable economy and a just peace."[71] On March 12, the Senate established a 10-man committee with George as its chairman. Senator George favored creating employment opportunities by free enterprise rather than by the Federal Government's "pump-priming" that marked the last decade. Not to be outdone, Representative Everett M. Dirksen (R–IL) immediately asked his colleagues to set up a committee similar to the one led by Senator George. Four days later, Senators Joseph H. Ball (R–MN), who supported Donald Nelson's appointment to the WPB, Harold H. Burton (R–OH), Carl Hatch (D–NM), and Joseph L. Hill (D–AL) reported the resolution they had been delegated to prepare for committing the United States to participate in an international organization. Their resolution proposed that America take the initiative in calling meetings for the purpose of forming an organization of united nations. The new organization would have authority to aid in prosecuting the war, administer Axis-controlled areas as they were liberated, manage relief and assistance in economic rehabilitation, establish means for peacefully settling international disputes, and assemble and maintain its own military force. After the House Appropriations Committee eliminated the appropriation for the National Resources Planning Board in August 1943, President Roosevelt placed the burden and responsibility for continued planning entirely on Congress. In response, the legislators did not rush to organize the international body.

A shift in prosecuting the war while planning for the coming peace also occurred in the USGS before the end of February 1943. Walter Mendenhall, the agency's Director since 1930, retired officially on February 27, after more than 48 years of service. Mendenhall reached the mandatory retirement age of 70 on February 20, 1941, but President Roosevelt twice extended Mendenhall's appointment for another year.[72] Secretary Ickes decided against asking for a third extension so that he might have a hand in selecting the Director who would plan for and lead the postwar USGS. Mendenhall guided the agency through the Great Depression of the 1930s and into the turbulent war years. Mendenhall's Quaker background made the latter task more difficult for him, but he acted on his assertion at a congressional hearing that "The effort of every individual and of every agency, legislative or executive, we know must be thrown completely into the war effort."[73]

Geologist William Embry Wrather (1883–1963) worked for the USGS in 1907 and then convinced wildcatters in Texas of geology's value in finding oil. His 1918 Desdemona field was the largest discovery in the State since Spindletop. Wrather served in 1942 as Alan Bateman's deputy in the Board of Economic Warfare's Metals and Minerals Division before succeeding Walter Mendenhall as USGS Director in 1943. During the next 13 years, Wrather and Thomas Nolan completed major reorganizations of USGS Branches (later Divisions) to incorporate recent scientific and technological advances and to respond to increased wartime needs. They established the USGS Science Advisory Committee and opened three new regional field centers but avoided creating regional directors and kept the chiefs of the program divisions in Washington. In 1950, they succeeded in restoring USGS block funding (discontinued since 1888) under the aegis of surveys, investigations, and research. Wrather, increasingly ill, retired in 1956. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0309, https://www.sciencebase.gov/catalog/item/51dda276e4b0f72b4471df5d.)

Mendenhall's directorship may well have been the most important in the agency's first century. Under his guidance, the USGS position as a research institution was firmly established, so solidly that subsequent challenges before 1979 proved to be only temporary. In reporting Mendenhall's retirement, the *Engineering and Mining Journal* gave him this accolade:

> **To have combined outstanding achievement in science with a long record of devoted public service is an accomplishment worthy of any man's respect. To these attainments, Dr. Mendenhall has added another: he provided for the men who have worked under his direction an environment in which scientific research, technical integrity, and practical skill could flourish, to the enrichment of all mankind.[74]**

Pending the appointment of Mendenhall's successor, Ickes selected Julian Sears, USGS Administrative Geologist since 1924, as Acting Director, to repeat Sears' earlier service on the occasions when Mendenhall was ill, traveling, or serving as Acting Assistant Secretary or Acting Secretary of the Interior. The Association of American State Geologists (AASG) held its annual meeting in the Director's Conference Room one week before Mendenhall's retirement. The meeting's attendees recommended to Ickes that the new

> **Director should be a geologist recognized for his integrity, high, unquestioned professional standing in Geology, proved administrative ability, and appreciation of technologic advancements and industrial needs. In addition, the State Geologists place a high value on the ability of the Director to cooperate with the States, and on such relationships today in war, and tomorrow in peace, such as the present Director has maintained.[75]**

Mendenhall, before departing as Director in 1943, appointed new Chiefs of two of the four operating Branches of the USGS, following similar action by Director Charles Walcott in 1907 before he left the agency to become the Smithsonian's fourth Secretary. The USGS Conservation Branch acquired a new Chief, following the death of Herman Stabler during November 1942. Hale Soyster, Chief of the Branch's Oil and Gas Leasing Division, replaced Stabler on February 8, 1943, and began reorganizing the Branch. John Northrop, who served as the Conservation Branch's Acting Chief during the interim, returned to his duties as Assistant Chief. Harold J. Duncan, who supervised the Branch's Rocky Mountain (later Northwestern) District, from its headquarters in Casper, Wyoming, succeeded Soyster in Washington. On March 18, Thomas Pendleton, Chief of the Topographic Branch's Photographic Mapping Section since 1941, became Chief Topographic Engineer, and John Staack, the former Chief, was reassigned as Assistant Chief. Charles H. Davey ended his tour as the head of topographic surveys in New England and came to Washington to lead the Branch's Photographic Mapping Section.

On April 9, 1943, President Roosevelt submitted the name of William Wrather to the Senate for confirmation as the sixth Director of the USGS. Wrather recalled his service as an assistant packer with a USGS field party in 1907 as "one of the most glorious summers I ever spent in my life";[76] after that experience, he completed his bachelor's degree and then studied law at the University of Chicago. Now, Wrather still served as Bateman's Associate Chief, at $6,500 per year, of the War Production Board's Metals and Minerals Division, but he had spent most of his career outside the Federal Government as a petroleum geologist in Texas.[77] Wrather, like Director George Otis Smith, was not a member of the National Academy of Sciences, but Wrather had presided over the American Association of Petroleum Geologists, whose Committee on Research he also led, and the Society of Economic Geologists, whose journal *Economic Geology* he also helped to edit. In addition, Wrather had been vice president of the GSAm, served on the Executive Committee of the American Association for the Advancement of Science (AAAS), and chaired the AIMME's Petroleum Division. Although Wrather publically supported Herbert Hoover's candidacy for President and "disagreed personally with so many aspects of the New Deal," he agreed with Secretary Ickes' "expressed opinion that politics should not be a factor in choosing a Director for the Survey."[78]

Secretary Ickes, in announcing Wrather as his candidate for the Director's appointment, said that "Wrather's name had been proposed * * * by a number of prominent geologists and scientific organizations, including a committee of the National Academy of Sciences especially appointed for this purpose"[79] at Ickes' request. Ickes initially asked Donald H. McLaughlin, a geologist and mining engineer then serving as dean of the College of Engineering at Berkeley, to consider succeeding Mendenhall. When McLaughlin demurred, Ickes turned for advice to geographer Isaiah Bowman, JHU's president and NAS vice president since 1941. Bowman, former vice chairman of Roosevelt's Science Advisory Board, chairman of the National Research Council (NRC), and adviser to Secretary of State Hull, suggested that Ickes ask the NAS for a list of candidates. Beginning with Director King's appointment in 1879, Presidents and Interior Secretaries asked individual members of the NAS for their opinions on selecting scientists to lead the USGS, but Ickes' decision to accept Bowman's idea marked the initial request to the NAS as a body. Ickes asked the NAS to recommend persons "who had high administrative ability as well as sound scientific and technical competence."[80] The NAS appointed a committee chaired by Massachusetts Institute of Technology (MIT) economic geologist Warren J. Mead, Bowman's immediate predecessor as NAS vice president and coauthor with Charles Leith of a metamorphic-geology textbook published in 1915. Mead's committee included Bowman; Stanford geologist Eliot Blackwelder, part-time with the USGS during 1901–18; University of Chicago geologist Rollin T. Chamberlin, with the USGS during 1905–07; geophysicist Arthur L. Day, with the USGS during 1900–07 and then head of the Carnegie Institution of Washington's (CIW's) Geophysical Laboratory (GL) until 1936; the ever-present Leith; and Chester Longwell. Of at least four candidates, "Wrather was number one on the list provided by that body."[81]

It is also likely that the Petroleum Administrator for War and his Assistant Deputy Administrator influenced the Secretary of the Interior in his selection on April 7, 1943, of a petroleum geologist as President Roosevelt's nominee for USGS Director. The oil situation was becoming progressively more difficult, and Ickes claimed that America was "running out of oil."[82] DeGolyer came to Washington in 1942, toured Mexico for Ickes, and advanced to be Ralph Davies' principal aide as Assistant Deputy Coordinator (later Administrator). When Wrather's "friends on the outside of government"[83] also promised their support, he accepted Ickes' offer. Wrather saw the USGS directorship principally as an "opportunity to participate in a continuing program of geological research."[84] Ickes, in recommending Wrather to Roosevelt, also assured the President that Texas Senator Thomas Connally would not oppose Wrather's appointment. Roosevelt nominated Wrather on April 9. A week later, the AASG suggested that FDR's selection

> **should meet with hearty approval of geologists, for Mr. Wrather is well and favorably known throughout the profession, especially among those engaged in the search for petroleum, for that has been his principal field of activity. However, Mr. Wrather's interests and perceptions are broad enough to comprehend efficiently and sympathetically the entire scope of the work of the U.S.G.S.[85]**

Wrather's nomination joined the Senate's consent calendar and he was not asked to appear before a committee prior to his confirmation as the fifth Director

Geologist Julian Ducker Sears (1891–1970) joined the USGS full time in 1919 just after earning his Ph.D. at Johns Hopkins. He passed from studies of manganese ores in Costa Rica and Panama to investigations of regional geology, geomorphology, and energy resources in the Rocky Mountains of Colorado, New Mexico, Utah, and Wyoming. In January 1924, Sears succeeded Philip Smith as Administrative Geologist, and the Director's principal assistant, with full authority to act in duties the Directors specifically assigned. Sears also occasionally served as Acting Director and he represented the Director's Office on and chaired the Publications Committee from its founding in 1949. Sears requested and was granted a return to full-time research and publication in 1953. (Photograph from Bradley, 1973.)

of the USGS on May 3. Wrather took his oath of office 4 days later. Wrather, well aware that he "was the first Director to be chosen from outside the Survey,"[86] immediately asked Julian Sears to invite the Washington-area staff to headquarters to meet him as part of a day-long "open house." On July 10, Regional Geologist Harry Ladd, writing from Rolla to Josiah Bridge in Washington, noted Bridge's opinion that "Mr. Wrather is going to make a good Director and an aggressive one." Although Ladd added that he had "yet to hear a single item of unfavorable criticism about our new Director,"[87] members of the USGS Pick and Hammer Club reserved opinion until they resumed the club's annual shows.

By May 1943, coal rather than oil remained uppermost in Secretary Ickes' thoughts in his capacity as Solid Fuels Administrator for War. Hardly a week passed since the beginning of the year without some kind of labor crisis, but those in the bituminous-coal mines proved among the most troublesome. When 15,000 coal miners began a wildcat strike early in January, Roosevelt ordered them back to work. When the 2-year contract between miners and operators neared expiration in the spring, union chief John L. Lewis, who signed a no-strike pledge, challenged the economic-stabilization plan by demanding a $2-a-day increase in wages. The miners walked out again late in April and refused the President's request to return to work. On April 19, an Executive order changed Ickes' title from "Solid Fuels Coordinator for War" to "Solid Fuels Administrator for War," with commensurately greater authority and responsibilities.[88] On May 1, Roosevelt authorized Ickes to take over the mines if necessary. The next day, only 20 minutes before the President's scheduled radio address to his fellow Americans, Lewis ordered the miners back to work for 15 days. On May 3, Ickes proclaimed a 3-day week, which effectively raised wages; most of the miners returned to work by the next day. They struck again when the War Labor Board refused to authorize the increase in pay. On November 9, Ickes established Interior's Bituminous Coal Advisory Committee,[89] and the 78th Congress also intervened to try to assure continued adequate supplies of domestic coal. Senator Connally's bill, making a penal offense any strike or incitement to strike in the federally controlled war industries, passed the Senate by a large majority. The House considered an even harsher measure. Early in June, both houses approved the compromise Smith-Connally bill. Although Roosevelt vetoed the legislation, because it conflicted with labor's no-strike pledge, Congress passed the bill over his veto by a wide margin. In spite of the new War Labor Disputes Act[90] and the President's order to draft miners, the back-to-work movement yielded sporadic results.

As William Wrather became USGS Director, the House continued to consider the Interior Department's appropriation bill introduced in March for fiscal year 1943–44. The President's budget recommended an Interior appropriation two-thirds less than the funds approved on July 2, 1942, but the USGS share of $4,543,000 for 1943–44 represented just a 3-percent reduction. On March 26, 1943, Acting Director Julian Sears and Director Emeritus Walter Mendenhall led the USGS delegation to hearings held by the Subcommittee on Interior Department of the House Committee on Appropriations. Chairman Edward Taylor died in September 1941, and Oklahoma's Jed Johnson (Sr.) now led the subcommittee, whose new members included Michael J. Kirwan (D–OH), William F. Norrell (D–AR), and Benton F. Jensen (R–IA). At the Department's hearings earlier in March, Chairman Johnson asked the members of his subcommittee to "make every effort to cut these [Interior's] requests to the bone without seriously impairing the efficiency of the various departments and agencies."[91] He also refused to consider seriously "any and all new projects pending the duration of the war."[92]

The USGS hearings sparked no animated discussion; the subcommittee only nibbled at the budget items and recommended to the Committee on Appropriations that it approve nearly $4,475,000 for the USGS. On May 20, Johnson reported to the House that his subcommittee urged "a total cut of only $72,702" because a "considerable portion of the work of the Survey is of direct value to the war."[93] The House passed the Interior Department's funding bill later that day, following the recommendations of Johnson's subcommittee as approved by the Appropriations Committee. President Roosevelt and Secretary Ickes sent to the Senate a request for supplemental appropriations for Interior that included $300,000 to enable the USGS to "conduct an intensive geologic search for supplies of petroleum and natural gas,"[94] $40,000 for the agency's supervision of mineral leasing, and more than $124,000 for investigations of Alaskan mineral resources. The USGS required additional monies for its work in Alaska because the WPB did not transfer funds to the USGS for war-minerals studies in the Territory as the House anticipated when its members held the budget hearings.

Director Wrather led the USGS delegation when the Senate subcommittee began its hearings about the agency's appropriations on May 28, 1943. Ohio's Harold Burton joined his Republican colleagues on Carl Hayden's subcommittee. The USGS request for an additional $300,000 for oil and gas investigations immediately became the center of interest. Wrather explained that appropriation would "enable the Geological Survey to resume its work in oil geology." When the war began, it seemed that all the oil required for a war of any duration was available and most USGS geologists were more urgently needed for work on strategic and critical minerals. Now it became apparent that every effort must be made to discover new fields. "New discoveries for the past several years," Wrather continued, "have been quite inadequate to replace current withdrawals and we are faced with the problem of finding large supplies of oil." The USGS, he added, must "resume its geologic investigations relating to oil."[95] That required additional funds and geologists. Senator Hayden questioned the amount requested for the new studies and quickly learned that the USGS originally asked for $1,065,000 for geologic surveys—including $675,000 for searches for new supplies and $390,000 for background studies to aid secondary recovery—an additional $175,000 for classifying the public lands, and an extra $164,725 for supervising mineral leases. The Bureau of the Budget approved only the $300,000 for searches for new supplies and $40,000 for monitoring mineral leasing. The question then became one of personnel. Were people available and, if so, could the USGS find and hire them? Support existed for the USGS contention that geologists were available despite personnel shortages. As for the agency's ability to employ them, Arthur Baker of its Fuels Section mused that "If you have the money, you can try."[96] If additional geologists were found and hired, the USGS expected to prevent those younger than age 37 from being drafted. In July, William Rubey reported that of the 230 short-term deferments requested for the 306 men in this category, representing two-thirds of the geologic staff, only 17 requests had been denied and 14 of those successfully appealed.

As the discussion progressed, Patrick A. McCarran (D–NV) who also chaired the Judiciary Committee and its Subcommittee on Appropriations for the Commerce, Justice, and State Departments, queried Wrather about past estimates of America's oil resources. McCarran, observing that in years past, investigations by the USGS and other organizations indicated that the United States has ample oil for any contingency, asked "Were all those studies erroneous? Were they all wrong?"[97] Wrather replied that

> **[n]obody seems to have anticipated a daily domestic production approaching 4,000,000 barrels of oil. I remember very well when I first heard of a million barrels a day. That seemed like an enormous figure. The needs of the Nation and our allies have gone up and up because of war demands until all previous figures have been completely outdistanced.[98]**

The Senate subcommittee asked the USGS to come back with a supplemental request that included the disallowed items. The revised request, presented on the next day of hearings, included $500,000 for oil and gas investigations, combining the search for supplies and geologic investigations as a basis for secondary recovery; $175,000 for classifying mineral lands; and more than $164,000 for mineral-leasing activities. The subcommittee wrestled with the problem of expanding USGS funding, not wanting to appropriate money that could not be used or to skimp. Its members finally recommended to their colleagues the increase of $500,000 to a total of $1,380,000 for geologic surveys, including those for oil and gas, and appropriations of $275,000, almost $170,000 more, for public-land classification and more than $550,000, up by about $211,000, for mineral-leasing supervision.

Discussion of the Alaskan supplemental request naturally included the question of developing oil in the Territory. Difficulties of transportation, remoteness, rigorous climate, and economic considerations thus far prevented any development of Alaska's oil potential. As in Hawaii, every drop of oil used in Alaska needed to be shipped into the Territory. Philip Smith, the Chief Alaskan Geologist, told the Senators on May 31 that "showings of oil"[99] were known to be present in the 37,000 square miles of Naval Petroleum Reserve No. 4, where he personally conducted some of the exploratory work some 20 years earlier, but that its development posed serious problems involving personnel and equipment. Smith pointed out that attempts to explore for, locate, and develop oil fields in NPR–4 would face the same problems that the Army encountered in initiating similar work in adjacent Canada, in an area of comparable geography and geology. Following Lt. William Foran's recommendation, a USBM party, including geophysicist Henry R. Joesting (of the Alaskan Territorial Department of Mines) and an Army Engineer Captain, traveled by light plane to NPR–4 and other areas in Arctic Alaska late in the summer of 1943. "The group visited the known seepages, including those at Cape Simpson, * * * [and] three [new] small seepages near * * * Umiat,"[100] on the Colville River, about 130 miles to the southeast.

The increasing demand for crude oil encouraged the Senate subcommittee and the whole Senate to approve the additional funds for work in Alaska. The conference committee compromised on a USGS appropriation that included $1,187,500 for geologic surveys, $307,500 more than the House bill, $150,000 for Alaskan mineral resources, up by $76,000, $224,00 for public-land classification, an increase of $130,000, and $475,000 for mineral-leasing supervision, up by $145,000. In the bill approved on July 12, 1943, the USGS received just over $5,143,000 in direct appropriations,[101] or about 12 percent more than the amount in the President's budget. With transferred and repaid monies, the USGS received in fiscal year 1943–44 a total of some $11,585,000, a $456,000 increase over fiscal 1942–43, for salaries for and operations by its staff of more than 2,400 full-time people and another 500 seasonal workers.

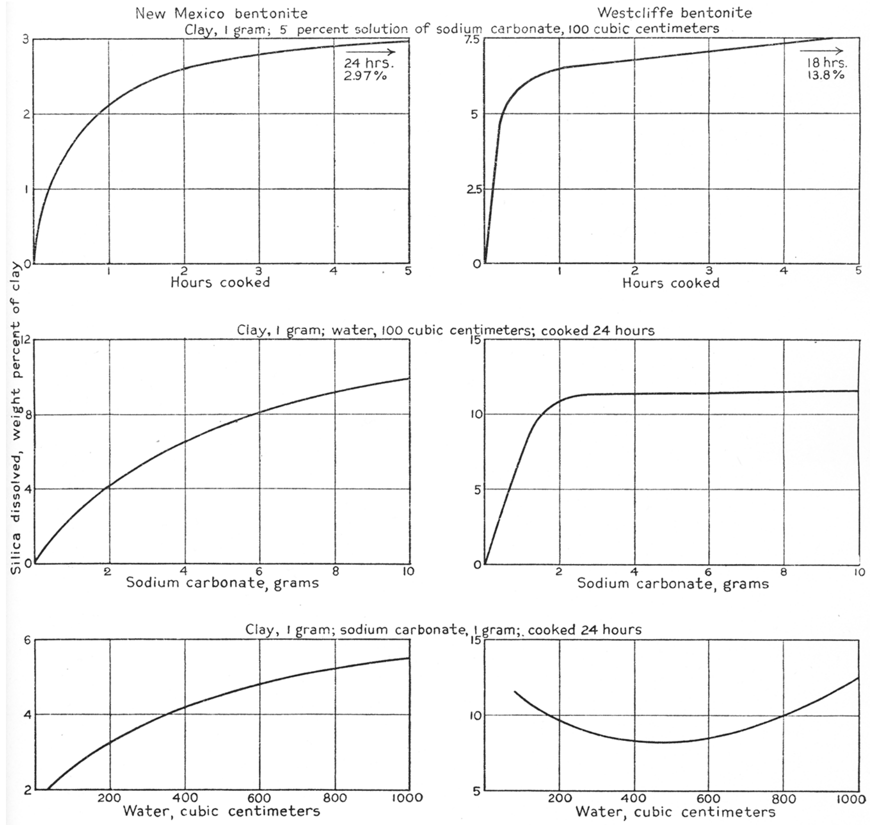
As Wrather began to lead the USGS, the Allies' campaign in North Africa neared its end, and in the Pacific, their forces regained the western Aleutians and prepared to continue advances in New Guinea and the Solomons. Hitler ordered an ailing Rommel out of Tunisia in March, but the Führer could not save the Axis ground troops there. On May 7, American ground forces, now under Major General Omar N. Bradley, captured Bizerte. General Montgomery's British units took Tunis. The Luftwaffe pulled out and Italo-German resistance ended on May 13; 250,000 Axis troops surrendered, a loss almost as great as that at Stalingrad. Two days earlier, American and Canadian forces landed on Attu in the Aleutians. The Allied soldiers repelled a ferocious suicide charge and completed the island's recapture on May 29 but at the cost of nearly 1,700 casualties. From now-isolated Kiska, the Japanese secretly and successfully evacuated their garrison on July 29. The entire Aleutian chain returned to American control when American and Canadian forces occupied Kiska on August 15.

Wrather knew that the USGS was "committed to a war program, and its work was pretty well defined as long as the war lasted."[102] The Geologic Branch received a total of $2,624,000 in fiscal year 1943–44, which was $708,000 more than in the previous year. The USGS geologic program took on another new orientation, drawing on the year's total funds for geologic surveys of nearly $1,853,000, some $678,000 more than the past year. The Fuels Section's staff grew from fewer than 20 to 100 persons, justifying Arthur Baker's optimism about its ability to hire oil geologists. Hugh Miser, in meetings with a number of petroleum-industry people, determined that they wanted as aids in developing new supplies the rapid publication of USGS regional stratigraphic and structural studies as a framework for their own detailed investigations. Fuels Section personnel began in 23 States these new regional studies of the distribution of potentially oil-bearing formations and broad areas where conditions might have led to accumulating petroleum. These investigations targeted areas in California, the Rocky Mountains, the northern Great Plains, the Mid-Continent, the Mid-South, the Gulf of Mexico Coast, the Michigan Basin, and the Appalachians. Before the end of the fiscal year, a newly devised and more rapid method of publication led to the results of these studies being issued in 10 preliminary Oil and Gas Investigations Maps (OM) and Charts (OC), beginning with Thomas Hendricks' [OM]–1, on the geology of the Black Knob Ridge area in southeastern Oklahoma, and Ralph Stewart's [OC]–1, on a biostratigraphic study of the Coalinga anticline in central California. Other geologists mapped sands and asphalt deposits in Oklahoma and California deemed to have considerable potential as sources of petroleum and made preliminary examinations of deposits in other States in cooperation with the USBM and the PAW. Fuels Section geologists continued to investigate coal deposits, mainly in the Western States, where expanded war-related activities increased demands for coking and steam coal. They also undertook detailed mapping in Alabama, Colorado, Nevada, and Oregon, in conjunction with exploratory drilling by the USBM, and also examined other coal deposits in Oklahoma and Washington.

Geologic Branch personnel also continued strategic-mineral investigations in the southeastern and western manganese districts; California's mercury deposits; tungsten districts in California, Idaho, and Nevada; and the vanadium districts of southeastern Idaho and the Colorado-Utah area. These studies drew on the $771,000 (which was $30,000 more than in fiscal year 1942–43), provided by direct, deficiency, and transfer appropriations. The growing success of the Allied antisubmarine campaign during the winter of 1942–43 made it possible to import larger quantities of some essential minerals. By the fall of 1943, as Alfred E. Eckes, Jr., and other historians observed, the demands for domestic sources of some of these minerals began to fall, but domestic reserves of some of the common metals were being seriously depleted. In response, the USGS gradually shifted more of its geologists to work in districts with good prospects for locating new deposits and developing significant reserves of these common metals.

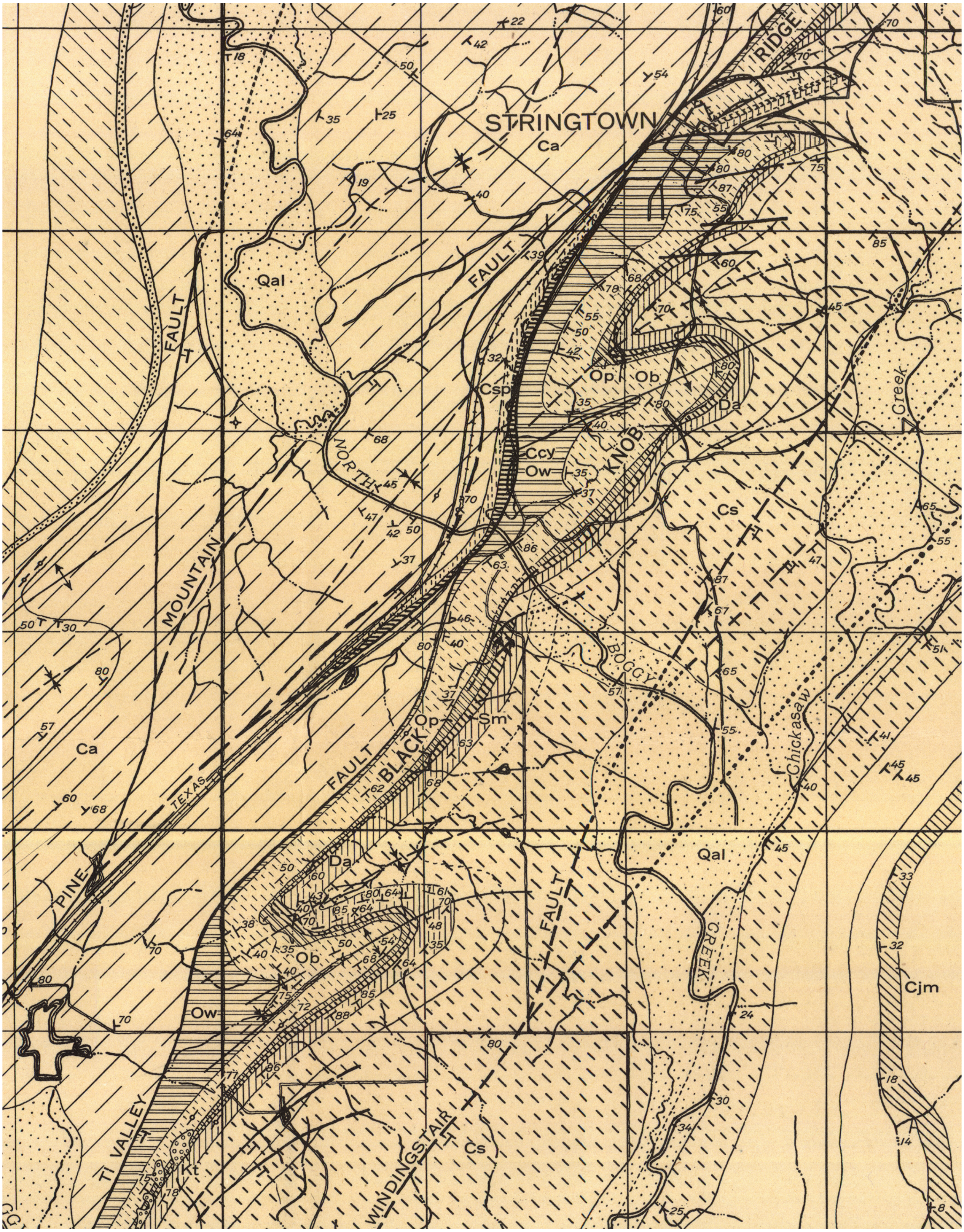
Resources of iron ore, aluminum ore, and fluorspar by now were matters of grave concern. The Geologic Branch carried out studies of iron-ore deposits in more than 50 separate areas in 20 States. Harold James and other Branch geologists began a long-range program in northern Michigan, including the Iron River and Crystal Falls districts, to determine the quantity and distribution of undeveloped low-grade ores and try to discover additional high-grade ores beneath glacial drift. At the same time, curtailed shipments from the Lake Superior region emphasized the need for further development of resources in the Eastern and Southern States; work in New York concentrated on deposits in the Adirondack and Highland regions. The growth of the steel industry in the West, including the establishment of federally aided plants, called for intensive efforts by the USGS, particularly in

This diagram by mineralogist Perley G. Nutting shows the amount of silica from six bentonites dissolved by dilute acid and alkaline solutions. Clays are used widely in ceramics, decolorizing oils, drilling muds, fertilizers, fungicides and insecticides, molding sands, and water softeners, and they are catalysts in producing fuels from petroleum. Nutting served with the National Bureau of Standards and Eastman Kodak before joining the USGS in 1925, where he studied the identification, distribution, physico-chemical properties, products, and uses of absorbent (bleaching) clays to determine the most economical treatments. Low-grade or impure clays, he found, could not be upgraded by chemical means. (From Nutting, 1943a, pl. 13; see also Nutting, 1943b.)



the southeast Utah area considered the most urgent by the Metals Reserve Company. Aided by $317,000 transferred from the USBM from its $1,860,000 for work on bauxite and related deposits, Preston Cloud, Jr., and other Branch geologists continued detailed surveys of bauxite in nine areas in the Gulf of Mexico Coastal Plain. The cooperative drilling program by the USBM and the USGS in Saline and Pulaski Counties, Arkansas, delimited more than 11 million tons of bauxite of commercial grade. Their colleagues conducted nationwide searches for other sources of aluminum and for magnesium and included studies of alunite, high-alumina clay, brucite, dolomite, and magnesite. As war uses of fluorspar nearly depleted the known resources, the three USGS parties established in 1942 continued work in the Kentucky-Illinois district and Tennessee, in Colorado, Idaho, Washington, and Wyoming, and in Arizona, New Mexico, and Texas. A new fourth party began studies in California, Nevada, and Utah, and temporary groups initiated work in northern Idaho, northwestern New Mexico, and Montana.

The status of copper, lead, zinc, and other commodities also became critical, and some substitutes were used. To save copper for war use, in October 1942 the WPB ordered U.S. gold mines closed for the duration and the U.S. Mint began producing, in February 1943, the zinc-coated steel pennies authorized by statute in December 1942. USGS geologists began or renewed studies in virtually all of the copper-mining districts of the country, including the Foothills Belt of California, Globe in Arizona, and areas in Michigan. They also initiated lead-zinc projects in areas in a dozen States, including the Metaline district in Washington, the Pioche and Goodsprings districts in Nevada, Eureka in Utah, and those in southwestern Wisconsin and eastern Tennessee. More than 250 pegmatite deposits containing sheet mica, beryllium, tantalum, lithium, and feldspar were examined in 13 different States, after which the USGS recommended several for additional exploration by the USBM. Other commodities investigated included asbestos, corundum, graphite, potash, quartz crystals, talc of insulator grade, and vanadium. Work also progressed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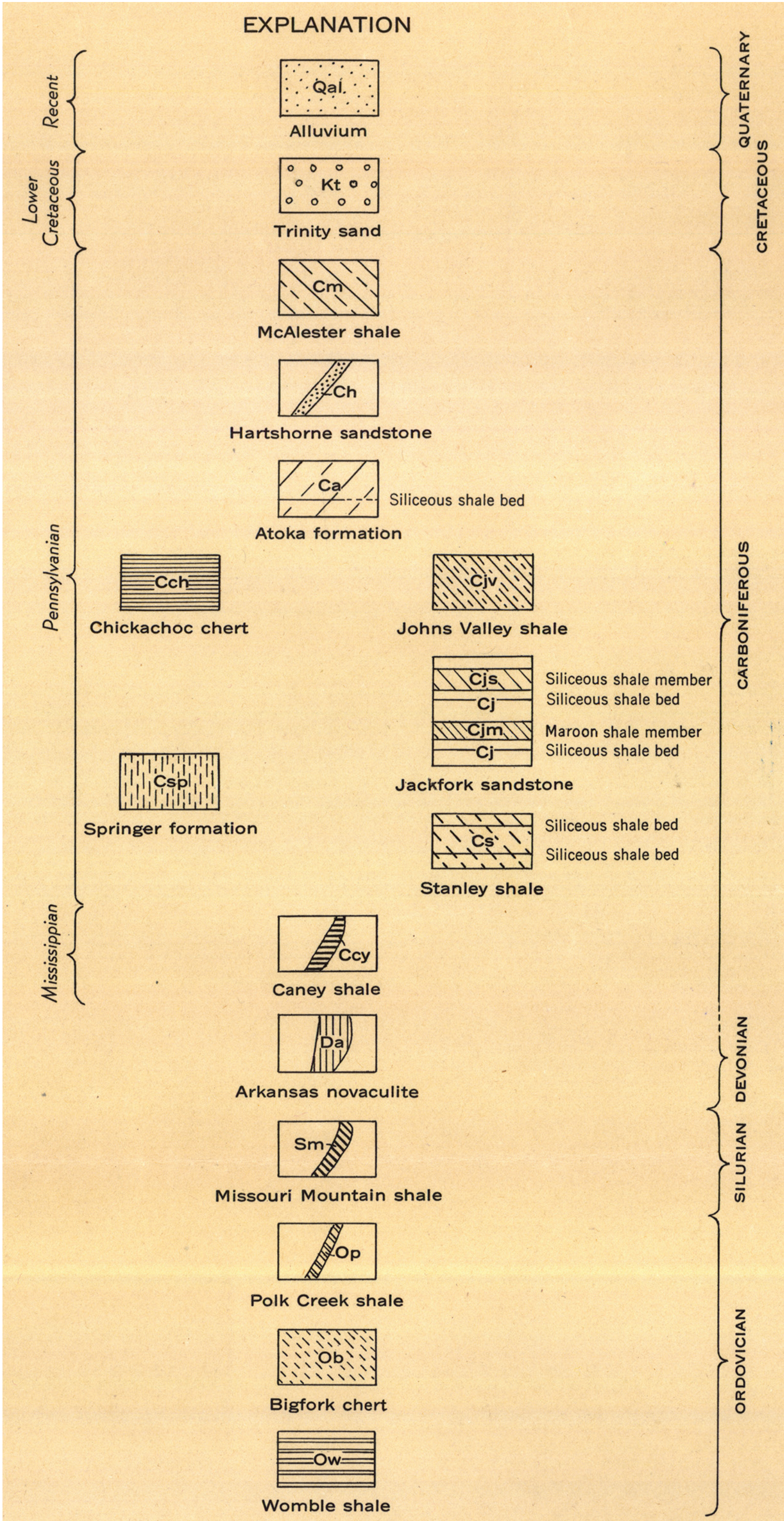
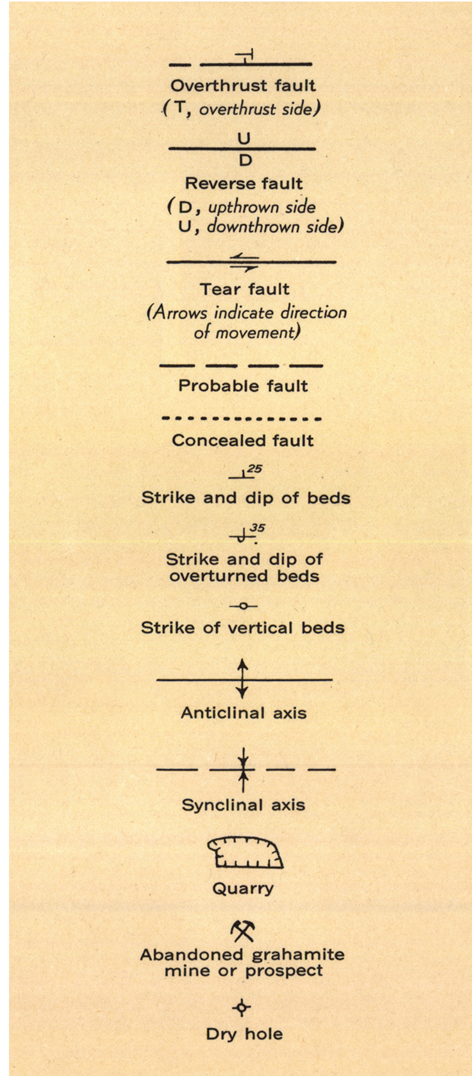
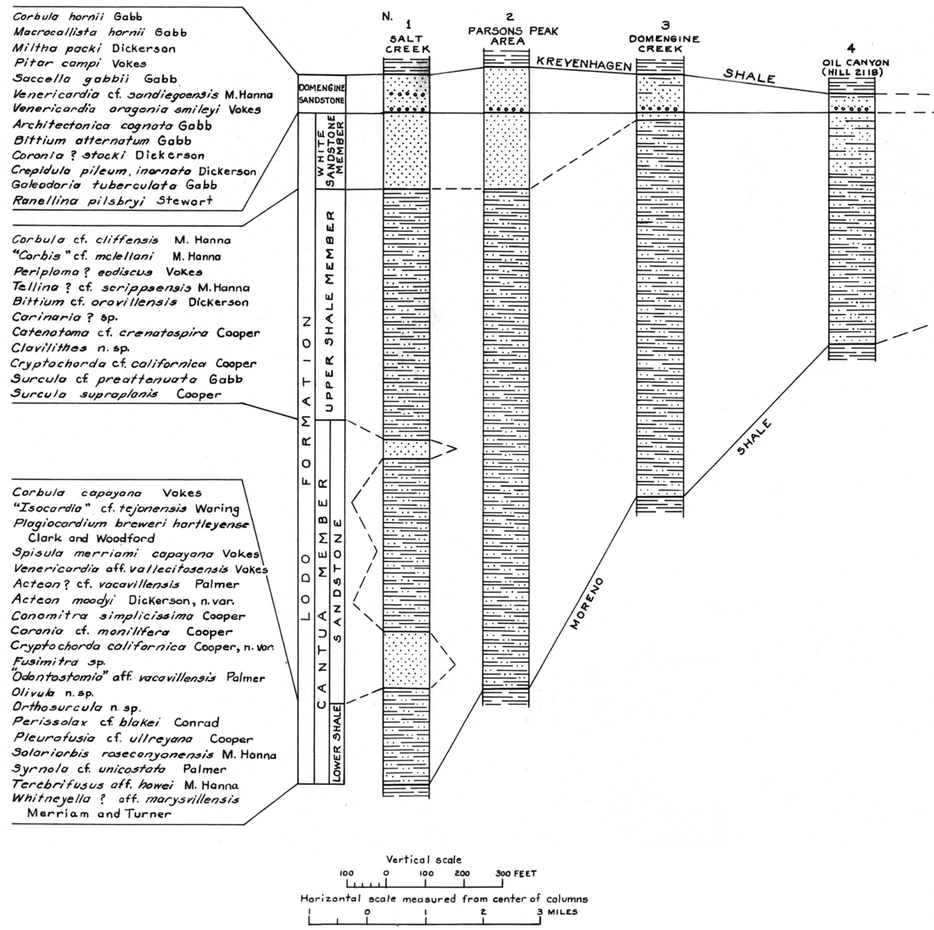
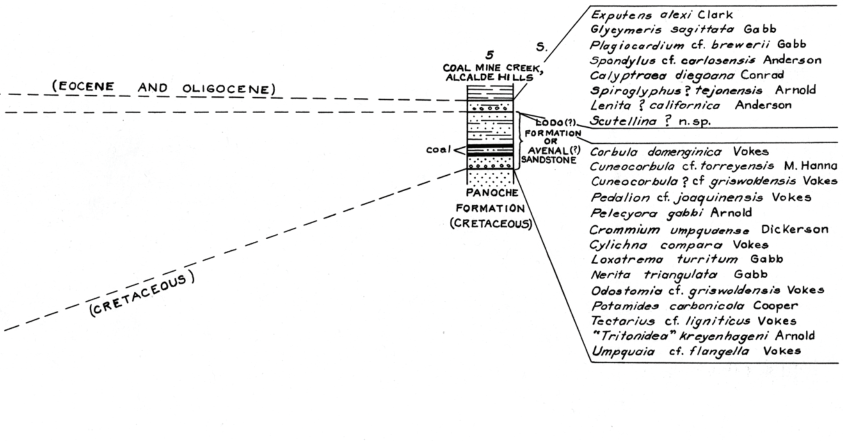
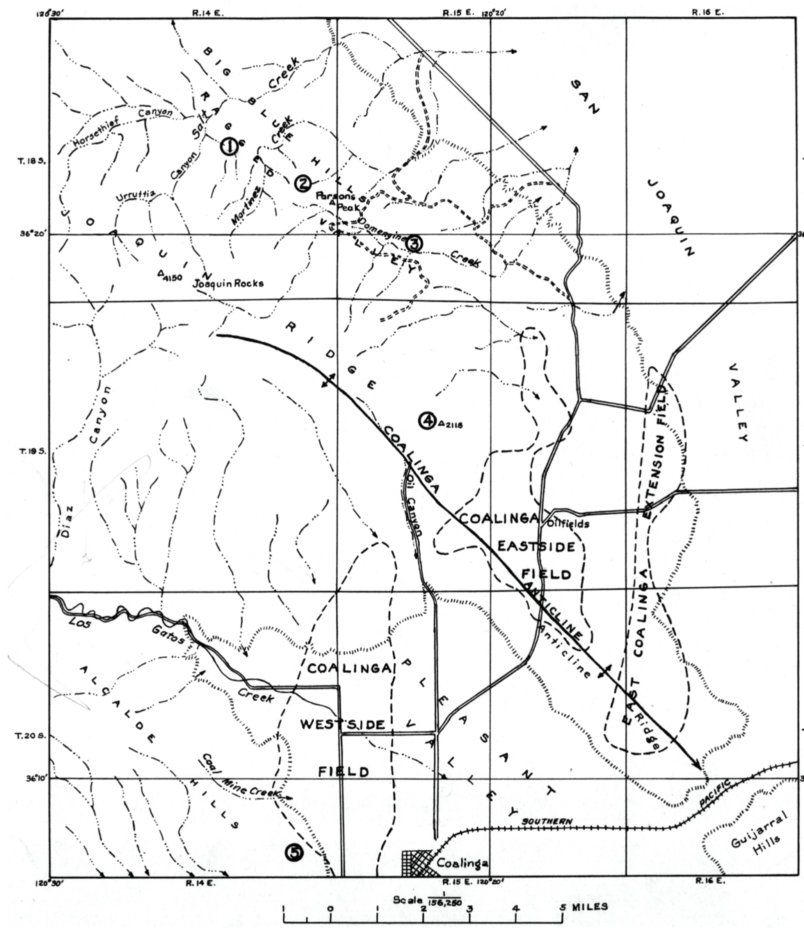




This portion of the geologic map (at 1:42,240 and originally on white stock) of the Black Knob Ridge area (facing page), in Oklahoma's Atoka County, shows the major folds and faults that divided the area, located at the western end of the Ouachita Mountains, into several structural blocks. The east-to-west increase of carbon ratios in the adjacent Arkansas-Oklahoma coal basin and the equivalent decrease in "the porosity of potential oil bearing horizons" in deep wells east of the coal basin's oil fields indicated that the best petroleum targets would be the anticlines "adjacent to the Choctaw fault [just west of the area shown in this part of the map] * * * near its west end, or the part in the Black Knob Ridge area." Each square of the map's grid represents a section (1 square mile) of the cadastral survey. The map sheet also contained an explanation (above), a geologic section (along the northwest to southeast line), text, and a correlation diagram. This map was the first published in the new series of USGS Oil and Gas Investigations Preliminary Maps and reflects the increased emphasis by the USGS on petroleum geology after Secretary Ickes chose William Wrather to succeed Walter Mendenhall as Director. (From Hendricks, T.A., 1943.)

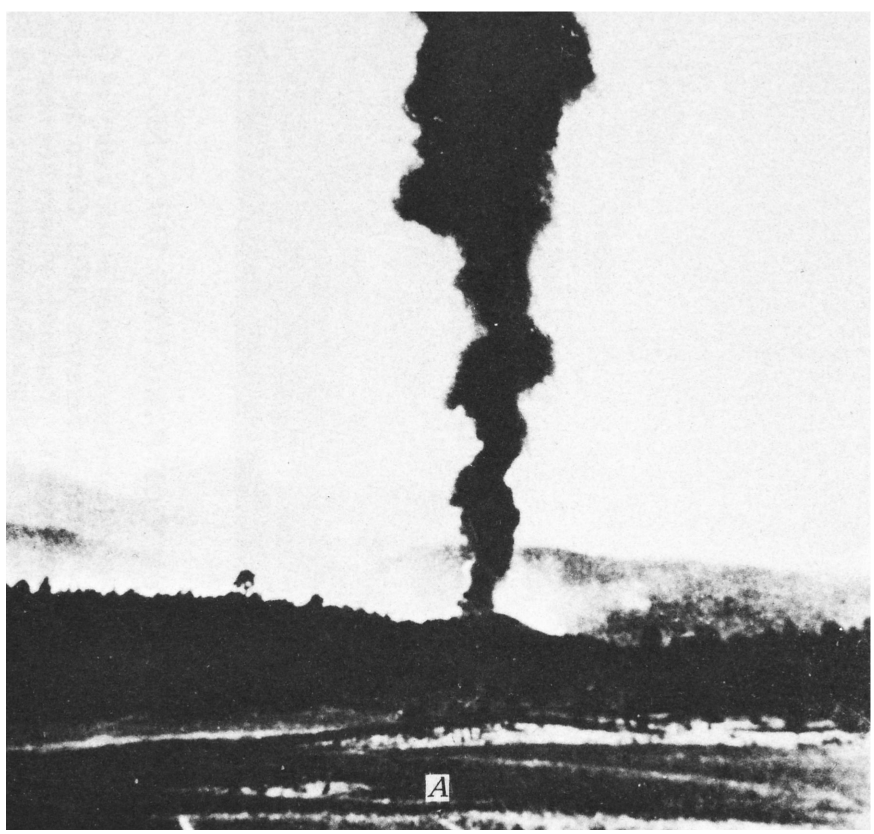


This correlation chart shows the Eocene formations and key macroinvertebrate fossils (mostly gastropods and bivalves) from strata exposed in areas near the southeast-plunging Coalinga anticline on the west side of California's San Joaquin Valley. In preparing this chart, geologist Ralph Stewart drew on his own studies and those of his colleagues in the USGS and in academia. This excerpt is reduced; Stewart presented the correlation diagram at about 1:110,000 (horizontal scale) and about 1:3,200 (vertical scale) and the location map at 1:156,250. Miocene strata in the Coalinga anticline began producing petroleum in 1901. The discovery of oil in 1937–38 in Eocene formations in the Kettleman Hills, to the southeast along the anticlinal trend, and in the Coalinga Eastside field increased exploration activity in the area. By about the same time, other paleontologists had convinced the petroleum industry of the value of foraminifers and other microfossils obtained from well cores in dating and correlating subsurface strata. This chart was the first published in the new series of USGS Oil and Gas Investigations Preliminary Charts. (From Stewart, Ralph, 1944.)

in the Almaden and Oat Hill mercury districts in California and on the tungsten deposits in three districts—Pine Creek in California, Yellow Pine in Idaho, and Mill City in Nevada.

John Dorr, Montis Klepper, William Pecora, Ralph Roberts, Frank S. Simons (Jr.), and other USGS geologists continued or began investigations of strategic and critical minerals in nine Caribbean and Latin American countries during fiscal year 1943–44, drawing on the $74,000 transferred by the State Department or working on detail to the Board (later Office) of Economic Warfare, and the latter's successor, the Foreign Economic Administration (FEA), founded in the Office for Emergency Management by Executive order on September 25, 1943.[103] The FEA entirely sponsored similar investigations, supervised by Alan Bateman, of the mineral resources of Colombia, Costa Rica, Guatemala, Honduras, Nicaragua, and Panama by Earl M. Irving, Chief of the FEA's Minerals and Metals Mission to Central America since 1942, and USGS geologists on detail to the FEA or others employed by that agency. Irving spent the months between September 1942 and August 1945 studying copper deposits in Guatemala and Costa Rica and chromite and iron occurrences in Guatemala. From January 1944 through August 1945, Irving also worked with Roberts on antimony, copper, and iron in Guatemala. Roberts investigated iron, mercury, and silver in Honduras during 1943. Simons studied manganese in Panama between July 1943 and June 1944.

The USGS also continued to draw on the Smithsonian Institution's staff for its strategic-minerals work in Latin America. William Foshag pursued his cooperative studies of mercury, tin, tungsten, and other strategic minerals in Mexico during 1943, aided by USGS geologists Carl Fries, David Gallagher, James McAllister, and Donald White and USGS topographer Kenneth Segerstrom. These geologists all gained additional experience during the development of a new volcano. On February 20, 1943, after 2 weeks of seismic tremors, a volcanic eruption began in a cornfield just southeast of Parícutin Village, some 20 miles from Uruapan in the



This view looking southwest shows Parícutin Volcano on February 21, 1943, one day after its eruption began in a cornfield just southeast of Parícutin Village, some 20 miles from Uruapan in the State of Michoacán and about 200 miles west of Mexico City. In this short time, the new cone (just to the right of center at the base of the eruptive column) reached a height of nearly 100 feet and grew rapidly thereafter as the volcano ejected bombs, lapilli, and lava. Ezequiel Ordóñez, Chief Geologist of Mexico's Comisión Impulsora y Coördinadora de la Investigación Científica, began photographing the volcano on February 24 and, with USGS geologist Donald White, began studies of the volcano on March 25. (Photograph by Salvador Ceja, from Foshag and González-Reyna, 1956, pl. 17*A*.)

State of Michoacán, and about 200 miles west of Mexico City. Ezequiel Ordóñez, Chief Geologist of Mexico's Comisión Impulsora y Coördinadora de la Investigación Científica, and Donald White reached the site on March 25. Through the rest of 1943, Foshag, his USGS colleagues, the Smithsonian's G. Arthur Cooper, the American Museum of Natural History's Frederick H. Pough, Ordóñez, Jenaro R. González-Reyna, and Adán Pérez-Peña briefly and intermittently observed Parícutin spew ash, gas, and lava as the volcano rose above the plain to an elevation of nearly 1,500 feet.

In the first half of 1943, while Parícutin continued to grow, Bill Bradley's Military Geology Unit responded to increasing requests for its services, supported by an additional $85,000 received from the Army Engineers. By the MGU's first birthday in June, Bradley's staff numbered 46 people, including groundwater experts, whose studies Charles Theis and his successors coordinated beginning in February. Among them were specialists on the USGS permanent staff, when-actually-employed academics, members of industry, and war-service appointees. They worked in close quarters in what they called the "Dungeon," a part of the basement of Interior's "old" building. The cramped offices and long hours spent on rush jobs, often completed from inadequate information, led not to serious acrimony but to good morale. The MGU's motto, "In military geology, any intelligent quick action is better than delay in search of the ideal,"[104] was burlesqued internally as "Don't think—act!"[105]

During calendar 1943, the Military Geology Unit completed for the Army Engineers more than 50 numbered SES reports and other unnumbered compilations. These reports provided terrain and other information about Afghanistan, Albania, Bulgaria, China and Siberia, Corfu, Corsica, Crete, the Dodecanese Islands, France and its Mediterranean coast, French Indochina, Greece, Iraq, Italy (Naples and areas south to Calabria, Rome, and the Po Valley), Java, the Mediterranean, The Netherlands and its portion of New Guinea, Nigeria, Norway, Palestine, Sicily, Spain, Sumatra, Transjordan and other countries in the Levant, Turkey, and Yugoslavia. Topical studies by geologists and hydrologists included those about permafrost, among them an overview in SES 62 by Stanford's Siemon Muller and a look by Theis, while on detail to the Army Engineers during October 1943–March 1944, at the involved thermal processes to aid the search for water supplies for bases along the new Alaskan-Canadian (Alcan) Highway. The MGU also finished assessments of seven possible airfield sites in the Solomons and the Bismarcks, with feasible lengths of runways, and commodity targets for bombing by the U.S. Army Air Forces.

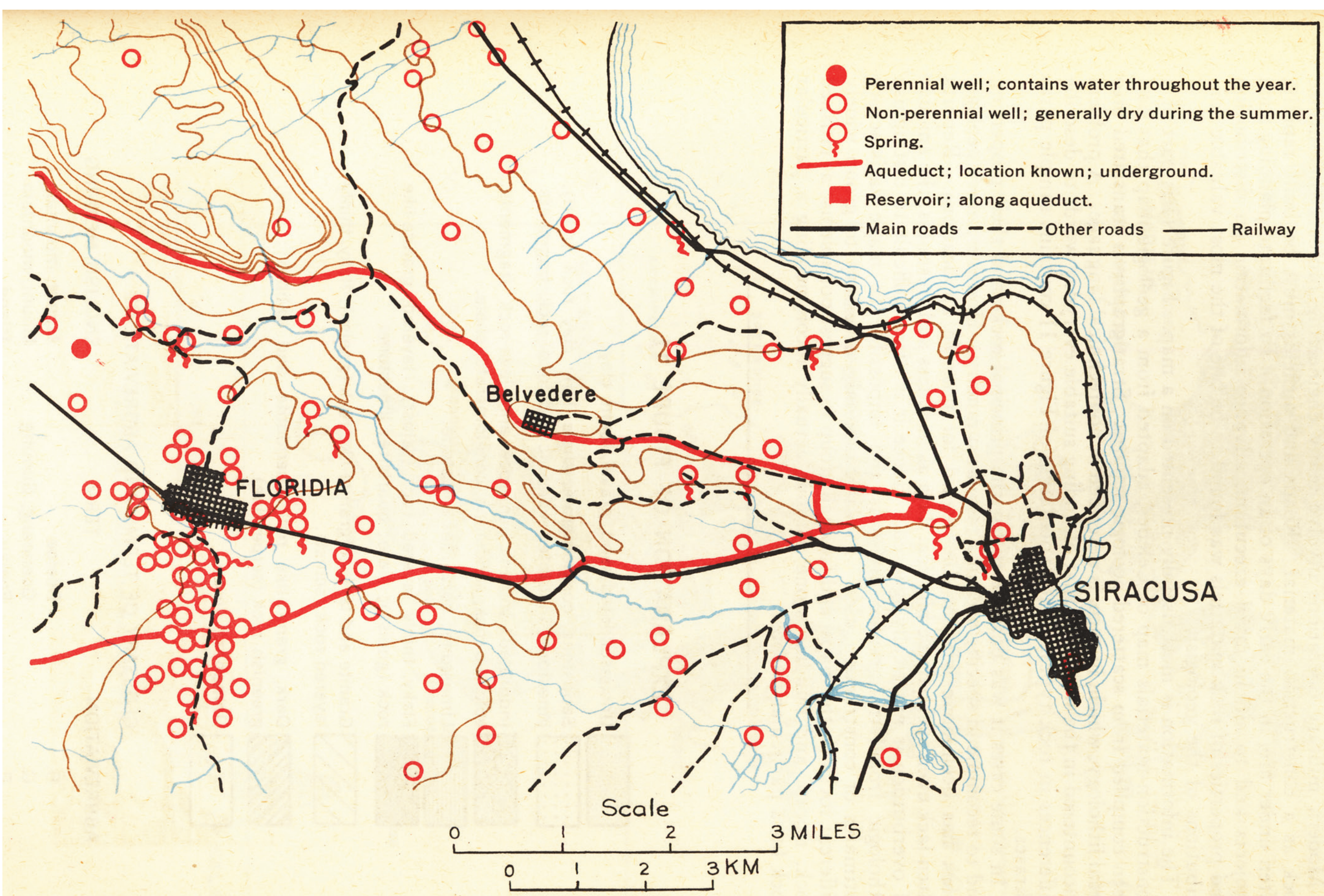
At Casablanca in January 1943, the Combined Chiefs of Staff approved Sicily as the next objective in the Mediterranean. On 25 March 1943, Colonel Garrison H. Davidson, Chief Engineer of Lt. General George S. Patton, Jr.'s I Armored Corps (later 7th Army), began planning for engineer operations during the U.S. landings near Palermo. Operation Husky, the invasion of Sicily, involved 175,000 British, Canadian, and American troops of General Harold R.L.G. Alexander's 15th Army Group. To provide strategic intelligence for Husky, General Eisenhower's Allied Forces Mediterranean headquarters, having moved to Algiers, requested the Chief of Engineers and the MGU to deliver a comprehensive report on Sicily by July 1. General Eisenhower rejected as too risky the suggestion by General Marshall that Patton's troops and those of General Montgomery's British 8th Army (also in 15th Army Group) go ashore in northeastern Sicily near Naval Base Messina-Reggio and isolate the island's Italo-German garrison of some 260,000 regulars and reserves.

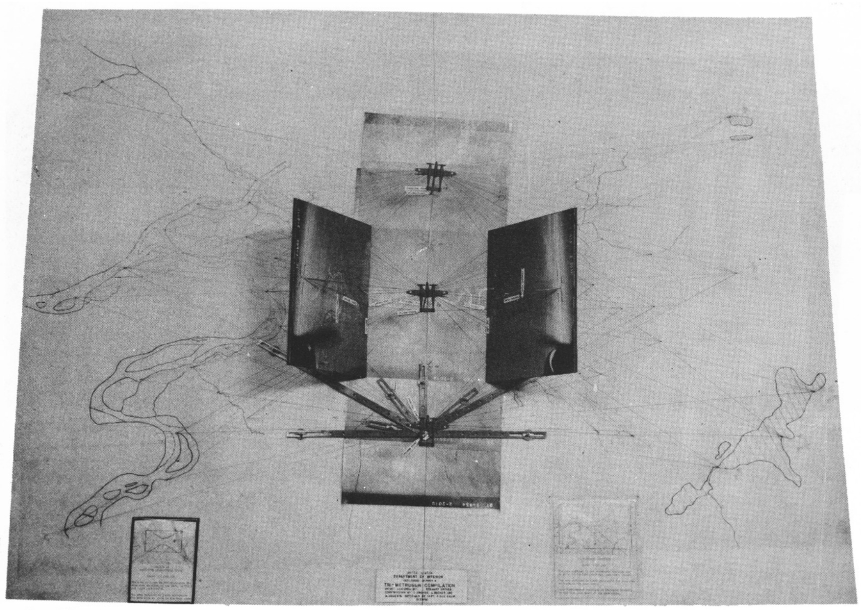
The MGU, building on Marcus Goldman's 30-page report on Sicily, began the terrain-intelligence folio about that island by preparing preliminary reports on the aqueducts and water supplies of Messina and other locales. On May 9, 1943, the Army Engineers advanced the due date for the MGU's Sicily report to June 1.

The MGU and the Army Map Service (AMS) split the time available. Beginning on May 10, 28 members of the MGU compiled data about airfield sites, construction materials, geology, mineral resources, seasonal states-of-the-ground, terrain appreciation, and water resources. The MGU presented its SES 50, a 56-page compilation, accompanied by a bibliography and maps at a scale of 1:650,000, to the AMS on May 20. The AMS printed 600 copies of the folio and delivered them on time to the planners at the Survey Directorate in Algiers. Topographical-engineer units reproduced some of the folio's detailed maps for issue to the 15th Army Group's principal combat units. The MGU then produced separate, more-detailed folios for Sicily's western and eastern halves as parts 2 (83 p.) and 3 (101 p.) of SES 76. These folios included terrain-water-airfield maps at 1:100,000, road construction and maintenance maps at 1:200,000, bibliographies, photographs, and physiographic (later termed "terrain") diagrams by Philip King. The MGU also completed a larger report on Sicily's aqueducts as part 4 of SES 76 and its maps at 1:1,000,000. On June 13, Colonel Davidson issued a complete engineer-operations plan for the 7th Army's invasion, now reoriented to beaches (part 1) on Sicily's southwestern coast.

As the Army pushed ahead on Operation Husky, total funds for the Alaskan Branch in fiscal year 1943–44 fell by $360,000 to about $889,000. The Branch's direct and deficiency appropriations grew by $102,000, but the OEM's contribution ended and the War Department's transfer sum decreased by more than $298,000 to $712,000. All of the Branch's new field projects during the 1943 season gathered information on mineral resources. In the southeastern part of the Territory, George C. Kennedy, Matt S. Walton, Jr., and other USGS geologists sought ores of chromium, molybdenum, and nickel and assessed copper-iron basic intrusive and

This water-supply map (originally at 1:1,000,000) of the Siracusa (Syracuse) area, derived from a 1:100,000 map published in 1943, shows the general distribution of aqueducts, reservoirs, springs, and wells (printed in red), and streams (blue) as compiled for the Allied invasion of Sicily. In May 1943, the USGS Military Geology Unit's Strategic Engineering Study 76 presented analyses of Sicily's landing beaches (part 1), terrain intelligence on the western (part 2) and eastern (part 3) halves of the island, and its aqueducts (part 4). Parts 2 and 3 contained maps and charts of terrain appreciation, construction materials and fuels, roads and maintenance, possible airfield sites, and Italian ground photographs taken in the 1920s and 1930s. (From U.S. Geological Survey and U.S. Army Corps of Engineers, 1945, fig. 10; also published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 4.)

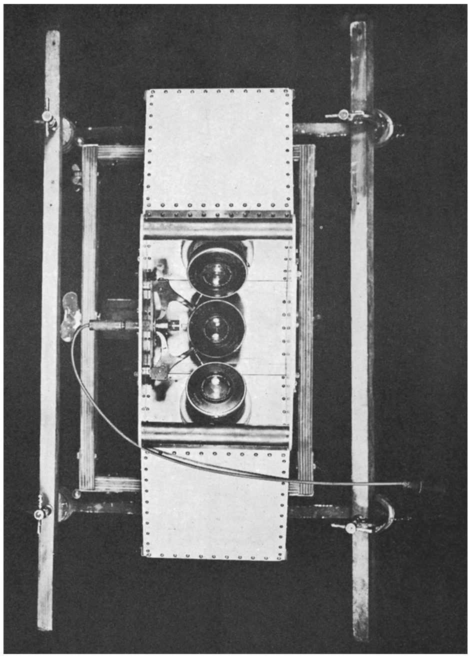




This model of trimetrogon aerial photogrammetry shows the method that was cooperatively developed during 1941–42, by personnel of the U.S. Army Air Forces and an eight-man USGS team led by Gerald FitzGerald, to economically and quickly compile planning and operational aeronautical charts and other small- to medium-scale strategic maps. Images taken by a group of three cameras, equipped with wide-angle "metrogon" lenses and (within the assembly) oriented vertically (first camera) and at 60 degrees oblique (second and third cameras), were processed by plotters, intersectors, angulators, and other instruments to produce the maps. Large parts of Alaska and Antarctica later were mapped at reconnaissance scales by this method. (From Thompson, 1958, fig. 11; see also FitzGerald, 1944b, for trimetrogon-photographic mapping, and 1944a, for aeronautical charts.)

magnetic rocks. Don Miller, Robert F. Black, and Ralph E. Van Alstine searched intensively for copper deposits in the Nizina and Kotsina-Kuskulana districts, east of the Copper River. In the Cook Inlet-Alaska Railroad belt, other USGS geologists examined tungsten deposits, lead and zinc ores, chromite, and portions of coal fields. USGS geologists also made detailed studies of mercury deposits in the Kuskokwim region. Investigations of tin resources continued on the western Seward Peninsula, and preliminary work began on tungsten deposits near Nome and Solomon. Field parties also looked at occurrences of asbestos, graphite, and quartz crystals.

During fiscal year 1943–44, the USGS Topographic Branch continued to be largely engaged in producing maps of both domestic and foreign areas for the War Department, which provided about $1,739,000, a reduction of nearly $460,000 from the previous year. Funds supplied by States, counties, and municipalities and those transferred from other Federal agencies decreased slightly, but miscellaneous repay monies rose by $36,000. Drawing on total funds of almost $2,940,000, Branch personnel carried out field surveys in 34 States and Puerto Rico; agencies in 17 of the States and Puerto Rico cooperated in the work as did the TVA and the War Department. USGS topographers mapped nearly 18,560 square miles in the States. Of the 253 quadrangles completed and the 90 others in progress, 279 were within the War Department's strategic areas.[106] The Section of Photographic Mapping also produced topographic maps of areas in the United States covering approximately 7,120 square miles and planimetric and other base maps of some 13,900 square miles. By October 1943, less than half of the United States, Wrather told Ickes, was plotted comprehensively. Fortunately, most of the areas that needed additional mapping lay in the central and western States. In several strategic areas along the Nation's coastlines, military requirements yielded a 60-percent increase over fiscal 1942–43 in the number of square miles of mapping produced monthly by Branch employees. Crediting advances in photogrammetry, Wrather emphasized that the technique was only about one-third as expensive as and from three to five times faster than prewar methods. Wrather predicted significant postwar uses for photogrammetry, beyond those demonstrated by the TVA–USGS collaboration, in drainage enterprises, erosion control, flood-control planning and execution, forest



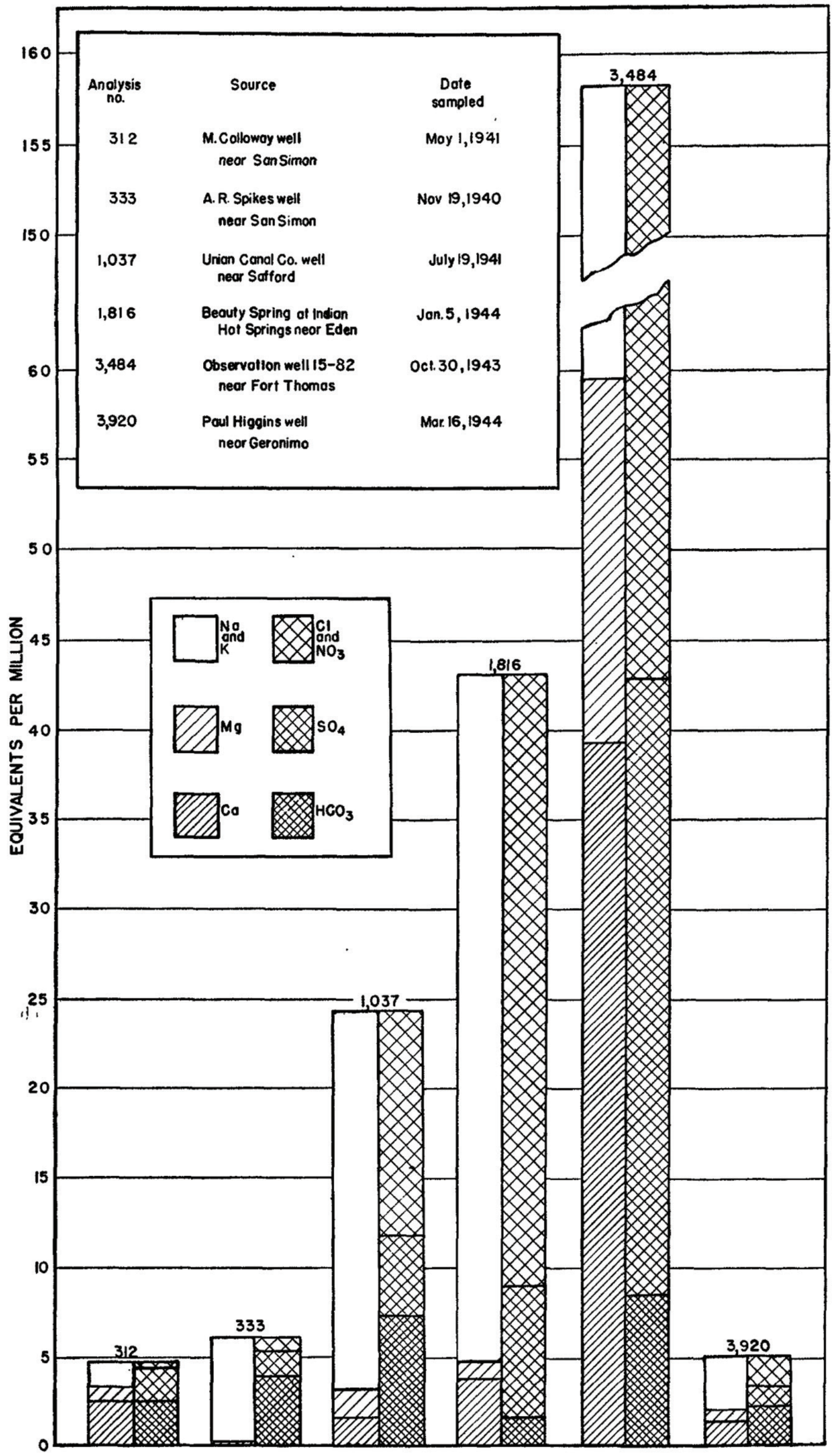
The tri-lens camera shown here (rotated 90 degrees from the horizontal) is an improved version of the one designed in 1916–17 by USGS topographer James Warren Bagley (1881–1947), aided by his agency colleagues John Mertie and Fred Moffit, and developed by the Army Engineers. The camera's base supported "three compartments and a magazine capable of carrying a roll of film 400 feet long." As mounted in aircraft, the optical axis of the central compartment's lens (f/6.3, 6-inch focal length) pointed down; the side compartments' lenses (f/6.3, 7-inch focal lengths) were tilted at 35 degrees to the central lens' axis. Only the shutters between the lenses operated automatically. The camera's field "was roughly three times the flight altitude. Later, cameras of this general design were built with 4- and 5-lens combinations." This assembly subsequently formed the model for the metrogon-lens camera used in trimetrogon photography and mapping in the 1940s, as shown and described on the facing page. (Quotations and photograph from Thompson, 1958, p. 5, 6, and fig. 3; for a summary of Captain [later Lt. Colonel] J.W. Bagley's career with the USGS and the Army Engineers, see Bagley, C.T., 1996.)

administration, highway location and construction, mineral and soil surveys, power and irrigation projects, and river and harbor improvements.

The USGS mapping program carried on at the request of and with funds supplied by the USAAF, under the auspices of the Alaskan Branch, proved so useful that it gradually expanded to include mapping large strategic areas in other countries. The Topographic Branch withdrew many engineers from fieldwork and assigned them to the Section of Photographic Mapping to revise, by means of aerial photographs, maps of foreign territory showing about 26,000 square miles and to compile contour maps from older hachured maps totaling some 13,000 square miles. Branch personnel assembled in changed format and redrafted existing maps of an area of 43,000 square miles. They completed for use by the USAAF a considerable number of shaded-relief maps at 1:1,000,000 and larger scales. Branch members also compiled from aerial photographs planimetric maps showing nearly 5.5 million square miles and topographic maps depicting 500,000 square miles. These maps initially included aeronautical-approach charts for the continental United States; then the geographic scope was expanded to comprise target charts for and revisions from aerial photographs of parts of Europe and areas in the Pacific for the USAAF and the AMS. Work also continued on five sheets of the 1:1,000,000-scale International Map of the World, of which the Chicago sheet neared publication.

Funds for water-resources investigations by the USGS during fiscal year 1943–44 totaled more than $3,542,000, including about $1,437,000 in the Interior Department appropriations bill and two supplemental bills, cooperative funds of $1,152,000 supplied by State, county, or municipal agencies, and nearly $954,000 from other Federal agencies. The supplemental legislation that provided an additional $90,000 for gaging streams also raised the sum provided exclusively for State-municipal cooperation from $975,000 to $1,065,000. Of the total from other Federal agencies, nearly $712,000 came from the War Department; the TVA added $59,500, the Defense Plant Corporation transferred nearly $58,000, and the State Department provided $50,000. The number of requests from industrial and military sources for special reports on water supplies continued to increase; the Water Resources Branch produced more than 5,000 such reports during the year in response to specific queries. At the same time, enlistments in and drafts for service in the armed forces depleted the Branch's workforce, and the remaining employees had little time for other efforts. Some of the experts who now entered military service continued to be assigned to Army water-supply units in the theaters overseas.

As in the preceding year, the Water Resources Branch conducted studies of surface water and groundwater and of water quality. Nathan Grover, the former Chief Hydraulic Engineer, was recalled to active service with the USGS on April 20, 1942. Members of the Branch's Surface Water Division continued to collect records of the stage, quantity, and availability of surface waters at about 5,000 gaging stations and to make periodic measurements of water levels or artesian pressure in some 7,000 observation wells. Division personnel made the surface-water studies in every State and the Territory of Hawaii, for the most part in cooperation with 161 State and municipal organizations or other Federal agencies. Their work was aided by the new manual for stream-gaging procedures, begun by a Branch committee in 1930, continued from 1934 by Don M. Corbett and Charles H. Pierce, and their colleagues Marion C. Boyer, Arthur H. Frazier, and Guy C. Stevens, and published in 1943. To aid the Branch's work, Congress and the President authorized Secretary Ickes and the USGS on December 24, 1942, to acquire lands for use in establishing stream-gaging stations and to obtain easements or rights-of-way to them; lands could be acquired by condemnation, donation, or purchase from



This graph shows the concentrations of eight ions (four of which were combined in two of the six patterns) in samples of groundwater taken during 1940–44 from five wells and one spring in the Gila River Basin below the mouth of Bonita Creek. John D. Hem, Raymond T. Kiser, and their USGS colleagues, with cooperation from the Arizona State Land Commission, the Army Engineers, the Defense Plant Corporation, the Office of Indian Affairs, and the Phelps Dodge Corporation, analyzed changes in surface-water and groundwater quality and the effects of bottom-land vegetation in the nearly 12,900-square-mile area of the Gila River Basin above Coolidge Dam during January 1940–December 1944. (From Hem, 1950, fig. 6.)

appropriations, and they could be “not in excess of ten acres for any one * * * station.”[107] Groundwater investigations continued in nearly every State and in Hawaii, where they included cooperative efforts with 61 State and municipal agencies. Groundwater studies included those involving most of the critical areas of heavy pumping to determine whether or not war demands caused significant shortages in water supplies. More than 9,000 water samples, many of them collected in connection with investigations of supplies for Army and Navy establishments, and for munitions plants and housing developments, were chemically analyzed in five Branch laboratories in Albuquerque, New Mexico, Austin, Texas, Raleigh, North Carolina, Safford, Arizona and Washington, D.C. Cooperative studies of the chemical character of surface waters were underway in six States. The Branch also continued other activities, including publishing the monthly *Water Resources Review*, administering responsibilities relating to permits and licenses of the Federal Power Commission (FPC), and investigating water problems along the boundary between the United States and Canada. Between June 1943 and February 1944, Nelson Sayre and George C. Taylor, Jr., investigated groundwater resources in El Salvador and Nicaragua for the Office of the Coordinator of Inter-American Affairs.[108]

The Interior Department’s appropriations act, a supplemental funding bill, and transfer monies from other Federal agencies gave the USGS Conservation Branch more than $856,000 for fiscal year 1943–44, a gain of some $273,000 from fiscal 1942–43. Increased demands for new sources of oil, gas, coal, magnesium, and potassium produced a 38-percent rise in the number of mineral-classification cases during the year to almost 10,900. Members of the Water and Power Division, in addition to re-evaluating power-site reservations, made topographic surveys of 142 linear miles of river valleys and published maps of 580 miles of river valleys and 8 dam sites. To meet the heightened demands for service, the Branch established new regional field offices, each with a resident geologist in charge, at Los Angeles, California, and Great Falls, Montana, and opened suboffices in the Denver region at Casper, Wyoming, and at Salt Lake City, Utah.

Members of the Conservation Branch’s Mining Division supervised operations on 636 public-land properties, 225 Indian properties, and 4 Secretarial authorizations, from which the output value totaled more than $62 million. Mining Division personnel undertook two special studies to try to resolve the problems caused by the war-induced expansion of mining operations. Under instructions from Secretary Ickes to reverse the accelerated diminution of known potash reserves in New Mexico, the USBM and the USGS contracted for test-hole drilling that proved additional high-grade reserves of national importance in and adjacent to the potash reserves President Hoover created by an Executive order in 1932. In Oklahoma, zinc production from leased Indian lands depended on working ores of successively lower grade, which was made feasible by production premiums. Joint studies there aimed to increase production by improving recovery practices and determining probable reserves of low-grade ore that might be mined by large-scale mechanized operations.

Members of the Conservation Branch’s Oil and Gas Leasing Division, operating from 18 field offices and suboffices in 7 States, supervised more than 5,300 public-land properties and nearly 4,600 leaseholds on Indian lands. Division personnel also managed production from properties under lease in California’s Naval Petroleum Reserve No. 2. The Division opened new suboffices at Bakersfield in California and at Artesia (between Roswell and Carlsbad) in New Mexico. Its members reported notable increases in energy-resource production from Indian lands in Oklahoma, Montana, and Wyoming. Income from supervised operations in the public domain, including Indian lands and NPR–2, amounted to nearly $3,545,000, an overall increase of $445,000 from fiscal year 1942–43, but a total that also represented a loss of $240,000 in royalties as the number of active wells in the NPRs fell from 300 to 259. Production under approved unit agreements constituted about 59 percent of the petroleum, 69 percent of the natural gas, and 84 percent of the gasoline and butane obtained from the public lands. During the fall of 1943, however, the USGS suggestion to make unitization mandatory created considerable opposition among oil operators who preferred voluntary agreements.

During the late spring, summer, and early fall of 1943, the Federal Government made major changes in its program of mobilizing the Nation's resources. On May 27, as the effort to enlist all national resources still limped along, President Roosevelt established the Office of War Mobilization (OWM) "To develop unified programs" and "to provide for the more effective coordination of the mobilization of the Nation for war."[109] This time, Roosevelt did not add just another stratum to the bureaucratic layering. The next day, as the USGS delegation met with the Senate subcommittee on Interior's appropriations, the President appointed OES Director James Byrnes to lead the new superagency. As head of OWM, Byrnes became in fact what many called him during preceding months, "for all practical purposes * * * [another] Assistant President."[110] Byrnes' initial efforts to develop unified programs and more effective coordination included trying to resolve the long-smoldering conflict between Vice President Henry Wallace, head of the Board of Economic Warfare, and Commerce Secretary Jesse Jones over the purchase of strategic minerals, a struggle similar to the one that Donald Nelson and Brehon Somervell waged to control war production. On July 15, 1943, Roosevelt abolished the BEW and transferred its functions to a new agency, the Office of Economic Warfare (OEW)[111] established in the Office for Emergency Management. At the same time, the Export-Import Bank, the U.S. Commercial Company, the Rubber Development Corporation, and the Petroleum Reserves Corporation (PRCo), together with the functions, powers, and duties of the Reconstruction Finance Corporation and the Secretary of Commerce with respect to them, also passed to the new OEW. Roosevelt named Leo T. Crowley, Chairman of the Board of Standard Gas and Electric Company and the Alien Property Custodian since 1942, to lead the OEW. By August 1943, the Nation's minerals and metals situation improved to such an extent that the growing stocks of the resources seemed to be potential threats to raw-materials markets at the end of the war. To guard against that possibility, the War Production Board reduced stockpile objectives to a 1-year supply.

When Roosevelt established the Foreign Economic Administration as an umbrella agency on September 25, 1943, and appointed Crowley to lead it, the President expressed one of the extreme views of the United States' role in the postwar world. Vice President Wallace envisioned a worldwide New Deal that would use American resources in reconstructing the globe's devastated areas. Influential publisher Henry R. Luce, on the other hand, proclaimed the coming of the American Century, in which the world would be a vast market for U.S. businesses and be remade gradually in the American mode by their efforts. Wendell Willkie provided one of the most compelling voices for internationalism. His book, "One World," published early in 1943, sold a million copies in just 8 weeks. Willkie, who believed that whatever was secured for internationalism had to be won during the war and not in the subsequent peace,[112] urged that during the fighting the United Nations must develop mechanisms for working together after the combat ended. The alternative seemed to require ad hoc and convenient choices that could breed subsequent discord among newly freed peoples and countries, not just those of the United Nations.[113] Willkie concluded that to win the peace, three goals must be met: (1) worldwide peace must be planned for immediately; (2) worldwide economic and political freedom must be secured promptly; and (3) the United States must actively and meaningfully help to win the war and then keep a worldwide peace.[114] Roosevelt, remembering well the Senate's vote to keep the United States out of the League of Nations after World War I and the country's subsequent long interval of isolationism, proceeded with extreme caution on postwar organization throughout most of 1943. He did allow Secretary Hull and others in the State Department to move ahead quietly on postwar planning. Founding the FEA made this and related efforts more public. Roosevelt moved the Lend-Lease Administration, Foreign Relief and Rehabilitation operations, and the OEW into the FEA. In late October, Crowley reorganized the FEA into two parts—Areas and Supplies. Areas included general, liberated, special, German-Austrian, and Pan-American bureaus. Supplies included export and import controls and the Lend-Lease Program. The FEA brought in new consultants and administrators, many from banking and business who tended to regard the new agency as a spearhead for protecting and promoting American commerce during the war and providing an aggressive export policy after it ended.

The Federal Government also considered the mobilization of scientific resources in the postwar world. Science became so important to the war effort that on July 8, 1943, a bipartisan group of 23 Senators, representing all the Nation's major geographical regions and led by Harley M. Kilgore (D–WV), who served on the Truman committee, asked James Byrnes to set up a central scientific and technical body. Kilgore and his legislative colleagues knew well Vannevar Bush's insistence that the Office of Scientific Research and Development (OSRD) was purely a temporary agency and that Congress would have to make fundamental decisions about the future of Government-supported science once the war ended. Kilgore, who arranged major hearings before a subcommittee of the Senate Committee on Military Affairs in 1942 and 1943, viewed the problem of science and government from the perspective of the war industry and, hence, science as applied science. The Senate hearings therefore stressed inventions, patents, industrial research for small business, and the imperfect utilization of technical manpower. As the OSRD did not work on materials or methods of wide use in industry, and generally did not concern itself with supplying research support to war industry, the Kilgore subcommittee aimed at recommending an organization to work in such an area. Bush opposed Kilgore's bill to establish a formal and general office of technical mobilization, to be led by a director appointed by the President and approved by the Senate.

In the fall of 1943, as the Roosevelt administration cautiously moved ahead on postwar planning, Allied offensives in the Pacific and in the Mediterranean continued as part of the proposed return to the Philippines and to Western Europe. On the Eastern Front, the Wehrmacht's offensive forces in February and March, moving east against heavy odds, recaptured Kharkov. On July 9–10, as the Germans and the Soviets struggled at Kursk in the war's largest tank battle,[115] Patton's 7th Army landed on Sicily near Gela and Licata, and moved on that area's airfields, while Montgomery's 8th Army came ashore on the Pachino Peninsula and on beaches southwest of the Naval Base Syracuse-Augusta. Patton's army, supported by the 401st Water-Supply Battalion and the 517th Water-Supply Company (both with USGS hydrologists in uniform), struck northwest and then east, as the British forces slowly moved north. Although Italy joined the Allies late in July, German planners intended to delay the Allied forces only as long as required to withdraw Axis troops across the narrow Strait of Messina to Calabria. The 15th Army Group occupied all of Sicily by August 17, but some 50,000 Germans and most of their vehicles escaped in a masterful withdrawal led by General of Panzer Troops Hans V. Hube.[116]

The MGU's terrain-intelligence reports about Sicily, especially the summary of the eastern half of the island, "won the Unit its spurs,"[117] and the Army Engineers provided the MGU with $233,000 for operations and salaries in fiscal year 1943–44. After Sicily fell, giving the Allies new air and other bases and access to additional sulfur deposits, Colonel Davidson appraised the information in the MGU's folios.

Davidson termed the intelligence about anchorages, beaches, harbors, powerplants and powerlines, railroads, rivers, roads, and weather received from the other civilian and military organizations cooperating with General Reybold's office, as "accurate and complete * * * [and] at times indispensable."[118] General Reybold personally expressed the Army Engineers' appreciation to USGS Director William Wrather for the MGU's "valuable contribution to the success of our arms," especially "the Sicilian studies * * * extremely useful both in the planning stages and in actual field operations."[119]

After gaining Sicily, the Allies moved to increase their control of the Mediterranean and continued reclaiming Soviet lands from the Germans. During the Trident Conference in Washington in May, the Allies agreed to invade the Italian mainland and to postpone for a year the cross-Channel invasion of France. On September 3, the British 8th Army crossed the Strait of Messina and invaded Calabria. The Italians agreed to an armistice on September 8, the same day that civilians on Corsica rose against the Italo-German garrison. On September 9, the U.S. 5th Army, under Lt. General Mark W. Clark, assaulted beaches in the Gulf of Salerno, south of Naples, and British forces landed at Taranto. Mussolini and diehard Italian Fascists established in the north the Salo Republic. The Germans withdrew from Sardinia, and British troops occupied the island on September 18. Sardinia, unlike mineral-deficient Corsica, held significant deposits of antimony, coal, copper, lead, lignite, salt, talc, and zinc. After holding off skillful German counterattacks, the Allies broke the stubborn cordon around Salerno in mid-September and took Naples and its heavily damaged port on October 2. The Allied armies then began slogging north up the often-muddy peninsula and across German defensive lines anchored on mountain ranges and rivers, toward Rome, aided by supporting units that included Frank Foley's Army Engineer construction battalion. In Russia, the German offensive regained lands eastward in a salient reaching the Don River, but Soviet forces again counterattacked. By the end of November, the Red Army recaptured Smolensk and Kiev, reached the Dnieper, and isolated the German troops in the Crimea.

Allied forces also advanced in the Pacific. In the Southwest Pacific, General MacArthur's American and Australian units continued to leapfrog west along New Guinea's northern coast. Coevally, Marine and Army units continued to move northwest up the Solomons; they captured Munda on New Georgia, landed on Vella Lavella, and prepared to invade Bougainville, where Admiral Yamamoto died on April 18 when USAAF fighter pilots, primed by decoded messages, ambushed his aerial party. Admiral Koga Mineichi, Yamamoto's successor, faced a new attack on the Japanese perimeter. In the Central Pacific, Admiral Nimitz's forces planned a series of assaults on Micronesian atolls in the Gilbert and Marshall Islands.

In the fall of 1943, the U.S. Government increased its consideration of the state of the postwar world. A bipartisan movement designed to commit America to participation in an international organization, formed to found and enforce global peace, began in the Senate in March but the House took action first. On September 21, by an overwhelming vote,[120] the Representatives passed a concurrent resolution, offered by J. William Fulbright (D–AR) that favored establishing an international entity with the authority and power sufficient to reach and maintain a just and lasting peace among the nations of the world, with the participation of the United States by means of its constitutional processes. The Senate Committee on Foreign Relations proposed instead a more general resolution that incited prolonged debate between the isolationists and a group of interventionists led by Senators Ball, Burton, Hatch, and Hill who favored greater U.S. involvement. On November 5, the Senate adopted a resolution by Thomas Connally similar to Fulbright's but one requiring Senate ratification of any international accord. When Roosevelt signed the agreement to establish the United Nations Relief and Rehabilitation

Administration on November 9, he echoed Willkie by noting that "As in most of the difficult and complex things in life, Nations will learn to work together only by actually working together."[121]

By that time, the United States, Great Britain, and the Soviet Union were beginning to cooperate more effectively. During the summer, many grievances and misunderstandings strained American-Soviet relations, even though the Soviets now received Allied war supplies in increasing amounts but not any data on Tube Alloys. Henry Stimson, Vannevar Bush, and lawyer Harvey H. Bundy, Stimson's principal contact with General Groves' Manhattan Project, conferred in London on July 23, 1943, with Churchill and Oxford physicist Frederick A. Lindemann, Lord Cherwell. Lindemann was the Prime Minister's principal scientific adviser rather than Tizard, who, after opposing Lindemann's policy of saturation-bombing German cities rather than concentrating air attacks on U-boat bases and other strategic targets, returned to Oxford in 1942. The attendees agreed on the details of exchanging Tube Alloys' information and personnel.

At the Quadrant Conference in Quebec, during August 14–24, attended only by American and British representatives, Churchill and Roosevelt agreed on the 19th never to use the nuclear weapon against each other, not to give information about or employ it on a third country without mutual agreement, and to share in a fair and just postwar production. The two leaders set up a Combined Policy Committee[122] composed of Stimson, Bush, Conant, Field Marshall John G. Dill, the former Chief of the Imperial General Staff and now head of the British Joint Staff Mission in Washington, Colonel John J. Llewellin, the British Ministry of Supply's representative in the Capital, and Clarence D. Howe of Canada. General Groves and Charles Leith acted as advisers to the Combined Policy Committee, while Harvey Bundy served as the Committee's American secretary for its information-exchange, progress-review, materials-allocation, plant-production, and related functions. Roosevelt also accepted Churchill's proposal to establish a Southeast Asia command, led by a British officer, and the Prime Minister agreed to the President's idea that an American should direct the invasion of France. After the Quebec meeting, Stalin bitterly complained that the campaign in Italy was not the long-promised Second Front because it involved far fewer German divisions than the Allied forces opposed. Stalin accused Roosevelt and Churchill of allowing Soviet forces to take the brunt of the fighting while keeping it out of effective decisionmaking about the global conflict and the postwar world. Unexpectedly, Stalin then endorsed the idea of a gathering of foreign ministers in Moscow and agreed to meet with Churchill and Roosevelt near the end of the year.

The Allies held their initial three-power ministers meeting during October 19–30, 1943. Secretary of State Hull, Foreign Secretary R. Anthony Eden, Foreign Minister Molotov, and some of their military advisers convened in the Soviet capital, where businessman W. Averell Harriman, formerly with the OPM, became U.S. Ambassador on October 1. Harriman's friendship with Harry Hopkins gave him direct access to Roosevelt, who made him responsible for coordinating lend-lease activities in London and then Moscow. In the Moscow Declaration, signed at the close of the conference, the three ministers adopted the American draft for a four-power pact (including China) that recognized

> **the necessity of establishing at the earliest practicable date a general international organization,[123]**

with membership open to all peace-loving sovereign states, to maintain global peace and security. The foreign ministers also established a framework for the meeting of the "Big Three" proposed in May, recognized China as a member of the Grand Alliance, and confirmed the plan to invade France in May 1944 and the decision that the Nazis must surrender unconditionally to the Grand Alliance. They also promised to set up a European Advisory Commission to work out the basic principles for the postwar treatment of Germany and proposed an Allied commission to investigate war crimes. Stalin pledged to enter the war against Japan after the Allies defeated Germany.

As agreed during the Moscow meeting, Churchill, Roosevelt, Stalin, and their staffs met in the Eureka Conference at Tehran in Iran between November 28 and December 1, 1943. Roosevelt, Arnold, King, Leahy, and Marshall sailed to Oran, then flew to Cairo to confer with Churchill and Chiang Kai-shek in the first Sextant Conference during November 22–30. Continuing by air to Tehran, Roosevelt and Churchill chiefly discussed with Stalin the Allied invasion of Western Europe, by American, British, Canadian, and Free French forces in May 1944, supported by a flanking attack on the French Mediterranean coast and timed to coincide with a Soviet general offensive against Germany's Eastern Front. Stalin again pledged to enter the conflict with Japan when Germany was beaten, but he refused to recognize the Polish government in exile in London and presented his version of Poland's postwar frontiers. The conferees also formulated a plan for an international organization to keep the peace.

Returning from Tehran, Roosevelt and Churchill stopped at Cairo to talk again with Chiang (December 4–6). In the two meetings in Cairo, these three of the now "Big Four" leaders agreed to continue the war against Japan until its leaders surrendered unconditionally. Then they would deprive Japan of all the Pacific islands it acquired since 1914, restore to China all of its territories conquered by the Japanese, and later secure a free and independent Korea. After Roosevelt announced that he could not spare General Marshall from Washington, the President and Churchill agreed to appoint General Eisenhower as the Supreme Commander of the Allied Expeditionary Forces for the invasion of France and General Montgomery as commander of Eisenhower's land forces. Lord Louis Mountbatten, King George VI's cousin and now an acting Vice Admiral, became Supreme Allied Commander for South East Asia earlier in 1943. Churchill also met for a second time with Ismet Inönü, Mustafa Kemal's successor as president of Turkey, who again refused to join the war against the Axis. Roosevelt reported the results of these conferences to Americans by radio on December 24. The President relayed his favorable impression of Marshal Stalin and asserted that "we are going to get along very well with him and the Russian people."[124] Recalling recent combats in the Pacific and Mediterranean, Roosevelt predicted many bigger and costlier battles ahead. Americans should expect, he cautioned, "large casualty lists—dead, wounded, and missing. War entails just that. There is no easy road to victory. And the end is not yet in sight."[125]

In the fall of 1943, America's war production reached a peak and thoughts began to emerge about scaling back military output and reconverting U.S. industry to civilian production. Although the Nation's mineral situation now was well in hand, the status of its petroleum resources was becoming increasingly difficult. Although Roosevelt told Congress on September 17 that "Since the outbreak of war in Europe, we have increased our output of petroleum by 66 percent,"[126] the rise proved insufficient to meet every need. The demand for oil in the United States reached an all-time high as requirements for aviation gasoline and fuel oil for shipping and naval uses increased significantly after the year's first quarter. Transportation of these products now posed less of a problem than ensuring their supply as a result of increased tank-car movements, greater and more secure ocean-tanker traffic, and the reopening of the Mediterranean route to Persian Gulf oil that made unnecessary the longer haul around Africa. Two new domestic pipelines would further increase the flow of petroleum and its products—the Big Inch, a 24-inch-dameter pipe for crude oil, and the Little Inch, a 20-inch-diameter pipe for gasoline and other refined products. The two pipelines, begun, respectively, in August 1942 and April 1943, would carry hundreds of thousands of barrels each day from Texas and the Southwest across, respectively, 1,254 miles and 1,475 miles to the East Coast, when completed early in 1944.[127]

The major problem in petroleum now shifted to the supply of crude oil. Production of crude in the United States was approaching the maximum rate desirable with respect to conservation. Since July 14, 1943, Ickes served as president of the Petroleum Reserves Corporation (PRCo),[128] founded on June 30 by Roosevelt, with the support of Ickes and Assistant Secretary of the Navy William C. Bullitt. The PRCo's Board of Directors included the Secretaries of State, War, Navy, and Interior and the FEA's Director. Ickes again claimed that America, drawing heavily on its own reserves, was running out of oil. Known reserves, he predicted, would last only 12 to 13 years at the prewar rate of consumption; the Nation could not service another global conflict or prepare properly for peace, and soon it would be a net importer of petroleum. To compensate in part, Ickes called for oil production from coal and oil shale, but commercial amounts from these sources required far more research and development than that yet done by the USBM pilot program. Senator George echoed the Secretary's warning by agreeing that the United States would be a future supplicant for petroleum. William Heroy, Director of Reserves in Ickes' Petroleum Administration for War since July 7, 1942, predicted that without new U.S. fields, the domestic supply would eventually be exhausted. "Industry," Heroy asserted, "is challenged as never before to find, develop, and produce more oil."[129] Clearly, the Allies needed additional sources of supply to meet their war needs. When U.S. domestic-exploration programs could not supply these requirements quickly enough, imports increased sharply, and they stimulated American interest in foreign sources. Senator Henry C. Lodge, Jr. (R–MA), asked the administration to involve itself directly in concessions abroad.

The House Committee on Interstate and Foreign Commerce's investigation of petroleum resources noted in July 1943 that "There are great supplies of oil in the Persian Gulf area. More substantial supplies should now come from that source."[130] In the view of Clarence Lea's committee,

> **the conservation of our own resources, as well as a more assured supply for military and civilian purposes, require that every practicable effort be made to increase these foreign supplies for war purposes. Such increase would decrease the demands upon our oil reserves, shorten our shiplines, reduce the war transportation hazards, increase the amount available for civilian use, and prolong the available supply of oil for America.[131]**

Historian Daniel Yergin's "The Prize" described and analyzed the major roles that Gulf, Standard Oil Company of California (Socal), and Texaco, three of the "Seven Sisters" companies, played in gaining American concessions for oil exploration and development in the Middle East beginning in the late 1920s. Socal found commercial quantities of oil at Awali in Bahrain in 1932, the year Abd al-Aziz [II] Ibn Abd al-Rahman al Saud, known in the West as Abdul Aziz Ibn Saud, or just Ibn Saud, but as Abd al-Aziz to his people, established the modern Kingdom of Saudi Arabia. Ibn Saud claimed kingship in 1926 and received prompt recognition as such from the Soviet Union and Britain, although America delayed its acceptance until 1931. The following year, the King united most of the Arabian Peninsula under his caliph-like dual role as its secular ruler and also hereditary spiritual leader of the ultraconservative Wahhabist-Sunnis.

King Ibn Saud hoped that his domain contained oil and other valuable resources, but he especially wanted artesian wells and other new supplies of water. In 1923–24, he granted oil concessions in the Hasā (Ahsā) region, just west of

Bahrain, and in the Neutral Zone that Saudi Arabia shared with Kuwait, to Frank Holmes' Eastern and General Syndicate after the Anglo-Persian Oil Company found Saudi Arabia's prospects unpromising. The concession yielded only the rental fee before it passed to Holmes and Gulf and then to Socal, whose Canadian-cooperative Bahrain Petroleum began drilling at Awali in October 1931 and stuck commercial quantities of oil during the following May. Between February and May 1933, Sheik Abdullah Suleiman al-Hamdan, Ibn Saud's Minister of Finance and National Economy, Socal representatives, Britain's Harry St.J.B. ("Jack") Philby, and Karl S. Twitchell (a U.S. mining engineer who tried but failed to find artesian wells in the Kingdom) negotiated a revised Hasā concession. Ibn Saud regranted for 60 years the 360,000-square-mile concession to the California Arabian Standard Oil Company (Casoc), Socal's operating unit. Casoc offered a far greater sum against royalties than did Anglo-Persian and Iraq Petroleum—$175,000 as an up-front loan and first-year royalty, another $100,000 as a loan in 18 months, and a third $500,000 loan for a commercial discovery.[132] Casoc also promised to educate Saudis to replace American workers as quickly as possible without losing economy or efficiency. In December 1934, Gulf and Anglo-Persian signed a 75-year concession with Sheikh Ahmad al-Sabah, the Emir of Kuwait and Ibn Saud's ally. The two companies brought in a high-sulfur discovery well at Burgan in southeastern Kuwait in February 1938.

Meanwhile, Casoc's geologists explored the Hasā concession and quickly focused on the "two backs" anticline at Jabal Dhahran (Zahrān), also known as the Dammam Dome, inland from the fishing village of Dammām, and about 25 miles west of Bahrain's Awali oil field. Seismological surveys and aerial photography aided their ground studies. Drilling began during the summer of 1934, but six expensive wells drilled into the eastern extension of the "zone" at Awali produced only shows of oil or water, and dry holes. Casoc's drillers extended Dammam No. 7 to below 4,700 feet and, on March 16, 1938, they struck commercial quantities of oil in what became known as the "Arab zone."[133] Socal then exercised a secret clause in the 1933 agreement to expand the concession by 80,000 square miles. In April 1939, King Ibn Saud visited Casoc's pipeline terminus at Ras Tantra (Tannūrah) on the Persian Gulf as the initial tanker began loading crude oil. He and President Roosevelt exchanged letters, but the wily monarch also made arms deals with the Germans and Italians. In August 1939, the State Department made the U.S. minister to Egypt additionally responsible for representing America in Saudi Arabia. Full diplomatic recognition of the Kingdom followed in February 1940. Eight months later, four Italian aircraft flew from Rhodes to Massawa on Eritrea's Red Sea coast, bombing en route but not damaging targets in Bahrain and the stabilization plant at Dhahran, Casoc's operations center, about 8 miles south of Dammām. Casoc made additional discoveries south and north of Dhahran, and production rose to 20,000 barrels a day during 1940,[134] but the increasing Italo-German threat to the region led to reducing the staff for field operations, cutting the number of employees at Dhahran and the small refinery at Ras Tantra (like the pipeline, built by Bechtel International), and plugging all the wells in Kuwait.

Ibn Saud awaited the military outcome in Africa and the Near East. The King, still wary of the British, requested additional aid from the United States. In February 1942, Roosevelt, knowing British concerns, rejected Casoc's request of the previous April to advance Ibn Saud some $6 million per year against future oil royalties. During 1943, the administration focused on U.S. interests in the region both during and after the war. In January, Assistant Secretary of State Dean Acheson asked Lend-Lease Administrator Edward Stettinius to make Saudi Arabia eligible for aid. In mid-February, the presidents of Socal, Casoc, and Texaco traveled to Washington to urge State Department officials to send their money or Federal dollars to Ibn Saud and to block the British. Roosevelt lunched with Ickes on February

Geologist Everette Lee DeGolyer (1886–1956), like Wrather, worked for the USGS in 1907. He then joined an oil company that became the British-Mexican El Aguila and located prolific oil fields along the Golden Lane structural trend. After 1916, DeGolyer continued to study salt-dome fields and geophysical applications while organizing three firms—Amerada Petroleum, the Geophysical Research Corporation, and DeGolyer and MacNaughton. During World War II, DeGolyer served as Director of Conservation and then Assistant Deputy Administrator of Harold Ickes' Petroleum Administration for War. In 1943, DeGolyer joined other colleagues in recommending William Wrather, his friend and fellow bibliophile, to Interior Secretary Ickes to replace Mendenhall as USGS Director and also serve on DeGolyer's Middle East Oil Mission. In postwar years, DeGolyer continued to advise organizations in academia, government, industry, and science. (Photograph from Pratt, 1958, pl. 5; also published in Tinkle, 1970, frontispiece.)

16. Two days later, the President found Saudi Arabia's defense vital to the United States and authorized lend-lease aid to the Kingdom. In June the JCS's Army-Navy Petroleum Board, originally established by General Somervell and the Vice CNO in July 1942 to coordinate petroleum operations for all U.S. armed forces, predicted serious shortfalls in U.S. petroleum production for 1944. Shortly after the Board's projection, Harold Ickes, Frank Knox, Henry Stimson, and James Byrnes, while lunching at the White House later that month, agreed that the administration must become more actively involved in Saudi Arabia. In August 1943, Ickes offered the presidents of Socal and Texaco, now equal partners in the renamed Caltex in Saudi Arabia, a Federal takeover of all or part of the concession in the manner of the now Anglo-Iranian Oil Company. Ickes suggested Caltex should be restyled American-Arabian, offered to buy one-third of the company for $40 million, which would fund a new and larger refinery at Ras Tantra, and indicated that the Federal Government would settle for 51 percent of the operation in peacetime but wanted 100 percent during war.[135] The companies' presidents refused; they already opposed Ickes' policies as head of the PRCo and any restrictive Federal control after the war.

As part of the Roosevelt administration's new diplomatic offensive, the President invited Ibn Saud to visit the United States. Neither the King nor Crown Prince Saud could make the trip, and so the monarch sent his second son, Prince Faisal, and Faisal's half-brother, Prince Khalid. They arrived in Washington by air on September 30, 1943. Secretary Hull remained indisposed and Under Secretary Sumner Welles' resignation on August 16, requested for security reasons by Roosevelt, had just become effective. Adolf A. Berle, Deputy Under Secretary and Acting Secretary of State, who directed the Department's global-intelligence operations, greeted the two Saudi princes at National Airport. Faisal, quartered at Blair House during October and November, talked with Ickes and Stettinius, now Under Secretary of State. Berle and Stettinius assured Faisal on November 1 that the United States would not support any unfriendly actions against Saudi Arabia by the King's Hashemite enemies in Iraq and in Transjordan, or through British influence there, or in the Arabian Peninsula, Palestine, Iran, or Syria. The United States would foster a "Good Neighbor" policy for the Middle East and enforce the Atlantic Charter's first and second articles that prohibited territorial aggrandizement or any changes not approved by the countries concerned.

Ickes, already Petroleum Administrator for War and president of the Petroleum Reserves Corporation, also began serving, with the Secretaries of State, War, and the Navy, on the Foreign Economic Administration's Board of Directors on July 14, 1943. The political, military, and economic concern for U.S. interests in Bahrain, Kuwait, and especially Saudi Arabia, heightened by Prince Faisal's visit, led Ickes to decide to send a U.S. technical oil mission, sponsored by the PRCo, to the Persian Gulf region to appraise independently its existing and potential resources that could be useful to the Allies during the war and to the United States after the conflict. Ickes selected Everette DeGolyer, his trusted troubleshooter, to lead the mission to the Middle East. DeGolyer, as the PAW's Assistant Deputy Administrator from June 8, 1942, to September 20, 1943, also helped Ickes promote both the Big Inch and Little Inch pipelines, for which the DeGolyer and MacNaughton firm provided the low bids. William Heroy deputized for DeGolyer, who reluctantly accepted the new assignment. DeGolyer dissuaded Ickes from sending on the mission Abe Fortas, Interior's Under Secretary since 1942.

Three men accompanied DeGolyer to the Middle East. They were DeGolyer's friend USGS Director Wrather, on detail to the PRCo, which paid his salary and his travel and other expenses; Army Colonel Jacque C. ("John") Morrell, a PAW petroleum engineer and, since January 19, 1943, one of the Special Assistants to Deputy Administrator Ralph Davies; and C. Stribling Snodgrass, Director of the PAW's Foreign Division during 1942–43 and, after October 20, 1943, Director of the PAW's Foreign Refining Division. DeGolyer's party left the United States on November 12. U.S. officials going to the Allied conferences in Cairo and Tehran flew from Miami over the Caribbean to Port-of-Spain in Trinidad, from there southeastward to Natal in Brazil, then crossed the Atlantic to Dakar, and continued over Africa to Cairo. Security arrangements twice delayed DeGolyer's mission en route. *The Oil and Gas Journal* for November 18 reported that Ickes planned to ensure postwar peace by gaining, through "some sort of international agreement,"[136] Allied control of the world's oil resources to prevent potential aggressor nations from obtaining reserves sufficient to support military conflicts. The *Journal* apparently suspected a connection between Ickes' plan and DeGolyer's mission. Truman's committee, then holding hearings on the Army's Canol Project in northwestern Canada, also was expected to look into the global oil situation.

To serve as Acting Director of the USGS during Wrather's absence from the Capital, Thomas Nolan, then in Denver interviewing tungsten-commodity geologists, came east on a day's notice. Wrather's letter of November 3, sent to Boulder, arrived in Denver on the 11th and Nolan reached Washington 4 days later. Nolan, Foster Hewett's field-operations supervisor since 1938, was largely responsible for the organization and administration of the revived strategic-minerals program. Hewett, who disliked administrative work, generated ideas and continued to deal with the often thorny problems involved in working with the USBM and the other cooperating agencies. He also gave Nolan specific responsibility for the program's tungsten project in 1939, prelicensing reports on mines for the War Production Board (where Nolan renewed his contacts with Alan Bateman and met Wrather), and coordination with the British Geological Survey's equivalent minerals program. Wrather discussed Nolan's appointment with Interior's First Assistant Secretary Michael Straus, Julian Sears, and Foster Hewett, who all supported the selection, but not with Nolan. Wrather decided that Nolan's "intimate acquaintance with the Bureau situation" and new "position of authority" would enable him "to take any necessary steps to safeguard Survey interests." Sears last led the USGS during the directorial interregnum earlier in 1943 and did not wish to be considered for a repeat appointment because he wanted to continue as the agency's Administrative Geologist. Wrather promised Nolan that Sears "will be an invaluable adviser on many matters with which you may be unfamiliar." Sears also assured Wrather that he would give Nolan "every assistance."[137]

Geologist Thomas Brennan Nolan (1901–92) joined Gerald Loughlin's Geology of Metalliferous Deposits Section in 1924 and spent most of the next two decades assessing geology and ores in the Western United States. Nolan left his roles as tungsten-commodity geologist, straw boss for Foster Hewett's field program, and representative to related government cooperative programs to serve as Acting Director during November 1943–February 1944, while William Wrather accompanied Everette DeGolyer to the Middle East. In December 1944, Nolan filled the newly established post of Assistant Director, where he functioned as chief executive officer while Wrather operated as chairman of the board. Nolan succeeded Wrather as Director in January 1956 and served until September 1965. Nolan continued to encourage innovative basic and applied research throughout the agency, setting an example by continuing his own studies and mapping of the geology and ore deposits at Eureka, Nevada, and elsewhere in the Basin and Range Province. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0287, https://www.sciencebase.gov/catalog/item/51dda267e4b0f72b4471df4f.)

Chapter 4.
A Double Task, 1943–1945

> **While we move toward complete defeat of our enemies, we must lay the groundwork to return the Nation to peaceful pursuits. This double task is the essence of the Government's program.[1]**
>
> **—Franklin D. Roosevelt**

President Roosevelt, in his State of the Union Message to Congress on January 11, 1944, formally acknowledged what had been apparent to some Americans for several months: the need for postwar planning. The Commander in Chief marked the beginning of a new interval in what he called "the world's greatest war against human slavery."[2] Although ultimate victory seemed to be far in the future, planning for the postwar period, Roosevelt indicated, should not be delayed. The war, he vowed, "shall not be followed by another interim which leads to new disaster," caused by "the tragic errors of ostrich isolationism." The United States, he pledged, "shall not repeat the excesses of the wild twenties when this Nation went for a joy ride on a roller coaster which ended in a tragic crash."[3] Roosevelt sought "to concentrate all our energies and resources on winning the war, and to maintain a fair and stable economy at home."[4] As part of a renewed and enhanced New Deal, he asked Congress to pass a "realistic tax law," continue the statute that recognized war contracts to "prevent exorbitant profits and assure fair prices to the Government," enact bills for "cost of food" and "national service," and extend the price "stabilization statute of October 1942."[5] "[T]rue individual freedom," he continued, "cannot exist without economic security and independence." The new legislation, essentially a second Bill of Rights, would guarantee "security and prosperity * * * regardless of station, race, or creed," sufficient-salaried jobs, a decent living for farmers, businesses free from unfair competition, decent homes, adequate medical care, "adequate protection from the economic fears of old age, sickness, accident, and unemployment,"[6] and good education.

As Roosevelt spoke, British and American aircraft continued round the clock their combined offensives against the Luftwaffe, the German aircraft and related war industries, and their supporting civilian infrastructure. On August 1, 1943, nearly 180 Consolidated B–24 Liberator bombers of the 8th and 9th Air Forces had attacked the vital Romanian oil fields and refineries at Ploesti, doing some damage but also suffering heavy losses. The Royal Air Force's (RAF's) major strike on Peenemünde during mid-August destroyed most of the German test facilities for the two vengeance weapons being developed there—the Luftwaffe's pulse-jet cruise missile (V–1) and the Army Ordnance's rocket-powered ballistic missile (V–2). The Germans moved the equipment, specialists, and slave labor to underground sites at Nordhausen in the Harz Mountains and elsewhere in Germany, where work resumed on the V–2 within 6 months. In October 1943, the RAF began attacking the ramp sites along the English Channel coast built to launch the V–1s against Britain. U.S. Army Air Forces' (USAAF's) B–17s bombed the ball-bearing works at Schweinfurt and the Messerschmitt fighter factory at Regensburg, delaying for 5 months work on the new Me-262 Swallow, a swept-wing, turbojet fighter, but American losses on the two missions neared 20 percent. When the new P–51 Mustang and other long-range fighters began escort operations early in December, Allied deep-penetration attacks continued with repeated 600- to 1,000-bomber raids, at night by the RAF and during the day by the 8th Air Force, now led by Lt. General Doolittle. Coevally, Soviet armies on the Eastern Front pressed their winter offensive to regain territory in the Ukraine.

As the Allies resumed their strategic-bombing campaign in December 1943, Roosevelt decided that General Marshall must remain in Washington as Army Chief of Staff. Roosevelt and Churchill agreed to appoint General Eisenhower as Supreme Commander of the Allied Expeditionary Forces. Eisenhower took command and oversaw continued planning for Operation Overlord, the cross-Channel invasion of northwest Europe, and the subsequent campaign to defeat the German armed forces. Also that month, Hitler entrusted Army Group B's defense of the French coast between the Brittany Peninsula and The Netherlands to Field Marshall Rommel, now restored to health. Rommel moved quickly to energize and improve the defenses of the new "West Wall." The Wehrmacht's best chance for victory depended on quickly driving the Allied forces back into the sea, but Hitler refused Rommel's request to shift armored divisions forward from a central reserve far inland to locations close to the potential invasion beaches.

In the Pacific, Allied forces advanced along New Guinea's northern coast, forged northwest up the Solomons, and began new attacks to the north, aided by new capital ships and smaller vessels of America's two-ocean navy. In the Central Pacific, Vice Admiral Spruance now led the U.S. 5th Fleet, whose aircraft struck Marcus (Minami-tori-shima), the Gilbert and Marshall Islands, Wake, and the Japanese major air-naval base at Truk in the Carolines (now Chuuk in the Federated States of Micronesia) during August and October 1943. In November, as U.S. land-based and naval aircraft attacked Rabaul, to cover the marines' landing on Bougainville, 7th Air Force B–24s, flying some 750 air miles from a base on Funafuti Atoll in the British Ellice Islands (now in Tuvalu), continued bombing targets in the Gilberts as a prelude to invasion. Charts from a triangulation survey of Tarawa in 1841, by Navy Lt. Charles Wilkes' U.S. Exploring Expedition, aided the invasion's planners.

On November 20, 1943, after days of air and naval bombardments, marines and soldiers of the V Amphibious Corps assaulted two coral and sand atolls in the Gilberts—Makin (Butaritari) Island, the seaplane base, and Tarawa Atoll's Betio Island, the headquarters and principal airstrip in the Gilberts, about 110 miles to the south. On 300-acre Betio, the 2d Marine Division (reinforced) encountered a very low tide[7] and skilled and tenacious Japanese forces. After 3 days of savage fighting, the marines secured Betio on November 23, but their 3,200 casualties (including nearly 1,000 dead) and dramatic photographs of the carnage showed Americans at home the cost of defeating a brave and fanatical enemy. More than 1,000 sailors also were killed or wounded on or off Makin and Tarawa. Seventh Air Force bombers, flying from the Gilberts, pounded Japanese airfields in the Marshall Islands, some 1,000 miles to the northwest.

In the Southwest Pacific, General MacArthur continued to plan the next steps in capturing New Guinea's entire northern coast as a prelude to returning to the Philippines. In July 1943, General Marshall ordered MacArthur to isolate the Japanese base at Rabaul. MacArthur's forces landed in December on the southwest and northwest coasts of New Britain. MacArthur also planned to invade New Ireland and Manus in the Admiralties to forge the remaining links in the Allied ring around Rabaul.

As the Allies advanced on all fronts, America's search for and production of mineral resources, a matter for concern in winning the war, now also became significant in planning for the peace. The value of mineral production in the United States, despite severe restraints on civilian, and in some instances military, consumption of most minerals, reached new highs during 1942–44. Domestic industry could not meet all the war needs for some minerals, but after the Board of Economic Warfare arranged large-scale imports, the War Production Board reduced its stockpile objectives in February 1944. Deflation of the metal markets, forced curtailment of production, and widespread unemployment followed World War I. To avoid a repetition, Senator James Scrugham, acting for himself and the Special Committee to Study and Survey Problems of Small Business Enterprises, introduced a defense-stockpiling bill on June 3, 1943. Scrugham's bill, revised after public hearings and cosponsored by Carl Hayden and three other Senators, reemerged on December 8. Although substantial support existed for creating mineral stockpiles for national defense, freezing stocks at war's end to provide a nucleus for permanent stockpiles, and preventing undue dislocation of postwar markets, the 78th Congress took no action on Scrugham's bill or similar legislation during the first half of 1944. In March, the Army and Navy Munitions Board adopted a new definition of strategic and critical minerals, without differentiating between the two groups, and then divided them into three categories according to the practicability of stockpiling them. That fall, as the Allies' strategic situation improved and maritime shipping became less hazardous, Congress passed emergency legislation regulating the disposal of public property, including federally owned strategic minerals and metals, pending the enactment of permanent stockpiling measures.

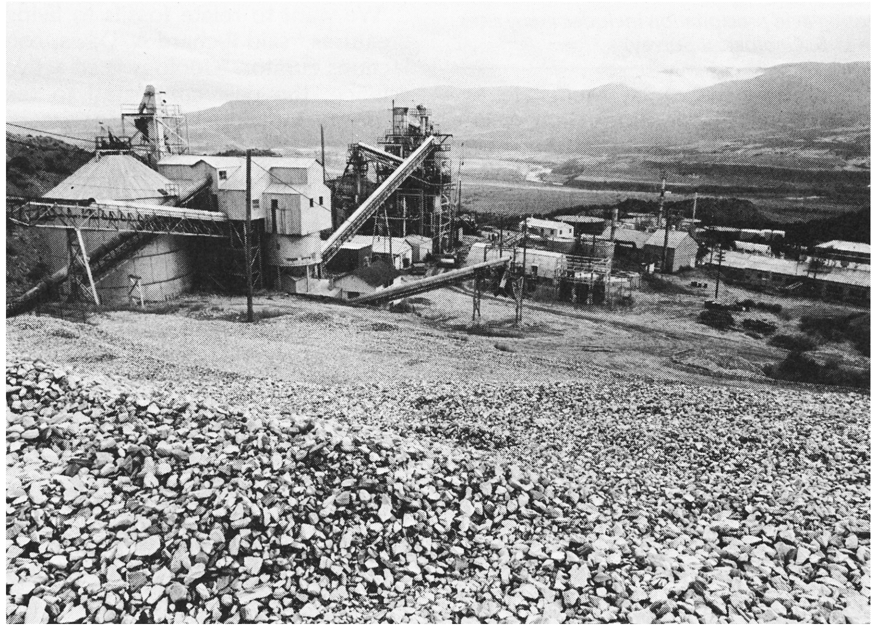
Petroleum and petroleum products posed different problems than those presented by metals. While domestic petroleum output made up an ever-increasing share of the value of total mineral and energy production in the United States, it provided a decreasing portion of America's total consumption. While Everette DeGolyer, "John" Morrell, Stribling Snodgrass, and William Wrather assessed Middle East production and reserves, Harold Ickes, still wearing his four hats as Secretary of the Interior, Petroleum Administrator for War, president of the Petroleum Reserves Corporation (PRCo), and Solid Fuels Administrator for War, publicly pleaded for increased American petroleum supplies. In the *American Magazine* for January 1944, Ickes warned of the dangers of and offered solutions to petroleum depletion. Supplies of and accessibility to oil, Ickes claimed, would be principal postwar problems. America now supplied 95 percent of Allied aviation gasoline, but U.S. proven oil reserves of 20 billion barrels in 1942 would last only 14 years, based on the rate of production in 1939, and the Nation could not service "a World War III." He urged oil stockpiling, new domestic discoveries, wiser use of domestic reserves, increased secondary recovery, developing fuels from coal, natural gas, oil shale, and tar sands, and securing greater peaceful and legal access to foreign oil resources. "The capital of the oil empire is on the move to the Middle East,"[8] and "we must be prepared to go where the gasoline is to be had." In 1942, Persian Gulf sources held an estimated 14.5 billion barrels of proven and probably recoverable reserves expected to last 161 years at 1939 rates, but reserves were predicted to increase significantly during the projected postwar development. The Soviet Union held 8.5 billion barrels of recoverable reserves; Europe, 743 million barrels; the Mediterranean (including Iraq), 6 billion barrels; and the Far East (including Burma), 1.6 billion barrels. The Eastern Hemisphere's reserves totaled 23 billion barrels, a number Ickes believed conservative, just 7 billion barrels less than the Western Hemisphere's reserves. Ickes awaited DeGolyer's revised estimates of Persian Gulf reserves as one source to meet the Nation's future petroleum requirements. Ickes recommended that the United States buy and store petroleum, "underground where possible and aboveground where necessary," to "build up and maintain reserves that will last 20 years, regardless of what the demands may be."[9]

On January 22, 1944, DeGolyer's Technical Oil Mission to the Middle East, where Caltex geologists Max Steineke and Richard Bramkamp guided its work, returned to the United States. DeGolyer's team reported by letter dated February 1 to the president (Ickes) and directors of the PRCo. The American Association of Petroleum Geologists received a copy of DeGolyer's letter on March 31 and published it in its *Bulletin* for July. There, they repeated Ickes' claim. "The center of gravity of world oil production is shifting," they asserted, "from the Gulf-Caribbean area to the Middle East—to the Persian Gulf area—and is likely to continue to shift until it is firmly established in that area." Four companies or groups of companies, mostly British, owned all of the region's "important oil fields and practically all important prospective oil territories," and they controlled production. Anglo-Iranian's fields in Iran yielded 325,000 barrels daily, but each day the company returned another 50,000 barrels of residue to the ground. Iraq Petroleum's fields produced 90,000 barrels per day and were shared equally by Anglo-Iranian, Royal Dutch-Shell, Near East Development—Standard of New Jersey (later Chevron) and Socony-Vacuum (later Mobil and now Exxon-Mobil)—and a French consortium. Iraq Petroleum also controlled fields in Qatar, shut in since the Italian air raid in 1940, and "important concessions in Syria, Palestine, and the Trucial Coast" (Trucial States, now the United Arab Emirates). Caltex, renamed Arabian-American Oil Company (Aramco) in September 1944, and Bahrain Petroleum Company (both run by Socal and Texaco) continued to produce 35,000 barrels a day from the fields in Saudi Arabia and Bahrain. They also held "a substantial concession" in Saudi Arabia. Kuwait Oil, owned by Anglo-Iranian and Gulf, controlled the single field in Kuwait, also still shut in, and "a concession covering the entire Sheikdom."[10]

In assessing refineries and reserves, DeGolyer's team noted that the Bahrain refinery processed the short-haul Saudi crude but petroleum from Iraq's Kirkuk field went to the Mediterranean "by a pipeline system with terminals at Haifa, Palestine [now in Israel] and Tripoli [Trablous], Syria [now in Lebanon]." The foursome estimated that the daily capacity of the region's three refineries—at Abadan (in Iran), in Bahrain, and at Haifa—"when extended will become 500,000 barrels per day." The United States owned, through a Canadian firm, only 11.5 percent of the region's total refined output, which equaled 11 percent of U.S. capacity. DeGolyer and his colleagues estimated the Persian Gulf's proved reserves, those developed or "discovered but not yet fully explored,"[11] at 25 to 27 billion barrels. Of this total, 9 billion barrels were in Kuwait, 6 to 7 billion in Iran, 5 billion in Iraq, 4 to 5 billion in Saudi Arabia, and 1 billion in Qatar. The region's proved and indicated reserves compared well with those of the United States, but all Middle Eastern reserves had been discovered by fewer than 150 wildcat wells. By contrast, "more than twenty times this number" were drilled each year in the United States. "For the next ten to fifteen years at least, the Middle East area is likely to develop and maintain productive capacity of as much as four times its probable market outlet."[12]

The Roosevelt administration proposed tapping the known oil resources and developing others in the Middle East by acquiring a complete, or at least a controlling, Federal interest in them and constructing a pipeline from Saudi Arabia and Kuwait to the Mediterranean. This offer and its views of international trade in petroleum caused grave concern in the U.S. Senate and in America's petroleum industry. To encourage production from hitherto little-used domestic sources, Congress passed and the President signed on April 5, 1944, the Synthetic Liquid Fuels Demonstration Plants Act to aid the war effort and conserve and increase the Nation's oil resources. The new law authorized "the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances." These plants would "be of the minimum size which will allow the Government to furnish industry the necessary cost and engineering data for the development of a synthetic liquid-fuel industry." To allay the petroleum industry's fears, the statute also required "that the combined product of all the plants constructed in accordance with this Act will not constitute a commercially significant amount of the total national commercial sale and distribution of petroleum and petroleum products."[13] The law enabled the Secretary of

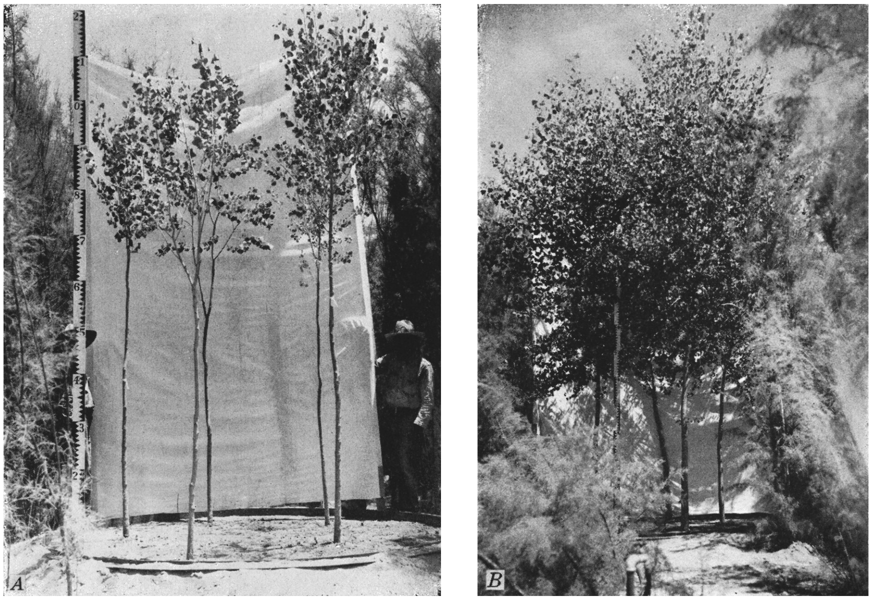
The U.S. Bureau of Mines (USBM) established in 1944 this retort-research facility on Naval Oil Shale Reserve No. 3 at Anvil Points, about a mile west of Rifle, Colorado. Under authority of the Synthetic Liquid Fuels Demonstration Plants Act, the USBM operated the facility until 1956. Development Engineering, Inc., leased the facility from the Interior Department in 1962. When the Department of Energy could not arrange for a subsequent lease in 1982, the company contracted with Mountain Region Construction Corporation at Grand Junction to remove all structures, dispose of dangerous materials, and reclaim the site. (Photograph by R.R. Peabody, U.S. Department of Energy; published in *Geotimes*, v. 30, 1985, p. 20.)



the Interior to acquire the patent rights and properties necessary to ensure the project's success and authorized up to $30 million to fund the work. On June 28, 1944, a second measure actually gave the U.S. Bureau of Mines $5 million during fiscal year 1944–45 for constructing, maintaining, and staffing the demonstration plants.[14] Later in 1944, the USBM established an experimental facility for oil-shale retorting at Anvil Points on Naval Oil Shale Reserve (NOSR) No. 3 near Rifle, Colorado.

Water supplies also received increasing interest during the first 6 months of 1944. On February 3, Mexico and the United States signed a treaty to divide the water of three international rivers—the Colorado, the Tijuana, and that portion of the Rio Grande (Río Bravo) along its length between Fort Quitman, Texas, and the Gulf of Mexico—"to obtain the most complete and satisfactory use thereof."[15] The United States proposed the agreement following increased use of Colorado River water for irrigation in Mexico just south of that country's border with California. The Mexican Government was no less concerned about the division of Rio Grande water due to the rapid expansion of irrigation on the U.S. side of the lower Rio Grande Valley. Although the U.S. Senate retained responsibility for consenting to ratification, the House of Representatives promptly passed a resolution directing its Judiciary Committee to examine the treaty.

Flood control again became a matter of some urgency after floods along the Missouri River during the spring of 1944 broke all previous records. After the spring floods in 1943, the House Committee on Flood Control requested a review to determine flood-control and irrigation needs on the Missouri. Colonel Lewis A. Pick, of the Army Engineers' division at Omaha, Nebraska, had prepared a response plan before leaving for India's Assam Province in 1942 to supervise (as a Brigadier General) construction of the Ledo Road begun that December to facilitate future Allied operations aimed at recapturing northern Burma. The Army Engineers approved Pick's scheme for the Missouri River Basin—528,000 square miles in 9 States—by the end of August 1943. The Bureau of the Budget (BoB) and an Inter-Agency River Basin Commission, established on December 29 and composed of representatives of the Army Engineers, the U.S. Bureau of Reclamation (USBR), the Department of Agriculture, and the Federal Power Commission, reviewed Pick's plan by February 1944. The USBR expressed reservations about the plan because W. Glenn Sloan, that agency's Assistant Regional Director at Billings,



These cottonwoods were grown during 1943–44 at the USGS Glenbar experimental station to assess the amount of groundwater lost in the American West to deep-rooted and rapidly developing phreatophytic trees and other plants. The cottonwoods, placed in tanks up to 10 feet in diameter, used 6 acre-feet of water in doubling their foliage height and width in less than 3 months. For comparison, the USGS also grew mesquite and salt cedars under the same controlled conditions at the Glenbar station, located near the Gila River and about 12 miles northwest of Safford, Arizona. (Photographs by the Phelps Dodge Corporation [at left] and Thomas W. Robinson [at right] from Gatewood and others, 1950, fig. 32*A*, *B*.)

Montana, was preparing a flood-control plan for the river. Sloan's proposal for controlling floods along the Missouri went to Congress early in May 1944, but, on May 9, the House passed a flood-control bill without considering Sloan's alternative plan.

A week earlier, Secretary Ickes established a Departmental Water Resources Committee[16] to coordinate the efforts of all of Interior's units to maintain liaison with other Federal organizations engaged in developing water resources. He expected the new Committee to consider all projects proposed by Interior's agencies and to forward those it approved for review by the Inter-Agency River Basin Commission. Ickes named forester Lee Muck, his assistant in charge of land utilization, to chair the new Committee; hydrologist Glenn Hoyt transferred from the USGS to serve as vice-chairman and executive officer. On July 20, Interior set procedures governing future cooperation in river-basin surveys and investigations between its units and the Army Engineers. The new requirements for approval by the Committee and the Secretary did "not extend to established procedures of the Geological Survey." Interior expected the USGS "to continue with regard to the installation, operation, and maintenance of gaging stations and the collection of ground-water data, or other information, provided that requests for the transfer of funds in connection with the rendering of such service shall be submitted to the Office of the Secretary for consideration and approval."[17]

The USGS, like many Federal agencies between fall 1943 and fall 1945, also pursued the double task of helping to win the war while planning for the future peace. The Federal budget for the fiscal year beginning on July 1, 1944, presented to Congress in January, called for a total expenditure of $100 billion, of which $90 billion would support the war effort. The estimate for Interior for fiscal 1944–45 totaled only $87.9 million, a reduction of $18.6 million, or more than 17 percent, below the sum for fiscal 1943–44. The budget for the USGS, still classified as a war agency, was just under $6,753,000 for salaries and expenses, representing an increase of more than $1.6 million, or nearly one-third more than the funds provided on July 12, 1943. For most items, the USGS requested only small increases to cover the costs of overtime and automatic in-grade raises in salaries. For topographic surveys, the agency asked for $1.25 million, or nearly twice the appropriation for the fiscal year then underway. Because fears of invasion had ended, the War Department decided not to transfer to the USGS any funds for mapping in the

United States; instead, the War Department would shift to the agency $1,060,000 for preparing maps for the actual theaters of war. The USGS, therefore, requested $342,500 to complete the strategic mapping begun under War Department auspices and an additional $102,000 to expedite mapping for the agency's strategic-minerals investigations.

The House subcommittee began hearings on the Interior Department's appropriations bill on February 28, 1944, more than 3 weeks after Secretary Ickes announced on February 6 the principles of the proposed agreement of January 24 among the Petroleum Reserves Corporation, Aramco, and Gulf. The new understanding provided for the construction, ownership, and maintenance by the PRCo of a trunk-pipeline system to transport crude petroleum from Saudi Arabia and Kuwait to the Mediterranean. The pipeline agreement clearly involved many problems—constitutional, economic, and military, as well as international—and both conservatives and liberals criticized it immediately, but Ickes' warning about insufficient petroleum for a future war had the most profound effect. Three days before Ickes spoke, Senators Ralph O. Brewster (R–ME, a member of the Truman committee) and Edward H. Moore (R–OK) noted that "adequate petroleum reserves are essential to our national security and economic welfare." Ickes, as Petroleum Administrator for War (PAW), "recently stated that the United States was not in a position 'to oil another war.'" The Senators proposed establishing a special committee, composed of members of the Foreign Relations, Interstate Commerce, and Public Lands Committees, "to make a full and complete study of petroleum resources and the production and consumption of petroleum and petroleum products, both within and outside the United States, in relation to our national welfare and security."[18]

When Director Wrather made his initial appearance, on March 6, 1944, before the House subcommittee responsible for reviewing the USGS budget, its members deluged him with questions about oil and oil reserves, Arabian oil, and the proposal for an Arabian pipeline, with which he disavowed any connection. Wrather's bout with amoebic dysentery,[19] beginning on Christmas day 1943, kept him in Aramco's headquarters at Dharhan after DeGolyer, Morrell, and Snodgrass left Saudi Arabia for London. Toward the end of January, Wrather accompanied two Aramco executives on a day's visit to Riyadh (Riyād) and an hour's audience with King Ibn Saud. They then traveled some 50 miles south to the Nejd's Kharj district, where Aramco aided agricultural development in the group of oases by installing pumps and building a canal to bring water 7 miles from limestone-pit sources. Wrather returned by air to Washington on February 5, a day before Ickes' announcement and 3 days after William Heroy (Sr.) became the Petroleum Administration for War's Director of Foreign Production. Wrather, still recovering from his illness, did not return to his USGS desk until well into February to end Thomas Nolan's 3-month tour as Acting Director and to reassume the responsibility for postwar planning. Wrather knew that

> **Survey operations had expanded greatly during the war. The organization had demonstrated its usefulness and its services were in demand in various fields of government activity. There was good reason to believe that it would expand further, if it fully occupied its authorized field.[20]**

Wrather decided that the USGS needed major organizational changes "to cope successfully with the greatly increased work load,"[21] but he postponed any modifications of the program branches until he knew more about USGS employees and their operations. He quickly discovered that "the Director's office was sadly understaffed."[22] With the approval of Secretary Ickes and the BoB, Wrather asked Representative Jed Johnson (Sr.), still the chairman of the subcommittee on Interior's appropriations, to authorize an Assistant Director for the USGS.

Johnson and his six-member subcommittee expressed their appreciation for Wrather's work as part of DeGolyer's mission and USGS efforts at home. Representative Michael Kirwan voiced his colleagues' apparent sentiment in observing

> **[w]hen I think of the amount of money being spent for the building of airplane factories and the billions upon billions spent for other purposes, I think that the few men which the Interior Department has sent to the mountains and the deserts, who have made all these discoveries and given to the country these additional resources—that money was certainly very well spent.[23]**

The subcommittee then made only minimal cuts of $7,500 for new appointments in the Office of the Director, $69,600 from topographic surveys ($42,500 from mapping strategic areas and about $27,100 from mapping strategic minerals), and $17,600 from publication expenses. The House accepted its subcommittee's recommendations. On April 7, the Representatives passed Interior's appropriations bill that provided for the USGS total funds of a little more than $6,258,000, or nearly 93 percent of the requested amount.

While the House evaluated the USGS appropriation for fiscal year 1944–45, the Senate Special Committee Investigating Petroleum Resources was duly authorized on March 13, 1944, and its members appointed on the next day by Vice President Wallace. The new committee, chaired by Senator Francis T. Maloney (D–CT), included 10 other Senators, 5 of them from the Foreign Relations, Interstate Commerce, and Public Lands Committees. The Maloney committee immediately began investigating Ickes' proposed Arabian pipeline. They seriously doubted that the framers of the act[24] of June 25, 1940, which authorized the Reconstruction Finance Corporation to create corporations to produce, acquire, and carry strategic and critical minerals, envisaged the establishment of a body such as the Petroleum Reserves Corporation with power to inaugurate a long-term program of oil procurement and pipeline construction and ownership either within or outside the United States. The law likely would be held as unconstitutional if it were interpreted as authorizing the establishment of a body empowered to make a contract calling for governmental action. Before the United States made any commitment along the lines of the pipeline proposal, the Maloney committee concluded, a long-range policy should be carefully developed and publicly considered. Early in April, the committee learned of a proposed agreement between the United States and Britain on international trade in petroleum; on May 24, it reminded Secretary of State Hull about the Senate's prerogative. On June 12, Roosevelt told Maloney that he asked Ickes not to enter into any contract relating to the Arabian pipeline without giving the Special Committee 30 days' advance notice.

On May 12, 1944, while the President considered the pipeline issue, the Senate appropriations subcommittee began hearings on the USGS budget for fiscal year 1944–45. By that time, the petroleum situation was so critical that the USGS submitted a supplemental item for $1,075,000 to explore for oil in Alaska. When Hayden's Senate subcommittee reviewed this request, Michael Straus spoke for Interior, William Heroy represented the PAW, and Wrather and Philip Smith testified for the USGS. Straus reported on the Navy-Army-Interior agreement reached earlier in 1944 to share exploration in Alaska. The Navy would continue work in Naval Petroleum Reserve No. 4 (NPR–4) in northwestern Alaska, the Army would look in the Wide Bay area of the Aleutian Range, and the USGS would examine, by naval-military request, other areas in the Territory. The USGS proposed to investigate five prospects: Yakataga and Katalla (southeast of Cordova), Iniskin (near Oil Point in the Aleutian Range), the Alaska Peninsula, and northern Alaska. Earlier work by the agency indicated that these regions seemed the best possibilities for significant petroleum reserves. The USGS planned to map the geology, appraise sources of petroleum, determine locations for drilling test wells, determine future work, and correlate and integrate the data gathered to guide the development of any discoveries that might be made.

Wrather told Hayden's subcommittee that finding sufficient oil to service the war in the Pacific was becoming increasingly difficult and that he anticipated still more demands. While every known source of oil was being tapped to meet Navy and Army needs, Alaska remained practically untested. In past years, the USGS had made some progress in investigating petroleum resources in the Territory, but appropriations only allowed it to scratch the surface. It was "increasingly urgent that the Geological Survey should perform its obvious function and proceed with the geological exploration which must precede any actual drilling for oil,"[25] and the USGS could begin such work almost immediately after funds became available. Most of the study areas were in southern Alaska near the coast, and no more than 20 to 25 miles of pipeline would be required to send any new-found petroleum to shorelines, where it would be immediately accessible for refining and war use. The subcommittee recommended the full amount of the USGS supplemental request and it also restored the cuts made by the House in the budget items for topographic surveys and publication costs. The Senate followed its subcommittee's recommendations, but the House figures held when its members of the conference committee refused to accept any of the Senate's amendments.

The discussion in the House of Representatives on June 20, 1944, following the reading of the conference committee's report on the USGS budget, provided an illuminating view of conflicts of interest in attaining certain goals. Anthony J. Dimond, Alaska's Democratic delegate since 1933, asked why the funds for oil exploration in the Territory had been dropped from the USGS appropriation. Iowa's Benton ("Ben") Jensen replied by stating that the conference committee decided not to permit the monies because the House turned down an amendment to raise the price of crude oil by about 35 cents a barrel. "Just as long as the Congress insists on not giving [fair prices to] the oil producers of this Nation, the small producers in this Nation, where we know the oil is and where it is already flowing in the lower producing fields," Jensen continued, "I for one, as a member of the Interior Appropriation Committee, will insist that we do not go outside of the confines of the United States and spend a lot of money to get oil and to make investigations, because we can get all the oil we want right now in this war period, and we would be getting it if we will pay a fair market price."[26]

Representative Michael J. Mansfield (D–MT) reminded Jensen that Alaska was part of the United States and Mansfield believed that it was up to Congress to facilitate the exploration and development of the Territory's natural resources. America could spend $100 million to develop Canadian properties, Mansfield added, but it would not expend $1 million to develop its own resources. Perhaps, he suggested, the House should give serious thought to statehood for Alaska. Arkansas' William Norrell hastily assured Mansfield that the conference committee was not discriminating against Alaska but it wanted no Federal appropriation for oil exploration until the oil companies had an opportunity to spend their own funds. Dimond pointed out the impasse; Alaska lands were Federal lands, and all potential oil lands were reserved from entry, and so no private individual or company could explore them. Despite the logic of Dimond's position, the House adopted the report of the conference committee. Roosevelt signed Interior's appropriations bill into law[27] on June 28, which gave the USGS a little more than $6,738,000 in direct appropriations for fiscal year 1944–45, only $15,000 less than requested. Subsequent deficiency and supplemental appropriations and funds from outside sources raised the total to almost $12,599,000 for the agency's some 2,800 regular and seasonal personnel and their operations during the year, an increase of slightly more than $1 million from the sum received in fiscal 1943–44.

In the 6 months after Roosevelt's address to Congress in January 1944, the Allies continued their successful offensives in both hemispheres. In the Italian campaign, Anglo-American forces landed at Anzio on January 22, during which operation William Rasmussen earned a Bronze Star while leading a water-supply company. Churchill hoped the Anzio invaders would outflank the Germans' Gustav Line. Instead, the Prime Minister got a partial replay of Salerno; Allied forces dug in rather than advancing rapidly toward the Alban Hills. The Allied forces repelled all German attacks and finally broke out of the beachhead on May 23. Linking up on the 25th with other Allied troops moving north from Cassino, they captured Rome on June 4.

Just 2 days after the Allies liberated the Eternal City, General Eisenhower's Anglo-American forces landed on the coast of Normandy to begin the long-awaited second front in Europe. In the weeks before the invasion, Allied aircraft flew mostly tactical missions, but they also struck German synthetic-fuels installations and transportation targets. Allied ships and aircraft conveyed General Montgomery's 21st Army Group, including the nine divisions of Lt. General Omar Bradley's U.S. 1st Army and General Miles C. Dempsey's Anglo-Canadian 2d Army. Paul Thompson, now a full Colonel, was badly wounded while leading the 6th Engineer Special Brigade on D-day (June 6, 1944).[28] By June 11, more than 300,000 Allied troops were safely ashore in France. They defeated German piecemeal counterattacks and consolidated their landing areas into a solid front, helped by Hitler's decision to hold back panzer and other reserves to defend against the long-suspected, but bogus, invasion at the Pas-de-Calais. The Allies took Cherbourg on June 27, began clearing the port, and started constructing the Pipe Line Under The Ocean (PLUTO) beneath the English Channel to send oil from Britain to France. Although 1 million men, including Raymond Nace's company of the 487th Water Supply Battalion, were in Normandy by July 1, units of Field Marshal Rommel's Army Group B, their defenses enhanced by the difficult bocage country, resisted all Allied attempts to break out of the Cotentin Peninsula.

On the Eastern Front, the Soviet Union's winter offensive relieved Leningrad's defenders, broke German lines along the Dnieper River, cut off German forces in the Crimea, and moved westward toward the Dniester River. By April 1944, although delayed by a skillful and tenacious German defense, the Soviets reoccupied the entire Ukraine. On June 22, Soviet forces led by Marshal Zhukov, now Stalin's second in command, launched an offensive to recapture White Russia and timed to support the Allies in Normandy. Soviet armies mauled units of the Wehrmacht's Army Group Center, took Minsk on July 3, and began pushing into easternmost Poland. Other Soviet troops punched through the Mannerheim Line and forced Finnish forces to seek a truce on September 4 that took their country out of the war. Other Soviet armies cleared the Crimea in May, but not before the Germans evacuated most of their forces from Sevastopol to Odessa.

In the Central Pacific, the American V Amphibious Corps invaded Kwajalein Atoll in the Marshall Islands on January 29, 1944. Benefiting from lessons learned at Tarawa, the marines and soldiers captured Kwajalein's principal islands by February 7. Admiral Nimitz moved up to February 17 the scheduled assault on Eniwetok (Enewetak) Atoll to the northwest, and marine and army units completed taking the atoll 6 days later. After MacArthur's troops captured Hollandia, they landed during February and March on Green Island, and on Los Negros and Manus in the Admiralties, closing the ring around Rabaul. Admiral Spruance's 5th Fleet raided Truk on April 30 and went on to strike Wake and Marcus in May as additional preludes to the invasion of the volcanic Mariana Islands, which included Guam to the south and the Northern Mariana Islands (now the Commonwealth of the Northern Mariana Islands, CNMI).

The American assault on June 15 on Saipan (in the Marianas),[29] about 1,200 miles northwest of Enewetak and an equal distance south-southeast of Tokyo, brought an immediate and major Japanese response. The Combined Fleet, under Admiral Toyoda Soemu since Admiral Koga's accidental death on March 31, sortied from bases in the western Carolines to stop the invasion and destroy the 5th Fleet. Japanese planners in the 1st Mobile Fleet proposed adding attacks from Marianas-based aircraft to those from the carrier-based aircraft (launched beyond the range of U.S. planes and refueled ashore before returning to their ships). Between June 19 and 21, Japanese and U.S. naval aircrews fought over the Philippine Sea. Japan's rebuilt forces lost three carriers (to U.S. aircraft and submarines) and lost more than 400 aircraft and most of their crews. Some 130 American planes and 75 crewmen were lost, but no U.S. ship was sunk or even significantly damaged.

As the global war continued to turn in the Allies' favor and the new fiscal year began on July 1, 1944, the USGS employed 2,800 people, not counting those assigned abroad or the gage and well readers at home, of whom about 87 percent worked full time. Some 90 percent of the staff served in the program branches, and the others, in the general administration or in the engraving and printing units. While the USGS remained focused on efforts to advance the Allied war effort, Director Wrather also prepared the agency for "a normal peacetime program"[30] during the postwar years. As Wrather's many organizational changes could not be done "all at once," he reformed the program divisions "one at a time," as Director Walcott did during the 1890s. Wrather knew that

> **[s]ome of the men occupying key posts were approaching retirement. Some of them were my personal friends of long standing. I believed that the division chiefs, at least, should be younger men with the prospect of long service ahead. I had no intention of running the divisions. That responsibility would rest on the division chiefs and I believed they should have a hand in shaping the organization for which they would be responsible.[31]**

Wrather began his changes in July by relieving Wilmot ("Bill") Bradley of his duties as Chief of the Military Geology Unit (MGU) and appointing him as the new Chief Geologist.[32] Bradley succeeded Gerald Loughlin, who, like David White before him, asked to return to research. The Director made Loughlin a Special Scientist and consultant on his staff to undertake work on problems in economic geology, fulfilling Loughlin's wished-for role in the postwar USGS. A revolt within the Geologic Branch, designed principally to break the logjam of Branch manuscripts, all of which Loughlin had to read before they received Director's approval for publication, also fueled Wrather's decision. Wrather asked Loughlin, as part of his new duties, to review and classify for elimination or completion, as publications or open-file versions, the many existing unfinished manuscripts in the files left there by deceased, resigned, or retired authors.[33]

Bradley succeeded Loughlin as Chief Geologist on July 17, 1944. Charles Hunt replaced Bradley as head of the MGU, which continued operations under the second agreement signed with the Army Engineers nearly 6 months earlier on January 22. Fritiof M. Fryxell, a geologist and mountaineer on leave since 1942 from teaching at Augustana College, later took Hunt's place as Assistant Chief. Wrather asked Bradley to concentrate on planning for postwar geological activities in the prewar regional centers and to rebalance basic and applied research. Bradley, like his predecessors David White and Walter Mendenhall, strongly supported fundamental studies and quickly remade the Geologic Branch. He restored "Division" as an administrative level between the Branch and its Sections, repeating the arrangement in place during 1902–26. The two new Divisions—Economic Geology and Basic Sciences—more philosophically resembled Director King's original organization of the USGS into Mining Geology and General Geology than Walcott's Divisions of Geology and Paleontology, Chemistry and Physics, and Mineral Resources.

Bradley assigned the Sections of the Geology of Fuels, Geology of Metalliferous Deposits, and Geology of Areal and Nonmetalliferous Deposits to the Division of Economic Geology. He placed the Sections of Chemistry and Physics, Paleontology and Stratigraphy, Petrology, Military Geology, and a reactivated unit for editing geologic maps in the Division of Basic Sciences. Whenever possible, Bradley, encouraged by Wrather, chose younger geologists as Section managers to combine innovative ideas with technological advances.

In another break with tradition, the Geologic Branch's new Division chiefs did not also serve concurrently as Section chiefs. Both Harold Bannerman, who led the Division of Economic Geology, and Basic Sciences' William Rubey were new (or almost new) to the Geologic Branch's administrative hierarchy. In November 1943, when George Mansfield retired, Bannerman replaced him as head of the Geology of Areal and Nonmetalliferous Deposits Section. Rubey also chaired the National Research Council's (NRC's) Division of Geology and Geography, to which he had been elected for a 3-year term in 1943, after service with Bradley, Gilluly, Heald, Longwell (chair), and Paige on the Committee on War Projects in 1942–43. On July 19, 1944, Bradley began additional managerial changes within the Branch. He designated Foster Hewett a Staff Geologist, and Thomas Nolan became Acting Chief of the Geology of Metalliferous Deposits Section. Josiah Bridge, primarily a biostratigrapher who led the agency's ongoing bauxite program, succeeded Bannerman as the head of the Geology of Areal and Nonmetalliferous Deposits Section. On October 31, Bradley and Rubey appointed geochemist Waldemar T. Schaller to lead the Section of Chemistry and Physics, replacing Roger Wells, in whose place Schaller had acted since Wells' death in April.

Bradley continued to modify the Geologic Branch's administration. On November 24, he and Bannerman relieved Nolan, freeing him for reassignment, and appointed Charles Park, Jr., who had concentrated on manganese and other strategic-mineral investigations, to lead the Geology of Metalliferous Deposits Section. Effective the same day, Bradley and Rubey established, within the Basic Sciences Division, a new Engineering Geology Section, under Edwin B. Eckel, who managed the Division's studies of domestic mercury deposits and then replaced Hunt as Assistant Chief of the MGU before being succeeded by Fryxell. Bradley also relieved Stephen Capps as Assistant Chief Geologist in November and reassigned him to the MGU. Joe W. Peoples, who studied chromite deposits in Montana's Stillwater Complex and remained interested in geophysical prospecting, succeeded Capps.

Bradley also changed assignments in the Geologic Branch to reflect modified emphases on the importance of its work. On July 28, Bradley received a copy of an informal committee's study, dated May 3, that Wrather requested to gage "the relative importance of projects now being carried out by the geologic staff * * * and the revision of the distribution of personnel to those projects." Foster Hewett (chairman), Harold Bannerman, Carle Dane, John Reed (Sr.), and Charles Park, Jr., evaluated the existing or potential importance of 36 ongoing projects and project groups. They used six criteria: (1) "immediate contributions to the war effort," (2) staff knowledge of commodities on the War Production Board's (WPB's) mineral-classification lists, (3) extent of requests "for information from the War Agencies," (4) the USGS value of commodities based on "consumption, imports, production, reserves, and substitutes," (5) "requests for information, cooperation, or assistance from State or other Federal agencies," and (6) the "availability, fields of experience, and special qualifications" of USGS geologists. Each project received a rating of "A" (utmost importance), "B" (intermediate importance), or "C" (minor importance), a second and similar rating letter for personnel now assigned, and the number of possible changes in their personnel. These ratings reflected "an attempt to retain a practical view as to the size of the [geologic] staff and the scope of the duties the Survey might be expected to perform" but "arbitrarily ignored the Selective Service situation as well as expected projects."[34]

The informal committee's members gave A rankings to 11 projects and recommended adding 35 geologists to 5 of them. Those funded by the War or Navy Departments would gain 25 geologists; the uranium project, 4; Alaskan oil, 3; fluorspar, 2; and minor metals, 1. The staff sizes would stay the same for the remaining 6 projects: Alaskan coal, asbestos, conterminous U.S. oil, foreign work, optical calcite, and pegmatite. Twelve projects received B ranks: natural gas, iron, copper, lead and zinc, manganese, magnesite, strontium and barium, potash and phosphate, talc, work with Massachusetts, cooperation with other States, and Alaskan minerals. Hewett's committee suggested that seven geologists should be reassigned from the iron (–5) and copper (–2) projects and four geologists should be added to the studies of lead and zinc (+1), strontium and barium (+2), and talc (+1) for a net loss of three geologists in the B category. For the 12 C-level projects, they suggested a net reduction of 40 geologists: conterminous U.S. coal (no change), tar sand (–2 geologists), bauxite (–20), chromium (–2), mercury (–10), tungsten (–1) vanadium (no change), dolomite (–2), alunite (–2), clay (no change), magnesium (no change), and areal geology (–1). The report also listed glacial geology studies by François E. Matthes as the 36th and only unranked project. The committee called for "a continuing reappraisal of personnel requirements," including the unstudied support staff, a group they thought "badly needed" increased help.[35]

During fiscal year 1944–45, Bradley's Geologic Branch received for geologic surveys and strategic- and critical-minerals investigations by its some 620 full- and part-time employees (as of June 30, 1944) a total of about $2,967,000. That sum represented an increase of more than $343,000 over the total available for fiscal 1943–44. Direct appropriations provided a little more than $2 million, but the War Department transferred $410,000 and the USBM shifted $317,000 to make up the new total. On May 27, 1944, with approval from Secretary Ickes, the USGS and the USBM signed an administrative order that defined their respective functions. Geologic Branch specialists continued their scientific work in field and laboratory entirely devoted to war-related projects. By the end of fiscal 1944–45, their wartime work aided the discovery of new mercury and tungsten ores worth $25 million, but war consumption depleted 97 percent of the Nation's mercury, 78 percent of its chromium, 70 percent of its vanadium, and considerable (if lesser) reserves of copper, fluorspar, manganese, tungsten, and zinc. For copper, the long-continued basic studies by the USGS of principal mineral districts as a basis for future exploration, now in cooperation with the USBM and its drilling program, identified copper reserves at San Manuel in Arizona estimated to be as large as 64 million tons for mostly sulfide ore averaging just 0.1 to 0.2 percent below the content of the deposits being worked extensively elsewhere in Arizona and in Utah. Similar wartime work added about 10 million tons of domestic bauxite ore[36] to the known reserves of 75 million tons.

The results of the Branch's studies on bauxite, uranium, and other important commodities provided a positive response to Interior's report, with USBM input, to the WPB early in 1944. USGS investigations through August 1943, the report claimed, discovered only a small number of higher grade deposits from which minerals could be produced under peacetime conditions. The report acknowledged that the many lower grade deposits of strategic and critical commodities recently disclosed by USGS studies might become useful if acute shortages arose before war's end or in future emergencies, provided technical developments continued to reduce production costs. Finding new and better grade mineral deposits to restore reserves still required accurate and detailed geologic mapping, but only some 7 percent of U.S. lands were mapped at scales adequate to serve a discovery program sufficient to sustain the Nation's industries.

To help meet these mineral needs, Geologic Branch personnel also investigated new techniques in geochemical and geophysical analyses. Victor Vacquier and other engineers at Gulf Research and Development's Geophysical Division developed "a gyro-stabilized magnetic detector which saw limited antisubmarine use early in the war." The Germans introduced the saturable core in 1936, by which "accurate magnetic measurements could be made by employing the principle of the fluxgate or flux valve."[37] The Naval Ordnance Laboratory (NOL), the Bell Telephone Laboratories (BTL), and the Airborne Instrument Laboratory of Columbia University's Division of War Research (under contract to the National Defense Research Committee, NDRC) then combined their talents to develop a self-orienting fluxgate Magnetic Airborne Detector (MAD), including one wingtip-mounted version. The new detector was designed to measure the submarine-caused transient anomalies but also registered total magnetic intensity. In 1942, the United States and Canada equipped more than 100 B–18 medium bombers with the MAD and search radar to help the Allied hunt for U-boats in the Atlantic and the Caribbean.

Late in 1942, USGS geophysicist Herbert E. Hawkes, Jr., heard about the new device when asked about interpreting the effects of rock masses on the MAD because "spurious signals from geological conditions" were only "partially removed by a series of filters."[38] Hawkes, who earned his Ph.D. at the Massachusetts Institute of Technology (MIT) in 1940 before joining the USGS for work on chromite deposits, recognized the detector's potential use as an exploration tool in the agency's searches for strategic minerals. In 1943, as the NOL tested its magnetometer, the USGS published the results of James Balsley's and John A. Reinemund's plane-table and alidade mapping and their compass and dip-needle survey in September 1942 of four vanadium-bearing magnetite and ilmenite deposits in the Sanford Hill district, about 30 miles west-southwest of Westport, in northeastern New York. Balsley, while working with the Office of Scientific Research and Development (OSRD) and the Manhattan Engineer District (MED), also recognized the detector's geophysical potential. He began discussions in December 1943 with physicist L. Hamilton Rumbaugh, the NOL's Chief of Research and Torpedo Engineering, about the "modifications necessary to adapt the magnetometer for mapping extensive areas." Subsequent modifications of the magnetometer involved "some improvements in the electronic equipment," but most of them related to "aerial navigation and determination of the plane's position for geophysical mapping."[39]

Cooperation by Philadelphia's Aero Service Corporation, Bell Labs, the Navy's Bureau of Aeronautics, and the USGS enabled the USGS to field test the USGS-modified Navy magnetometer early in 1944. Aero Service sent its best pilot and a Beech Model 17 biplane—a single-engine, staggered-wing light transport—to carry the officially still-secret AN/ASQ–3A Magnetic Airborne Detector and its bomb-shaped cover, together known wryly to its operators as the "bird." In the low-level flights, the "bird" trailed out on a cable behind and below the aircraft to a point beyond the immediate effect of its own magnetic field. The initial test of the modified detector came in April 1944 on the magnetite deposits in Triassic diabase near Boyertown, Pennsylvania, some 40 miles northwest of Philadelphia, as part of a multiagency program requested by the WPB. The area's mines were among Pennsylvania's principal producers of iron ore between 1850 and 1900 but had been shut down since then. The USBM completed a ground-magnetic survey in 1943 that the USGS resurveyed and extended in 1944. The Defense Plant Corporation used these surveys as the basis for a two-hole diamond-drilling program, logged by the USGS, to supplement the data from commercial drilling in 1916–17. The results of the new deep drilling demonstrated the magnetite deposits' downdip continuity.

The USGS and the USBM then combined their efforts in geologic and magnetic surveys of areas in and near Boyertown. Arthur F. Buddington directed the USGS portion of the project and provided geologic interpretations. Herbert

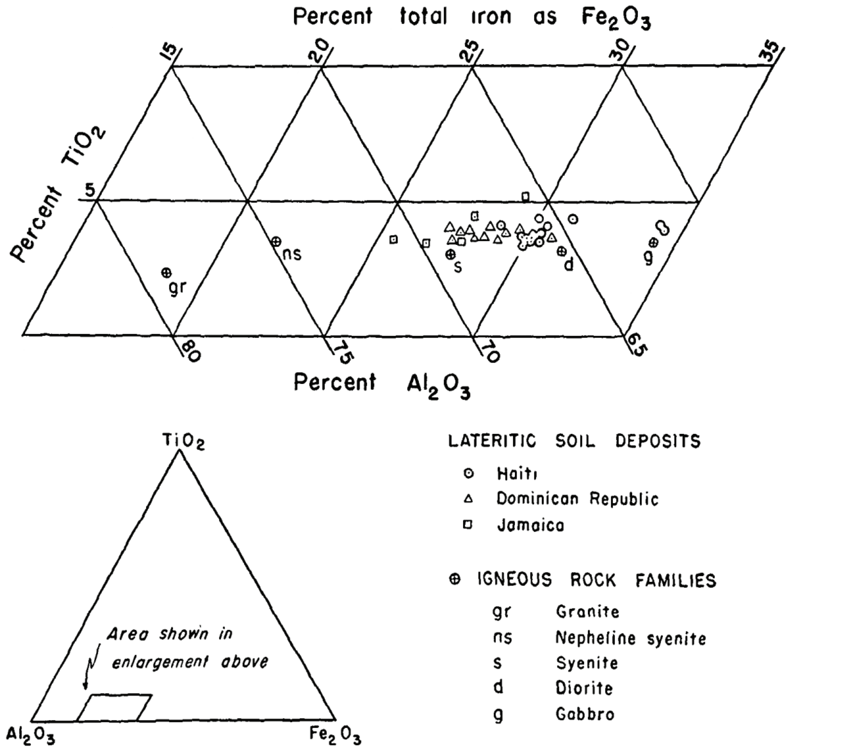
Geophysicist James Robinson Balsley, Jr. (1916–94), educated at the California Institute of Technology (Caltech) and Harvard, joined the USGS full time in 1941. He adapted the Navy's airborne magnetometer, used to hunt Axis submarines, for aerial geophysical prospecting and surveys. In August 1944, Navy Captain William G. Greenman arranged for Balsley's team to survey magnetic anomalies associated with known oil-producing structures in Oklahoma and Wyoming and compare them with the results of ground surveys. In 1945 and 1946, Balsley's team, flying in a PBY–5A Catalina, surveyed nearly all of the 37,000 square miles of Naval Petroleum Reserve No. 4 in northern Alaska. Continuous photography from the PBY–5A linked to existing trimetrogon records ensured ground control. Results disclosed a regional magnetic gradient to the northeast, confirmed the structure at Umiat that had been identified from the surface geology, and suggested other anticlinal closures elsewhere. Balsley flew magnetometer surveys over Antarctica during the Navy's Operation Highjump (1946–47), led the USGS Geophysics Branch (1953–59), and served as Assistant Chief for Geologic Processes (1959–62) and as Assistant Director for Research and for Land Resources (1970–79). His support of basic research led to the development of key evidence for plate tectonics and the paleomagnetic time scale. (Photograph from the USGS Denver Library Photographic Collection in the "Magnetic Detectors" subject album as magnet08, https://www.sciencebase.gov/catalog/item/51dd7f42e4b0f72b4471b403; published in Yochelson and Nelson, C.M., 1979, p. 35.)

Commodore William Garrett Greenman (1888–1956) was "the officer most responsible for the exploration for oil in [Alaska's] Naval Petroleum Reserve No. 4." Captain Greenman's *Astoria* was one of four Allied heavy cruisers that the Japanese sank at the Battle of Savo Island in August 1942. Although wounded, he then led Naval Base Guadalcanal before commanding the Advanced Base Planning Section in the Central Pacific Area and earning a second Legion of Merit. In June 1944, Greenman was appointed Director of Naval Petroleum and Oil Shale Reserves (DNPR); he had spent 1936–39 inspecting operations on NPRs 1 and 2 in California. The Navy promoted Greenman to Commodore (now Rear Admiral, lower half) in November 1945. He completed his tour as DNPR in December 1950 and retired in April 1951. (Photograph and quotation from Reed, J.C. [Sr.], 1958a, facing p. V.)

Hawkes, Jr., and Helmut Wedow, Jr., handled most of the ground-based geological and vertical-intensity magnetometer surveys. Balsley led the aeromagnetic-survey flight team, including geologists Cleaves L. Rogers and Darwin L. Rossman, in measuring total intensity. Balsley's crew also completed five experimental airborne-magnetometer traverses—two northeast of the town, approximately parallel with the ground-level magnetic surveys, and three, without such control, across the old mine workings at Boyertown. The traverses, flown at altitudes of 600 and 900 feet, recorded relatively large anomalies that reflected the ore bodies of two of the former mines, but industrial anomalies, which masked the ground survey, also adversely affected the results from the overflight at 300 feet. These aerial surveys "came within a few miles of finding a major magnetite deposit (the Grace Mine) later discovered by Aero Service."[40] The flights did demonstrate "the speed, accuracy, and broad applicability of the equipment." In May and June, the same plane and magnetometer overflew "1,500 square miles of wood and swamp land"[41] near Iron River, in the western, iron-rich part of Michigan's Upper Peninsula and recorded significant positive and negative linear trends.

For greater safety in transporting the 350-pound magnetometer payload, the USGS sought a twin-engine aircraft to support additional tests. Discussions with Captain William G. Greenman, the newly appointed Director of Naval Petroleum and Oil Shale Reserves (DNPR), convinced him to use the new geophysical technique in a rapid and extensive reconnaissance survey of Alaska's NPR–4. The Navy Department also was under new management; Secretary Frank Knox died in April 1944 and Under Secretary James V. Forrestal replaced Knox on May 9. Captain Greenman relieved Rear Admiral H.A. Stuart as the DNPR on June 10. Greenman had served afloat in everything from destroyers to battleships and carriers but also ashore as Inspector of Naval Petroleum Reserves in California during March 1936–July 1939. On August 9, 1942, the Japanese wounded Greenman and sank his *Astoria*, one of the four Allied heavy cruisers lost in the Battle of Savo Island. Greenman, after recovering, served in support capacities in the Pacific before becoming DNPR. In August 1944, Greenman, "who recognized the applicability of the equipment for making surveys in Naval Petroleum Reserve No. 4," arranged to use a Navy twin-engine Beech SNB–1 for further experiments in a new project with the NOL and the BTL. The Navy's SNB–1, like the Army Air Forces' AT–11 Kansan bombing trainer, was a modified Beech Model 18 with a glazed nose, dorsal dome, and twin-boom tail. During December 1944, Balsley and his team used the SNB–1 to survey "typical low-gradient anomalies associated with oil structures"[42] around Mangum, Oklahoma, and compared them with ground surveys. The USGS then employed the ever-improving equipment in May and June 1945 to survey nearly 3,200 square miles and the high-intensity, near-surface, and extensive magnetic anomalies in the iron-bearing area of the northern Adirondacks, including the Benson and other iron mines of New York's St. Lawrence County.

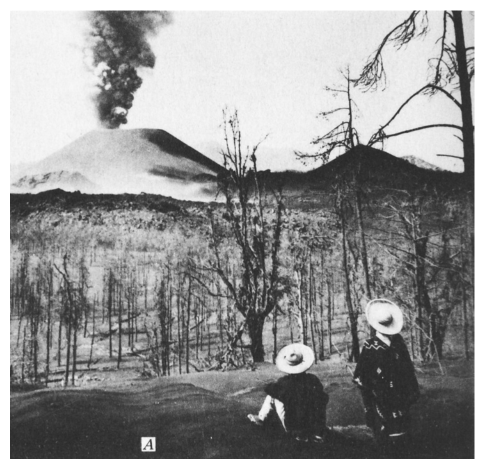
To the Geologic Branch's funds for geologic surveys and studies of strategic and critical minerals during fiscal year 1944–45, the State Department transferred $90,500, a $16,000 gain, for work in other American Republics. The Foreign Economic Administration (FEA) contributed $64,000. Under these auspices, and those of the Institute of Inter-American Affairs, which replaced the Office of the Coordinator for Inter-American Affairs (the former Interdepartmental Committee for Cultural and Scientific Cooperation), Branch geologists, in cooperation with their Latin American colleagues, continued or began investigations of 13 mineral commodities in Brazil, Chile, Cuba, the Dominican Republic, Haiti, Mexico, and Puerto Rico. The Smithsonian's William Foshag continued his cooperative work in Mexico on its mercury, tin, tungsten, and other strategic minerals, and at the still-growing Parícutin Volcano. At intervals during the fiscal year, scientists joining Foshag in studying the minerals and (or) the volcano included USGS geologists John Dorr 2d, Edwin B. Eckel, Carl Fries, Jr., David M. Larrabee, Ward Smith, and Francis Wells



This graph shows the proportions of the oxides of aluminum, iron, and titanium in the laterites of the Dominican Republic, the Republic of Haiti, and Jamaica. After high-grade aluminous lateritic soils were discovered in Jamaica in 1942, Reynolds Mining Corporation confirmed in July 1943 similar occurrences in Haiti, as suggested by USGS geologists in 1921. For the State Department, USGS geologists Samuel S. Goldich and Harlan R. Bergquist studied the geology and estimated reserves of laterites in Haiti during October 1943–April 1944. Using differential thermal analysis to identify principal minerals and assess grades, they located several deposits with as much as 50 percent alumina that totaled 15 million long tons, of which 10 million seemed recoverable. (From Goldich and Bergquist, 1948, fig. 7.)

and volcanologists Richard E. Fuller (University of Washington), Howel Williams (Berkeley), E. George Zies (Carnegie Institution of Washington's [CIW's] Geophysical Laboratory), and their Mexican colleagues Jenaro González-Reyna, Ezequiel Ordóñez, and Eduardo Schmitter.

Fuller arrived in Mexico on August 14 as Chairman of the U.S. Committee for the Study of Parícutin Volcano, formed by the NRC's Division of Geology and Geography at the request of Fuller's Section of Volcanology of the American Geophysical Union (AGU). The Committee, formed "to integrate the study of the eruption and its effect before the record was lost,"[43] worked in cooperation with a corresponding committee of seven Mexican scientists led by Ordóñez. Fuller's 15-person Committee included Fred M. Bullard, University of Texas; William Foshag; Louis C. Graton, a former USGS geologist on Harvard's faculty; Foster Hewett; Ezequiel Ordóñez; William Rubey (ex officio); Francis Wells; Howel Williams; and George Zies. Some of the State Department's funds went to support an initial 8-month's mapping and study of the volcano and the surrounding area by Williams and Kenneth Segerstrom. Other money from the State Department funded magnetic and seismological observations at the volcano directed by Austin E. Jones, of the U.S. Coast and Geodetic Survey, who conducted a seismic study of Kilauea's eruption in 1931–32. The Geological Society of America, as urged by Graton, gave Fuller's committee $15,000 for aerial and gravity surveys of Parícutin, and the American Philosophical Society provided additional financial support. Fuller's Committee established its field headquarters, staffed by onsite observer-caretakers for 8-month tours each, near the volcano. Segerstrom's topographic control and aerial photographs taken for the Committee by the Compañia Mexicana Aerofóta in April passed to the Secretaria de Agricultura's Departmento de Geografía y Meteorología, directed by Manuel Medina, a member of the Mexican Committee, to produce Multiplex-map coverage on mosaics at scales of 1:10,000, 1:20:000, and 1:40,000. During 10 days in July, the USAAF's Air Service Command supplied a helicopter to ferry parties to Parícutin and photograph in color eruptive activity from above and on the volcano's rim. During that interval, the participants



This view of Mexico's Parícutin Volcano, taken in March 1944, looks southwest from the Cerro de Equijuata along the line of the 1943–44 vents toward the main cone more than 2 miles distant. Satellite cone Sapichu stands at the foot of Parícutin, and the lava flows of June 1943 occupy the middle distance. The volcano's cone grew rapidly after the eruption began in February 1943 and ash and lava flows quickly covered large parts of the surrounding area. (Photograph by Arno Brehme; published in Foshag and González-Reyna, 1956, pl. 39*A*.)

Lava of the Parangaricutiro tongue of Parícutin's Taquí flows spared the bell tower and most of the church of San Juan Parangaricutiro (shown here), but beyond the church, the tongue buried completely the town of San Juan Parangaricutiro, northwest of Uruapan, Mexico. (Photograph, January 25, 1945, from Foshag and González-Reyna, 1956, pl. 43*A*.)

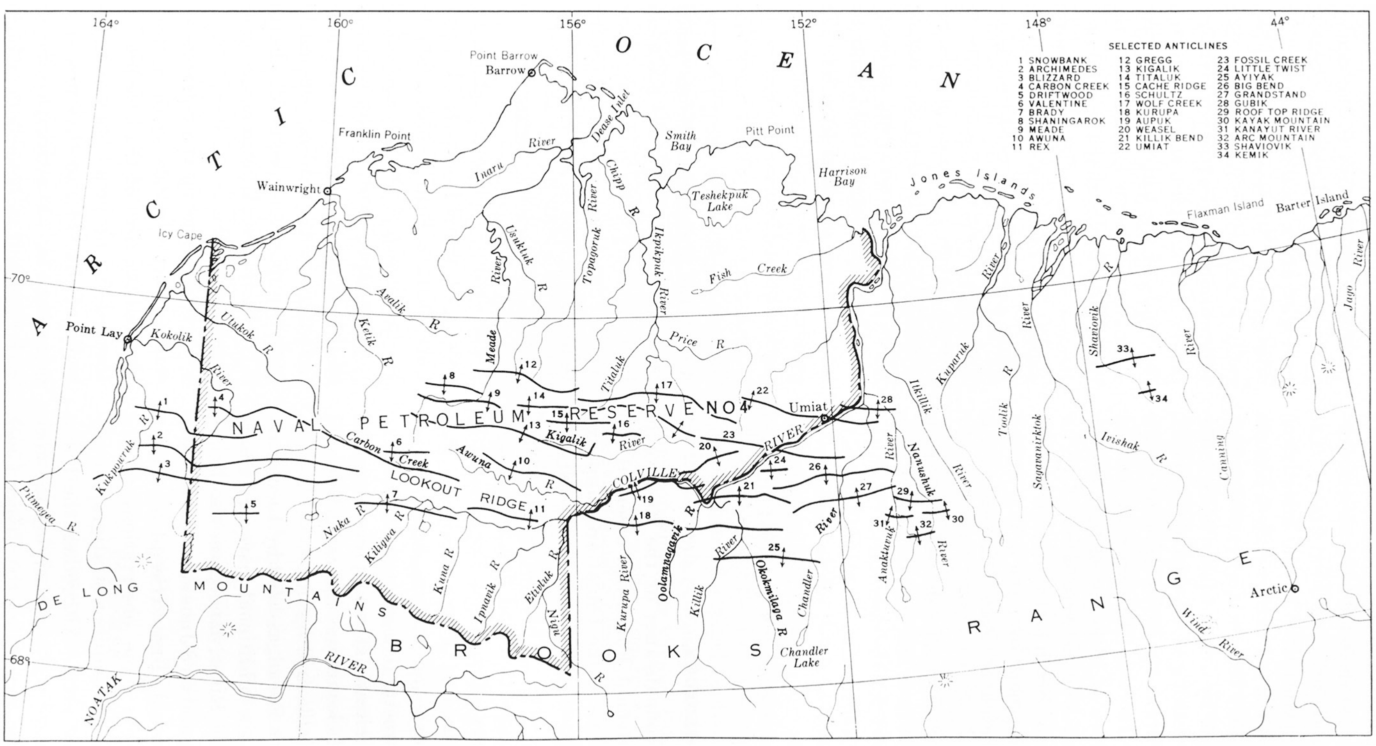
included Bullard, Foshag, Graton, Medina, Ordóñez, Frederick Pough, Segerstrom, and Igor T. Sikorsky, whose R–4B helicopter they used had been in production since 1942.

Domestic investigations of metallic minerals by the Geologic Branch emphasized basic geologic studies of the principal ore-producing districts in the United States to provide a better foundation for further exploration. Some of these investigations paid off immediately. In addition to the copper discoveries at San Manuel, Arizona, Branch scientists also sought new deposits of several rare elements needed for war projects, including uranium for the nuclear-weapons program. The Branch's vanadium project on the Colorado Plateau, begun in 1939 as part of its strategic-minerals investigations, produced geologic studies by Richard Fischer and his colleagues of the uranium-vanadium deposits in carnotitic sandstones and other rocks, a diamond-drilling exploration in cooperation with the USBM in 1943, and a classified report about the region's uranium deposits later that year for the MED that expanded on the previous year's estimate for the OSRD. "This study helped to crystallize an optimistic assessment of a large uranium potential on the Colorado Plateau."[44] In June 1944, the USGS sent four field parties, advised by the results of laboratory analyses and equipped with Geiger-Müller counters, to search for radioactive-mineral deposits in the conterminous United States and in Alaska Territory.

In October, after representatives of the MED and the USGS conferred, the two organizations established a joint program to explore for domestic sources of radioactive commodities, especially uranium and thorium. The program's field investigations, managed by William Rubey (within the Geology of Metalliferous Deposits Section), were initially directed toward occurrences indicated by gamma-ray measurements of the mill- and smelter-product samples and later expanded along different lines based on additional data. Chemical, radioactive, and spectrographic determinations of these elements continued to supplement field studies. Geochemist Michael Fleischer left his studies of the mineralogy of manganese-oxide minerals as aids to prospecting and joined chemist Frank S. Grimaldi, the MGU's Esper S. Larsen 3d (the son of E.S. Larsen, Jr.), William Pecora, John Rabbitt, and other USGS geologists in related contributions to the MED's search for new sources of uranium and thorium, and for beryllium, boron, columbium, germanium, the lanthanides, selenium, tellurium, and other rare elements. As USGS work progressed, expanding estimates of ore tonnage at 0.001 percent of uranium led to raising the lower limit of potential reserves to 0.01 percent of uranium in black shales, phosphatic sediments, late-phase differentiates of igneous rock, placers, and deposits of fluorite, manganese, and tungsten. In November 1944, James O. Harder replaced Rubey as head of the trace-elements program. To improve administration and security, Bradley took the trace-elements work out of the Geology of Metalliferous Deposits Section on April 26, 1945, and made Harder the Chief of a Trace Elements Unit (TEU) that reported directly to Rubey.

During fiscal year 1944–45, Geologic Branch personnel also continued oil and gas investigations and published 28 preliminary maps and charts. They also expanded their fuels-related work in Alaska. The studies completed during 1945 included preliminary geologic and topographic maps and sections of the Katalla area by Don Miller, Darwin Rossman, and Charles A. Hickcox. Although Congress denied the USGS a supplemental appropriation to explore for oil in the Territory, Branch geologists Robert Coats and George Gryc accompanied the Navy party in Naval Petroleum Reserve No. 4. Captain Greenman enthusiastically supported the increased effort, aided by Lt. Commander William H. Rex's Seabee detachment from the construction battalion led by Commander Bart W. Gillespie, then assistant for oil matters to Rear Admiral Ben Moreell, Chief of the Navy's Bureau of Yards and Docks and its Civil Engineer Corps. Between early June and early August 1944, Lt. William Foran's group, including geologist and Lt. James J. Brazil, concentrated

This index map of northern Alaska (originally at about 1:3,750,000) shows the boundaries of Naval Petroleum Reserve No. 4 and the general locations of 34 selected anticlinal structures, including one of the more promising ones at Umiat on the Colville River. Prudhoe Bay, not identified on the map, is east of the northeast end of NPR–4, beyond the Sagavanirktok River's delta and east of the Jones Islands. (From Reed, J.C. [Sr.], 1958a, fig. 12.)



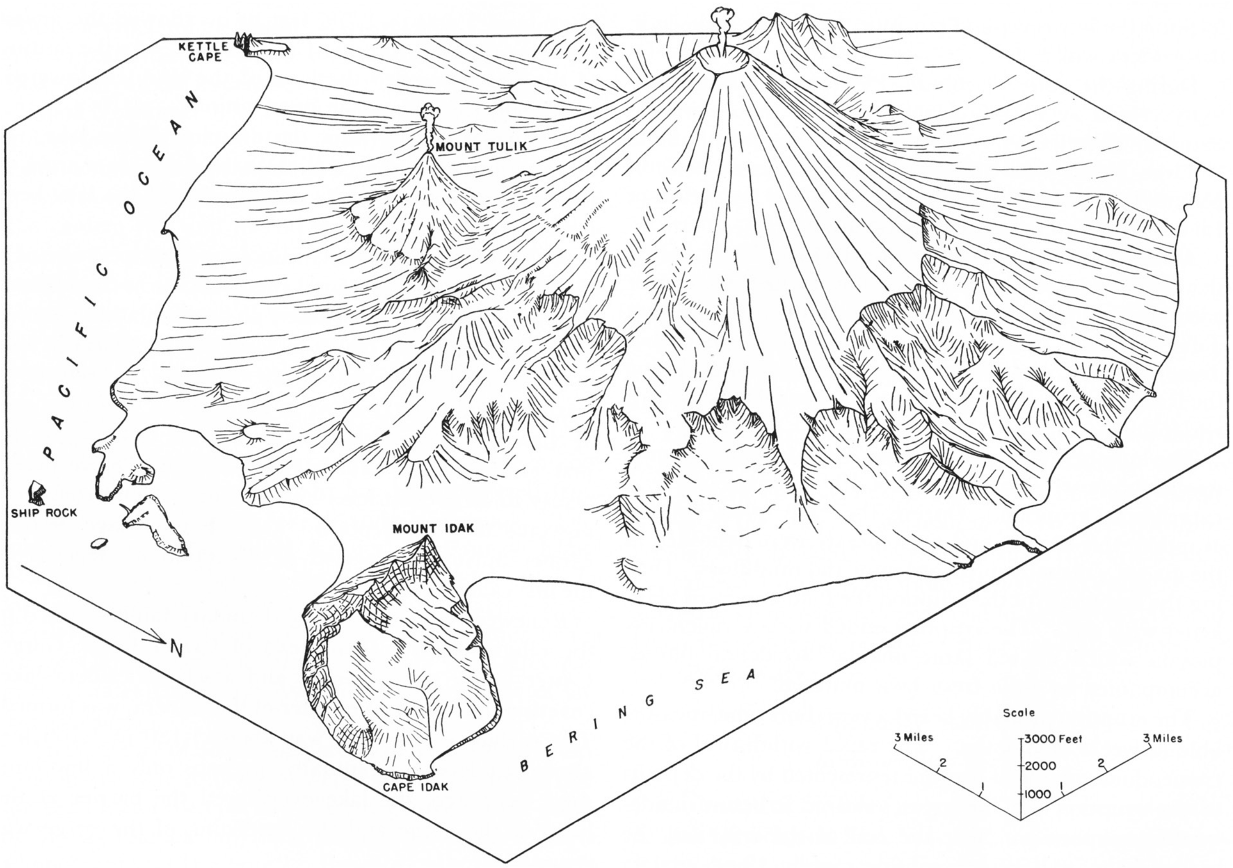
on preparing structure maps of a major anticline in the Umiat area in the far east-central part of NPR–4. The USGS geologists focused their studies on the stratigraphy of the Colville River bluffs, from above Umiat to about 40 miles downstream from that point. In October, near the Navy's new base at Barrow, Rex's party failed to recover cores from shallow test wells and lost one rig to fire but successfully drilled a third well to a depth of 685 feet.

The Navy received $1,620,000 to conduct operations in NPR–4 during the 1945 field season. On December 13, 1944, Admiral King asked Greenman to advise Secretary Forrestal about establishing general principles for work in NPR–4. Greenman, Gillespie, Lewis W. MacNaughton, Brazil, and one of Admiral Moreell's officers met to evaluate Rex's plan to drill an initial test well at Umiat and shallow cores at Cape Simpson. Greenman also advocated "an agreement whereby the Geological Survey would carry out a large part of the geological studies,"[45] rather than authorizing additional work by Navy geologists or turning to civilian contractors for geologic expertise. In January 1945, Secretaries Forrestal and Ickes authorized Greenman to deal directly with Wrather in planning the cooperative work for the coming field season. Greenman used two companies—(1) Hoover, Curtice, and Ruby, and (2) DeGolyer and MacNaughton—as consultants. Hoover's United Geophysical signed on for geophysical surveys, and the newly organized Arctic Contractors took on the drilling work.

The Alaskan Branch, now with more than 280 employees, received for its efforts during fiscal year 1944–45 a total of slightly more than $830,000, including a $20,000 increase in direct appropriations. Transferred monies included $600,000 from the War Department, but that amount actually represented a loss of nearly $112,000; although the Navy provided $50,000, the Branch received for the year some $60,000 less than in fiscal 1943–44. Branch specialists continued to use aerial photographs to compile aeronautical charts and maps for the USAAF. They made maps of some parts of Alaska but mostly made maps of other areas worldwide. To staff that work adequately, the Branch postponed regular detailed mapping in the Territory, although the need for such maps grew ever greater. The USGS estimated that more than 99 percent of Alaska lacked planimetric or topographic maps at suitably large scales. Two-thirds of the Branch's geologists worked on the military and naval projects. In addition to the studies in NPR–4, they continued to assess coal, copper, mercury, tin, and zinc deposits within the Territory. In conjunction with the Military Geology Unit, they also paid increasing attention to the nature of and problems associated with building and maintaining facilities on permafrost. Siemon Muller left the MGU in 1943 to begin consulting work for the USAAF in Alaska. He prepared an expanded edition of the MGU's Strategic Engineering Study (SES) 62 about permafrost, and the new version appeared during calendar 1945.

Requests to Alaskan Branch geologists to assess volcanic hazards on the Alaska Peninsula and in the Aleutians reemerged when another explosive-extrusive eruption began "on or a few days before the evening of June 4, 1945,"[46] in the 7-mile-wide Okmok Caldera on the northern part of Umnak, one of the Fox Islands. The volcano had been active in 1931 and 1938. Mild tremors that began late in May 1945 preceded June 1's "sharp earthquake" felt at Fort Glenn (later Cape Air Force Base), less than 10 miles south of the caldera, but clouds hid the caldera's rim. "On June 4, pilots [of the 11th Air Force] reported a column of black ash rising from the southern part of the caldera to a height of 9,000 feet, and that evening the clouds lifted above the rim to reveal red reflections."[47]

Lt. General Delos C. Emmons, who had commanded the Alaska Defense Command since 1944, requested advice from the USGS about the real and potential dangers to the personnel, main and active-satellite airfields, and other facilities at Fort Glenn and those some 60 miles to the northeast at Fort Mears and other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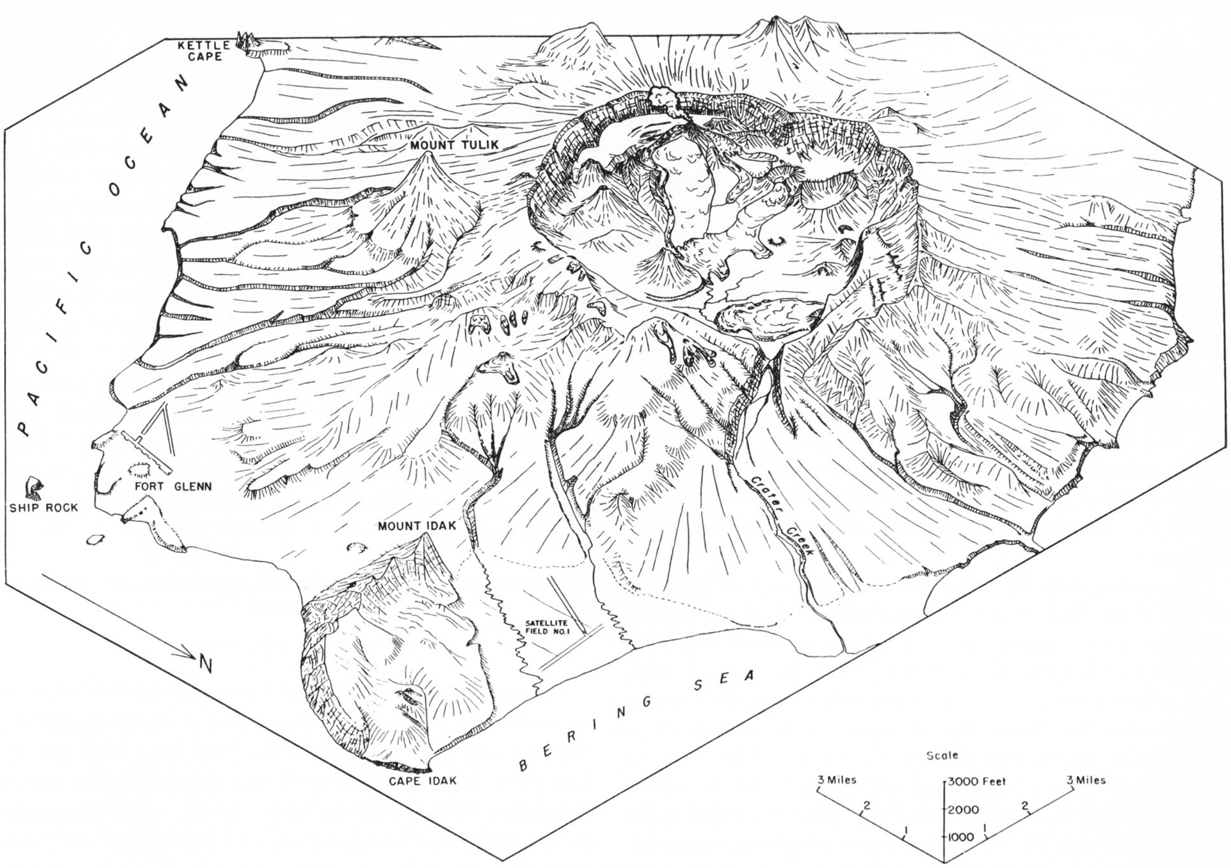
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On June 10, 1945, a four-man military-civilian team prepared to descend into Okmok Volcano's 7-mile-wide caldera to assess the ongoing eruption and its hazards. The team included geologist Ray Everett Wilcox (born 1912, at left), then a 2d Lieutenant in the U.S. Army Signal Corps, and USGS geologist Gershon Duvall ("Robby") Robinson (1918–2005, at right). The ash-steam cloud to Robinson's right issued from an erupting cone about a half-mile from the rim. Studies of volcanoes and volcanic processes by USGS geologists began with Clarence E. Dutton's investigations in the Hawaiian Islands in 1882. The USGS operated an Aleutian Volcano Investigations Unit at Adak, supported primarily by Army and Navy funds, during 1949–54. (Photograph by Army Colonel G.A. Polk; published in Robinson, G.D., 1948, p. 516.)

installations around Dutch Harbor on Unalaska. Emmons had seen Alaska's and Hawaii's volcanoes and their dangers firsthand. On June 6, 1912, ash from the Novarupta-Katmai eruption[48] threatened then Lt. Emmons and his fellow passengers on their ship in Shelikof Strait. In December 1935, Colonel Emmons, now a air-wing commander, and Thomas A. Jaggar, Jr., Director of the Hawaiian Volcano Observatory (HVO) since 1912, overflew the tunnel through which lava from Mauna Loa advanced at a mile per day toward Hilo's water supply. Emmons approved Jaggar's plan for B–18 bombers to target the tunnel, slowing and then stopping the flow in the headwaters of the Wailuku River. As a Lt. General, Emmons ended his tour as leader of the USAAF's Combat Command to take over the Hawaiian Department on December 17, 1941. He authorized Jaggar's scheme for bombing another flow from Mauna Loa in 1942.

Emmons now feared that a major eruption of Okmok might destroy Fort Glenn; if the base needed to be evacuated rapidly, the garrison would encounter transportation difficulties for lack of a natural harbor. Emmons knew that the major explosive eruption on June 12, 1944, of Mount Cleveland, on Chuginadak Island and only 95 miles southwest of Fort Glenn, killed a soldier and closed the small outpost there. Although Stephen Capps accompanied the Navy's reconnaissance of the Aleutians in 1932, Jaggar, now in his mid-70s, remained the geologist most familiar with the Aleutians' volcanoes. USGS funds aided Jaggar's studies after the HVO came into the agency in 1924, still operating under its motto *Ne plus haustae aut obrutae urbes* (No more burned or buried cities), and he began leading the Geologic Branch's Section of Volcanology 2 years later. In 1932, Jaggar reported on Okmok's eruption during the previous year. The Interior Department shifted the HVO in 1935 to the National Park Service, whose Hawaii Volcanoes National Park, established in 1911, enclosed about 198,500 acres. In 1940, Jaggar retired and turned the HVO over to Ruy H. Finch, who joined Jaggar's staff in 1919 and led studies of Lassen Peak, California, between 1926 and 1935.

On June 6, 1945, a colonel on General Emmons' staff appealed to the USGS office in Anchorage to send a specialist to assess the danger to Fort Glenn. USGS geologist Gershon D. ("Robby") Robinson took the call. With no volcanologist

◀ These two isometric views (originally at about 1 inch = 3.5 miles) of Okmok Volcano, on Umnak Island in the eastern Aleutians, look southwest before the caldera formed (above) and after (below) the eruption early in June 1945. As part of the USGS' assessment of the caldera-forming eruption, geologist Frank M. Byers, Jr. (1959, p. 341), estimated that the blast removed between 7 and 16 cubic miles of material from the volcano's summit. Ash falls from the volcano posed a hazard for the U.S. Army Air Forces' base at nearby Fort Glenn, but lava flows remained confined to the volcano's caldera. (From Byers and others, 1947, fig. 9*A*, *B*; fig. 9*B* also appeared [at about 1 inch = 5.5 miles] as Byers, 1959, pl. 50.)

immediately available, Robinson left within the hour for Umnak by air and while en route saw steam and ash rising from the Pavlof (near the tip of the Alaska Peninsula) and Shishaldin (on Unimak) Volcanoes. Once at Fort Glenn, Robinson assured the base commander that the lack of strong earthquakes accompanying the ongoing eruption indicated that it was not a major volcanic event. When the weather cleared on June 10, Robinson, Army Colonel G.A. Polk, 2d Lt. Ray E. Wilcox of the Signal Corps (who earned a Ph.D. at Wisconsin in 1941 with a study of the optical mineralogy and petrology of basalts and rhyolites on the Gardiner River in Yellowstone National Park), and a sergeant reached the caldera and descended into it.

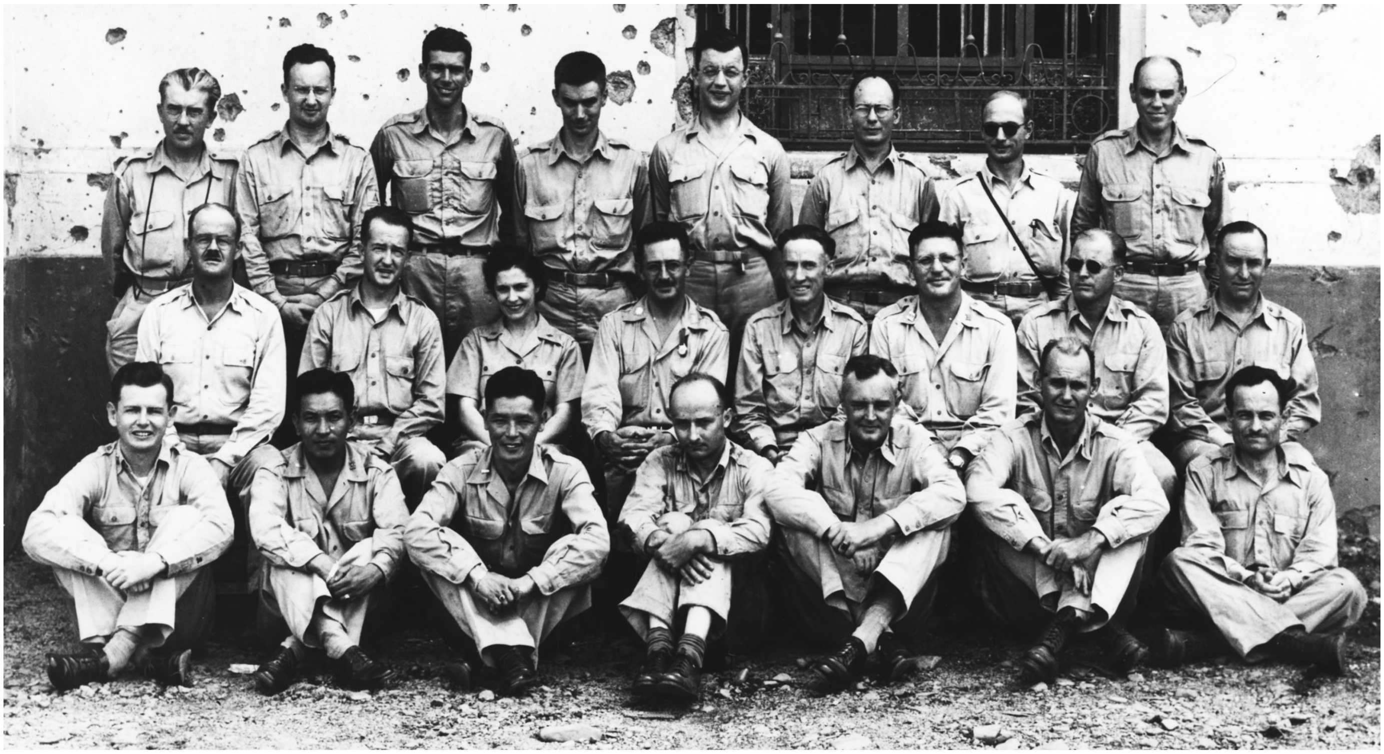
On Okmok's plain, the four men saw ash "being erupted copiously from a small cinder cone near the southwest edge of the caldera floor and lava was flowing from the base of the [150-foot-high] cone" in a 40-foot-wide stream at "about 30 feet per minute."[49] Northwest winds carried ash to form deposits several feet thick on the caldera's southeast floor and several inches thick on its rim. Only a fraction of an inch of ash fell at points within a mile of Fort Glenn, which was built on Okmok's earlier pyroclastic deposits. Robinson returned to Anchorage and "reported to General Emmons that there was little risk of a disastrous eruption"[50] that might heavily damage or destroy the Umnak airbase. Emmons authorized placing Wilcox "in charge of the volcano. I was to show visitors around—in addition to my other duties," Wilcox later recalled. "Howel Williams came up from Mexico to check it out; I had known him before and we had a good time."[51] Okmok's "explosive activity declined somewhat in the last half of June, but increased again early in July." Wilcox reported that after "about a month of intermittent, but declining, activity," the lava extended 4 miles from the cone but was still well within the caldera. "By late July [on the 22d], lava effusion practically ceased and the amount of ash in the eruptive column generally decreased until only steam was emitted, and that only in weak surges."[52]

While USGS investigations continued in Alaska, Bradley's Military Geology Unit, as requested by the Office of the Chief of Engineers, expanded its terrain and materials studies. The MGU also supplied some 50 geologists to the overseas theaters of operation for strategic and tactical intelligence or scientific and engineering consulting in combat operations. The MGU reduced its work in the Mediterranean and played only a minor role in the planning for the invasion of France. Geologist-historian Edward P.F. Rose, a retired Colonel of Royal Engineers, described how British specialists took over most of the assessments of the loess, sand, and other materials of Quaternary age overlying the relatively flat Jurassic bedrock on Normandy's beaches and adjacent areas on the Calvados Plain chosen for their trafficability (off-road movement) and construction materials over the older and harder rocks to the west at Cherbourg and elsewhere on the northern and western Cotentin Peninsula.[53] Studies of airfields and airfield sites, beaches, construction materials, German defenses, and water supplies passed principally to the geographers, geologists, and photo-interpreters of the Inter-Services Topographical Department (ISTD) at Oxford since 1941, aided by members of the Imperial General Staff's Geographical Section and the staff of General Montgomery's 21st Army Group. To support staff planning, the MGU contributed a series of small-scale terrain maps of all the coastal countries of western and northern Europe and a terrain-appreciation folio of France (SES 87, at 1:3,000,000).[54] Members of the MGU, with those from the Tennessee Valley Authority (TVA), also participated in the Anglo-Canadian-American Benson Program, which extended earlier and ongoing mapping, at scales of 1:250,000, 1:100,000, and 1:50,000, by using RAF aerial photographs to provide (1) Multiplex-generated base maps at 1:25,000 for the French coast and areas inland and (2) maps at 1:12,500 for the specific invasion locales in Normandy.[55]

A few American geologists and related specialists in uniform, among them Private (later Sergeant) Clifford A. Kaye, formed the Information Section of the Chief Engineer's Intelligence Division at General Eisenhower's Supreme Headquarters Allied Expeditionary Forces (SHAEF). Kaye and his colleagues began their contributions "following the assumption of full-scale staff work in the theater by U.S. forces in the spring of 1944."[56] The SHAEF Information Section's initial products included maps of the "main terrain units and the major beach exits"[57] in Normandy, air-photo interpretation of sediments and bedrock in Quiberon Bay to aid the construction of an artificial port, if the existing ones in Brittany could not be captured and restored for use, and air-photo analyses of bomb-crater shapes as a guide to the nature of unconsolidated sediments. The Section's staff then concentrated on preparing terrain-appreciation maps and reports.

The MGU also exchanged information and personnel with one of the ISTD's units. On July 7, 1944, a month after the Allies invaded Normandy, Charles Hunt sent to the ISTD's Daniel C. Ion, a Squadron Leader (later Wing Commander) in the RAF, the MGU's constructive criticism, in its Miscellaneous Paper 11, of the ISTD's 1:500,000 geologic map and terrain analysis of Formosa. Ion, an Oxford-educated geologist who worked for Anglo-Persian (Iranian) Oil Company in the Middle East, joined the ISTD as a geographer in April 1943. Later that year, the ISTD established specialist Sections for engineering, resources, and geology. Ion's letter of thanks on August 6, 1944, led to a visit to the ISTD's Geological Section during September 5–28 by the MGU's Fritiof Fryxell and Robert L. Pendleton to exchange information and methods with Ion, his four geologists, including Lt. (later Major) John L. Farrington, and four soils scientists serving as Captains of Royal Engineers. After Fryxell's interval with the ISTD's Geological Section at Oxford, and his time spent in Cambridge at the Naval Intelligence Division's subcenter and in London at the Imperial General Staff's Geographical Section, Hunt visited the Geological Section early in October. Hunt and Ion agreed to additional exchanges between their staffs to improve cooperative efforts, and they also tried but failed to arrange for a postconflict collaboration to prepare a mutual history of wartime geology. Farrington came to Washington between October 19 and November 9, spending much of that time with the MGU. The MGU continued to report to Major Arthur H. Spillers, Jr., a forester in civilian life, who replaced Colonel Paul Thompson as head of the Army Engineers' Strategic Intelligence Branch in Washington after Thompson's transfer to Britain early in 1943. Fryxell recommended to Major Spillers that German mineral resources be surveyed as the country was occupied, especially to determine how Germany achieved some self-sufficiency in raw materials. In December 1944, Fryxell also suggested that Hunt consider sending a MGU representative to the Mediterranean Theater and also establish a reserve corps of military geologists. The Anglo-American collaboration also generated supportive visits to the ISTD's understaffed Geological Section in 1945–46 by the MGU's geologists Maxim M. Elias (Army Engineers) and Louis L. Ray (USGS) and geochemist Lyman C. Huff (USGS).[58]

By the end of 1944, at the Army Engineers' request, the MGU completed shifting most of its efforts to the Pacific, initially in General MacArthur's Southwest Pacific Area, and then expanding to the Pacific Ocean Areas of Admiral Nimitz. Colonel (later Brigadier General) Hugh J. Casey, as MacArthur's Chief Engineer, began his Intelligence Division's operations in Australia on August 25, 1942, by gathering information about northern Australia and New Guinea from local residents and Australian publications. During 1943 and early 1944, Australian civilians and some U.S. officers joined Casey's Intelligence Division to map and study areas in New Guinea, making ever-increasing use of aerial photographs as aids to the continuing offensive on the island by MacArthur's troops. Casey's Division added additional Australian geologists and expanded its assessments to New Britain and the East Indies, while the OSRD sent Harvard and USGS geologist



This photograph shows Army officers and USGS Military Geology Unit (MGU) members, Research and Reports Branch, Engineer Intelligence Division, Office of the Chief Engineer (Major General Hugh Casey), Southwest Pacific Area (and Army Forces Pacific), outside the bullet- and shell-pocked Manila City Hall (Luzon, Philippine Islands) in September 1945. Personnel shown include (from left to right): (front row) Wallace de Laguna (4th) and Robert Bryson (7th); (middle row) Major Arthur Spillers (2d), Lt. Colonel Hubert Schenck (4th), Fritiof Fryxell (5th), Captain Roger Baker (6th), and Philip Stephenson (8th); (rear row) James Thorp, Morris Austin, John Collins, Walter White, Frank Whitmore, Jr., Vincent McKelvey, Leopold Stach, and Edward Sampson. Casey began his Intelligence Division's operations in Australia in 1942. The initial MGU team, led by James Gilluly, joined the Intelligence Division in May 1944. His team aided plans for the invasions of Leyte and Luzon and three of its members landed with U.S. troops on Leyte in October. In March 1945, Fryxell led a second team to relieve Gilluly's group and directed the MGU's and the Army officers' terrain research of Honshu and Kyushu, respectively, as part of preparations for the planned (but later canceled) invasions. Members of the MGU's third team, assigned to the Pacific Ocean Areas and originally based on Oahu, contributed to planning for the invasions of Iwo Jima and Okinawa. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Group–1900's identified" folder; published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 8.)

Marland P. Billings to New Caledonia to assess that island's nickel deposits. Casey, before taking over (as a Major General) the Army Service Command, requested a team of terrain specialists from the MGU to aid the U.S. officers in the Intelligence Division.

The MGU's initial field-research team, all civilian consultants with simulated-officer status and led by James Gilluly, arrived in Brisbane in May 1944. The Engineer Terrain and Intelligence Team moved to Hollandia (now Jayapura) on New Guinea and later to Morotai. Gilluly's team included Geoffrey B. Bodman, a soils scientist from Berkeley; geologists A. Lincoln Dryden, Jr., a heavy-minerals specialist from Bryn Mawr, and William C. Putnam, an expert on coastal geology from the University of California at Los Angeles (UCLA); and groundwater hydrologist Nelson Sayre. Gilluly's group concentrated on preparing reports, based principally on more detailed data from improved aerial photographs and increased coverage, to aid planning for operations in northwestern New Guinea, on Morotai, and in the Philippines. Dryden analyzed landing beaches, and his colleagues focused on inland-engineering problems, water supplies, and other concerns. Gilluly's team produced increasingly briefer and less technical reports and maps at 1:10,000 or 1:20,000, the same scales as most of the aerial photographs. Unfortunately, Gilluly's team did not form a separate section in the Intelligence Division. After Casey's departure, the team was not delegated the same operational initiative and responsibility for assignments given to the MGU. Officers unfamiliar with the team's expertise tried to dictate how the specialists should do their work. The quality of the team's subsequent reports varied, and the team missed some deadlines. When attempts to remedy the situation failed, some team members sought field-force assignments.[59]

As the MGU aided military operations in the Pacific, under the third overall agreement signed with the Army Engineers on May 25, 1944, the Topographic Branch continued to divide its work between war-related projects, principally the production for the War Department of maps from aerial photographs, and domestic mapping. For salaries and operations by the nearly 680 full- and part-time employees (as of June 30), the Branch received slightly more than $3 million during fiscal year 1944–45, but that sum represented an increase of just $64,000 over the previous year. Direct appropriations for topographic surveys rose sharply from $672,500 to just above $1.8 million, and miscellaneous repay funds more than doubled, offsetting the loss of about $589,000 in War Department transfers. Of the direct appropriations to the USGS for its topographic surveys, Congress limited $240,000 to State-municipal cooperation, a sum more than met by the $330,000 contributed by those governments. Branch personnel in the Arlington, Virginia, and Chattanooga, Tennessee, offices, devoting about 80 percent of their time and services to producing maps of areas in countries abroad, compiled stereophotogrammetric coverage of some 64,000 square miles.

To make the new mapping techniques available to a wider audience, the American Society of Photogrammetry sponsored a preliminary edition of the "Manual of Photogrammetry," published in New York late in 1944 and distributed in January 1945.[60] Ronald Wilson, still Chief of the Topographic Branch's Computing Section, Alaskan Branch topographic engineer John I. Davidson, and three of their colleagues outside the USGS coedited the new volume. Wilson also wrote the book's sections on regular coordinates and standard horizontal data and on oblique photographs for the surveyor. Davidson and Branch engineer James L. Buckmaster combined to produce a section on the USGS radical-intersection method, while Branch engineer Channing P. Van Camp discussed practical tilt corrections for single-lens aerial photographs. Branch Chief Thomas Pendleton wrote one section on the Multiplex instrument and its use and a second section about field inspection and completion. Lt. Colonel Gerald FitzGerald led the preparation of the volume's section about reconnaissance mapping via trimetrogon photogrammetry[61] by members of his USAAF Aeronautical Chart Service (then including Buckmaster and Davidson and other USGS topographic engineers in the Alaskan Branch). FitzGerald then accompanied Interior Department delegate Thomas Pendleton to the Second Pan American Consultation on Geography and Cartography in Rio de Janeiro during August 14–September 2, 1944. Colonel Minton Kaye, still FitzGerald's commander, supplied the new book's preface, and William Putnam, before serving with the MGU in the Pacific, contributed the section on photo interpretation.

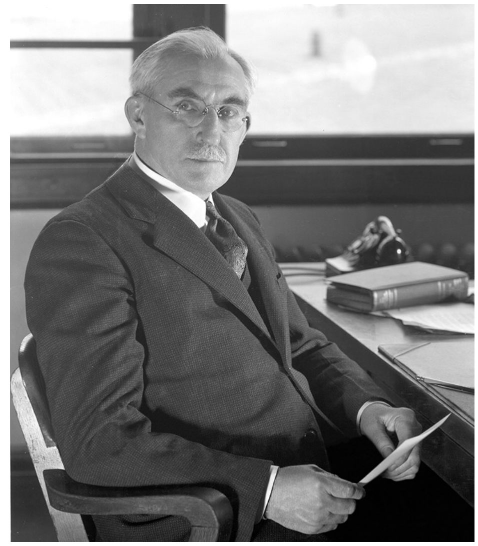
Other parts of the Topographic Branch's domestic work also supported the war effort.[62] More than 180 of the maps published during fiscal year 1944–45 included areas termed strategic by the War Department. Branch engineers also completed another 6,300 square miles of map coverage for areas within the United States and 9 special projects to support investigations of bauxite and other sources of aluminum, copper, iron, manganese, zinc, and other strategic minerals. The domestic program also included field surveys in 35 States. USGS topographers worked cooperatively with colleagues in 19 of these States, with the TVA, on flood-control projects of the Army Engineers, and on 5 large-scale maps for the Bureau of Reclamation's irrigation and reclamation projects. Field mapping within the United States totaled some 14,000 square miles, including resurveys of 5,400 square miles.

During fiscal year 1944–45, the Water Resources Branch received nearly $4.1 million in total funds, $500,000 more than in fiscal 1943–44; the total included cooperative monies and those transferred from other Federal agencies for work with a greater domestic emphasis. Congress supplied $1,590,000 in direct and supplemental appropriations; State, county, and municipal governments added another $1,269,000, $169,000 above the congressional limit; and other Federal departments and agencies furnished the remainder. The War Department transferred about $919,000, an increase of $207,000 over the previous year; the USBR raised its contribution by nearly $7,000 to more than $76,000; and slight increases in contributions by the State Department and the TVA, and new funds from the FEA, helped to offset an $18,000 reduction by the Defense Plant Corporation. As the fiscal year began, the Branch employed 765 full- and part-time persons. The number of requests for special reports in connection with war activities continued to decline, although Branch members completed about 4,220 reports during the year, part of a total of some 15,000 since July 1941.

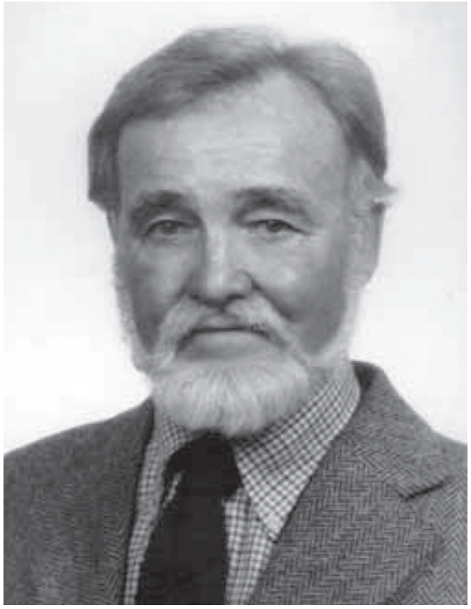
In fiscal year 1944–45, the USGS expanded its activities outside the national domain. During July 1944, the Geologic Branch established a Committee for Cooperative Investigations Abroad, chaired by John Dorr, who reported to Bannerman's Division of Economic Geology. Later that year, Glen F. Brown left his domestic studies for the Water Resources Branch to work in Saudi Arabia as part of one of the missions of Federal experts striving to improve economic conditions in strategic countries by surveying and planning for utilizing, improving, and developing local resources. Brown's assignment developed from appeals by King Ibn Saud to President Roosevelt and to the U.S. Minister Plenipotentiary in Jiddah for help in searching for and developing water supplies, especially in the central part of the Kingdom, to foster agriculture as an aid to oasis farmers and to Bedouin resettlement. During May–December 1942, Karl Twitchell's team, after traveling some 11,000 miles in the Kingdom, contributed to plans that included establishing model farms in the Kharj district. Twitchell returned to Saudi Arabia to lead a preliminary-evaluation team, including two specialists from the Agriculture and Interior Departments. Wrather, during his hour's audience with the King in January 1944 before visiting Kharj, agreed to send a USGS geologist to serve as the requested longer term adviser on water supplies and other natural resources.

Although USGS personnel still lacked specific statutory authority to serve officially outside the national domain, they had worked unofficially and intermittently since 1882 in Hawaii, Nicaragua, the Philippines, and the Caribbean. The Interior Department now employed a long-used Federal method to send Glen Brown to Saudi Arabia. On August 10, 1944, Under Secretary Michael Straus, as Acting Secretary,[63] approved Director Wrather's preliminary agreement with Leonard Parker, of the State Department's Saudi desk, to have a USGS groundwater geologist accompany for 1 year a second U.S. agricultural mission being recruited by the FEA's Food Programs Division. David A. Rogers, a graduate agronomist who farmed in Arizona's Skull Valley and participated in a War Relocation Project on Arizona's Gila River, led the second mission that included two of Rogers' farmer neighbors. Under an 18-month contract that extended to December 1945, Rogers' demonstration team established their headquarters at and thereafter worked principally in and from the 3,500-acre experimental farm in the Kharj district owned by Sheik and Minister Abdullah al-Hamdan. Two days after Under Secretary Straus approved the Wrather-Parker understanding, Oscar Meinzer, still Chief of the USGS Ground Water Division, agreed to detail a USGS scientist to the FEA's mission. For this work, Meinzer selected Glen Brown, who examined the geology of mineral deposits in China and the Philippines during 1936–38 and then investigated groundwater resources in Mississippi, including water supplies for Army camps, and in California as part of units managed by Victor T. Stringfield and Arthur Piper.

On November 11, 1944, Secretary Ickes approved Wrather's arrangement for Brown's reimbursable detail to the FEA.[64] Wrather, in writing to FEA Administrator Leo Crowley on November 28, expected that Brown "will be given wide latitude for independent judgment in the conduct of his technical work, such as will be involved in the reconnaissance of recharge areas and outcrop belts of the aquifers being developed by the [second agricultural] mission."[65] On January 2, 1945, Ickes formally approved the transfer of Brown's official-duty station from Washington



Geohydrologist Oscar Edward Meinzer (1876–1948) joined the USGS as a geologic aid in 1906. He succeeded Walter Mendenhall as Chief of the Ground Water Division (later Branch) in 1912 and led the unit until he retired in 1946. During those years, Meinzer made major contributions to advancing basic and applied quantitative studies of groundwater, including artesian aquifers and large springs, and he encouraged similar work by his younger colleagues. Improvements in field and laboratory techniques accompanied his melding of chemistry, engineering, geology, and physics with hydrology in broadening qualitative and quantitative studies of groundwater. His 1942 book on hydrology became a standard reference. He also cofounded and chaired the American Geophysical Union's Section of Hydrology. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0242, https://www.sciencebase.gov/catalog/item/51dda25be4b0f72b4471df43.)



Geologist and hydrologist Glen Francis Brown (1911–2001), after joining the USGS in 1938, investigated groundwater supplies for military installations and other consumers in Mississippi and California. He began USGS operations in Saudi Arabia in October 1944, while on detail to the Foreign Economic Administration (FEA) and David Rogers' U.S. agricultural mission to the Kingdom. Brown's association with the FEA's mission, during which he mapped geology and located water supplies, extended into May 1946. He then served on a 2-year reconnaissance of Thailand's geology and mineral resources. Brown returned to Saudi Arabia as chief of the USGS field team during 1950–54 and 1963–69, while continuing to advise the U.S. and Saudi Governments. With Aramco's aid, members of the USGS-Saudi program completed mapping Saudi Arabia at 1:500,000 in 1958. (Photograph from Reinemund, 2002; see also the 1945 photograph of Brown and Rogers with King Ibn Saud in Hart, 1998, p. 101.)

to Dhahran. On February 14, Roosevelt and Ibn Saud chatted aboard an American heavy cruiser anchored in the Suez Canal's Great Bitter Lake (Buheirat Murrat el Kubra). The President approved additional aid for the Kingdom, which by then received more than $33 million in oil revenues. In discussing the Palestine question, the President assured the King that his administration would take no action hostile to the Arabs and that America would not change its policies regarding Palestine without first consulting with both Arab and Jewish leaders.

Glen Brown's association with the FEA mission to Saudi Arabia extended into May 1946. He flew to Dhahran, the site of a planned major airbase on the military transport route between Cairo and Karachi. Aramco provided Brown's radio links and ground transportation; his mail and supplies came through Parker T. Hart, who opened the U.S. consulate in Dhahran in September 1944.[66] Brown, based near the U.S. Embassy in Jiddah, paid particular attention to water supplies and mineral deposits in his preliminary reconnaissance of surficial geology. David Rogers and his FEA colleagues continued to examine sinkholes, repair pits and wells, and supervise the construction of new irrigation channels to facilitate better production of wheat, other grains, and vegetables in the Kharj district. Working 60-hour weeks, Brown completed his studies at Kharj,[67] located several aquifer sources in the Nejd region, supervised wells dug in Riyadh, discovered additional water supplies in Jiddah and elsewhere along the Red Sea littoral region, and mapped in detail the Mesozoic–Tertiary geology and surface features of some 800 square miles, aided by information from Aramco's Steineke and Bramkamp. None of these finds, however, yielded water in amounts sufficient for major irrigation. Between December 1944 and June 1946, the FEA transferred to the USGS nearly $9,400 to support Brown's work in the Kingdom, which produced a realistic, if preliminary, appraisal of the groundwater resources in the region he examined. Ibn Saud asked Brown to stay on in Saudi Arabia with the agriculture mission, but Brown returned to America later in 1946. There Brown took charge of groundwater studies in Mississippi during 1946–47 and used his work in the Kharj district as his doctoral dissertation at Northwestern completed in 1949.[68]

While Glen Brown worked in Saudi Arabia, the Water Resources Branch continued to operate its principally domestic program. The Branch's Surface Water Division collected records of the stage, quantity, and availability of surface water at some 5,600 gaging stations in every State and in the Territory of Hawaii. Division hydrographers also advanced the ongoing special studies of the utilization and control of streams, investigations in connection with the Federal Power Commission, and those along the international boundaries. During fiscal year 1944–45, the Ground Water Division made periodic measurements of water levels or artesian pressure in about 7,000 observation wells, and continued investigations underway in nearly every State and in Hawaii. Studies of specific areas completed and published included Charles Jacob's analysis of precipitation and groundwater levels on Long Island that explained the potentiometric surface's retreat after recharge ended and demonstrated that aquifers' geohydrologic characteristics determined their responses to varying conditions during recharge and discharge. Division hydrologists pursued investigations designed to determine the depletion of groundwater caused by war industries and other war establishments, believed to total as much as several hundred billion gallons, and to provide against possible shortages. The Division's staff also looked at natural and artificial replenishment of groundwater supplies and at their maximum utilization for many prospective postwar demands. Members of the Quality of Water Division began cooperative studies of the chemical character of surface waters in Pennsylvania and Virginia and continued similar investigations in Florida, Georgia, Louisiana, New Mexico, North Carolina, and Texas. They analyzed chemically more than 6,900 water samples, many of them collected in connection with studies of water supplies for Army and Navy establishments,[69] munitions plants, and housing developments. Albert Horton's illness ended the existence of his Division of Power Resources as a distinct unit. On March 31, 1945, the Division's functions passed to Royal Davenport's Division of Water Utilization; Horton died on April 22.

The Conservation Branch's work during fiscal year 1944–45 remained entirely domestic in its orientation but very much a part of the war effort as its members continued to supervise the production of mineral and energy resources, worth nearly twice 1939's sum, from public and Indian lands. The Branch, now with 210 full- and part-time persons (as of June 30, 1944), received $240,000 in direct appropriations, and almost $2,500, mostly from States, counties, and municipalities, for classifying the public lands. To the $557,000 Congress provided in direct funds for mineral-leasing activities, other Federal units, principally the Office of Indian Affairs (OIA) and the Navy, added some $108,000. The Branch used a total of nearly $907,500, about $51,500 more than in fiscal 1943–44, for work directed by its new Chief Harold Duncan. Secretary Knox agreed with Secretary Ickes' request to postpone from April 1943 to January 1944 the beginning of active duty for Hale Soyster, Herman Stabler's successor as Chief of the Conservation Branch since February 8, 1943, and a Lt. Commander in the Naval Reserve. The delay gave Soyster time to complete a reorganization of the Branch, to inspect its field operations, and to attend to some allegedly irregular personal concerns. Soyster left the USGS on January 27, 1944, for duty with the Bureau of Ships; the USGS officially furloughed Soyster for military service on April 20, and the Navy reassigned him to Captain Greenman's Office of Naval Petroleum and Oil Shale Reserves. Duncan, who succeeded Soyster as Chief of the Oil and Gas Leasing Division in April 1943, became the Conservation Branch's Chief a year later on April 11, 1944, replacing John Northrop, who acted in that capacity after Soyster's departure. Soyster died at Bethesda Naval Hospital on January 24, 1945.

All four of the Conservation Branch's divisions continued their work during fiscal year 1944–45. Members of the Water and Power Division supervised some 530 power projects, surveyed the topography of nearly 150 linear miles of streams and 8 dam sites, and acted on more than 2,200 case of hydraulic and waterpower classification. Power-site and reservoir-site reserves now totaled, respectively, nearly 6.8 million acres and about 137,000 acres. The Mining Division supervised operations on 572 public-land properties, 235 Indian properties, and 3 Secretarial authorizations. In addition, Division engineers served as consultants to the U.S. Department of Agriculture (USDA) on its mining leases and also supervised production of public-land minerals by the Metals Reserve and Defense Plant Corporations. The total output of minerals from the lands supervised by the division had a value exceeding $66 million. Oil and Gas Leasing Division personnel supervised operations on more than 7,000 properties on public lands, nearly 4,800 leaseholds on Indian lands, and, for the Navy Department, 31 properties under lease in NPR–1 and NPR–2. Income from all supervised petroleum operations on the public domain rose by some $127,000 from the previous year's total to about $3,674,000. Production of oil, natural gas, and natural gasoline and butane increased from the now 312 active NPR wells in California; their royalty value reached $600,000. In addition, investigations by the Division's four special-study groups aided secondary recovery operations and other engineering practices required for the conservation and maximum ultimate recovery of petroleum from public-land leases. The Mineral Classification Division's staff acted on more than 13,000 cases, an increase of 20 percent over the preceding year. The Division opened an additional regional office at Tulsa, Oklahoma. On June 28, 1944, Secretary Ickes began arranging for leasing, under the Mineral Leasing Act of 1920 and through advertisement, competitive bidding, or other regulated methods, of up to 640 acres each of the Nation's asphalt lands, but no person, association, or corporation could hold more

Petroleum engineer Harold Judson Duncan (born 1895), an Army veteran, spent 6 years in the oil industry before joining the USGS Conservation Branch and its Mineral Leasing Division shortly after the Branch's establishment in 1925. He supervised the Rocky Mountain (later Northwestern) District from Casper, Wyoming, during 1932–43. Duncan then served a year as Chief of the Oil and Gas Leasing Division in Washington before becoming the Chief of the Conservation Branch (later Division) in April 1944. He retired in August 1965, one month before Thomas Nolan resigned as USGS Director. (USGS photograph, Public Inquiries Office 63–12 [1b].)

than 2,560 acres.[70] Leases could be offered for up to 20 years in return for advance payments, increasing from the first (25 cents per acre) to the fifth ($1 per acre) years, and royalties of not less than 25 cents per ton. By the end of fiscal 1944–45, production from all public-land mineral and energy resources under Branch supervision rose to $150 million, royalties reached nearly $12 million, and the estimated value of the resources under lease climbed to more than $2 billion.

Congress remained in session until September 21, 1944, but national campaigning began just a few weeks after the Allies invaded Normandy. On June 27, the Republicans, meeting in Chicago, nominated for President Thomas E. Dewey, the Governor of New York, and nominated Ohio's Governor John W. Bricker as Dewey's running mate. The Democrats also convened in the Windy City on July 20. They selected Roosevelt for a fourth term after the President said he did not seek but would not refuse another call to service while the war continued. Roosevelt dropped Henry Wallace from the ticket. The President, convinced that James Byrnes' record also was a liability, picked Senator Harry Truman as his candidate for Vice President. Both parties supported winning the war and establishing an international organization to secure the peace.

In this interval, planning for postwar peace and security became more definite. On July l, delegates met at the United Nations Monetary and Financial Conference at Bretton Woods in New Hampshire to arrange for postwar development.[71] During a 3-week session, conferees from 44 nations, but not the Soviet Union, agreed to establish an International Monetary Fund of $8.8 billion to stabilize national currencies and foster world peace. Conferees also founded an International Bank for Reconstruction and Development, capitalized at more than $9 billion, to extend loans to nations requiring economic rehabilitation. President Roosevelt, in his budget message to the new 79th Congress on January 3, 1945, urged the legislators to act on the proposals for the International Bank and International Monetary Fund as "integral parts of a broad program for cooperation among the United Nations."[72] On February 12, Roosevelt again urged Congress to adopt the agreements. He called for improved international economic cooperation as the basis for expanding world trade that would also discourage any future attempt by any nation to achieve "the control of cartels and the orderly marketing of world surpluses of certain commodities." The President specifically recommended securing international understandings on "civil aviation, shipping, and radio and wire communication" and "an international oil agreement."[73] Secretary Ickes, in his article in *Collier's* for December 1944, noted the Truman committee's report that "consumption had increased 28 percent (1939–1944), [but] proven reserves have increased only 15.7 percent." Assuming a desired rate of production could be maintained, the committee estimated these reserves "would be equivalent to only about a 14 years supply, based on current consumption."[74] Congress, agreeing to provide one-quarter of the monies for the Fund and 35 percent of those required for the Bank, ratified the agreements on July 31, 1945.

During the American political conventions in June and July 1944, major military and political crises occurred in Japan and Germany. American forces, after heavy fighting, captured Saipan on July 13 but at a cost of more than 16,000 U.S. casualties, proportional losses far greater than those at Tarawa. Prime Minister Tojo and his Cabinet resigned 5 days later. General Koiso Kuniaki took Tojo's place, and Admiral Yonai Mitsumasa, briefly Prime Minister in 1940, became Navy Minister and Deputy Prime Minister. These changes seemed to favor political moderation but Koiso, Yonai, and other hard-liners continued the war. On July 21, marines and soldiers assaulted Guam; 4 days later, other marines landed on Tinian, just south of Saipan. These islands, captured by August 10, provided additional bases that placed American strategic bombers within range of the Japanese home islands.

In Europe, as the Anglo-American armies strove to break out of Normandy and the Soviets continued their summer offensive, German Army plotters again tried but again failed to assassinate Hitler. Those implicated in the July 20 plot included Field Marshal Rommel, badly wounded in his vehicle on July 17; 3 months later, Rommel swallowed poison to save his family and avoid a trial by the Nazi's People's Court. In Normandy, meanwhile, reinforcements brought into the line the U.S. 12th Army Group, commanded by General Bradley, and its 1st and 3d Armies, the latter led by General Patton. On August 1, Patton's forces broke through the German left flank in Normandy. Aided by the MGU's and other trafficability maps, 3d Army troops spread rapidly west and southwest toward Brest, and the other naval and air bases in Brittany, and moved swiftly southeast toward Le Mans. Repelling Wehrmacht counterattacks, they trapped some German elements in the Falaise-Argentan pocket and moved rapidly toward the Seine River. Free French forces liberated Paris on the 25th. American, British, and French units of the 7th U.S. Army landed in Operation Dragoon in southern France on August 15. Brigadier General Garrison Davidson, still the Chief Engineer, and Reuben Newcomb, who led a water-supply company, participated in the invasion. Seventh Army troops rapidly pursued the Germans up the Rhone Valley.

On August 21, representatives of the United States, Great Britain, the Soviet Union, and China began a series of meetings at Dumbarton Oaks in Washington to discuss a draft charter for the permanent international organization designed to preserve world peace and security. Secretary Hull gave the opening address. Because the Soviets were not at war with the Japanese, Russian and Chinese delegates met with the others in separate sessions. On October 9, the conferees published a draft as the basis for continued discussion at a later meeting but they failed to agree on a veto policy for the proposed Security Council.

While advances continued in Europe and in the Pacific, American and British representatives signed the agreement on international trade on August 8. President Roosevelt transmitted the agreement to the Senate on August 24 for consideration as a treaty. Before the Senate's Committee on Foreign Relations could schedule a hearing, however, individuals and groups connected with the petroleum industry began to lobby against the agreement. On December 1, Secretary Ickes established a Departmental Petroleum Committee[75] that included the Directors of the USGS and the USBM, the General Land Office's (GLO's) Assistant Commissioner, the Assistant Solicitor, and, as chairman, Edward B. Swanson, Director of the PAW's Research Division since 1941. Ickes asked the Committee to review and coordinate the petroleum work by Interior's agencies and to recommend changes to increase effectiveness. On January 10, 1945, Roosevelt asked the Senate to remove the trade agreement from its legislative calendar, so that he could have it revised to eliminate any grounds for misunderstanding.

Also in August 1944, Congress began considering bills to change Byrnes' Office of War Mobilization (OWM) to the Office of War Mobilization and Reconversion (OWMR) and to regulate the disposal of surplus property if the war ended before the legislators enacted measures for permanent stockpiles. Congress passed both bills on October 3. The Surplus Property Act authorized any Federal agency to dispose of unneeded acquired lands. The new law also provided that federally owned strategic minerals and metals, when determined to be surplus, would be transferred to the Treasury's Procurement Division. The statute covered "copper, lead, zinc, tin, manganese, chromite, nickel, molybdenum, tungsten, mercury, mica, quartz crystals, industrial diamonds, cadmium, fluorspar, cobalt, tantalite, antimony, vanadium, platinum, beryl, graphite (and to which may be added aluminum or other minerals or metals in such quantities or amounts as the Army and Navy Munitions Board may determine to be necessary for the stockpile authorized by the Act of June 7, 1939)."[76] The new law also required the Army and Navy Munitions Board to submit within 3 months a report to Congress recommending the maximum and minimum amounts of each strategic mineral or metal that, in its opinion, should be held in the stockpiles authorized in 1939. Roosevelt's Executive order,[77] issued the same day, transferred all records and property of the OWM at the pleasure of the Bureau of the Budget's Director. The War Production Board again reduced its stockpile objectives on October 31 to 3 months' total requirements or 6 months' imports, whichever was greater. At the same time, the WPB broadened the stockpile formula for federally held materials to include industry stocks in excess of safe working inventories. In March 1945, bills to amend the Strategic Materials Act of 1939 were introduced in both houses of Congress.

In mid-August 1944, the War Production Board authorized a partial conversion of war industries to civilian output. The WPB then underwent another metamorphosis in its top management. Late in August, WPB Chairman Donald Nelson departed on a special mission to China, as the President's personal representative, and Executive Vice Chairman Charles Edward Wilson resigned in September. Wilson, still known as "Electric Charlie," to distinguish him from General Motors' president Charles Erwin ("Engine Charlie") Wilson, returned to the presidency of General Electric that he left in September 1942. Vice Chairman Julius Krug, who led the WPB's Office of War Utilities and served as a Lt. Commander in the Navy since April, succeeded Wilson as the WPB's Acting Chairman. Krug became Chairman when Roosevelt accepted Nelson's resignation early in October. Although Krug made many changes in the WPB's personnel after September 1944, Charles Leith remained Chief of the Metals and Minerals Branch of the Office of Production Research and Development. Leith, Alan Bateman, and Foster Hewett continued as members of the Minerals and Metals Advisory Committee.

During this interval, Gifford Pinchot, who successfully opposed Harold Ickes' efforts to establish a department of conservation and public works, suggested to President Roosevelt that he convene in Washington a conference of united and associated nations to try to reach an international consensus about a worldwide policy for the conservation and use of natural resources.[78] Pinchot hoped that this conference would, like those at Bretton Woods and Dumbarton Oaks, yield results to aid securing a permanent peace. On October 24, Roosevelt sent Pinchot's idea to Edward Stettinius, Jr., who succeeded Sumner Welles as Under Secretary of State in 1943 and since then often served as Acting Secretary during Cordell Hull's illnesses. Stettinius, replying on November 10, favored making conservation part of a planned international discussion of economic policy under the auspices of the United Nations Economic and Social Council. Roosevelt disapproved, insisting on November 22 that the State Department "failed to grasp the real need of finding out more about the world's resources and what we can do to improve them."[79] Pinchot again appealed to Roosevelt on March 28 and April 10, 1945, the latter date just 2 days before the President died at Warm Springs, Georgia.

As discussions continued during 1944 about the wisdom of holding an international conference on conservation and resources, the Allies military position further brightened. The Allied armies crossed the Seine on August 27. Eisenhower favored an advance on Antwerp to replace the port facilities at the now distant Cherbourg and the Normandy beaches. Allied forces captured the Channel ports and the fixed sites in the Pas-de-Calais for the German V–1 cruise missiles launched against Britain since June 13. When the Allies subsequently overran the sites for V–1s in Belgium, Holland, and easternmost Germany, Luftwaffe crews continued to deploy these relatively inexpensive, 150-mile-range missiles from aircraft until December 24. The Allies captured Brussels on September 3. On the next day, they liberated Antwerp and its port wrecked by the Germans, who still held its approaches in the Scheldt estuary. The port reopened on November 27.

In September, the Germans added to their new aerial blitz the V–2 ballistic missiles—liquid-fueled, multistage, 46-foot-tall rockets, launched from ingenious transporter-erectors—that delivered a 1-ton warhead of conventional explosives. Historian Michael Neufeld described and analyzed how in the 1930s a German Army team, led by Captain (later Generalmajor) of Artillery Walter R. Dornberger and including designer-engineer Wernher M. von Braun, developed the later versions of the A-series of four liquid-powered rockets. Von Braun chose Peenemünde as a site for continued development and tests. The team moved there in 1937, successfully test-fired their gyroscope- and radio-controlled A–4 (V–2) rocket on October 3, 1942, and refined it during the following year to extend its range to 220 miles. On September 8, 1944, the Germans began launching the V–2s as a second terror weapon against London and Antwerp. Fighter aircraft and antiaircraft guns, aided by proximity fuse ammunition, shot down some of the V–1s during their 400-mile-per-hour flights, but those defenses proved helpless against airborne V–2s that reached 4 times the speed of sound during their 60-mile-high trajectories. British deceptive measures, however, did succeed in moving the Germans' general target areas to less populated locales. German Army crews continued to launch the V–2 missiles, nearly 2,000 in all, until March 27, 1945.[80]

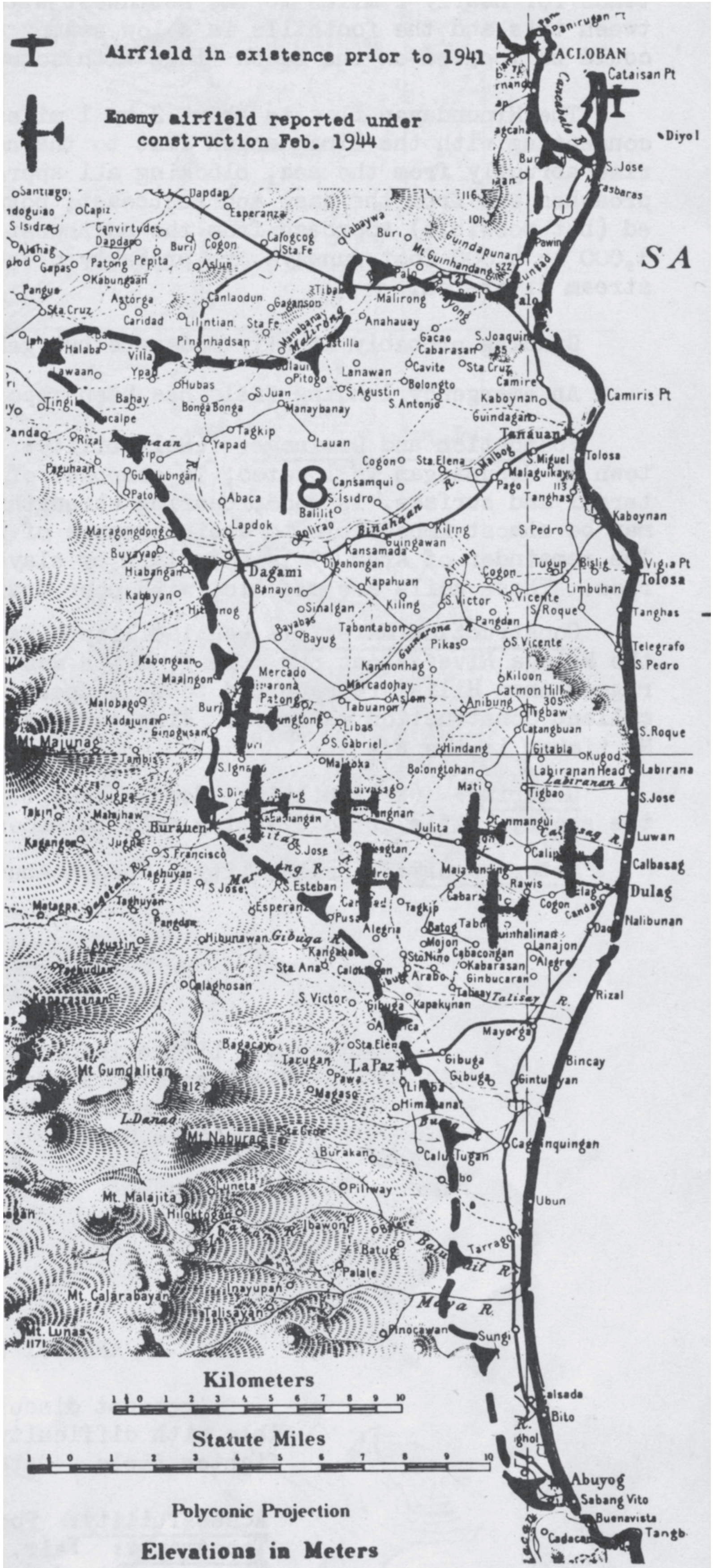
The Germans' new attacks by air did not slow the Allied advances on the Continent. Allied forces in southern France linked up with Patton's 3d Army at Dijon on September 11, 1944; 4 days later, the U.S. 7th Army and French 1st Army were joined in the new 6th Army Group. American troops liberated Luxembourg and closed on the Siegfried Line in mid-September, although gasoline shortages severely limited their mobility. The Germans defeated an combined airborne-ground attempt during September 17–26 by Montgomery's troops to turn the Wehrmacht's northern flank by capturing Arnhem, but Allied forces, now more than 2 million strong, assaulted the Line on October 1, hoping to destroy German units west of the Rhine. By mid-December, the best gains came in the south, where Patton's troops took Metz and units of the 6th Army Group reached the Rhine in several places. On the Eastern Front, Soviet troops swept across eastern Poland to the gates of Warsaw, but then they stood by in August and September as German SS units crushed a revolt within the city by anticommunist underground forces. The Soviets concluded armistices with Romania on August 23 and with Bulgaria on September 8. Soviet forces occupied Bucharest and the damaged oil fields and refineries at Ploesti. When the Luftwaffe bombed Bucharest, Romania declared war on Germany. In the Balkans, Soviet and Bulgarian troops, and partisans led by Josip Broz (Tito), captured Belgrade on October 20 and advanced toward the Danube and Budapest. Soviet armies in the north reached the Baltic near Memel, cutting off German forces in Latvia.

As the American part of the Allies' campaign in France progressed, the advance toward the Rhine River led to requests for a summary of Germany's coal deposits and for terrain reports for the anticipated U.S. sector of Germany. SHAEF's Information Section moved to Rennes in August 1944 and then to Paris in September. Using German printed sources and recent aerial photographs, the Section's staff prepared reports for each of four 1:250,000 map sheets covering an area in Germany west of the Rhine. The maps classified the terrain into five categories of expected movement and also showed corridors and additional obstacles. The Section's members also assessed the Rhine's bottom sediments and adjacent quarries, studied the foundations of the river's bridges destroyed or damaged by Allied or German actions, and produced 1:100,000 trafficability maps of the Lower Rhine Plain. When Edwin B. Eckel and two other members of the MGU arrived in Paris, on an engineering geology "mission not directly connected with current military operations," and "saw the limited facilities of the military-geology group in the Information Section,"[81] they offered the MGU's help. Beginning in mid-January 1945, the MGU prepared for the Information Section 1:100,000 trafficability maps that displayed slope and soil factors for the entire U.S. sector north of the Alps. In April, additional 1:100,000 maps of the Bavarian and Austrian Alps addressed Eisenhower's concern about an effective last-ditch resistance from a National Redoubt in those ranges.

In the Pacific, the Allies also moved ahead of their original schedule. Roosevelt, Leahy, MacArthur, and Nimitz met at Pearl Harbor in July 1944 to plan new offensives against Japan. The President, moved by considerations both military and political, allowed MacArthur and his staff to plan for recapturing the Philippines, which the Navy now wished to bypass, beginning with Mindanao. Roosevelt authorized Nimitz and his staff to prepare to invade Yap, follow with a joint assault with MacArthur's troops on Leyte (in December), and go on to take Iwo Jima (Sulfur Island) and then Okinawa. Between April 27 and July 30, MacArthur's troops captured additional Japanese bases on and islands off New Guinea. MacArthur's forces invaded Morotai, northwest of New Guinea, on September 15, the same day the III Amphibious Corps' marines attacked Peleliu in the Palau Islands. U.S. Navy aircraft supported both operations and also raided Yap and the Philippines. Other American units occupied Ulithi, another atoll in the Carolines to the northeast and near Yap, and turned Ulithi's lagoon into the Navy's major fleet anchorage in the Western Pacific.

On the Asian Continent, meanwhile, Japanese troops started a major offensive in May against Allied tactical- and strategic-bomber fields in eastern China. From some of these forward airstrips, Boeing B–29 Superfortresses, the new strategic bombers successfully promoted by General Arnold in a $3 billion program, of XX Bomber Command began to attack targets in Formosa, Kyushu, and southern Manchuria in June. By November, the Japanese captured 7 of the 12 Chinese bases used as staging fields by B–29s flying from Calcutta and Assam. To increase the economy and effectiveness of the raids on Japan, Arnold authorized the transfer in October of XX Bomber Command, now under Major General Curtis E. LeMay (who led the Regensburg raid), from India to the new operational fields in the Marianas, already the home of the B–29s of XXI Bomber Command. LeMay took over XXI Bomber Command and, in November, began a series of high-altitude raids on Japanese industries. The B–29 crews, struggling against the jet stream, icing, fog, and Japanese fighter aircraft from Iwo Jima and Japan, incurred losses as high as 6 percent on these missions.

On September 10, 1944, as the Allies advanced in Europe and the Pacific, Roosevelt, Churchill, and their military staffs met in the Octagon Conference in Quebec. The leaders agreed to continue concentrating on the campaign in France and avoid additional efforts in southeastern Europe, where Churchill continued to believe that an American and British presence would better position them for dealing with the Soviets in the postwar world. As some of the attendees thought that Germany would surrender by year's end, the conferees also planned for occupation zones in Germany and how to govern that country. In late October, the Big Three agreed to recognize General de Gaulle's Committee for National Liberation as France's provisional government. The British, also heavily involved in recapturing Burma, promised to cooperate fully in defeating Japan in the Pacific; the Combined Chiefs of Staff estimated that victory there could be won in 18 months. When Admiral Halsey's pilots encountered lighter-than-expected resistance by Japan's depleted air forces in the Philippines, Halsey recommended and Nimitz approved canceling the invasions of Mindanao and Yap and moving up the date for the landings on Leyte. Nimitz also offered to loan ships and troops to aid MacArthur's forces and sent the proposals to the Joint Chiefs of Staff (JCS). MacArthur, as urged by the JCS, accepted Nimitz's offer.



This map (originally at about 1 inch = 4 miles) of Area 18 (Tanauan) on eastern Leyte in the Philippines was prepared by the USGS Military Geology Unit (MGU) as part of its Strategic Engineering Study (SES) folio 131. The map includes the invasion beaches, inland terrain, and airfields built before 1941 or in progress by February 1944. The airfields included the seven under construction by the Japanese in the central part of Area 18 between Dulag and Burauen. Runways on those fields were expected to be up to 6,000 feet long and capable of accommodating two-engine aircraft. In August 1944, maps in SES 131 depicted the airdrome sites, climate, construction materials and maintenance, geology, soils, terrain, vegetation, and water supplies of Samar and Leyte. The MGU produced SES folios for all of the Philippines' major islands. (From U.S. Geological Survey, Military Geology Unit, 1944b, p. 55; also published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 6.)

This low-oblique photograph, a view looking northwest, shows the prewar airfield at Cataisan Point in eastern Leyte. Tacloban is in the middle distance at left. In 1944, the USGS Military Geology Unit (MGU) assessed the airfield, with its less than 5,000-foot-long runway for single-engine aircraft, as good but decided that the runway could not be lengthened to accommodate larger planes. Unlike the Sicily folios, Strategic Engineering Study (SES) 131 for Samar and Leyte used recent Allied aerial-reconnaissance photographs to supplement the ground images, maps, and tables. (Photograph from U.S. Navy, Office of Naval Intelligence, 1657574; printed in U.S. Geological Survey, Military Geology Unit, 1944b, p. 55; also published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 7.)

The MGU and Gilluly's team assessed terrain on all the Philippine islands, concentrating on selected sites and areas in eastern Leyte. On October 20, 1944, troops of the U.S. 6th Army's X and XXIV Corps landed on the northeastern shore of Leyte, between Dulag and Tacloban, the island's administrative center. An Engineer Terrain Intelligence team and an Army water-supply section accompanied each Army division. The Army forces, supported by Navy gunfire and aircraft, moved inland against units of the single Japanese division, later heavily reinforced, that garrisoned Leyte and into difficult terrain, heavy vegetation, and then the rainy season to capture existing airfields and sites recommended by Gilluly's team. Gilluly, Putnam, and Sayre landed on Leyte on D+1 and served under fire with the 5201st Engineer Construction Brigade. Sayre's work there earned him the Army's Medal of Freedom. The improved but still small airfield at Tacloban reopened in mid-October; those at Dulag (improved) and Tanauan (new) began operations in late November and mid-December; Burauen and the two other sites to the west were abandoned.[82] Gilluly's group worked at Tacloban, aiding planning for the invasion of Luzon, while operations continued until western Leyte fell late in December. The U.S. 6th and 8th Armies assaulted Luzon in January 1945. Gilluly's team shifted to Manila, after the city was secured on 4 March, before returning to the United States.

The Japanese thought keeping the Philippines, no less than Formosa and the Ryukyus, vital to maintaining the flow of oil and other materials from the Southern Resources Area, and so they fought all out for Leyte. The Imperial Army reinforced its garrison on the island, and the Imperial Navy sortied to crush the U.S. 7th Fleet that supported MacArthur's forces ashore. The Japanese plan, no less complex than theirs at Midway, drew on four groups of warships in harbors in Borneo, Malaya, Japan, and the Ryukyus. As in the Midway and Philippine Sea battles, the Japanese plan fell apart after operations began. In four separate actions with Admiral Halsey's 3d Fleet and the 7th Fleet, a total conflict larger and far more decisive than Jutland in World War I, the Japanese lost 4 fleet carriers and 3 other capital ships, 23 smaller warships, and more than 500 planes. Complete control of the waters around the Philippines passed to the U.S. Navy, at a cost of 3 small aircraft carriers, 3 smaller warships, and some 200 planes. Japanese kamikaze ("divine wind") aircraft initially appeared in planned suicide sorties during the battle's later stages; thereafter they attacked in increasingly greater numbers and effectiveness. Leyte fell to MacArthur's 6th Army on December 25, at a cost of nearly 16,000 American casualties; the Japanese lost more than 70,000 men. By then, 6th Army forces continued their attack on Samar and captured Mindoro, where Army Engineers promptly built the needed airstrips to support MacArthur's return to Luzon.

While the struggle for Leyte continued, OSRD Director Vannevar Bush (who appeared as General of Physics on the cover of *Time* for April 3, 1944) continued to oppose the new agency for scientific and technical mobilization proposed by Senator Kilgore and other Members of Congress earlier in 1944. On November 17, after more than a month of administration preparations approved by Harry Hopkins, Roosevelt asked Bush for his own views on such an agency. Roosevelt, in his letter to Bush, who reviewed a draft version, claimed that

> **[n]ew frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life.[83]**

The President termed the OSRD "a unique experiment of team-work and cooperation in coordinating scientific research and in applying existing scientific knowledge to the solution of technical problems paramount in war." He then asked Bush to apply profitably OSRD's lessons "in times of peace"[84] by giving him personally Bush's considered judgment, after consulting "with your associates and others" on four principal questions. Roosevelt inquired what could be done (1) "consistent with military security, * * * to make known to the world as soon as possible the [wartime] contributions * * * to scientific knowledge," (2) "to organize a program" to continue the war work "done in medicine and related sciences," (3) to provide Federal aid to "research activities by public and private organizations," and (4) to propose "an effective program * * * for discovering and developing scientific talent in American youth," to assure that the country maintained scientific research comparable to that "done during the war."[85]

Congress reconvened on November 14, just a week after President Roosevelt's reelection to a fourth term. The polling proved closer than in 1940, but Roosevelt still beat Dewey by nearly 3.6 million popular votes and 333 electoral votes.[86] Although the Democrats lost two seats in the Senate, they easily retained control of that body; they gained 24 seats in the House to increase their margin there to 52. Roosevelt's special message to Congress on September 20 asked the legislators to establish a Missouri River Basin Authority similar to the TVA, but the legislators took no action before recessing the next day. The Senate took up the flood-control bill passed by the House in May. Rather than begin an authority for the Missouri, the Senators wrote into the flood-control bill a joint plan for that river basin prepared by the Army Engineers and the Bureau of Reclamation. The Senate amended the bill to require that its authorized projects should not conflict with navigation of waters arising in States lying wholly or partly west of the 98th meridian or with any beneficial use of these waters for domestic, municipal, stock-raising, irrigation, mining, or industrial purposes. The bill fully established the principle of multipurpose development for Federal reservoirs by providing for hydroelectric power and irrigation where feasible on Army Engineers' projects and also, for the first time, recreational facilities. Both houses passed the amended bill on December 12, and Roosevelt signed it into law 10 days later. The Flood-Control Act of 1944 authorized projects in many parts of the United States as well as formally approving the Pick-Sloan Plan for the Missouri River Basin; the new law provided for the most comprehensive river program yet undertaken.[87] The statute also authorized appropriations of $200 million each to the USBR and the Army Engineers. Working together, the two agencies planned to build more than 100 new dams, some 150 irrigation units to serve about 6 million acres, 30 powerplants with 2.5 million kilowatts of capacity, and hundreds of miles of levees and dikes. Their effort would furnish water supplies for at least 19 cities and deepen the river to provide 760 miles of uniform navigation.

Two days before Roosevelt signed the Flood-Control Act, Wrather took another step in strengthening his staff and developing the USGS postwar persona by announcing on December 20, 1944 (effective the next day), the appointment of Thomas Nolan to fill the newly established position of Assistant Director. Nolan later decided Director Walter Mendenhall "was about the best Director the Survey ever had * * * in providing both personal and scientific leadership,"[88] but Nolan, wishing to continue active fieldwork, declined Mendenhall's request to become his principal deputy in 1942. "I would have done the same thing with Wrather," Nolan later recalled, "if he hadn't been so new."[89] In the midst of war and with USGS postwar organization at stake, Nolan decided he could not, "out of the sense of duty," refuse Wrather's request. "We all liked Bill Wrather" but, Nolan continued, "he wasn't, first of all, familiar with the Survey programs and people, and, second, he was unaccustomed to managing or administering a large organization."[90] Nolan would, Wrather said,

> **serve as principal assistant to and deputy of the Director, with commensurate authority, in the general administration of the Geological Survey with particular reference to the planning and preparation of broad programs of scientific and engineering work, to coordination of the functions of the several operating branches in the execution of such programs, and to making the results of the Survey's work more widely useful to other Federal and State agencies and the public.[91]**

Nolan would "also act as representative and deputy of the Director to serve on official or technical committees or in conferences with officers of the Department, of other Federal agencies, or of cooperating State agencies."[92] In essence, the Director delegated to the Assistant Director the supervision of internal operations and reserved to himself only the broader phases of congressional, public, and professional relations. "In corporate terms, Nolan was the Chief Executive Officer of the Survey and Wrather the Chairman of the Board."[93] Wrather handled the congressional budget hearings, most other "outside relationships," and "presided at the Advisory Committee meetings"[94] convened at his request. As suggested by Secretary Ickes and the National Academy of Sciences (NAS), Wrather also formed the five-member USGS Science Advisory Committee. The new Committee included Donald McLaughlin, president of Homestake Mining, as chairman; Eliot Blackwelder, professor emeritus at Stanford; William Heroy, a partner in Beers and Heroy and vice-president of the Geotechnical Corporation; Morris M. Leighton, chief of the Illinois State Geological Survey and an adviser to the War Production Board and the Navy; and Abel Wolman, professor of sanitary engineering at Johns Hopkins, a consultant to the WPB, and an adviser to the Army, the Navy, and the

National Resources Planning Board. The USGS Science Advisory Committee also met with Ickes while in Washington, but they received no Federal funds for travel to or service in the Capital. Nolan appeared at the BoB hearings, which usually sought more details about USGS programs than the congressional appropriations subcommittees, and occasionally represented Wrather at other committees' meetings. The pair also developed a policy of alternate visits to field sites, to gain perspective and try to raise morale, so that one of them "would always be in Washington."[95] In working regularly with Nolan, Wrather quickly found that "I could nearly always agree with his judgment."[96]

On January 2, 1945, less than 2 weeks after President Roosevelt signed the Flood-Control Act, the Army and Navy Munitions Board (ANMB) submitted its report on strategic and critical materials as required by the Surplus Property Act. In addition to the mineral commodities listed in the act, the ANMB believed that several fibers, chemicals, drugs, and oils also should be stockpiled. Strategic and critical materials, as defined on March 6, 1944, included the materials required for essential uses in a war emergency when their procurement in adequate quantities, qualities, and times would be sufficiently uncertain for any reason to require prior provision for supplying them. Using that definition, the ANMB grouped strategic and critical materials into categories A, B, and C. Category A included materials for which stockpiling seemed the only satisfactory means of ensuring an adequate supply for a future emergency: asbestos (Rhodesian chrysotile and South African amosite), bismuth, celestite, columbite, corundum, iridium, kyanite, monazite, rutile, sapphire and ruby, talc, and zirconium ores. Category B comprised commodities whose stockpiling was practicable; the ANMB recommended their acquisition only to the extent that they might be available for transfer from Federal agencies because adequate supplies could be ensured either by stimulating North American production or by partially or completely using available substitutes. Category B included bauxite, English chalk, emery, osmium, palladium, rhodium, ruthenium, selenium, and ground steatite. Category C held commodities not recommended for permanent stockpiling because storage difficulties outweighed any advantages gained thereby. These items comprised asbestos (Canadian chrysotile), iron ore, petroleum and petroleum products, radium, and iron and steel scrap. Although category C's materials could not be stockpiled, the ANMB noted that the availability of adequate supplies for future emergencies required advance planning of stocks.

The ANMB recommended constant review and revision of lists of strategic and critical materials, and of stockpile objectives, to reflect technologic developments and shifts in political and economic factors that affected the materials' strategic status. For some of the materials in categories B and C, the members felt that constant checks would best be secured if the military maintained permanent advisory committees of technical personnel from industry and Federal civilian agencies. In March 1945, the chairmen of the Committees on Military Affairs of the Senate and the House of Representatives introduced identical versions of a bill to amend the Strategic Materials Act of June 7, 1939, that related to acquiring stocks of strategic and critical materials for purposes of national defense. The bill would establish a permanent stockpiling program to include freezing postwar surplus stocks of strategic and critical materials, procuring adequate additional supplies after the war ended, and encouraging the conservation and development of sources of these materials within the United States.

Two months earlier, on January 6, President Roosevelt concluded his State of the Union Message by suggesting that "1945 can be the greatest year of achievement in human history." Roosevelt hoped the new year would see the end of the "Nazi-Fascist reign of terror in Europe," the closing in of forces "about the center of the malignant power of imperialistic Japan," and "the substantial beginning of the organization of world peace."[97] A few days later, the President's budget message indicated that actual expenditures during the fiscal year beginning July 1 depended on the course of the war. Estimates of war expenditures were less than in the preceding year, ranging from $60 billion to somewhat more than $80 billion. More money would be spent for other purposes than in any fiscal year since 1939. Roosevelt, in his fourth inaugural address on January 20, again promised to "work for a just and honorable peace, a durable peace. * * * We can gain it only if we proceed with the understanding and the confidence and the courage which flow from conviction."[98]

As Congress debated the new stockpiling bills in March 1945, few doubted that the war in Europe was nearing its end. The Kriegsmarine's development for its U-boats of acoustic torpedoes, multiple antiaircraft guns, snorkel devices to recharge batteries while submerged, advanced but passive detectors of radar and sonar, hydrogen-peroxide fuel, and more streamlined hulls did not achieve victory in the Battle of the Atlantic or in battles in other oceans, during which nearly 650 boats and most of their crews were lost. Allied bombs, gunfire, and mines left a heavy cruiser as the Kriegsmarine's largest operational warship. Allied 1,000-bomber raids continued on German military and civilian targets; the one on Dresden, during February 13–14, created a firestorm, like Hamburg's in 1943. Even the new Me-262 jet fighters and the rocket-powered and delta-winged Me-163 Komet interceptors did not enable the Luftwaffe to regain air superiority over Germany. Plagued by fuel shortages, incompletely trained pilots, and heavy losses, the Luftwaffe could not even delay the Allies' aerial onslaught.

Hitler and his Wehrmacht did not end their struggle without mounting one last major offensive, this time in the West. In December 1944, Roosevelt promoted Leahy, Marshall, King, MacArthur, Nimitz, Eisenhower, and Arnold (in that order of seniority) to five-star rank to mark the value of their contributions toward victory; Halsey's similar promotion followed a year later. Eisenhower learned of his advancement to General of the Army on December 16, just hours before the Germans shattered Allied optimism and complacency by attacking thinly spread American forces along an 80-mile front in the Ardennes in Belgium and Luxembourg. Hitler planned to have his troops split the Allied army groups in the West, drive to Antwerp, and solve the Wehrmacht's desperate need for fuel by capturing some of the Allies' vast stores of gasoline now stockpiled in Belgium. The Germans waited for an interval of bad weather to ground the Allied air forces before beginning their assault. Although initially successful in the Battle of the Bulge, the German drive stalled on the penetration's flanks, especially at the rail and highway junctions at Bastogne and St. Vith. When skies cleared on the seventh day of the offensive, Allied planes filled the air and attacked everything German. The next day, Patton's realigned 3d Army began the Allied counterstrokes that halted the Wehrmacht's advance on Christmas and repelled it after New Year's Day. Before January 20, the Germans were back where they started, having lost 100,000 men, 600 tanks and armored artillery, many other vehicles, and most of their remaining aircraft. Allied losses from all causes exceeded 60,000 men and more than 700 armored vehicles, but their armies then pushed deeper into the Rhineland and the Ruhr. To the east, Soviet forces, advancing steadily westward, reached the Oder River on the last day of 1944 and captured Warsaw on January 17, 1945.

As Soviet forces moved toward Berlin, Roosevelt, Churchill, Stalin and their principal diplomatic and military advisers met in the Magneto Conference at Yalta in the Crimea during February 4–11. Roosevelt, now obviously ill,[99] ignored Churchill's warnings about Soviet intentions worldwide and continued the efforts he began at Tehran to charm and manipulate Stalin as he did so many American and other politicians. When the President failed to do either, he decided to compromise by recognizing existing realities, including the Soviet forces in most of Poland, Hungary, and Yugoslavia. The Big Three's specific discussions at Yalta, many of which were not made public until after the war ended, related mostly to the time after combat stopped in Europe, the postwar borders of Poland and some other European countries, the disposition of territory and resources in the postbellum world (including four occupation zones in Germany and Austria and four occupation sectors in Berlin and Vienna), and the conduct of the United Nations. Stalin repeated his pledge to enter the war against Japan, after Germany's surrender, in return for territory and influence in the Far East and in Eastern Europe. The leaders reaffirmed their unconditional-surrender formula and pledged themselves to install freely elected postwar governments in all the liberated countries of Europe. They also agreed to send representatives to San Francisco to discuss on April 25 the United Nations Charter and try to resolve several remaining differences, including the nature of voting in the Security Council.[100]

Roosevelt, in reporting to Congress on March 1 the results from Yalta and from his meetings with King Ibn Saud of Saudi Arabia, King Farouk of Egypt, and Emperor Haile Selassie of Ethiopia, asserted that "We have made a good start on the road to a world of peace."[101] The President assured the German people that unconditional surrender did not mean "destruction or enslavement" but it did require "temporary control" by the Big Four, the end of Nazism, "complete disarmament,"[102] and "reparations in kind for the damage which has been done to the innocent victims of its aggression." "The final decisions"[103] about areas "of political confusion and unrest,"[104] the President cautioned, "are going to be made jointly; and therefore they will often be the result of give-and-take compromise"[105] for "a more stable political Europe than ever before."[106] In the Pacific, Roosevelt added, "It is still a long, tough road to Tokyo," but "the unconditional surrender of Japan is as essential as the defeat of Germany."[107] Destroying both militarisms would keep "the sons and grandsons of these gallant fighting men" from having "to do it all over again in a few years."[108] "On the problem of Arabia [Palestine]," Roosevelt noted, "I learned more about the whole problem—the Moslem problem, the Jewish problem—by talking with Ibn Saud for five minutes than I could have learned in the exchange of two or three dozen letters."[109] The President did not report the King's query about giving Arab lands to the Jews or his suggestion that the Jews instead receive lands in Germany. Roosevelt also did not mention Ibn Saud's warning that the Arab countries would fight to prevent any increase in or further dispersion of the Jewish population in Palestine, beyond the British-specified areas, and respond in kind if Jews killed Arabs. Less than 2 weeks after the Yalta conference, delegates from 20 Latin American countries convened in Mexico City at the Inter-American Conference on Problems of War and Peace. Conferees signed the Act of Chapultepec to enhance regional security until the global conflict ended.

On March 1, 1945, the House appropriations subcommittee began its hearings on the Interior Department's budget for fiscal year 1945–46. Secretary Ickes, while appearing before the subcommittee, expressed his concern regarding the Nation's policy about and supplies of mineral resources and about the related roles by Interior and the USGS during the postwar interval:

> **We will be required, after this war, to make important decisions concerning the extent to which our mineral supplies will meet our needs for a period of years; the degree within which foreign sources should be utilized; and the amount which we should maintain in reserves of strategic minerals. The programs of this Department dealing with the discovery and recovery of strategic minerals should be considered in the light of this country's need for the development of a long-term mineral resources policy.**[110]

Ickes also recalled that:

> **This war caught us with most inadequate knowledge of our topography and our water resources. As a result, millions of dollars have been expended under emergency conditions to obtain information essential to the location and construction of military reservations and war production facilities. * * * There is no means of accurately measuring the total losses which have resulted from planning structures and facilities without proper knowledge as to terrain or the surface and ground water available to serve such facilities, but it is certain that it represents many times the amount of money which would have been involved in obtaining and maintaining the topographic and water resources data which are essential to sound engineering planning.[111]**

The budget estimate for Interior for fiscal year 1945–46, $133 million, exclusive of the amount for the Solid Fuels Administration for War and the War Relocation Authority, clearly anticipated a relatively early end to the war in providing for an increase of more than 50 percent over the amount in the previous year's request. Interior's estimate included nearly $1,073,000 to support development in Alaska. Ickes presented the new program as a postwar effort in the Territory "to fill gaps in available information, to provide for intensive work in the areas considered most favorable for immediate settlement, and to examine the possibilities for servicemen and other settlers to develop agricultural, aquatic, mineral, and timber resources as a means of livelihood."[112] The USGS estimate totaled some $8,555,000, an increase of more than $1.8 million over the appropriation for the year underway. Its three largest items were $3,075,000 for topographic surveys, nearly $1,896,000 for streamgaging, and about $1,338,000 for geologic surveys, but only the first two included substantial increases; most of the items, except for publication costs, actually had been reduced. Interior's Alaska development program included $410,000 for topographic mapping, streamgaging, mineral-resource studies, and classification of lands by the USGS, bringing the total requested for the agency to about $8,965,000.

As the House subcommittee evaluated Interior's budget request, the Allies continued their successful advances on all fronts. In Europe, Allied units crossed the Rhine at Remagen and completed plans to break through Italy's Gothic Line in April. Finland joined the Allies. The Soviets cleared Poland and continued advancing toward Berlin and Vienna. In Southeast Asia, the Army Engineers completed the Ledo Road and its accompanying oil pipeline.[113] Major General Raymond A. ("Spec") Wheeler supervised that work and the construction of the Assam airfields from December 1942. Wheeler, the principal Allied administrative officer in the theater from November 1943 and a Lt. General in February 1944, became Admiral Mountbatten's deputy commander in November. Brigadier (later Major) General Lewis Pick directed on the ground the 2-year completion of the road that linked the Assam railhead at Ledo with Mogaung station on the Burmese railway. After the Allies captured the railway's northern terminus at Myitkyina, Pick's Army Engineers extended the Ledo Road through Bhamo to tie it to the new road from Kunming built by American troops and Chinese laborers that opened late in January 1945. The initial convoy over the Ledo-Burma Road reached Kunming on February 4, reducing the load carried by the USAAF's transports that lifted personnel and supplies from Assam over the Himalaya's 15,000-foot-high "Hump" to China. In central Burma during March, British and Commonwealth troops recaptured Mandalay, the former capital, Meiktila, and the Yenangyaung oil fields. Continuing south, they retook Rangoon on May 3.

In the Philippines, units of the U.S. 6th Army began landing on Luzon at Lingayen Gulf on January 9 and moved south, reinforced by the 8th Army. After bitter fighting, MacArthur's soldiers freed Manila on March 4. U.S. troops captured

Corregidor on April 17 and then continued operations northward into the mountains. Charles G. Johnson, assigned to the staff of the 6th Army's Chief Engineer, received the Medal of Freedom for his work with the troops in northern Luzon. The Japanese lost 200,000 men during the campaign; American casualties totaled about 40,000.

In March 1945, as Gilluly's team left MacArthur's command, the MGU organized a similar but larger group to replace them. General Casey returned to the Philippines as Chief Engineer of MacArthur's Southwest Pacific Area and (later) Army Forces Pacific. He established the MGU team as a separate Section with completely delegated responsibility under a new standing operating procedure that defined its missions, organization, responsibilities, and work. Fritiof Fryxell led the second team to Manila. Fryxell, as Chief of the Research Division, reported to Major (later Lt. Colonel) Hubert G. Schenck, head of the Branch of Research and Reports in the Intelligence Division, and on leave from Stanford since 1943. Fryxell led the terrain research by two teams as part of Allied preparations for Operation Downfall, the invasions of two of the Japanese home islands intended to force a nationwide surrender. Fryxell's Team 1—USGS geologists Walter White and Vincent McKelvey, Army Captain Roger Baker, War Department geologist George Kemmerer, soils scientist James Thorp of the USDA's Soil Conservation Service (SCS, now Natural Resources Conservation Service), and Australian Leopold W. Stach—evaluated southeast Honshu's Kwanto Plain and reported their preliminary results on July 15 to the generals planning Operation Coronet, scheduled to begin in March 1946. Team 2, a group of Army Engineer officers, assessed southern Kyushu as part of plans for Operation Olympic set to commence in November 1945.

During 1944–45, the MGU in Washington also provided strategic-intelligence studies for Kyushu (SES 125, at 1:900,000 and, separately, at 1:250,000, its southern and northern halves), Honshu (SES 126, 1:1,250,000), the Tokyo area (SES 174, 1:250,000), Hokkaido (SES 127, 1:1,000,000), and Formosa (SES 137a–c) before invading that island disappeared from the Allied war plan. Esper Larsen 3d led the Honshu team that Ralph Roberts joined in July 1945 after returning from Central America. Roberts also replaced Edward Sampson in the group, which included Stanford geologist Konrad B. Krauskopf and soils scientist Marion M. Striker (SCS), that solved the Army Engineers' problems with the SCR–625 mine detector in Sicily, Italy, and the Pacific. The team's members demonstrated that the mine detector registered signals from soils containing maghemite (oxymagnite), a strongly magnetic iron oxide.[114] They helped to develop a more sensitive instrument by testing controlled soils of different origins, textures, and natural and supplemented magnetic susceptibilities and later field checked the detector in fortified areas in Honshu.

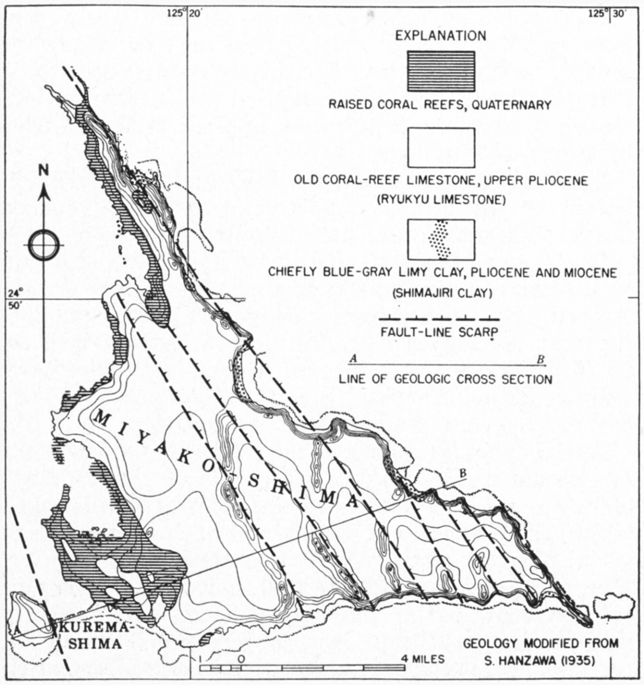
To serve the Pacific Ocean Areas command, Charles Hunt recommended to the Army Engineers that the MGU form a second Terrain and Intelligence Team and send it to Admiral Nimitz's headquarters in Hawaii. The Engineering and Terrain Intelligence Team led by Philip Shenon arrived on Oahu during November 19–21, 1944. Shenon and his team reported to Nimitz's Joint Intelligence Center, were attached to the 30th Engineer Battalion for quarters and workspace, and served there until September 1945. The initial members of Shenon's team included John G. Cady, soils and engineering; John T. Hack, geology and terrain analysis; Elmer Hertzler, roads and bridges; John Rodgers, beaches; Frank A. Swenson, water supplies; and Horace Wilcox, ports and harbors. A second group arrived on Oahu during April 23–May 3 and consisted of Robert M. Garrels, beaches; Harold James and John H. Moss, geology; Charles Johnson, water supplies; W. Bradley Myers, terrain; Sherman K. Neuschel, construction materials; Victor P. Sokoloff, soils; and Philip M. Stephenson, roads and bridges. Hertzler and Wilcox returned to the United States on May 7.

Shenon's team completed more than 120 tactical-level reports for (1) the Joint Intelligence Center; (2) Vice Admiral R. Kelly Turner, the commander of all of Nimitz's amphibious forces; (3) Herbert Loper, a Brigadier General since November 11, 1944, and now Chief Engineer on the staff of Lt. General Robert C. Richardson, Jr., who from August 1944 commanded all Army forces in Nimitz's theater; and (4) the chief engineer of the 10th Army, led by Lt. General Simon B. Buckner, Jr. Richardson, who headed the Alaskan command during 1940–43 before replacing General Emmons in Hawaii in 1943, specifically asked for Loper's transfer from Washington in March 1944, and Loper arrived on Oahu in June. By February 1945, the MGU team's reports provided intelligence, from aerial photographs and the resulting maps, on the offshore conditions and beaches of Iwo Jima in the Volcano Islands (Kazan-retto), but most of them focused on Okinawa and other islands in the Ryukyus (Nansei-shoto). When Shenon's initial group members finished their reports on Okinawa, they joined the second team for joint work on southern Kyushu. By March, the combined team on Oahu completed reports about terrain conditions offshore and on southern Kyushu and about beaches on Honshu.

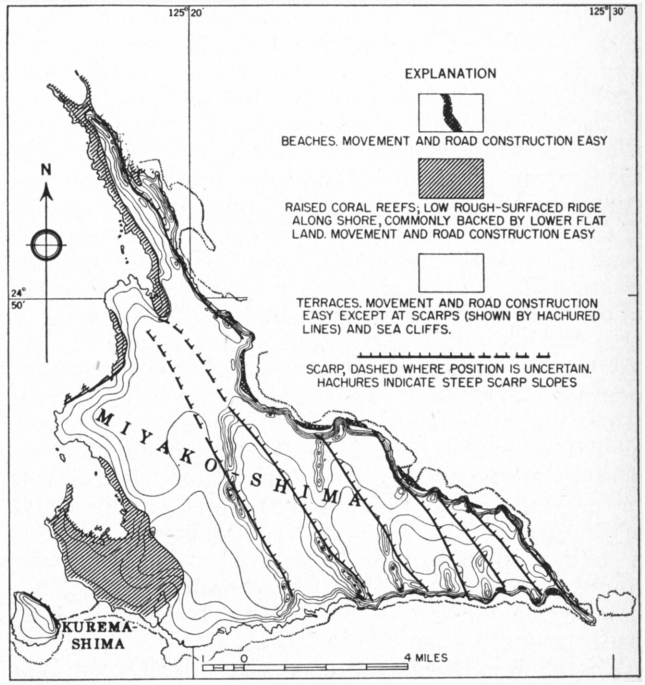
The MGU then consolidated its Pacific teams in Manila. Beginning in July 1945, Morris F. Austin (SCS), Robert Bryson, John J. Collins, Wallace de Laguna, Edward Sampson (Princeton and USGS), Major Spillers (now Schenck's Executive Officer), Philip Stephenson (from the team on Oahu), and Frank C. Whitmore, Jr. (the MGU's Chief Editor), arrived in Manila. They assisted or replaced members of Fryxell's teams in completing the ongoing reports, and in preparing 15 additional mixed-topical reports, mostly on mineral resources, for a total of more than 190 products. The teams continued to benefit from user critiques. Field checks by the MGU field teams provided data for Charles Hunt's critique in April 1945 of Washington's Strategic Engineering Study on Samar and Leyte (SES 131, at 1:300,000) and, later, those on Luzon (SES 124, 1:300,000, and SES 148, 1:63,000), Southern Luzon (SES 135, 1:500,000), and other islands in the Philippines. The combined group completed Preliminary Terrain Estimate (PTE) reports on the Kwanto Plain (PTE 33, Tokyo and vicinity, July 15) and three other areas on Honshu (Aomori, Shimonoseki, and the Kobe-Kyoto-Osaka triangle), the Ishikara area (northwest of Sapporo), and the Keijo-Jinsen (Inchon) region of the Korean Peninsula. SES 149 included an assessment of Korea's terrain at 1:1,000,000. Schenck and Fryxell then briefed the generals involved in preparing the Army's part in the planned invasion of Honshu and the possible assaults on Hokkaido and Korea.

While MacArthur's forces struggled on Luzon, units of the V Amphibious Corps landed on the black-ash beaches of Iwo Jima on February 19. In furious fighting, marines of three divisions captured the island by March 11. Frank Swenson, who left Oahu on February 22 for duty on Iwo Jima, found good groundwater,[115] part of the freshwater lens underlying the island for which the Japanese garrison searched without success, provided advice on gravel and quarry sites, and earned a Bronze Star for his efforts under fire. The marines declared the island secure on March 16. Taking Iwo Jima brought U.S. forces within 800 miles of Japan, but the campaign cost the marines and supporting sailors more than 25,000 casualties, a total greater than the island's 22,000 Japanese, of whom fewer than 5 percent surrendered. Beginning on March 4, Iwo's improved and extended airstrips served as a haven for General LeMay's Superfortresses returning damaged from raids on Kyushu and Honshu, and, after March 11, Iwo Jima was a base from which long-range fighter aircraft escorted the B–29s to their targets. More than 2,300 damaged bombers and their crews landed safely on Iwo; the number of American airmen saved thereby almost equaled the total of marines and sailors lost. Pre-invasion operations by air and sea against Okinawa began on March 14.

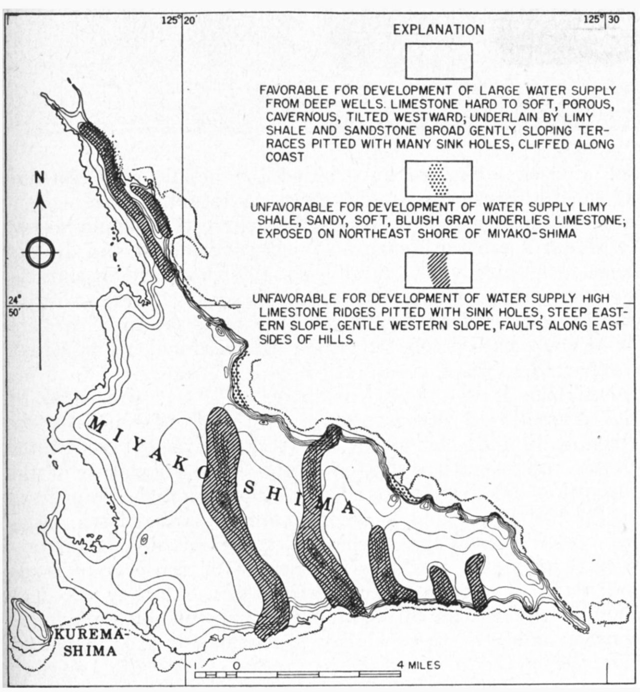
While conflict continued in the major theaters of war, both the USGS and the House appropriations subcommittee clearly anticipated the end of the war



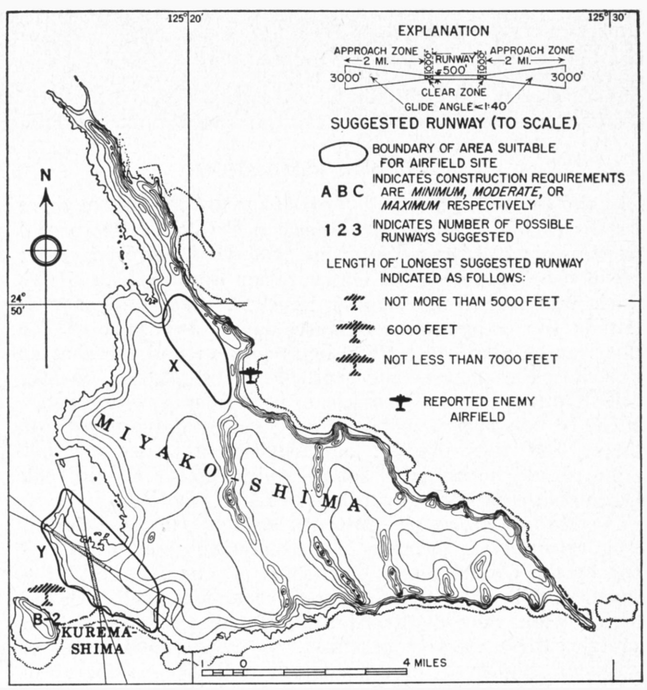
Geologic Map



Terrain Appreciation Map



Water-Supply Map



Airdrome Site Selection Map

The USGS Military Geology Unit (MGU), in part I of its Strategic Engineering Study 119, suggested in August 1944 these two potential sites for airfields (bottom right map) on Miyako-shima (Miyako-jima); this island is the northernmost of the southern Sakishima Islands group of the Ryukyu Islands. Map site X occupied an area just west of a reported Japanese field for two-engine aircraft. On map site Y, to the southwest, two runways (each not less than 7,000 feet long) could be built for four-engine planes with only moderate construction requirements. The three other maps, also products of the MGU's overall evaluation of terrain intelligence of Okinawa and the rest of the Ryukyu Islands, show Miyako-shima's geology, terrain appreciation, and water supply. (From Whitmore, F.C., Jr., 1954, p. 214–215; the maps from Whitmore were originally at about 1 inch = 4.75 miles; they were derived from maps at about 1 inch = 1.5 miles in U.S. Geological Survey, Military Geology Unit, 1944a.)

but in vastly different ways. To Wrather and his principal managers, who appeared before Jed Johnson's subcommittee on March 21, 1945, the end of hostilities meant returning to the mapping and science activities set aside to help the war effort. To the subcommittee, the war's finish implied a return to a prewar budget. The USGS asked for an additional $11,150 in administrative salaries to cover the reallocation of three positions, the costs of within-grade promotions and seven full-time slots filled late in the first half-year, and a new Current-Information Unit. Chief among the seven slots was the post of Assistant Director, about which the committee still held some doubts. Did the USGS not get along without a formal deputy until then? Julian Sears protested that during his 21 years in the Director's Office, the agency "consistently starved the central administration and held down the 'overhead costs' so every penny possible could be put into actual production in the field and in the laboratories,"[116] but there came a time when economy ceased to be a virtue. Wrather intervened, recalling that one of his initial observations on joining the USGS in 1943 involved understaffing in his office. No substantial change in the Director's Office staff occurred since the appointment of the Administrative Geologist in 1912. The Director's Office was now almost the worst bottleneck in the whole USGS, whereas the agency's war-related work demanded the greatest possible expedition and efficiency. Wrather, believing he must act, established the position of Assistant Director. Representative Michael Kirwan then observed mildly he was "under the same impression that you are, Doctor, that when the personnel has jumped from 800 to 2,400 or 2,500, and your budget had gone up to $12,000,000, it is almost time you came in front of the Appropriations Committee and ask to improve your own back yard or staff."[117] No amount of explanation convinced the subcommittee that the Current-Information Unit, intended as a small group tasked to prepare reports requested by Congress, other agencies, or the public about USGS activities, was needed and not just a publicity scheme.

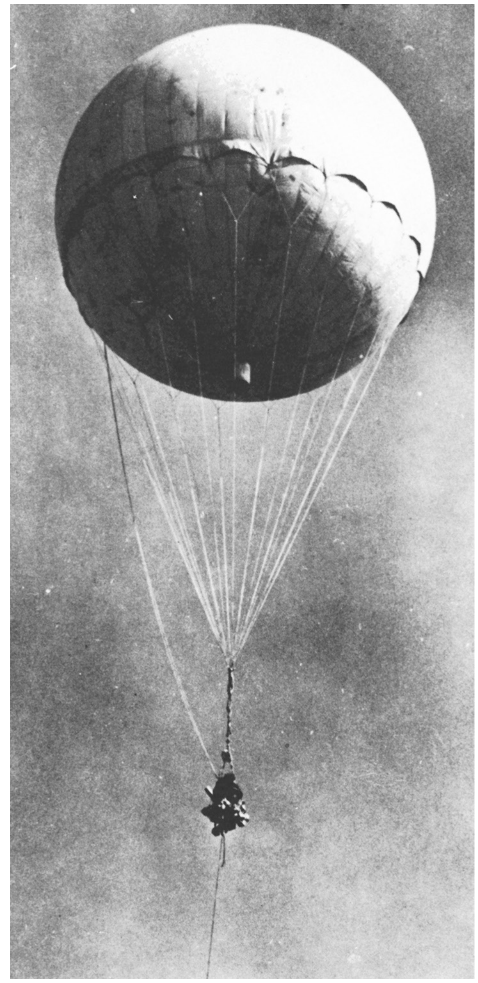
The USGS estimate for its topographic surveys in fiscal year 1945–46, more than twice its appropriation for 1944–45, excited considerable attention during the House subcommittee hearing. The increase included additional funds to match larger cooperative offerings from the States, but most of it would be used to complete U.S. maps begun with funds transferred from the War Department when invasions were feared. The remaining monies would fund the procurement of aerial photographs, the purchase of photogrammetric equipment, and the start of extensive mapping in the Columbia River Basin requested by the Army Engineers, pursuant to the Senate Committee on Commerce's directive of September 24, 1943, to develop water resources in the postwar period. The USGS also expected to start a topographic-mapping program in the Missouri River Basin, although funds for that effort were in the Bureau of Reclamation's budget request. In March 1945, Roosevelt asked Congress for nearly $5.5 million to enable Interior to prepare plans for developing the Missouri River Valley. In April, the USBR submitted a 10-year program of western water development costing $5 billion. Congress authorized $3.2 million, of which the USGS received $936,000, for the Missouri Basin to allow Interior agencies to begin economic and engineering studies and prepare plans for development. Kirwan now asked the perennial question, should all mapping agencies be in one department? His colleague William Norrell suggested that the USGS convene all the directors of Federal mapping agencies to see if they could be consolidated into "what might be designated as the mother agency?"[118]

The estimate for geologic surveys by the USGS in fiscal year 1945–46 remained unchanged from the previous year, but the request included $150,000 for what Chief Geologist Bill Bradley, making his initial appearance before the House subcommittee, circumspectly described as "a new high-speed method of geophysical exploration using certain classified equipment of the armed forces."[119] He enthusiastically characterized it as "a pretty 'hot' development."[120] Of that sum, $70,000 would purchase an airplane, and $48,000 would provide for its operation and maintenance. The word "magnetometer" did not appear in the hearing's transcript, and the subcommittee's members asked Bradley no questions, at least none for the record. The legislators did say that the War Department ought to gladly supply one of its many aircraft, since the USGS would be using it for war work. During antisubmarine searches with the airborne magnetometer, Navy personnel recorded peculiar anomalies when the instrument was used along several sections of the coast. Responding to the Navy's request for an explanation, James Balsley and geophysicist Homer Jensen, an engineer with the Naval Ordnance Laboratory (NOL), used the Navy SNB–1 aircraft to complete, during July 22–September 14, additional aeromagnetic surveys in these areas. The magnetometer, Balsley and Jensen noted, also would be useful in geological investigations.

The USGS estimate for its strategic-minerals investigations in fiscal year 1945–46 was only half of the 1944–45 appropriation. The agency, having nearly completed its initial surveys, shifted that work's emphasis to aid sustaining production and meeting quick changes in needs such as the recent sharp upswing in the demand for mercury. The same thing, Bradley said, was about to happen with tungsten. He added that requests for fluorspar also were high. "Another program," Bradley continued, "is tied up with [a] similar element—rather elements—and that is in the same situation, but it is in an effort to sustain production that we are requiring these funds now."[121] He trailed off without mentioning uranium or any related element; again, the subcommittee's members did not press him for more information. Some of the security measures regarding USGS activities, however, had been lifted. Bradley drew the legislators' attention to Martin Sommers' article about the Military Geology Unit, prepared in cooperation with the MGU and the Army Engineers and published in the *The Saturday Evening Post* for March 24. Sommers described the unit's origin, composition, and work, and touted its achievements, especially the Sicily folios and the Leyte report. The article's last sentence claimed that "some of the Army engineer officers figure that the Military Geology Unit of the Geological Survey is the biggest bargain the Army ever made in wartime."[122] Kirwan arranged to have the whole promotional article placed in the record.

The MGU's ongoing work included another unmentioned effort, one aimed at pinpointing the sites from which the Japanese Army launched hydrogen-filled balloons and their attached instruments and ordnance against North America. The balloons, riding the jet stream discovered by the Japanese in 1926, represented their only large-scale operational reprisal for the Doolittle raid.[123] Robert C. Mikesh and Yoshiro Koichi later individually described and analyzed the "Fu-Go" (balloon bomb) project, and Michael White melded their findings from documents and interviews in a later film.[124] The Fu-Go project, a multiyear effort, cost the equivalent of more than $2 million and required the labor of many adults and teenage women, under the overall supervision of Major General Kusaba Sueyoshi, assisted by Major (Technical) Takada Teiji. The Japanese mass-produced the lacquered mulberry-paper, A-type balloon, as it was lighter in weight than the rubberized-silk, B-type version. Each of these balloons, some 32 feet in diameter and holding nearly 20,000 cubic feet of hydrogen, carried five small bombs—one high-explosive device and four thermite incendiaries. The improved A-type balloon, ready by late 1943 and proved in trials from China, went into production in the Tokyo area for deployment from sites in eastern Honshu selected in August 1944. By then, the British were ending their 2-year operation that launched nearly 100,000 propaganda and incendiary balloons against German-occupied Europe.

On November 3, 1944, units of the Japanese special balloon regiment launched the first of these free-flight but ingenious devices into the winter-strong jet stream. The unit sent some 9,300 balloons skyward in the next 5 months. Reaching altitudes of 30,000 to 40,000 feet, the aneroid-barometer-equipped, height-adjusting, and radio-tracked balloons rode the jet stream eastward for about 5,500



Between early November 1944 and early April 1945, personnel of a Japanese Army's special regiment launched about 9,300 of these A-type balloon bombs from sites on the southeast coast of Honshu. Each mulberry-paper balloon was hydrogen filled and some 32 feet in diameter; it carried as part of the open gondola two aluminum rings bearing many ballast bags (each with 7 pounds of sand), four thermite incendiary bombs, and one explosive bomb. These balloons, powered by the winter-strong jet stream and maintaining their altitude by venting gas (daily) and dropping ballast (nightly), soared some 5,500 miles across the Pacific. They were designed to release their ordnance over forests and other wide-area targets in western North America. The balloon bombs failed as a military or terror weapon, and the Japanese did not deploy their pathogen-filled and soft-case bombs produced before the war ended. (Photograph from National Archives and Records Administration, Still Picture Branch, as A 37180C; published in Mikesh, 1973, fig. 3.)

U.S. Navy personnel examine the two aluminum O-rings from the open gondola of 1 of the 285 recorded Japanese balloon bombs that reached land; they were found principally in the Western United States and also in Alaska, Canada, Hawaii, and Mexico. The Japanese Army launched about 9,000 of its A-type balloons, and the Japanese Navy added 300 of its rubberized-silk, but less efficient, B-type balloons. The balloon's ordnance shown here includes one (at left) of four thermite incendiaries and the single high-explosive bomb (center). Analyses by USGS scientists of microfossils and heavy minerals from the sand in the balloons' 7-pound ballast bags (one shown at right) enabled these specialists to locate the launch sites on southeastern Honshu for aerial attack. (Department of the Navy photograph, National Archives and Records Administration, Still Picture Branch, as 80–G–326354; published in Mikesh, 1973, fig. 35.)

miles during their crossings of the Pacific lasting more than 60 hours. Appearing over wide areas of western North America, they reached 16 States and sites as far distant and separated as northeastern Alaska, southern Manitoba, southwestern Michigan, and northwestern Mexico. They also traveled to the waters off Oahu's northeastern coast and to Attu in the westernmost Aleutians. The United States responded by detailing troops to fight forest fires, distributing decontamination materials to farmers and other citizens, monitoring their homes and animals, experimenting with captured balloons, plotting Japanese radio signals, establishing a radar-warning line along part of Washington's coast, and flying intercepts by day- and night-fighter aircraft. The Japanese expected about 10 percent of their weapon balloons to reach North America. U.S. and Canadian personnel recovered parts or all of 285 of them during the war, and another 40 in postwar years, most from locations between 40 and 50 degrees north latitude and from the West Coast eastward to the 105th meridian.

The War Department sought to end these attacks by discovering and bombing the balloons' fabrication and launching sites. In January 1945, the War Department asked the USGS to have its military geologists try to determine the location of the sands used as ballast for the balloons. In the MGU, Julia Gardner and Kenneth and Katherine Lohman analyzed mollusks, diatoms, and foraminifers (no corals appeared), and Clarence Ross examined the hypersthene-rich heavy minerals in ballast from two balloons that grounded in Alaska and Wyoming. Their results and similar studies by Canadians, who found blast-furnace slag, indicated that the beach sands came from Shiogama (a flight-following station northeast of Sendai) and Ichinomiya (south of Ohara on the Chiba Peninsula southeast of Tokyo). Although Ichinomiya lacked a hydrogen-generating plant, it was one of the three launch areas on the coast of southeastern Honshu. As the jet stream's strength declined, the Japanese ceased launching weapon balloons in late April. Aside from an article in *Newsweek* in January, the U.S. Office of Censorship successfully stopped all but one other public mention of the balloons. The B–29 raids on Tokyo on April 12–13 destroyed many of the balloon-production facilities and the other two hydrogen-generating plants, along with key parts of the uranium-isotope-separation facilities of physicist Nishina Yoshio. The Japanese knew by radio-tracking and a notice in a Wyoming newspaper, repeated by the Chinese, that their balloons were reaching North America but not where, in what numbers, or the degree of their physical and psychological impacts. They also did not know that their weapon diverted some Allied personnel and resources from the combat theaters. Specifically, the balloons imposed a 3-day delay on the plutonium reactor at the Hanford Engineer plant in Washington, when, on March 10, shrouds landed on powerlines, started two minor fires elsewhere, and, on May 5, killed a woman and five children who disturbed the payload while picnicking in Fremont National Forest near Bly in south-central Oregon.

The Japanese balloon project failed as a military and terror device program, but its impact might have been greater if the Japanese, as they intended, had succeeded in transforming some balloons into biological weapons. The instruments' saltwater-solution battery contained no pathogens, but the Japanese developed and tested successfully a soft-cased bomb designed to contain plague-carrying fleas expected to survive the small detonation and then spread widely. Only the conflict's end prevented the bacterial bomb's production and deployment from aircraft.[125]

As the MGU analyzed the balloon ballast, the USGS Water Resources Branch responded to a major challenge to one of its important operations. Of the $305,000 the USGS requested for its studies of water resources during fiscal year 1945–46, $200,000 would support preparing plans and specifications for gaging-station work deferred during the war and $60,000 would match increases in cooperative funds for that purpose. The initial item, labeled "post-war planning,"[126] immediately created a problem. In January 1945, the USGS announced its postwar program of water-resources investigations. Lee Rogers, president of Minnesota's Lane-Western Company, one of several regional firms in the Lane national conglomerate, promptly complained in a letter to Representative Walter H. Judd (R–MN). Certain groundwater studies by the USGS, Rogers asserted, competed directly with those of private industry. In particular, he claimed, the agency's groundwater men were soliciting municipalities to drill for water, thus taking business away from firms such as Lane-Western. Judd gave Rogers' letter to Iowa's Ben Jensen, still a member of Jed Johnson's House subcommittee. The whole program of USGS water-resources work, rather than the budget item, which clearly pertained to surface waters, became the subject of the House subcommittee's inquiry. Chief Hydraulic Engineer Glenn Parker acknowledged that his Branch's postwar program included "test drilling" and explained that in the past, well-drilling companies helped the USGS by furnishing data from their wells, but the agency did not know whether these firms would be drilling in the areas where it wanted information. The USGS, Parker continued, lacked its own drilling equipment, although the agency sometimes operated equipment purchased by some of the States in connection with the cooperative programs. He concluded "that if the companies can do it more cheaply than we can do it, we must assuredly arrange for the companies to do that test drilling."[127] The subcommittee, satisfied with the response, turned Rogers' letter over to the USGS for reply and restored the groundwater funds temporarily withheld but added restrictive language to prevent the agency from ever operating as alleged.

The USGS response to Rogers uncompromisingly defended test drilling by the agency; it remained "an indispensable tool" in investigations of groundwater resources. These studies provided a means of collecting rock samples for study and introducing instruments to determine the direction and rate of movement of waters, their chemical character, and the supplies the rocks would yield. Well drillers who kept records of their operations cooperated with the USGS and furnished information of much value, but, where no wells existed, or where data from drilled wells proved inadequate, test holes must be drilled. Moreover, the USGS intended the systematic test drilling it supervised "to define the groundwater conditions of specific areas, such as counties, groups of counties, or drainage basins," and to obtain "exact and comprehensive information for an entire State." The USGS did not supervise drilling to locate sites for producing wells and did "not drill wells for the production of water supplies but only test holes in connection with its technical studies"[128] as part of gathering information. Wrather repeatedly refuted continued charges, including those by the Water Well Drillers Association, and finally convened in his office employees of Lane-Western and other companies. The USGS would honor existing agreements with the States but in any new cooperative contracts would not purchase drilling equipment with Federal funds. The agency also planned to advertise for bids on wells to be drilled, thereby avoiding in-house drilling equipment and their crews. The USGS promised that it would try to turn production drilling over to the commercial drillers, but when the agency needed drilling for research, the agreement allowed the agency to arrange to drill wells on its own. That compromise later formed the pattern the USGS followed with the commercial aerial-photography firms in arranging and executing contracts for air-photo coverage to advance topographic and related mapping.

The report by the House subcommittee greatly disappointed USGS management. Jed Johnson's subcommittee disallowed more than 75 percent of the requested increases, including the funds for all new staff positions, and recommended a total of just over $6,852,000 for the agency, including $1 million for geologic surveys, about $2,047,000 for topographic surveys, and just under $1,636,000 for streamgaging. Disapprovals included the $150,000 for airborne-geophysical exploration, $200,000 for postwar planning, and $60,000 for cooperative investigations of water resources. By cutting nearly $188,000 from the 1945–46 base for geologic surveys, the subcommittee ensured that the USGS would have to curtail fieldwork in investigations of fuels, metals, and nonmetals. Publication funds also were reduced, and the legislators disallowed all funds for Alaska development. With respect to the USGS Alaska program, the subcommittee, noting the availability of information in the Library of Congress (LC) and the GLO, observed that the USGS request for funds gave the clear impression that the general research proposed would be of little or no practical value toward securing homes and providing employment for veterans in the coming months and likely not for 1 or 2 years. In June 1944, Congress and the President demonstrated their concern by providing wide-ranging benefits to all returning veterans in the Servicemen's Readjustment Act.[129] That statute's clauses included a generous program of college education, better known as the G.I. Bill of Rights.

At the time the House subcommittee filed its report, Allied forces continued to advance everywhere. In Europe, they rapidly pushed forward from west and east into Germany. In April 1945, one of General Patton's units discovered a huge collection of archival and library materials in a deep "potash mine in Heringen"[130] near the Werra River in easternmost Hessen southeast of Kassel. This collection, transferred from Berlin a year earlier, included the German Patent Library, portions of the Prussian State Library, and military geology materials. Nearly 23,000 military geology items—books, maps, and reports in German, Polish, and Russian; photographs; and other documents—later passed to the Army Engineers' Intelligence Division. General Eisenhower decided against an all-out drive for Berlin; Allied troops continued to push into central and northern Germany to await the arrival of Soviet forces at the Elbe River. Soviet forces began their final drive on Berlin on April 6.

In the Pacific, Allied aircraft continued to strike targets in Japan and their amphibious forces invaded Okinawa. General LeMay modified the tactics of his B–29 strikes, by eliminating most of his planes' guns to increase their bomb loads and range, changed to incendiaries, and began low-level raids at night against major Japanese cities. Superfortress losses fell below 2 percent. On the night of March 9–10, some 330 B–29s dropped napalm (gasoline-gel) bombs on Tokyo. The resulting firestorm, like those at Hamburg and Dresden, was devastating; it killed or injured more than 180,000 people and burned out nearly 16 square miles of the city. LeMay's B–29s, reinforced from April by those of XX Bomber Command from India, went on to destroy the facilities and populations of most of the industrial and adjacent areas in Japan's six largest cities—Kawasaki, Kobe, Nagoya, Osaka, Tokyo, and Yokohama—but spared Kyoto, the ancient and venerable capital. The U.S. submarine and mine campaign against Japanese shipping increasingly isolated the home islands from the Southern Resources Area and other sources of construction materials, food, and oil supplies, but the Japanese continued to transfer home air and ground forces from China and elsewhere, train additional militia units, and stockpile aircraft and fuel for a fight to the bitter end.

On April 1, nearly 180,000 marines and soldiers of the five divisions in General Buckner's U.S. 10th Army—III Amphibious Corps and XXIV Army Corps—invaded Okinawa. Frank Swenson and USGS groundwater geologist D. John Cederstrom, who had worked with Harold Stearns in Hawaii, went ashore on Okinawa to advise construction troops. Cederstrom's contributions to the campaign earned him a Bronze Star. Okinawa held a Japanese garrison of 130,000 men, and their commander chose not to oppose the landings but to defend the south one-third of the island from the Shuri Line. On June 10, units of the 10th Army reached this principal defensive zone. When the Allied fleet stayed off Okinawa to support the troops while they assaulted the Shuri Line, kamikaze aircraft killed and wounded many sailors and sank or heavily damaged three American carriers and many destroyers and smaller warships on radar-picket duty.

The invasion of Okinawa and the Soviet Government's denouncement on April 6 of its 5-year nonaggression pact with the Japanese brought down the Koiso-Yonai Government. Former Admiral Suzuki Kantaro returned as Prime Minister on April 7. Although Suzuki hoped the Soviets would mediate the conflict, and new Foreign Minister Togo Shigenori had long opposed the war, the militarist majority continued the struggle. They depended principally on the home islands' 2.5 million troops, some 30 million real and potential militia, and rugged terrain. The U.S. 10th Army secured Okinawa on June 22, after losing more than 38,000 marines and soldiers killed and wounded. Kamikaze attacks caused an additional 10,000 Navy casualties, sank 36 ships, damaged another 370 vessels, and destroyed 760 planes. Okinawa cost the Japanese 70,000 killed and more than 50,000 wounded or missing, but some 7,000 others surrendered. Winning the war, the Allies decided, reluctantly, required invading the Japanese home islands,[131] although assaulting Kyushu and southeastern Honshu might cost the Allies an estimated 500,000 casualties, one-fourth of whom likely would be killed. They based this figure on the losses, proportional to the Japanese defenders, already incurred on Leyte, Luzon, Iwo Jima, and Okinawa, and elsewhere in the Pacific, and their estimate of the Japanese home forces. To form part of the more than 1 million men required for these operations in 1945–46, veteran U.S. Army air and ground units would be transferred after the war ended in Europe.

On April 12, 1945, as Allied forces moved forward on all fronts, Vice President Harry Truman presided over the Senate while Members discussed ratification of the year-old treaty with Mexico for sharing the waters of the Colorado and Rio Grande Rivers. When the session recessed, Truman went to the downstairs sanctum of his good friend Samuel T. Rayburn (D–TX), the Speaker of the House since 1940. There, Truman returned a call from the White House and learned that Roosevelt suffered a cerebral hemorrhage and died at 3:35 p.m. in the Presidential retreat at Warm Springs, Georgia. A few minutes after 7 p.m., Truman took his oath of office in the White House as the 33d President of the United States. When President Truman asked Eleanor Roosevelt if there were anything he could do for her, she asked whether she could do anything for him as the inheritor of FDR's crushing responsibilities.[132]

Truman immediately began changes in his Cabinet. He offered to nominate James Byrnes, Director of the Office of War Mobilization and Reconversion, to be Secretary of State, replacing Edward Stettinius, who took over after Cordell Hull officially resigned effective November 27, 1944. Nearly 2 months earlier, Hull made his last visit to the White House to oppose successfully Treasury Secretary Henry Morgenthau Jr.'s plan to punish Germany by levying reparations harsher than those assessed at Versailles in 1919 and making the country a solely agricultural nation. After Stettinius signed the United Nations Charter late in June 1945, Byrnes followed him into office in July as Morgenthau resigned his post at the Treasury. Truman nominated Fred Vinson as Morgenthau's successor, and the President advanced Dean Acheson to be Byrnes' Under Secretary. Before Byrnes left the OWMR, the President also issued an Executive order[133] providing for the release to the public of some scientific information gained during the war; 2 months later, Truman amended the order to include captured scientific and industrial data. In September, Secretary of War Stimson retired, and Under Secretary Robert Patterson replaced his schoolfellow, friend, and colleague, whom he followed into that Department in 1940.

The war in Europe, now in its climactic phases, did not pause at these peaceful passages in the United States. Between April 9 and 20, 1945, units of the Allied 15th Army Group broke through the Gothic Line in northern Italy and pushed northwest toward Genoa, north against Milan, and northeast toward Venice. Soviet forces took Vienna on April 13 and surrounded Berlin 12 days later. As American and other Soviet forces met at Torgau on the Elbe on the 25th, representatives of 50 nations, but not Spain, assembled in San Francisco to begin the United Nations Conference on International Organization. Units of the 6th Army Group met 15th Army Group troops and closed the Brenner Pass between Austria and Italy. After Hitler committed suicide in his underground bunker on April 30, the leadership of the Third Reich passed to Grand Admiral Karl Dönitz, who personally directed the U-boats' long campaign until he took over the Kriegsmarine in 1943. On May 2, Berlin fell to Soviet troops, and German forces in Italy surrendered, as did those in The Netherlands, Denmark, and northwestern Germany later that week. Generaloberst Alfred Jodl signed an unconditional capitulation in Allied headquarters in Rheims early on May 7.

Germany's surrender formally ended the war but not the suffering in Europe. As the Allied armies moved into Germany from the west and through Poland and into Germany from the east, they liberated an increasing number of the German concentration and extermination camps. There they learned the true horrors of what the Nazis inflicted on some of their own and captured peoples since establishing Dachau near Munich in 1933. The Nazis originally founded the camps to house Communists and other political enemies, Gypsies, homosexuals, physically or mentally handicapped persons, and Seventh-Day Adventists, Jehovah's Witnesses, and other religious dissenters, particularly the conscientious objectors to the war. Those condemned to the camp system came increasingly to include the Jews of Germany (and then all Europe), Poles, and Serbs. The camps' cast-metal gates carried the promise of ARBEIT MACHT FREI (work liberates), but the Germans delivered for most inmates only the freedom of death. At the Wannsee Conference held in a Berlin suburb in January 1942, Nazi officials proposed to solve their Jewish problem through extermination. Some information about the growing extent of the disaster, received from escapees and diplomats, reached the Allied leaders, but plans to bomb the more than 20 camps or the rail lines leading to them proved unrealistic in view of the goal of defeating the Wehrmacht first. On March 24, 1945, Roosevelt's public condemnation of German and Japanese war crimes at least held the perpetrators accountable. The President's plea to the German people to stop the savagery and help the victims, or at least to serve as future witnesses, did nothing to end or even abate the Nazis' comprehensive murder of Europe's Jews. Auschwitz, Bergen-Belsen, Mauthausen, Sobibor, Treblinka, and the names of other camps throughout Europe also entered the historical gazetteer of mankind's inhumanity to its own. More than 10 million persons, including 6 million Jews, 3 million Poles, 1 million Serbs, and hundreds of thousands of Germans and other Europeans, died in this Holocaust.[134] Some 4 million Soviet soldiers also perished in German prisoner-of-war camps, except for those who chose to fight their countrymen; others died in the Soviet Union's own gulag of undesirables. So too did hundreds of thousands of German troops captured by Soviet forces and sent eastward to labor and die before the few survivors were returned.

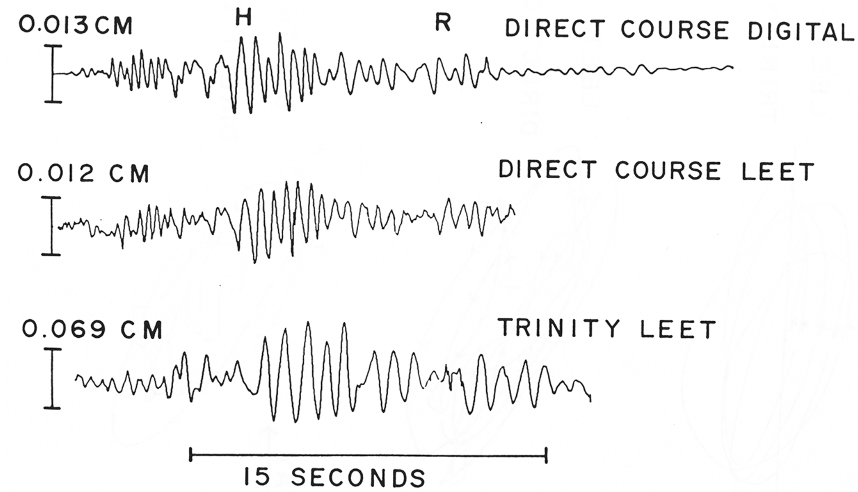
Only a few hours after the German surrender at Rheims, the Senate appropriations subcommittee began its hearings on the Interior Department's budget. Although the United States no longer faced a two-front war, Secretary Ickes minced no words in asking the Senators to restore the cuts made by the House. The Representatives' action on the USGS budget, Ickes said, "not only disregarded the primary role which the mineral industries must play in completing our victory in the Pacific, it also failed to recognize the fact that our future security is related directly to our mineral-resource position."[135] Hayden's subcommittee considered the USGS budget on May 14. Wrather asked the subcommittee to restore funds for the Assistant Director's post and an accompanying secretarial position and to undo the cuts in monies for topography, geology, and water resources. Hayden, while noting that the House complimented the USGS, repeated the Representatives' reasons for significantly reducing appropriations when "it is definitely known that the problems of a two-front war no longer exist"[136] and activities were expected to taper off during the next fiscal year. Echoing Ickes, Wrather replied that "as a war agency," the USGS held

> **numerous arrearages of things that we have had to put on the shelf. The war has made such inroads on our supplies of mineral raw materials, including underground water supplies, and has so focused attention on our need for accurate and modern maps that if Congress sees fit to appropriate the funds, there are, in my opinion, very few of these activities that could be totally dispensed with. * * * if we had the opportunity for reduction in any respect, we will do our best to take advantage of it. However, we have not seen that as yet.[137]**

These appeals by Ickes and Wrather did not convince the Senate subcommittee, the joint conference committee, or the full House and Senate to restore all of the budget cuts. Rather than $141,346,000 for Interior and most of its agencies during fiscal year 1945–46, the Department received on July 3 a little less than $102,603,000, a reduction of nearly $38 million. Of Interior's sum, Congress and the President provided the USGS with about $7,314,000 in direct appropriations[138] for salaries, including the Assistant Director's, and expenses but some $1,086,000 less than the requested amount. The July 3 appropriations included about $208,000 for salaries and expenses, nearly $2,147,000 for topographic surveys, about $1,188,000 for geologic surveys, $325,000 for strategic- and critical-mineral studies, nearly $158,000 for investigations of Alaskan mineral resources, almost $1,796,000 for water-resources investigations, $213,400 for classifying lands, nearly $476,000 for mineral-leasing supervision, and $275,000 for publications. Compared to the array of direct appropriations for fiscal 1944–45, those for 1945–46 both rose and fell: funds for topographic surveys and water-resources investigations increased, but funds for geologic surveys declined. To help the USGS meet its current obligations, the legislators provided an advance of $400,000, pending reimbursement from cooperating agencies, to be returned to the Treasury within 6 months after the close of fiscal 1945–46. They also authorized any Federal department or agency with "funds available for scientific and technical investigations within the scope and functions of the Geological Survey"[139] to transfer them to the USGS for its authorized work, provided the sum shifted did not exceed 5 percent of the direct appropriation for that purpose. The USGS received a total of more than $15.1 million from all sources during fiscal 1945–46, or $2,508,000 more than the total for fiscal 1944–45. The total sum for fiscal 1945–46 provided nearly $803,000 for administrative and publications support, almost $2,608,000 to the Geologic Branch, slightly more than $350,000 for investigations in Alaska, about $5,086,000 to the Topographic Branch, some $5,150,000 to the Water Resources Branch, and nearly $1,104,000 to the Conservation Branch.

On June 26, 1945, 4 days after the Allies declared Okinawa secured, delegates to the United Nations (U.N.) conference in San Francisco signed a charter that provided for an international organization with six principal executive, legislative, and judicial units.[140] The executive units included a Secretariat, with a Secretary-General and other administrators; a General Assembly of all member nations; and a Security Council, with Britain, China, France, the Soviet Union, and the United States as permanent members, each with individual veto power, and six other nations, each sitting for 2 years. An Economic and Social Council (of 18 countries); an International Court of Justice, at The Hague, with 15 judges elected

This diagram compares the seismologic record that Harvard's L. Don Leet recorded during the Trinity test of the atomic bomb in New Mexico in 1945 with those from a restored Leet mechanical seismograph and the digital instrument used in 1983's Direct Course experiment. In Direct Course, 500 tons of TNT was exploded on a tower less than 4 miles from the Trinity site. The 1983 test produced "good correlation between the surface wave phases (both 'Hydrodynamic' and Rayleigh) for the digital and Leet Direct Course records" but only a qualitative similarity to Leet-Trinity. (From Reinke and Olsen, 1984a, p. 10 and fig. 5.)



by the General Assembly and the Security Council; and a Trusteeship Council of the Security Council's 5 permanent members, plus other nations each with 3-year terms of office, completed the U.N.'s organization. The U.S. Senate ratified the U.N. Charter on July 21, President Truman signed it on August 8, and Cordell Hull received the Nobel Peace Prize on November 12 for his continued efforts toward establishing the new organization. John D. Rockefeller, Jr., donated nearly 18 acres on the East River's west shore in New York City to the U.N. as a site for its permanent headquarters.

Five days before the Senate approved the U.N. Charter, the $2 billion and countless hours spent by a peak force of 125,000 persons on General Groves' Manhattan Project paid off in the Trinity test. On July 16, 1945, MED personnel successfully detonated a plutonium-implosion device atop a 100-foot steel tower at a site on the Alamogordo Bombing Range (now the White Sands Missile Range), in the Jornada del Muerto desert east of the Rio Grande and some 200 miles south of Los Alamos in New Mexico. Observers included physicist Luis W. Alvarez, who designed the detonator at Los Alamos; Hans Bethe; Vannevar Bush; James Chadwick; James Conant; Enrico Fermi; George Kistiakowsky, the explosives expert; Ernest Lawrence; Edwin McMillan; Robert Oppenheimer; MIT physicist Isidor I. Rabi; Edward Teller; and Richard Tolman. They looked, with mixed emotions, at the fireball and the mushroom cloud rising from an explosion equivalent to almost 19,000 tons of TNT.

Before the Trinity test, some members of the Manhattan Project were concerned about blast damage to nearby towns and thought the test might produce an earthquake. Fermi feared wider destruction and even a runaway chain reaction that might set the atmosphere on fire. Nothing could be done about the latter possibility but, in April 1945, to address the concern about an earthquake, the MED brought in as a consultant L. Don Leet, Director of the Harvard Seismographic Station since 1930. Leet, fascinated by the Tokyo earthquake of 1923, spent a year in Tokyo as a secretary with the Young Men's Christian Association (YMCA) and examined shock damage and records. Leet's interest led to studies at Harvard and a Ph.D. in 1930 for his "Empirical Investigations of Surface Waves Generated by Distant Earthquakes." Thereafter, Leet and Columbia's W. Maurice Ewing investigated the velocity of elastic waves in granite and norite. Leet also examined the vibrations and ground effects of dynamite blasts in quarrying.

Leet studied "geologic maps of the [test] area, as well as seismic records obtained from a 100-ton calibration shot fired [earlier from a smaller tower] near Trinity's ground zero." Only "little possibility of seismic damage from * * * [the test] outside the 5,000-yard range, even if the yield of the blast were to be as high as 50,000 tons,"[141] Leet concluded, but air-transmitted shock waves might be another matter. Distant observers in buildings might not be able to distinguish between those shock waves and ground-transmitted vibrations. Leet, who developed a three-component, strong-motion portable seismograph, recommended that five of these instruments be installed in the surrounding area at San Antonio (northwest of the test site); Carnzozo, to the northeast; Tularosa, to the southeast; Elephant Butte, to the west; and a location 9,000 yards north of the Trinity tower. Beno Gutenberg also prepared to receive signals at Caltech. Leet gained a "particularly excellent and complete record"[142] of the test from the last-named of these seismometer sites, and Gutenberg obtained the best detonation time[143] after standard timing equipment malfunctioned at the Trinity site. Leet described the explosion as "producing 'a simple single instantaneous vertical impact on the ground' so that there was no question of a 'succession of primitive shocks' as had been proposed by [British seismologist Horace] Lamb as a possible explanation for the complicated nature of observational seismograms."[144] Leet's analysis also suggested that he observed what he named a Hydrodynamic wave, "a new wave to seismology"[145] with "distinctive particle motion which was prograde, in the opposite sense to that of the classical Raleigh wave, and possessed of an inclined elliptical orbit."[146]

America did not need its nuclear weapon for use against Germany, as the Wehrmacht reached the end of its meaningful resistance without gaining an atomic weapon. If Germany had developed an nuclear bomb, it might have been delivered by a V–2 or, more likely, by the specially modified Heinkel He-77A Griffin bomber—able to carry 6.6 tons—found in Prague at war's end. One of the Luftwaffe's new four-engine bombers—the operational jet Arado Ar-234C Lightning, or the prototype Junkers Ju-290 and Ju-390—also might have been used to deliver a nuclear weapon, provided its weight remained within their lesser payload capacities.

Richard Rhodes described how Groves, lacking reliable information, decided to determine German progress on the ground.[147] He sent to London in 1944 an MED scientific-intelligence team incautiously code-named Alsos ("Groves" in Greek). Lt. Colonel Boris T. Pash, an Army officer trained by the Federal Bureau of Investigation (FBI), led the Alsos team, which included Dutch-American physicist Samuel A. Goudsmit, educated at Leiden and by Niels Bohr, who spent 2 years at MIT's Radiation Laboratory before being recruited for Alsos by Vannevar Bush and his colleagues.

Aerial surveillance of suspected nuclear sites in Germany began in July 1944. Lt. Colonel Pash's team reached Frédéric Joliot-Curie's laboratory in Paris on August 25. Late in November, the Alsos team's members read documents in Carl von Weizsäcker's laboratory at Strasbourg, but they missed the fleeing von Weizsäcker. These materials indicated that results of the Germans' nuclear efforts badly trailed those of the Manhattan Project, and they also helped to fix the location of the former's experimental site in an area across the Rhine on the Black Forest's eastern edge. The Strasbourg records enabled Bush, then at Eisenhower's headquarters ending concerns about possible captures of Allied proximity fuses, to assure the chief of staff that the Germans would not deploy a nuclear weapon. The Strasbourg documents also aided Allied efforts to track down the facilities and materials in the German nuclear program. Allied forces captured an operating cyclotron at Heidelberg in March 1945 and a small amount of uranium ore, but no separated uranium-235, at Stadtilm. In April, another team of Anglo-Americans, serving with the U.S. 9th Army in Bradley's 12th Army Group, discovered near Stassfurt, west of the Elbe River, the remaining 1,100 tons of uranium ore and concentrates, but again no uranium-235, confiscated by the Germans in Belgium in

1940. The Allies sent another 30-odd tons of ore, liberated earlier at Toulouse, to Oak Ridge to be used in extracting additional uranium-235 for use in completing their uranium-gun bomb.

The Germans decided to begin applied work on nuclear reactors, for power and plutonium production, and isotope separation, for uranium-235, by centrifuge, after Heisenberg's initial report in November 1939 and his subsequent reports through February 1942 to Wehrmacht Army Ordnance that nuclear fission could produce bombs as well as manageable energy for powering submarines. The nuclear project passed in April 1942 to the Ministry of Education and Science's Reich Research Council. In June, Heisenberg briefed Minister of Armaments and Munitions Albert Speer before Speer met with Hitler. When Heisenberg said he would need at least 3 to 4 years' work and took only a portion of the funds Speer offered for heightened work, Speer decided that the results would not affect the war's outcome and released 1,200 tons of uranium for use as ammunition cores. Accidents at and bombs on the preliminary reactor sites in Berlin and Leipzig during 1943–44 caused physicist Walter Gerlach of Munich, who now led the effort, to move Diebner, Heisenberg, other nuclear physicists, and their equipment and materials to Hechingen and to Haigerloch, 10 miles to the west, in the upper reaches of the Neckar River system near the Swabian Alps. Gerlach's group left behind in Berlin significant amounts of metallic uranium, uranium oxide, and heavy water that the Soviets captured on April 29. In March, Heisenberg reported a sevenfold increase in neutron generation, but the pile, he estimated, remained about 50 percent short of reaching a controlled chain reaction.

Lt. Colonel Pash, Goudsmit, and the Alsos team, now supported by a battalion of combat engineers from the 7th Army's VI Corps, reached the Hechingen-Haigerloch area on April 23, 1945. In Hechingen, they rounded up Otto Hahn, Paul Harteck, Max von Laue, Carl von Weizsäcker, and other nuclear physicists and located hidden stashes of the project's research papers, uranium ingots, and drums of heavy water. At Haigerloch, within a locked cave below an overlying cliff, the Alsos team found one of the two German uranium machines. The atomic pile, in a lined cylindrical pit, comprised more than 600 uranium cubes fixed to chains attached to a graphite and metal plate and suspended in 1.5 tons of heavy water. Diebner, Gerlach, and Heisenberg had fled, but the Allied team found and took them into custody during May 1–3. The second reactor was captured at Frankfurt. When the submarine *U–234* surrendered at sea at war's end in Europe, the 1,200 pounds of uranium-oxide ore in its cargo of materials and technology went not to Japan but to Oak Ridge to produce additional uranium-235.

Although the Nazi nuclear bomb proved to be a chimera, arguments continued over whether or not Heisenberg and his colleagues really intended to make such a weapon. Diebner, Gerlach, Hahn, Harteck, Heisenberg, von Laue, von Weizsäcker, and three of their coworkers, along with Dornberger, von Braun, and other scientists and technicians, left Germany for confinement in Britain at Farm Hall, northwest of Cambridge. Manfred von Ardenne and a few other German nuclear (and rocket) scientists were captured by Soviet forces and established uranium-enrichment facilities on Georgia's Black Sea coast. Heisenberg and his colleagues heard with surprise and dismay British news broadcasts about the atomic bombs the Americans dropped on Japan. Jeremy Bernstein, an American physicist and historian of science, later demolished the myth the internees quickly devised that claimed they knew how to make a weapon but chose not to do so. The content of Heisenberg's lecture to the detainees on August 14, Bernstein demonstrated, showed that Heisenberg did not how to make a nuclear bomb.[148]

The German physicists held by the West returned in 1946 to (West) Germany, but the Soviets did not release von Ardenne and his colleagues to (East) Germany until 1954. Bohr, Gerlach, Hahn, Heisenberg, von Laue, and von Weizsäcker spoke privately and publicly against West Germany's efforts to build nuclear weapons. Dornberger and von Braun went to the United States and became naturalized citizens; von Braun and more than 100 colleagues he selected, protected by Project Paperclip,[149] began work at Fort Bliss in Texas toward producing American guided missiles.

As U.S. nuclear-weapon development continued in May 1945, a special committee began selecting potential targets in Japan. From May 31, Stimson chaired meetings of an Interim Committee composed of Bush, Byrnes, Karl Compton, Conant, Under Secretary of the Navy Ralph A. Bard, Assistant Secretary of State William L. Clayton, and Alternate Chairman George L. Harrison, another of Stimson's special consultants. Harvey Bundy, Arthur Compton, Fermi, Groves, Lawrence, Marshall, Oppenheimer, and Arthur W. Page, of American Telephone and Telegraph, attended as invitees. The Interim Committee considered control of the nuclear weapon during the war and after the peace, international competition, additional research and development, the release of information to the public, and possible legislation required to secure a permanent organization. Committee members recommended a domestic program to "Build up suitable stock piles of [fissionable] material for military use and for industrial and technical use."[150] On June 25, Stimson's committee accepted the recommendation of "direct military use"[151] made 9 days earlier by their Science Panel's Arthur Compton, Fermi, Lawrence, and Oppenheimer. The "weapon should be used against Japan at the earliest opportunity," "without warning," for greatest psychological effect, and "on a dual [military and civilian] target"[152] as the least detestable alternative of plans to end the war and save lives.

On July 17, as a special group of B–29 crews continued training in Utah to deliver atomic bombs on Japan if it continued the war, a petition signed by 77 nuclear scientists asked President Truman not to authorize the use of the bombs without giving the Japanese a chance to yield. On the same day, the Terminal Conference began in Potsdam, near Berlin, after the 1-day's delay that Truman requested to be certain of Trinity's outcome. On July 21, General Marshall gave Truman a copy of General Groves' report of July 18 describing the successful Trinity test. Truman learned about the Manhattan Project's existence in 1943, after his committee tried to decide if Hanford might be another Canol, but he agreed with Secretary Stimson's request on June 17 not to investigate the project. Stimson and General Groves briefed Truman on the details of S–1 on April 25, 1945. Groves' report now warned that even the Pentagon was not a safe shelter from the atomic bomb but he, like Teller, thought a successful combat test would provide the real deterrent. The news, Truman recalled, gave him fresh assurance[153] and a significant advantage in the meeting's efforts to organize the postwar world, especially as he tartly told Vyacheslav Molotov to live up to Soviet agreements made at Yalta and elsewhere.

Truman asked his principal advisers at the Potsdam conference to confirm estimates of the number of Allied casualties they expected would occur in invading Japan if the nuclear weapon was not used; in responding, most agreed that the bomb must be dropped. With the total of Americans killed in combat now nearing 300,000, the Army's manpower pool drying up, and estimates of Japanese home-islands forces rising, Truman declined to see the fighting on Iwo Jima and Okinawa replayed in Japan with far greater losses. On July 24, with Truman's and Stimson's approval, General Thomas T. Hardy, the Army's Acting Chief of Staff, ordered General Carl A. Spaatz to use the first of the new weapons. The instructions told Spaatz, now leading the U.S. Army Strategic Air Forces against Japan, to drop the weapon when good weather enabled visual (not radar) bombing after August 3 on Hiroshima, Kokura, Nagasaki, or Niigata. Other atomic bombs, the orders continued, would be dropped on these cities or additional targets when they were prepared by the MED's staff.[154] Stimson, unhappy about the fire bombings in Europe as well as those in Japan, specifically removed Kyoto from the list of targets.[155] Although Kyoto housed the Mitsubishi and other war factories, his decision spared Japan's ancient capital and its art and culture.

On the day that Spaatz received his orders, Truman, still at Potsdam, mentioned in passing to Stalin that the United States possessed a new and powerful weapon.[156] The revelation did not surprise Stalin because he knew all the important details of the Manhattan Project. Beginning in 1941, some British and American scientists and other Soviet sympathizers directly or indirectly passed to or allowed to reach their colleague-moles, handlers, or runners detailed data about the Allied nuclear-weapons program. Fearing a Nazi bomb and (or) wishing to make Soviet military power equal to the Allies, in part to ensure a postwar peace by restoring a balance of power, Niels Bohr, who arrived at Los Alamos in December 1943, Enrico Fermi, Klaus Fuchs, Robert Oppenheimer, Leo Szilard, and others circumvented General Groves' massive security precautions and consciously or inadvertently passed information that proved vital to the success of the Soviets' own project. How pervasive Soviet spying was in America before and after 1945 only became generally known when the Venona transcripts were declassified in the 1990s. Stalin responded to Truman's alert by expressing his pleasure at the news and his hope that the weapon would be used effectively on the Japanese.[157] Churchill observed the conversation and asked Truman about it.[158] The President replied that Stalin had asked no questions.[159] Only 4 days earlier, Stalin strengthened the Soviet nuclear program, restarted in 1943, by replacing Molotov with Lavrenti P. Beria, the head of the Soviet secret police and the project's chief of intelligence.[160] In February 1945, the Russians used captured German documents to discover new deposits of high-grade, if limited, uranium near Bukova, south of Sofia, in Bulgaria's West Rodopi Mountains. Stalin urged Beria, physicist Igor V. Kurchatov, and weapons-expert General Boris L. Vannikov, later termed the Soviet "Groves" by assassin-spymaster Pavel A. Sudoplatov, to speed their work, including the All-Union search for Soviet uranium deposits, isotope separation, and building a reactor.

The Terminal conferees also dealt with affairs in Europe. On June 5, the European Advisory Commission, founded by the Big Three Powers on January 1, 1944, divided Germany and Berlin, and Austria and Vienna, each into American, British, French, and Soviet (eastern) zones and sectors of occupation; the Soviets also controlled ground routes to Berlin. Truman, Churchill, and Stalin established a Council of Foreign Ministers from Britain, China, France, the Soviet Union, and the United States to oversee the Allied Control Councils for the two countries, which, in turn, monitored the military occupation of their zones. Attendees at Potsdam also discussed draft treaties with the European Axis Powers, trials for accused war criminals, German reparations in capital equipment and its economic future, the forced removal of some 6.5 million Germans from Czechoslovakia, Hungary, and Poland, and the repatriation of Soviet troops who joined the Wehrmacht. They agreed to have the Council of Foreign Ministers meet in London to refine the postwar arrangements.

During the Terminal Conference, Clement R. Attlee, the Labour Party's leader since 1935, replaced Winston Churchill as Prime Minister and in the delegation at Potsdam, following the Conservatives' defeat in the khaki (veteran-influenced) election. On July 26, 1945, Truman, Attlee, and Stalin sent a demand to the Japanese Government. Avoid Germany's fate, they urged, by following "the path of reason" that would end the war by surrendering unconditionally, accepting an Allied occupation to destroy Japan's war-making power, and returning to their rightful owners all lands conquered since 1895. The new Big Three made no mention of the Emperor Hirohito and his postwar status but promised that they would not make slaves of the Japanese or obliterate their nation.[161] The Allies' occupation would end when they accomplished their goals[162] and the Japanese people freely established a government of peace and responsibility. War criminals must face justice. Japan also must revive and strengthen its democratic impulses[163] and establish basic freedoms and human rights. Japan's only other option, the proclamation emphasized, was a quick and complete destruction.[164] On July 29, Prime Minister Suzuki's government responded with an equivocal message that the Allies translated as declaring their ultimatum beneath notice. Japan's reply convinced Truman, following his desk's buck-stops-here dictum, to let stand the order of July 24. On August 6, the crew of the *Enola Gay*, a B–29 from Tinian, dropped the "Little Boy" uranium-gun bomb on Hiroshima in southwestern Honshu. The area contained a communications center, military bases, and the 2d General Army's headquarters. The slender, 5-ton, Little Boy bomb was derived from the earlier Thin Man version. The bomb's 12.5-kiloton air blast devastated Hiroshima and its inhabitants.

On June 13, 1944, Roosevelt and Churchill expanded their agreement of the previous September by founding a Combined Development Trust to explore, survey, and control sources of uranium and thorium supplies. The two leaders further pledged on September 19, 1944, not to share information about Tube Alloys with any country and, when the bomb became available, and, after careful review, to use it against the Japanese, following a warning that other and similar bombs would be dropped until they surrendered. On August 6, 1945, the White House released Truman's statement about Hiroshima that again cautioned the Japanese to accept the Allies' terms or endure an aerial assault unprecedented in the history of war,[165] followed by invasions of the home islands. Two days later, Soviet forces invaded Manchuria on three fronts and pushed rapidly east, south, and west onto the Manchurian Plain and into Korea. The Soviets also attacked southern Sakhalin, Japanese-controlled since 1904, and the northern Kurils.

When the Japanese Government did not respond to the Hiroshima atomic bomb, the United States struck another of Japan's cities on August 9. With the primary target Kokura and its arsenal obscured by clouds, the crew of the B–29 *Bock's Car* unloaded the "Fat Man," a spherical, plutonium-implosion bomb, over Nagasaki, the secondary target in central-west Kyushu. Nagasaki's hills helped to confine and increase the air-blast's effects. Although dropped some 1.5 miles away from the aiming point, the 5-ton bomb's 21-kiloton explosion still destroyed parts of the city, its major port, the Mitsubishi shipbuilding yards, torpedo factories and other arms works, and electrical-equipment facilities. The two nuclear blasts killed outright nearly 120,000 civilians and military personnel, injured another 95,000 people, of whom some later died from the effects of radiation, and devastated more than 50 percent of the two cities. Truman, appalled by casualties among children, halted further atomic-bomb strikes to give the Japanese another interval in which to surrender. The next nuclear weapons would not be ready until August 19, but destructive conventional-bomb raids by Allied land-based and naval aircraft continued, and the Japanese retaliated by torturing and killing downed crews.

To end Japanese die-hard military resistance and the horrors of the conventional and nuclear bombings, Emperor Hirohito, who long supported the war, now openly declared for peace in meetings of the Supreme War Council during August 8–14. He ordered Prime Minister Suzuki and his ministers to terminate the conflict by accepting the Potsdam Declaration. Suzuki, now using the Swiss as intermediaries, offered to surrender if Hirohito kept his throne. In a disingenuous message recorded for radio and broadcast on August 14, the Emperor admitted that the war was not going in Japan's favor, deplored the enemy's use of its new and horrendous bomb, whose overwhelming power took the lives of many innocent civilians, and accepted the Allies' joint declaration."[166] Therefore, Hirohito decided to make a path to an unending peace by enduring and suffering an unthinkable end to the war.[167]

Peace meant survival for Allied and Japanese forces and prisoners; it also meant life for their descendants. On August 28, General MacArthur and his initial units arrived in Tokyo by air. Five days later, representatives of Japan's civilian government and its military arm signed the formal instrument of surrender on the deck of Admiral Halsey's flagship, the battleship *Missouri*, one of 260 Allied warships anchored in Tokyo Bay. MacArthur presided over the multinational ceremony as Supreme Commander for the Allied Powers in the Pacific. He expressed his profound concern for future security and civilization's survival in the atomic era. MacArthur called upon all nations to rise above past racial and other hatreds to reach the goals of what FDR called the united nations—keeping a world at peace, securing basic rights for all peoples, providing humanitarian aid, and promoting economic and social development.[168]

Under the capitulation's terms, a U.S. army of occupation controlled Japan's home islands and most of the remaining Japanese possessions in the Pacific, including those annexed or acquired by treaty before 1914, or mandated by the League of Nations after World War I. Formosa returned to China. Australia added the Bismarcks, the Admiralties, and Bougainville to its Papua New Guinea. Stalin, influenced by his agreement at Yalta and the present military realities, ordered his troops on the Kurils and southern Sakhalin not to invade Hokkaido. Roosevelt hoped that Korea would become a Big Four trusteeship, as a step toward the independence promised at Cairo, Yalta, and Potsdam, but the Soviets demurred. Soviet troops began to occupy northern Korea on August 10. Three days later, to keep the Soviets from gaining the entire peninsula, the United States proposed to accept all Japanese surrenders south of the 38th parallel and the Soviets quickly agreed to do the same north of that line. These decisions, as the Americans intended, gave them control in September of Seoul, Korea's capital since the late 14th century.

The fiscal year that began on July 1, 1945, thus comprised two distinct intervals of unequal length. The Allies won the war in Europe some 7 weeks before the beginning of fiscal year 1945–46. Seven weeks after the new fiscal year began, the Pacific-Asia war ended, and America and the USGS abruptly entered the postwar world and encountered both old and new domestic and international realities of an atomic age. During World War II, of the 16 million men and women who served in the U.S. armed forces, some 292,000 died in combat and another 100,000 perished from combat-related causes. Of the additional 800,000 wounded, captured, or missing, about 572,000 survived—many saved by plasma transfusions, sulfa, and penicillin—and 110,000 returned from captivity. During the conflict, more than 50 million persons died in combat or from war-related causes. After war-crimes trials in London, Nuremberg (Nürnberg), and Tokyo, nearly another 1,000 individuals, of some 5,700 brought before the bar and 4,400 convicted, would join them by execution.

Most of the Allies now hoped that the United Nations would work zealously and effectively to preserve global peace. On August 6, when President Truman announced the Hiroshima bomb's detonation, and again called for Japan's surrender, he pledged to continue to withhold from the public and from Britain, contrary to the Roosevelt-Churchill agreement, the atomic bomb's "technical processes of production or all the military applications, pending further examination of possible methods of protecting us and the rest of the world from the danger of sudden destruction." Truman also vowed to ask Congress to "consider promptly the establishment of an appropriate commission to control the production and use of atomic power within the United States."[169] Truman, echoing Churchill's hope, further recommended to the legislators how such power

> **can become a powerful and forceful influence towards the maintenance of world peace.[170]**

Chapter 5. Pioneering a New Course, 1945–1947

> **If our future standards of living are not to be lowered painfully, if victory is not to cost us the progress of generations, this Government must take the lead in all steps that will restore and promote the development of our natural resources. It must foster and support the labor and ingenuity of scientists and technicians who can pioneer our course to new sources and uses of materials and power.[1]**
>
> **—Oscar L. Chapman**

The United States emerged from World War II as the strongest nation in the world, even though its efforts toward winning the war cost $330 billion. Harry Truman asserted on September 1, 1945, that the United States held "the greatest strength and the greatest power which man has ever reached."[2] The President emphasized in an earlier speech that "[w]e all have to recognize—no matter how great our strength—that we must deny ourselves the license to do always as we please."[3] Winston Churchill observed on March 5, 1946, that the United States was now the world's premier power, but with that power, he cautioned, came a profound responsibility to future generations.[4] During the war years, the United States doubled its national income, wealth, and industrial production. U.S. steel output, a key indicator of industrial strength, reached in 1944 a level more than four times larger than those of the depression years, while wartime damage and scarce capital crippled the steel industries of Britain, the Soviet Union, and countries in northwestern Europe and destroyed those of Germany and Japan. The United States, to maintain its leading position, needed to increase rather than just conserve its existing resources in industrial plants, land, monetary reserves, power, raw materials, and scientific talent. The results of a comprehensive appraisal of U.S. mineral resources, begun in 1944 by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM), indicated a generally favorable outlook for minerals, but resources for several of those commodities remained deficient in quantity and (or) grade. The two agencies recommended a dynamic program of research and exploration to supply current and future needs.

The USBM and the USGS expanded significantly their funding, staffs, and operations in the war years. Between fiscal years 1939–40 and 1945–46, the USGS more than doubled its available funds to $15.1 million, of which $7.4 million represented direct appropriations. Transferred and repaid funds declined only from 52 to 51 percent of the agency's total monies. During the same years, the USGS nearly doubled its personnel; the agency's regular, or nonseasonal, staff increased from 1,472 to more than 2,490 scientists, engineers, and supporting persons. Although Fritiof Fryxell and other specialists employed by the USGS for the emergency returned during fiscal year 1945–46 to their career commitments in academia or industry, or resumed their formal education, Frank Whitmore, Jr., and others chose to stay on with the USGS. Fryxell and other war-service departees did continue part time with the agency via the long-established salary arrangement of "when actually employed."

To meet the increasing postwar demands for trained geologists, the USGS began early in 1946 a cooperative program with six universities—Chicago, Columbia, Harvard, Johns Hopkins, Princeton, and Yale—that gave supervised all-around training to those near-graduate, graduate, or postgraduate American geologists who served in the armed forces without gaining therein any significant professional experience. The Geologic Branch designed the temporary appointments of qualified discharged veterans to help them adjust rapidly and well while resuming their careers and asked those interested to apply to Chief Geologist Wilmot ("Bill") Bradley.

When the Japanese surrendered on September 2, 1945, the United States and its new President faced major continuing and new problems at home and abroad. The Nation's more widely perceived domestic difficulties, like those after World War I, involved fears of widespread unemployment, rising prices, housing shortages, and inflation. Labor unions, determined to prevent a recurrence of the setbacks they experienced after 1918, encouraged nearly 500,000 workers to strike once the war terminated. By the end of 1945, large-scale walkouts in several leading industries seriously curtailed production throughout the country. In addition, relations between the free world and the Soviet Union demanded increased attention, and, if possible, resolution. U.S. exchanges with the Soviets during the war were based on military necessity, but the conflict ended without a clear consensus in the U.S. Government about postwar relations. Some people believed that the United States and the Soviet Union could work together to establish a global-security system to prevent future wars; others saw the Soviets firmly committed to an unlimited expansion that the United States and her Western European allies must resist in trying to restore a worldwide balance of power.

In 1945, Joseph Stalin's Soviet Union could look back on nearly 500 years of intermittent Russian and Soviet expansion. At the end of World War II, Soviet contiguous territory stretched across 45 degrees of latitude and 165 degrees of longitude and embraced 11 time zones. The Soviets also occupied, dominated, or influenced additional areas westward (except for West Berlin) to the Elbe (the farthest west since 1814) and the Kaliningrad region annexed from Germany and Lithuania, north to Finland, southwest to Yugoslavia and Greece, south to Turkey, Iraq, Iran, and Afghanistan, southeast to China and the northern half of the Korean Peninsula, and northeast to Chukotka, Big Diomede Island in the Bering Strait, and the Komandorskiye (Commander) Islands west of the Aleutians. The Soviet Union aided Communist Parties trying to gain control of Greece, Italy, France, and other European nations as yet unoccupied by Soviet forces and helping indigenous peoples in Asia to overcome attempts by the West's colonial powers to reassert their rule. The West's rapid postwar demobilization gave the Soviets a huge advantage in ground forces, but to project power effectively beyond Eurasia, they needed nuclear weapons, long-range bombers and ballistic missiles, and a blue-water navy.

The Soviet Union's neighbor China remained divided by internal strife,[5] but Generalissimo and President Chiang Kai-shek and Chairman Mao Tse-tung (Mao Zedong) began negotiations on August 26, 1945, to try to resolve their differing views of their country's future and their respective roles in it. The two leaders did so in the light of the treaty of friendship and alliance between Nationalist China and the Soviet Union signed in Moscow on August 14 by Soong Tse-ven (Soong Tzu-wen), the Harvard-educated financier and older brother of Madame Chiang, who, since 1925, served Chiang as minister of finance, foreign minister, and now premier. The treaty made Dalian (Dalny or Dairen), the terminus of the South Manchuria Railway, a free port but leased half of its facilities to the Soviets and gave them joint use of the naval base at Port Arthur (Lüshun) that they held between 1898 and 1905. Chiang and Mao reached an uneasy truce on October 11, but their struggle to control Manchuria, as the Soviets withdrew, resumed later that month.

On September 2, as Chiang and Mao discussed Manchuria and other pressing issues, and the Japanese surrendered to the Allies, Hõ Chí Minh's Viet Minh,

Harry S. Truman (1884–1972), the 33d President of the United States (1945–53), led Battery D of the 129th Field Artillery Regiment in combat in France during 1918. Truman served as an elected judge of Missouri's Eastern District (1922–24) and Jackson County (1926–34), U.S. Senator (1935–45), Chairman of the U.S. Senate Special Committee to Investigate the National Defense Program (1942–45), and Vice President of the United States (1945). He succeeded Franklin Roosevelt as President after Roosevelt died in April 1945. Truman made the final decision to use the atomic bomb against Japan to end World War II, introduced the domestic Fair Deal, desegregated U.S. armed forces, promulgated the Truman Doctrine, approved the Marshall Plan and the Point Four Program, established the Department of Defense, authorized the U.S. military response to the invasion of South Korea, sent to the Senate the peace treaties with Germany and Japan, and supported the United Nations. Truman, although exempt from the term restrictions required by Article XXII of the Constitution in 1951, chose not to run for reelection in 1952. (Photograph from the Library of Congress, Prints and Photographs Division, 3b45707.)

the League for the Independence of Vietnam, declared the free and independent Democratic Republic of Vietnam, with its capital at Hanoi, Hõ as its president, and Võ Nguyên Giáp as its interior minister. Hõ cofounded the Communist Party of France, trained in Moscow, and served in China, where American influence freed him from Chiang's forces in 1943. His troops, organized in 1944 by Giáp, a former lawyer and history teacher turned military strategist, fought the Japanese in Tonkin, aided from July 1945 by a few American advisers and modest amounts of American equipment and supplies from Nationalist China. Hõ now appealed directly to President Truman and Secretary of State James Byrnes to recognize his government, but Hõ received no reply, even though he based his country's declaration of independence from France on America's from Britain.

Vietnam had endured many intervals of union and division. The Empire of Annam, founded in 1802 at Hue, comprised the principal administrative regions of Tonkin (northern), Annam (central), and Cochin China (southern). The French established authority over these three regions and adjacent Cambodia by conquests and treaties between 1862 and 1887, the year the French Government joined the four regions in its Union of Indochina, under a governor-general at Hanoi. The French added Laos to the Union in 1893. The Japanese restored the Empire of Annam, under Bao Dai, during 1941–45. By the Allied agreement at Potsdam, Japanese units in Indochina surrendered to British troops south of the 16th parallel and to French forces north of that line. Bao Dai abdicated, and the French returned to Saigon in force early in October 1945 and then occupied most of Cochin China. To discuss these and related issues, including a U.N. trusteeship for Korea (temporarily divided along the 38th parallel), the proposed joint American-British-Chinese-Soviet administration of Japan, the pending peace treaties for the European Axis Nations, and the international control of nuclear energy, the Council of Allied Foreign Ministers met in Moscow (as planned) during December 16–26.

On March 6, 1946, the French recognized Hõ's Republic as a free state within their Indochinese Federation and the wider French Union, agreed to stay while the Nationalist Chinese left, and to withdraw their own forces by 1952. Meanwhile, the French continued to increase their land, air, and naval units in Indochina. On June 1, the French established the Republic of Cochin China. Hõ's talks at Paris in July and August failed to yield true political independence for the Viet Minh alliance or his requested referendum to unite Vietnam. After French warships bombarded Hanoi's port of Haiphong on November 23, killing 6,000 people, Hõ again appealed (unsuccessfully) to the United States. He then called for national resistance but fled Hanoi on December 21. The French captured the city and the anthracite coals near the port of Quang Yen, 10 miles to the northeast. From their old bases in Tonkin's highlands beyond the Red River Delta, Viet Minh troops, operating under Giáp, and with additional aid from Mao's forces, began a guerrilla war as the initial phase in ousting the French.[6]

In U.S. postwar foreign and domestic affairs, the role of science and technology also became an issue. Truman's Executive order of June 8, 1945, provided for the release of scientific information,[7] with certain exceptions, and a subsequent order on August 25 extended access to include the scientific and industrial information gained from the Axis Powers.[8] The establishment of an organization to continue work in nuclear energy, as Truman promised, seemed inevitable. Support for research by the U.S. armed services along the lines of their own special interests appeared almost equally certain. Most of the scientific studies conducted during the war involved applied work, drawing in part on earlier basic research. To what extent should, or would, the Federal Government support basic research in the postwar world?

The U.S. Government considered to some degree all of these problems before the war ended, as it prepared an orderly transition to peace, but the executives all but abandoned planning in the abrupt ending of the conflict. On August 16, 1945, the day after Victory over Japan (V–J) Day celebrations, President Truman announced the lifting of most economic controls, except those required for a smooth transition to peacetime conditions. On the 18th, Truman issued an Executive order directing all Federal agencies "to move as rapidly as possible without endangering the stability of the economy toward the removal of price, wage, production and other controls."[9] Julius Krug, Chairman of the War Production Board (WPB), responded by revoking 210 orders that restricted production of household appliances, causing his Vice Chairman, Professor William Y. Elliott of Harvard, to resign in protest. As the WPB removed its controls over industry, the Government canceled $35 billion in war contracts and offered for sale both Army and Navy surplus goods. The United States terminated its Lend-Lease Program on August 21 and began an immediate demobilization of U.S. armed forces. Executive orders issued during August 31–October 4 abolished the Foreign Economic Administration;[10] the Office of Censorship; the Office of Economic Stabilization, reestablished on February 21, 1946; the Office of War Information, the WPB, effective November 3; and the War Refugee Board. On January 4, 1946, Truman ordered the Office for Emergency Management to direct the liquidation of the remaining war agencies.

On September 6, 1945, only 4 days after the Japanese surrendered in the formal ceremony, the President sent to Congress a 21-point message about reconversion that called the legislators' attention to the Nation's experience in national reconversion and recovery after World War I. "We must be sure this time," Truman emphasized, "not to repeat that bitter mistake."[11] His legislative proposals included bills for full employment, unemployment compensation, an increased minimum wage, comprehensive housing, protection and encouragement for small businesses, permanent price supports for farmers, and grants for hospital construction. The President also added recommendations for increased public works for discovery, development, and conservation of natural resources and the establishment of a single Federal agency to direct and fund scientific research. With regard to the latter, Truman said that

> **[n]o Nation can maintain a position of leadership in the world of today unless it develops to the full its scientific and technological resources. No government adequately meets its responsibilities unless it generously and intelligently supports and encourages the work of science in university, industry, and its own laboratories.[12]**

In recommending a single Federal research agency, the President endorsed the concept of an interrelated and cooperating system of academia, industry, and government that Vannevar Bush, as head of the Office of Scientific Research and Development (OSRD), introduced in his new "Science—The Endless Frontier." In that report, Bush and his team addressed the four topics of concern listed in the letter that Bush received from Roosevelt in November 1944 and evaluated by Bush's four "distinguished committees specially qualified to advise in respect to these subjects."[13] Walter W. Palmer, Bard Professor of Medicine at Columbia and Director of Medical Services at New York City's Presbyterian Hospital, headed the Medical Advisory Committee, which included seven professor-practitioners of medicine and Caltech's chemist Linus C. Pauling. Geographer Isaiah Bowman, still serving as president of Johns Hopkins University (JHU), chaired Bush's Committee on Science and the Public Welfare, which comprised physicist Isidor Rabi (who had worked at the Radiation Laboratory at the Massachusetts Institute of Technology [MIT's Rad Lab] and on the Manhattan Project), USGS Director William Wrather, and 14 other members drawn from academia, the Federal Government, industry, the Brookings Institution, and the Rockefeller Foundation. Henry A. Moe, the Guggenheim Foundation's Secretary-General, led the Committee on Discovery and Development of Scientific Talent that included James Conant and 12 colleagues from academia and industry. Irvin Stewart, Executive Secretary in Conant's National Defense Research Committee (NDRC), managed the Committee on Publication of Scientific Information, whose seven members included Williams College president and OSRD historian James P. Baxter 3d,[14] Karl Compton, James Conant, and Merle A. Tuve, Chief Physicist of the Department of Terrestrial Magnetism (DTM) of the Carnegie Institution of Washington.

During the war, Tuve led the NDRC's development of the proximity fuse, while directing JHU's Applied Physics Laboratory, and also served on 1944's Special Committee on Post-War Research. Charles Edward ("Electric Charlie") Wilson chaired that civilian-military group, appointed by Secretary of War Stimson and Secretary of the Navy Forrestal, whose members included Karl Compton, Frank Jewett, and Jerome C. Hunsacker, the innovative aeronautical engineer and Navy Captain who briefly led the new Naval Research Board in 1941 before replacing Bush later that year as the Chairman of the National Advisory Committee for Aeronautics (NACA). Wilson's Special Committee recommended founding a civilian-military, scientific Research Board for National Security, as a temporary special agency of the National Academy of Sciences (NAS), in succession to but in the style of the for-the-duration-only OSRD. The new Board, established early in 1945, comprised 20 civilians and 20 officers of general and flag rank, including the executive committee led by Karl Compton. Other members of the Board included Rear Admiral Harold Bowen, Chief of the Office of Research and Inventions since May 1945; University of Rochester physicist Lee A. DuBridge, who directed MIT's Rad Lab during 1940–45 and now presided at Caltech; Jerome Hunsaker; Ernest Lawrence; Ben Moreell, now a Vice Admiral; Linus Pauling; and Isidor Rabi.

The OSRD's four committees consulted a number of other specialists and reported their considerations and recommendations to Vannevar Bush between January 9 and June 4, 1945. Bush wrote a 34-page summary to accompany the committees' reports that formed appendixes 2 through 5 in the draft volume. J. Merton England, in his "A Patron for Pure Science," noted Bush's brief meeting with Truman on June 14.[15] The President read and approved the draft, agreed to release it, and promised to petition Congress after gaging public opinion. Bush emphasized that

> **[e]arly action on these recommendations is imperative if this nation is to meet the challenge of science in the crucial years ahead. On the wisdom with which we bring science to bear on the war against disease, in the creation of new industries, and in the strengthening of our Armed Forces depends in large measure our own future as a nation.[16]**

Bush transmitted the report to Truman with a letter dated July 5, but he did not wait for the President's return from Potsdam. By the time "Science—The Endless Frontier,"[17] delayed by higher priority appropriations documents at the Government Printing Office (GPO), appeared on July 19, Bush arranged for legislative action. On that day, Senator Warren G. Magnuson (D–WA) and Representative Wilbur D. Mills (D–AR) introduced bills inspired by Bush and his committees' recommendations. Establishing a national research foundation might end the Research Board for National Security that Senator Harry F. Byrd (Sr., D–VA) especially wished to continue.

The diversity of opinions about what sort of science should be advanced by the Federal Government renewed the old debate about "basic" versus "applied" studies. In 1945, some of the scientists who wished to make up their claimed wartime shortfall in scientific capital, revived the terms "fundamental" and "background" research as more effective sales tags than basic or "pure" science. The urgency of the Nation's domestic and foreign concerns led many of the other disputants to stress applied research. In responding to Roosevelt's queries of 1944, Vannevar Bush favored blending support for both types of science but not in the type of agency recommended by Senator Harley Kilgore. Bush urged the Federal Government to "accept new responsibilities for promoting the creation of new scientific knowledge and the development of scientific talent in our youth."[18] These responsibilities not only affected health, jobs, and national security but provided a modern way for the Government to foster opening new frontiers, as required by a long-standing U.S. policy. Effectively discharging such responsibilities would require the full attention of an agency devoted to that purpose. No Congress-funded agency in the existing governmental structure seemed able to supplement the support of fundamental research in academia and research institutes, support research on new weapons for the armed services, or administer a program of science scholarships and fellowships.

Vannevar Bush recommended establishing a Federal foundation to administer funds authorized "to support scientific research and advanced scientific education"[19] that would meet five fundamental requirements: (1) funding stability to ensure long-range programs; (2) citizen administrators selected for their capacity, interest, and understanding; (3) funds distributed by contracts or grants based on excellence and given only to nonfederal organizations; (4) colleges and universities given control of the "policy, personnel, and the method and scope" of the funded research (a condition "of the utmost importance"[20] to Bush); and (5) the agency made responsible to Congress and the President, especially for budgets, funds allocation, reports, and audits. Specifically, Bush recommended a national research foundation composed of a controlling board of nine members of broad interests and experience, who understood the peculiarities of scientific research and scientific education but were not otherwise connected with the Federal Government. Bush's table of organization included a director, appointed by and responsible to the members, and staff offices for counsel, finance, planning, and personnel. Each of the five program divisions—medical research, natural sciences, national defense, scientific personnel and education, and publications and scientific collaboration—would have a chair and at least four other persons, appointed by the members, and an executive officer selected by the director. The new foundation, Bush recommended, should have stable funding for at least 5-year intervals. He suggested $33.5 million for the initial year of full regular operation and $122.5 million in the fifth year, by which time "operations would have reached a fairly stable level."[21]

Isaiah Bowman's Committee members, in their report, appendix 3 of "Science—The Endless Frontier," described fundamental studies as "research without specific practical ends" that resulted "in general knowledge and understanding of nature and its laws." This knowledge in turn provided "the means of answering a large number of important practical problems, though it may not give a specific solution to any one of them."[22] Background research, the members continued, included such scientific endeavors as the "preparation of accurate topographic maps and geologic maps, the collection of meteorological data, the determination of physical and chemical constants, the descriptions of species of animals, plants, and minerals, and the establishment of standards for hormones, drugs, and X-ray therapy," which provided "essential data for advances in both pure and applied science." Successful studies required establishing as "reasonably clear" the objectives of background research before undertaking investigations. "Thus, comprehensive programs may be mapped out and the work carried on by relatively large numbers of trained personnel as a coordinated effort."[23] By their definition, applied research differed from fundamental science by the fact that "the objective can often be definitely mapped out beforehand, [and] the work lends itself to organized effort." "If successful," the Committee emphasized, "the results of applied research are of a definitely practical or commercial value."[24]

British biologist Julian S. Huxley concluded in his "Science and Social Needs" "that the simple alternative of pure versus applied [science] is quite inadequate." He wanted "at least four categories." "At one end," Huxley thought, was "'fundamental' research, with no practical objective conspicuously in view—like atomic physics or experimental embryology." Then came "background research, which must be quite fundamental, but has some distant practical objective—as in the case with soil science, or meteorology, or animal breeding." At the other terminus, "you have 'applied' research, with an immediate objective, like research on discharge tubes for lighting purposes, or on mosquitoes, for getting rid of malaria."[25]

The major conclusion in the second of two reports by Senator Kilgore's Subcommittee on War Mobilization, of the Committee on Military Affairs, also issued in July 1945, "closely paralleled"[26] that of Bush's committees. Kilgore and his supporters continued to press for specific differences in agency organization and policy, including a director appointed by the President, rather than Bush's part-time board of advisers, no patents for the results of federally supported research, a geographic distribution of funds, inclusion of the social sciences, and military participation. Kilgore introduced his own legislation to attain these goals on July 23. Senator William Fulbright's own legislation, introduced to establish a bureau of scientific research in the Department of Commerce, predated both the Kilgore and Magnuson bills. Truman endorsed the basic aims in Kilgore's bill during his message to Congress in September.

During October 8–November 2, as England recalled, Kilgore, Magnuson, Fulbright, and other Senators began public hearings for greater perspective "on bills embodying the recommendations for increased peacetime support of science and providing for the creation of a Federal scientific foundation." "More than 100 witnesses from all sections of American life," including Bowman, Bush, Oppenheimer, and other civilian and military specialists, favored the foundation but also noted "the problems involved in its creation."[27] Kilgore, in summarizing the testimony for the American Association for the Advancement of Science (AAAS) on December 5, said that the Nation "must have, and must have *now*, a full-fledged Government agency run by scientists."[28] Before that could happen, he urged, its promoters must agree on a plan to secure the best organization and its management, legislation ensuring free dedication to the public and full publication of research, and identification of those "social and economic problems which scientists can help solve."[29] Kilgore and his subcommittee carefully considered three types of administration for the foundation: (1) one Presidential appointee with sole authority; (2) a board of 3 to 9 full-time members, all appointed by the President and one of whom he would choose as its chairman; and (3) a single Presidential appointee as chief and advised by a board of 5 to 15 representative members from academia, industry, or elsewhere, selected by the President, but serving only part time. Kilgore, favoring the third option, introduced a bill to achieve this "national investment that may yield undreamed-of returns in knowledge, in wealth and in human progress."[30] A letter from Bowman's ad hoc, 35-member Committee Supporting the Bush Report, endorsed by some 5,000 scientists and other interested persons, went to Truman on November 24. Kilgore revised his bill and reintroduced it on December 21.

As President Truman evaluated those congressional proposals for continuing and expanding federally sponsored research and development, he also moved to express his similar concern for the discovery, use, and conservation of natural resources, especially "the long range world-wide need for new sources of petroleum and other minerals"[31] and "the protection and perpetuation of fishery resources."[32] On September 28, 1945, Truman declared the "Natural Resources of the Subsoil and Seabed of the Continental Shelf"[33] and the "Coastal Fisheries in Certain Areas of the High Seas"[34] subject to the jurisdiction of the United States and under its control but without impeding free navigation thereon. "In cases where the continental shelf extends to the shores of another State, or is shared with an adjacent State, the boundary," the President promised, "shall be determined by the United States and the State concerned in accordance with equitable principles."[35] In protecting America's coastal fisheries, Truman also hoped to improve "the jurisdictional basis for conservation measures and international cooperation."[36] The U.S. Department of Justice filed a suit on May 29, 1945, in the U.S. District Court in Los Angeles to determine whether the Federal Government or the State of California owned the energy and mineral deposits in the tidelands. Truman, in the two Executive orders issued on September 28, 1945, reserved and set aside the Continental Shelf's natural resources[37] and placed them "under the jurisdiction and control of the Secretary of the Interior, for administrative purposes, pending the enactment of legislation,"[38] and provided for the establishment of fishery conservation zones. The U.S. Supreme Court's ruling on June 23, 1947, confirmed full Federal dominion over them.

Congress remained more immediately concerned with the organization of atomic energy investigations and research in the armed services. As soon as the war ended, several Members of Congress introduced bills to control atomic energy. Truman, making good his promises of August 6, sent a special message to the legislators on October 3, in which he discussed the international and domestic aspects of the problem. In both areas, the President asserted, "the release of atomic energy constitutes a new force too revolutionary to consider in the framework of old ideas."[39] In the international realm, Truman conceded, the essential theoretical knowledge used to construct nuclear weapons already was widely known. He espoused the idea of "international arrangements, looking, if possible, to the renunciation of the use and development of the atomic bomb." The President now pledged to initiate talks toward achieving that goal, first with representatives of the British and Canadian Governments, and then with those of other nations but "these discussions will not be concerned with disclosures relating to the manufacturing processes leading to the production of the bomb itself."[40] Continued secrecy in that area, the President believed, would gain for America at least the minimum 15-year monopoly predicted by Major General Leslie Groves, who thought known uranium ores controlled by the Soviet Union too insignificant to successfully support the fabrication of plutonium and (or) uranium bombs. Some British experts, however, forecast only a 5-year monopoly. Truman proposed creating a U.S. atomic energy commission, composed of members he appointed, to control all nuclear stockpiles and plants, acquire minerals from which atomic energy was derived, and conduct all research, experimentation, and operations for the development and use of atomic energy for industrial, medical, military, and scientific purposes. America would not recognize any foreign government imposed by force, but Truman pledged that the Nation's atomic bombs would be held in trust for all mankind.

The international control of atomic energy, involving foreign policy as much as science, remained inextricably linked to the West's relations with the Soviet Union. To discuss these issues, President Truman, Britain's Prime Minister Attlee, and Canada's Prime Minister King met in Washington during November 1945. The three leaders proposed entrusting the international control of atomic energy to a United Nations (U.N.) commission authorized to complete sequential stages of scientific exchange, development of peaceful uses of atomic energy, elimination of nuclear weapons, and international inspection. Until the commission completed the entire process, the United States would retain a monopoly on its existing nuclear weapons, a condition to which the Soviet Union, with its own bomb program now in higher gear under Lavrenti Beria, Igor Kurchatov, and Boris Vannikov, was unlikely to agree. On January 24, 1946, the U.N. General Assembly established the United Nations Atomic Energy Commission (UNAEC) to study the worldwide control and use of nuclear energy.

The seemingly simple proposal for an atomic energy commission plunged Truman's administration into a long battle over the issue of military versus civilian control of atomic energy, one that came to rival the struggles in America during the last third of the 19th century over the issue of military versus civilian domination of science. The bill introduced in the 79th Congress' Military Affairs Committees by Representative Andrew J. May (D–KY) and Senator Edwin C. Johnson (D–CO) was based on model legislation drafted in the War Department by General Groves and his colleagues, with help from Vannevar Bush and James Conant. The measure provided for a nine-member, part-time commission empowered to select a full-time administrator; the selectee and some commissioners could be members of the armed forces. In October 1945, Groves, Oppenheimer, and Robert Patterson, who succeeded Henry Stimson as Secretary of War on September 27, supported the May-Johnson bill before the House Committee on Military Affairs. The members of the new Federation of Atomic Scientists, including many of the nuclear specialists who worked on the Manhattan Project, objected to the Army's security restrictions on research and attacked the May-Johnson legislation. Also in October, Senator Brien McMahon (D–CT) successfully urged Senator Harry Byrd and his other colleagues to establish a Special Committee on Atomic Energy and then served as its Chairman. McMahon and the committee's counsel, aided by some of the scientists, drafted an alternate bill and introduced it on December 20.

The McMahon committee's bill for developing and controlling atomic energy provided for fostering private research, controlling and disseminating scientific research and development to encourage scientific progress, conducting Federal programs for research and development, and continuing Government control of production and administration. The legislation also proposed policies and an atomic energy commission of five full-time civilian commissioners, appointed by the President and serving at the Chief Executive's pleasure. The commissioners would be assisted by a general manager and advised by two boards—one general and the other military. The bill gave the commission authority to conduct or contract for exploration and to acquire source materials. The measure encouraged research about nuclear processes, theory and production of atomic energy, utilization of fissionable materials, and protecting health during study and production. It also specified control of fissionable and source materials, authorized military applications, and requested biannual reports to a congressional Joint Committee on Atomic Energy but did not fix the level of funding. The McMahon committee held hearings during January–April 1946. Truman, after meeting with legislators and scientists in the White House, openly opposed the May-Johnson bill, and wrote to McMahon on February 1 to support his alternative that ensured civilian control.

Truman's Executive order of March 4, 1946, revoked his order of September 13, 1945, the latter signed to withdraw and reserve the "lands containing radioactive mineral substances,"[41] but continued their segregation subject to the new provisions for reserving "the rights to fissionable materials in lands owned by the United States." The new order opened to development by "lease, permit, or other authorization," under the mineral laws and especially to veterans, the public lands that contained "substantial deposits of fissionable materials" closed to entry during the last 6 months. The new order also continued to reserve for the U.S. Government the rights to "enter upon the land and prospect for, mine, and remove such materials."[42] An Interior Secretarial order of April 19, 1946, delegated to the USGS Director or Assistant Director the authority that Truman's Executive order gave to Interior for determining fissionable-materials deposits on U.S. lands, "other than public lands."[43]

After considerable debate in June and July 1946, Congress passed the McMahon bill and Truman signed it on August 1. The Atomic Energy Act now reserved to the United States "All uranium, thorium, and all other materials determined * * * peculiarly essential to the production of fissionable material, contained, in whatever concentration, in deposits in the public lands."[44] The new law and an Executive order also transferred full control of all records, materials, facilities, production, research, and information from the War Department to the new U.S. Atomic Energy Commission (AEC), which succeeded the Army's Manhattan

Engineer District (MED) on December 31, 1946.[45] Additional responsibilities for the new AEC would include prospecting for new sources of fissionable material at home and (or) buying it abroad, building more bombs and conducting research and development, controlling information, monitoring international arrangements (treaties), and establishing regulations for nuclear health and safety. David E. Lilienthal, a lawyer who led the Tennessee Valley Authority (TVA) during 1941–46, was confirmed as the AEC's Chairman in April 1947. Lilienthal's four co-commissioners included Cornell physicist Robert F. Bacher, who worked at the MIT's Rad Lab and at Los Alamos and helped to assemble the Trinity device. Gordon R. Clapp, the TVA's General Manager, replaced Lilienthal as the agency's Chairman at Knoxville. The Act also established within the AEC four divisions (Engineering, Military Application, Production, and Research), set up General Advisory and Military Liaison Committees, and founded in Congress a Joint Committee on Atomic Energy.

To aid the AEC, Truman appointed on December 12 a General Advisory Committee for "scientific and technical matters relating to materials, production and research, and development."[46] The Committee's nine members included Conant, DuBridge, Fermi, Oppenheimer, Rabi, and Seaborg, again at Berkeley. Truman, as advised by the Committee, appointed Carroll L. Wilson, Bush's executive assistant in the OSRD, as the AEC's General Manager. The MED's military functions and personnel passed to the Armed Forces Special Weapons Project, established by a joint letter of January 29, 1947, from the Secretaries of War and the Navy, and led by Groves, who also served on the AEC's Military Liaison Committee. Truman's Executive order of February 21 extended to the AEC[47] the provisions of an order in 1942 that authorized the emergency purchase of war material abroad. The USBM and the USGS expanded their ongoing programs of exploration for these commodities.

Vannevar Bush and his colleagues' definitions of fundamental and applied research clearly applied to the mineral-resources investigations and other studies done by the USGS from its founding in 1879. The USGS continued to be deeply involved in background studies, but Director Wrather had his own views of how to meet the challenges of postwar science, and they began with an almost complete reordering of his agency's internal structure. Chief Geologist Bradley, aided by Wrather and Assistant Director Nolan, continued reorganizing the Geologic Branch and formally established the new arrangement in the fall of 1945. To confirm the importance of the Interior Department's efforts outside the national domain, Secretary Harold Ickes established a Committee on Foreign Cooperation on August 21. Ickes appointed First Assistant Secretary Michael Straus to chair the Committee, which included Assistant Secretary Oscar Chapman and representatives of the Divisions of Territories and Island Possessions and of Budget and Administrative Management, the U.S. Bureau of Reclamation (USBR), the Fish and Wildlife Service (FWS), the USBM, and the USGS, represented by Harold Bannerman, Chief of the Geologic Branch's Division of Economic Geology. Ickes founded the new Committee to coordinate Interior's foreign programs and "to stimulate the development of" and secure funding for "sound cooperative programs"[48] to be proposed to the State Department's Interdepartmental Committee on Cultural and Scientific Cooperation, on which Straus represented Interior until replaced by Nolan on April 1, 1946.

Bradley's reorganization of the Geologic Branch's program units reflected both Ickes' continuing concerns and the Branch's own work during the war.[49] The Chief Geologist continued 1944's Committee for Cooperative Investigations Abroad, established a new Section of Geophysics, and reorganized the Trace Elements Unit (TEU). Bradley renamed the reactivated geologic-map editing unit as the Geologic Information and Reports Section, responsible for improving and expediting responses to public inquiries and more promptly and efficiently processing texts and maps. On October 2, 1945, he redivided the Section of Areal Geology and Nonmetalliferous Deposits. Bradley also established a special advisory research staff for long-range planning and founded a technical services and administrative group. He also changed leaders in two regional offices: in Spokane, Albert E. Weissenborn took charge of work in Idaho, Montana, Oregon, and Washington, and in Salt Lake City, Charles Hunt assumed responsibility for efforts in Arizona and Utah. Bradley confirmed Robert A. Laurence as Regional Geologist at Jefferson City (later at Knoxville) in Tennessee. He closed the Branch's regional offices at College Park and Rolla after they completed their wartime responsibilities.

Bradley also reorganized the Geologic Branch's two Divisions: Economic Geology and Basic Sciences. Bradley, Nolan, and Wrather "agreed that a program of research should be incorporated with the economic geology demanded by the public,"[50] continuing a policy begun in 1879 by Director King. Bannerman's Division received the TEU; its supervisor Frank W. Stead previously aided the Branch's efforts to develop new geophysical techniques, especially those for detecting radioactivity. Bannerman also retained John Dorr 2d's Committee for Cooperative Investigations Abroad and three Sections—Hugh Miser's Geology of Fuels, Charles Park, Jr.'s Geology of Metalliferous Deposits, and Josiah Bridge's Geology of Nonmetalliferous Deposits.

Seven other Sections and one Unit went into the Division of Basic Sciences, now led by Harry Ladd as William Rubey's replacement. The NAS elected Rubey a member in April 1945; he still chaired the National Research Council's (NRC's) Division of Geology and Geography, but he had just been named as well to a three-man committee to survey the NRC's functions and future activities. Rubey joined Foster Hewett, Gerald Loughlin, and Aaron C. Waters on the Geologic Branch's long-range planning staff. Ladd's Sections included Engineering Geology, founded under Edwin B. Eckel in November 1944 and returned to him when he came back from Europe; John B. Reeside, Jr.'s Paleontology and Stratigraphy; Clarence Ross' Petrology; Waldemar Schaller's Chemistry and Physics; John Hack's Areal Geology; James Balsley's Geophysics; and Don L. Carroll's Geologic Information and Reports. Ladd also supervised the Military Geology Unit, now under Assistant Chief Esper Larsen 3d after Charles Hunt's transfer to Salt Lake City.

Bradley, mirroring Wrather's wishes for newer and younger managers of the USGS principal program units, chose them to lead four of the Division's subgroups. James Balsley, John Dorr 2d, John Hack, and Esper Larsen 3d, had been with the agency for seven or fewer years. Dorr, then 35, was the oldest of the quartet. Larsen, nearly 33, was a year older than Hack. Balsley, at 29, was the group's youngest member. Bradley's youth movement, no less than his other organizational changes, was noticed by the USGS Pick and Hammer Club but went unremarked on stage until 1947 in the Club's second postwar show—"Slow Boat, or Nothing But the Truth"—their version of *Show Boat*, the 1927 musical by Jerome Kern and Oscar Hammerstein 2d. The sing-along "Wonderments," the long-used audience warmup, recalled:

> **A time when Section Chiefs were marked by graying hair,**
> **Acquired through many seasons doing Survey work with care,**
> **Now Section Chiefs are younger and their science is veneer—**
> **They multiply like locusts in their gala seventh year;**
> **What used to be the top is now the start of their career.**[51]

In "Gullible's Travails," the 1946 satire, the four-verse "Jolly Chiefs," a reworded "When I Was a Lad" from Gilbert and Sullivan's "H.M.S. Pinafore," began the internal critique of the other results of Bradley's reorganization. His enthusiastic and extensive participation in past shows did not restrict additional pointed comments in 1947 about other changes by "Wilnot Medley, Grand Duke of d'Visions"[52] and the other "chiefs" on his staff, including the new "schedograph," or "Sched-u-graph." Bradley and his administrators, in using this new aid to monitor the work and travel of Branch personnel, no matter where they labored or stayed, seemed to have increased their own work by half. In "A Round Delay," sung to "The Wearing of the Green," they summarized the changes by bemoaning how:

> **Some streams in spate flow swift and straight, with nary a bend or crook,**
> **And that's the kind Bill had in mind, when first he undertook**
> **Streamlining of geology, but look what happened then!**
> **Regimentation has produced a different regimen!**
>
> **Our stream meanders slowly through the jungles of red tape,**
> **And splendid plans in eddies writhe and ne'er take final shape;**
> **Bill Bradley in his iv'ry tower, high above the ground,**
> **May think we're going places, but we're whirling round and round![53]**

Bradley also "agreed in principle" with Wrather and Nolan that certain gifted members of the Geologic Branch and other branches "could be of greater service to the science and the bureau when working on research projects in which they were personally interested, and for which they were temperamentally and professionally qualified." They planned to free such people "as far as possible of administrative duties" and intended that the selectees "should command a salary rating based on their individual worth."[54] The three leaders knew that in past years the U.S. Civil Service Commission (CSC) only "had been inclined to approve higher ratings to scientists who performed administrative duties, even though their scientific qualifications were no higher than others who came under their supervision."[55] Bradley, hoping to avoid difficulties in favoring the research of a few colleagues over the work of his other scientists, cautiously began seeking ways and means to promote the establishment and funding of a few of these "supergrade" slots. His efforts were supported on August 1, 1947, when the 80th Congress and the President authorized in Public Law 313 up to 30 positions in the War Department and 15 others in the Navy Department to promote research and development that required "the services of specially qualified scientific or professional personnel."[56] That statute placed the new positions within the classified civil service, required CSC approval of candidates' qualifications but not competitive examinations, and authorized yearly salaries of $10,000 to $15,000.

On November 1, 1945, Nolan began representing the Interior Department on the Civil Service Commission's seven-member Advisory Committee on Scientific Personnel (ACSP), chaired by physicist and OSRD veteran Merriam H. Trytten, of the NRC's Office of Scientific Personnel. The ACSP facilitated in-service, graduate-level training in the Washington metropolitan area and also reviewed the regulations for the science positions in the civil service. Its two auxiliary committees prepared recommendations for review by the ACSP and the CSC; USGS geologist Kenneth Lohman served as one of the seven members of a group that evaluated regulations; later, he advised the Committee on Classification of Scientific Personnel. Initial delegations of personnel authority to the USGS began on December 17, when, with the transfer to the agency of its official files, the USGS began keeping and managing its own records. On February 4, 1946, Truman issued an Executive order that directed the CSC to resume peacetime operations and also contained provisions based on the ACSP's initial recommendations.[57]

As Truman addressed these and other inherited and new issues during fiscal year 1945–46, Bradley's earth scientists remained fully engaged in the war effort while the conflict lasted and then prepared reports on the wartime projects. Thereafter, as the Geologic Branch's reorganization continued, they began returning, at least part time, to their regular long-range research. That effort presented some new challenges and opportunities. Branch personnel used new or improved

This aerial view of the eastern front of the San Rafael Swell looks north across part of the Green River Desert and the San Rafael River in the foreground. The stratigraphic units delineated in 1946 by nonstandard symbols added to the photograph include (from oldest to youngest) Coconino Sandstone and Kaibab Limestone (Kc, "Permian"); Moenkopi Formation (M), Shinarump Conglomerate (S), and Chinle Formation (C) (all "Triassic"); Wingate Sandstone (W) and Navajo Sandstone (N) (both "Jurassic?"); Carmel Formation (Ca) and Summerville Formation (Su) (both "Jurassic"); and Salt Wash Sandstone Member (SW) and unnamed "shale" member (Mo) of the Morrison Formation (both "Cretaceous?" but now assigned to the Upper Jurassic). Geologist Arthur Baker, as part of USGS regional studies in southeastern Utah, mapped strata in the Green River Desert-Cataract Canyon area in 1930–31, providing regional-framework information used in the subsequent exploration for uranium on the Colorado Plateau. (Photograph by Barnum Brown, American Museum of Natural History; published in Baker, 1946, pl. 16. Photograph reproduced from the folded illustration in the published report; the vertical lines are creases in the paper print.)

methods of chemical and physical analyses, including radioactivity measurements, spectrographic procedures, and X-ray techniques. Petrologic studies included aluminum- and zinc-bearing clays and related substances. Significant applied work also began or continued on lead, zinc, and other war-depleted base metals, phosphates, coals, oil, and oil shales. Stratigraphic-framework and construction-materials investigations concentrated on the Missouri River Basin and the Rocky Mountains. Branch members also investigated landslides, made airborne-magnetometer surveys, and studied mineral resources abroad, including those in Bolivia, Brazil, Chile, Cuba, Mexico, and Panama, in cooperation with the State Department and the Foreign Economic Administration. At the end of fiscal 1945–46, the Branch employed nearly 450 persons full time and 35 others part time, a net loss of nearly 240 people since the end of fiscal 1943–44.

Wrather's plans for reorganizing the Topographic Branch, the agency's second-oldest program unit, were well underway within a month after the war ended, and they continued as USGS topographers completed maps and charts for the War Department during the remainder of fiscal year 1945–46. Wrather knew that Thomas Pendleton, Chief Topographic Engineer (CTE) since March 1943, "was a very competent engineer and had contributed substantially toward shifting the work * * * to the newer techniques of photogrammetry" in and after World War I. The Director also believed that Pendleton's "frail physique," "sensitive temperament," and tendency to worry "were undermining his health." Wrather encouraged Pendleton, now nearing 60, to "devote himself to research in mapping,"[58] but Pendleton refused to end his tour as the CTE, and Wrather did not insist on the change. To help reorganize the Topographic Branch, the Director chose Colonel Gerald FitzGerald, who led the Aeronautical Chart Service since 1943 in the trimetrogon-photogrammetric compilation of maps that covered more than 15 million square miles worldwide. FitzGerald, wishing to return officially to the agency and continue his prewar service, "was anxious to get George D. Whitmore, chief of the mapping service of the TVA, in the Survey."[59] Wrather successfully convinced Ned H. Sayford, who had led TVA's Maps and Surveys Division at Chattanooga since 1934, that "we might offer" Sayford's Assistant Chief Whitmore "a wider field of opportunity, which might attract him."[60] Whitmore reported for duty with the USGS on September 17, 1945, but the U.S. Army Air Forces (USAAF), reluctant to release FitzGerald from active duty, did not comply until November 1 and then only after a personal request from Secretary Ickes.

USGS topographers faced a daunting task as they returned to peacetime operations with their emphases on domestic mapping. Of the 48 percent of the country mapped to date, only one-quarter of that coverage remained adequate for current use, and many of these maps required revision before they could again be used as meaningful bases. Wrather and FitzGerald quickly agreed that the Topographic Branch "should be completely overhauled and reoriented" to eliminate plane-table surveying as much as possible, except for ground checks, and to adopt the newer and war-proven photogrammetric methods in "a long-neglected civilian program" of large-scale mapping, preferably at 1:24,000. They also decided to continue the decentralization of field operations and to begin a program to revise existing useful maps. Wrather got Ickes and the CSC to approve full-time positions for FitzGerald and Whitmore as Staff Topographic Engineers, respectively, for Plans and Coordination and for Research and Technical Control. They would "advise and assist"[61] the Chief Topographic Engineer and the Director in planning and implementing both the present programs and the anticipated long-range effort to ensure responses to national needs and to use efficient and economical mapping systems. Wrather made FitzGerald's staff unit responsible for map information, estimates and plans, production control, and liaison and coordination with State and other Federal officials. To Whitmore's staff unit went authority for research and development of procedures, techniques, and equipment.

Gerald FitzGerald and George Whitmore became chiefs of their respective and formalized Divisions on August 27, 1945. Wrather, whenever possible, joined FitzGerald and Whitmore in studying the Topographic Branch's requirements and planning how to meet them by perfecting "a pattern which could be expanded to meet future needs without material changes." The two new chiefs placed in responsible positions younger men "who could be expected to respond favorably to the new viewpoint in mapping."[62] Russell K. Bean, one of these younger men, promoted improved photogrammetry in topographic mapping. In the summer of 1945, Bean led a team that cooperated with the Army Engineers in locating, confiscating, and shipping to the United States some of the Zeiss stereoplanigraphs and other photogrammetric equipment remaining in Germany. Fitzgerald and his staff began to prepare a comprehensive mapping plan to overcome deficiencies in map information within 15 years.

While Wrather and his advisers continued their efforts to remake the USGS program branches during the winter of 1945–46, President Truman delivered his initial State of the Union and Budget messages (combined) to Congress, and Secretary Ickes resigned. On January 21, 1946, Truman called again for "building a just and enduring peace."[63] As the "strength of our Nation and the welfare of the people rest upon the natural resources of the country," he reemphasized, they required

Julius Albert Krug (1907–70), the 33d Secretary of the Interior (1946–49), served as the Tennessee Valley Authority's Chief Power Engineer in 1938–40 before shifting to the War Production Board, which he led during 1944–45. He succeeded Harold Ickes as Interior Secretary on March 18, 1946, and served until December 1, 1949. During 1949, Krug also received an honorary doctorate of engineering from the Colorado School of Mines. After leaving Interior, Krug became a power consultant in Washington and cofounded the Volunteer Asphalt Company in Knoxville, Tennessee. (U.S. Office of War Information photograph D–6274–A, from the Library of Congress, Prints and Photographs Division, 3c25763.)

taking, "as soon as possible, an inventory of the lands, the minerals, and the forests of the Nation."[64] Truman again asked the legislators to consider his "proposed central Federal research agency."[65] In January, the President also announced Edwin W. Pauley as his nominee to serve as Under Secretary of the Navy. During 1940–45, Pauley helped Roosevelt to fill Churchill's request for tankers, aided plans for establishing a Petroleum Coordinator for National Defense, coordinated Lend-Lease oil supplies for Britain and the Soviet Union, and chaired the Democratic National Committee. In May 1945, Truman appointed Pauley the senior U.S. representative on the Allied Reparations Commission. Pauley, in his ambassadorial capacity, attended the meetings at Moscow and Potsdam before traveling that fall to China, Korea, and Japan as U.S. Reparations Commissioner for Japan. Republican members of the Senate's Naval Affairs Committee felt that Pauley, the California oil producer, real-estate developer, and Democratic committeeman for his State, would have a conflicting interest in the Nation's Naval Petroleum Reserves. They summoned Ickes as a witness in the confirmation hearings, although Truman opposed his participation. Ickes, in his second appearance before the committee on February 5, disclosed his diary's entries that described Pauley's efforts to tie a contribution from oilmen to an abandonment of the Federal suit on tidelands oil. Truman continued to support Pauley, perhaps seeing him as Forrestal's eventual successor.

On February 13, 1946, Ickes resigned in protest, as he did so often during his years with Roosevelt, expecting to get his way in the Pauley matter or at least receive an FDR-style reaffirmation of Ickes' irreplaceability at Interior. Instead, Truman quickly accepted Ickes' decision to depart. When Ickes asked for 2 weeks to finish his responsibilities, Truman gave him 2 days to clear out his desk. Wrather later recalled that "[o]n the whole, I was sorry to see him go."[66] In 1947, The Pick and Hammer Club's players portrayed some of the effects of Ickes' departure on the USGS in "Well, Wrath-er," to the tune of "Oh, Willow, Titwillow, Titwillow!" from Gilbert and Sullivan's "Mikado":

> **Now our Harold has left us, but I stay behind—**
> **I Wrather; Yes, Wrather; Bill Wrather,**
> **And I struggle with letters that have to be signed.**
> **By Wrather; just Wrather, Bill Wrather.**
> **The Comptroller and Budget are causing me tears,**
> **And the regional set-up that threatens gives fears,**
> **While the callers I sidetrack to Nolan and Sears**
> **Yell "Wrather! O, Wrather! Bill Wrather!"[67]**

To succeed Ickes on February 26, 1946, Truman chose Julius Krug, the former chairman of the War Production Board. The Senators confirmed Krug on March 5, and the new Interior Secretary took his oath of office on March 18. Krug had "a calm, deliberate air" and impressed Wrather "from the start by his rational, open-minded attitude toward the affairs of the Department."[68] The Senators rejected Pauley, who, with Truman's consent, withdrew his nomination on March 13 and returned to his reparations work in China, Japan, and Korea.

The House Subcommittee on Appropriations for the Department of the Interior (DoI), still chaired by Jed Johnson, began its hearings on Interior's requested budget of about $342,119,000 for fiscal year 1946–47 on February 4, 1946. For the USGS, the Bureau of the Budget (BoB) recommended a direct appropriation of $13,131,000, almost twice the $7,314,000 approved on July 3, 1945. An additional $2 million, to support USGS mapping and studies of construction materials, power sites, and floods, was part of the USBR's nearly $23.8 million request for developing the Missouri River Basin. Direct appropriations recommended for USGS topographic surveys totaled $5 million, the amount suggested by the Secretaries of War, Interior, and Commerce in their joint report in 1939. The increase of $2.8 million over the previous year's funding included $500,000 for the purchase of surveying and mapping instruments, $345,000 for trucks for field-survey parties, and $237,000 for cooperative surveys. About $2,436,000, more than double the last year's appropriation, would go to geologic surveys, but the USGS did not request separate monies for strategic-minerals investigations. Increased funding would support the start of a long-range plan to complete the geologic mapping of the country in no more than 30 years, which would require successively larger appropriations each year until they reached $5 million in fiscal 1949–50. The $3 million for water-resources investigations represented an increase of $883,000, a portion of which included a transfer of base so that funds previously shifted from other Federal agencies for these studies would be appropriated directly to the USGS. The agency asked for nearly $136,000 for the classification of public lands, more than $214,000 for the supervision of mineral leasing, and about $223,000 for the publication of maps and reports.

Assistant Secretary Oscar Chapman, in testifying before the House subcommittee, repeated much that Ickes said the year before. Chapman, soon to be Krug's Under Secretary, pointed out that requirements during the war years forced the United States to draw upon its natural resources at an unprecedented rate. "Ironically, in seeking to preserve the American way of life," Chapman continued, "we destroyed or seriously damaged much of the very thing which, in a material sense, made that way of life possible." Reserves of metals, petroleum, the higher grade coals, and some nonmetallic ores, which Americans once thought made them "more than self-sufficient for many generations to come," had been more depleted than generally realized. If future standards of living were not to be lowered "painfully,"[69] Chapman cautioned, the U.S. Government must take the lead in restoring and promoting the conservation as well as the development of the Nation's natural resources, and it must also foster and support scientific and technological studies in the search for new sources and uses of materials and power.

When Director Wrather and his program and budget managers appeared before the House's Interior subcommittee on February 12, the legislators professed amazement that the agency did not expect to revert to its prewar budget. In response, Wrather defended the expanded request by saying it did reflect efforts by the USGS to return to its peacetime activities but the adjustment to wartime demands required complete disregard of normal activities so that the agency now was years in arrears in much of its work. He asserted that

> **[t]he hearings on the Kilgore and Magnuson bills and the Bush committee report all called attention to the fact that during the war we applied science and technology brilliantly and with great success, but that no advances were made in basic theory; and that our technologic leadership in the future would require renewed attention to fundamental research. This situation is as true of the fields of geology, hydrology, and photogrammetry as it is of the fields of chemistry and physics that are so much better known.[70]**

Crediting past Directors, like King, Walcott, and Mendenhall, Wrather recalled that

> **[s]uch research work has in the past been an essential part of the Survey's program and it must be resumed without delay if the Survey is effectively to carry forward its investigation of our natural resources. * * * the experience of the war years has taught us that the functions of the Geological Survey require a scale of operations which we have never remotely approached in the past.[71]**

USGS operations in the past, Wrather added, had been on so limited a scale that the agency had "only pecked at the problem and dealt with it piecemeal." A "far greater effort," he urged, would now have to be made in order for the USGS "to properly occupy the field which we are supposed to fill in the set-up of Federal agencies."[72] Wrather warned the legislators that although the budget allowance for topographic surveys had been nearly doubled for the coming year, it would have to be more than doubled again if they wished the national program to be completed within the coming generation. The Nation's known mineral reserves had been depleted to meet war demands, but the degree of depletion had not been adequately established. Known reserves were "uncomfortably low in many categories" and "dangerously low in others." The USGS remained responsible for assembling and evaluating this information nationwide as well as for exploring for new sources of supply. Properly evaluating the Nation's water resources, Wrather continued, involved a "limitless task" ahead. As for work by the Conservation Branch, he added, "This activity yields substantial revenue to the Federal Government and the States. It deserves to be handled in the most businesslike manner possible."[73]

Wrather's plea did not impress the members of Jed Johnson's subcommittee. They approved for topographic surveys $2,626,100, an increase of less than $466,000 over the amount provided for fiscal year 1945–46 and only a little more than half the sum requested. As only $759,000 had been granted directly for such surveys in fiscal 1940–41, the Representatives remained at a loss to understand why the new appropriation should be increased sevenfold. They endorsed for geologic surveys only $1.2 million, a little less than half the amount requested and less than the combined appropriations for geologic surveys and strategic-minerals studies in 1945–46. The subcommittee reduced funding for water-resources investigations to the 1945–46 level and required the USGS not to use any of this money for drilling water wells for the purpose of supplying water for domestic use. The members also decreased the appropriations for classifying lands, supervising mineral leasing, and publishing and the funds to be received from the USBR to support USGS work in the Missouri River Basin.

As the House subcommittee considered the USGS request for funding during fiscal year 1946–47, U.S. problems in foreign relations and domestic issues grew in intensity. On February 9, 1946, Premier Stalin, as head of state, remarked publicly that he foresaw no possibility of establishing a peaceful world order because capitalism, monopoly, and imperialism commanded the globe outside the Soviet Union. Four days later, a Communist-dominated Government led by former partisan Kim Il Sung took over the northern half of Korea, the more industrialized portion of the peninsula compared to the dominantly agricultural south. On February 15, Canada revealed Soviet attempts at atomic espionage within the Dominion and arrested 22 persons. Six days later the U.S. Joint Chiefs of Staff (JCS) warned President Truman that the Soviet Union now was America's greatest threat abroad. On February 22, George F. Kennan, the U.S. chargé d'affaires in Moscow, warned the State Department in a long telegram that the Soviet Union was "a political force committed fanatically to the belief that with [the] U[.]S[.] there can be no permanent modus vivendi, that it is desirable and necessary that the internal harmony of our society be disrupted, our traditional way of life be destroyed, [and] the international authority of our state be broken, if Soviet power is to be secure."[74] Eastern Europe likely would have to be conceded to the Soviets, Kennan continued, but they should be deterred from further advances and contained by American power and a system of alliances.

Senator Arthur Vandenberg, reporting on the U.N. General Assembly's meeting in London, told his colleagues on February 28, 1946, that U.S. foreign policy must match the Soviet Union's in outspokenness and firmness. On the following day, Secretary of State James Byrnes assured the Overseas Press Club that the Truman administration would not ignore threats or uses of force made by any country contrary to the principles and purposes of the U.N.'s Charter. One day later, Truman ordered the Navy to send the battleship *Missouri* to return home the body of the late Turkish Ambassador to the United States, and the President pledged support to Iran when the Soviets refused to remove their troops there. Showing the flag at Istanbul helped to end Soviet demands for bases in Turkey. *Missouri* and her escorts visited Piraeus on the return voyage. In August, *Franklin D. Roosevelt*, one of the three new and larger *Midway*-class aircraft carriers, and her escorts also sailed to Piraeus to support the pro-Western forces in the renewed civil war in Greece. In September, a plebiscite led to the return of King George II to Athens. The Navy also sent a light cruiser to the "free city" of Trieste, whose ownership Italy and Yugoslavia still disputed, and in October, reestablished a permanent naval presence, the future 6th Fleet, in the Mediterranean.

Seven months earlier, former Prime Minister Churchill made the situation in Europe dramatically clear. On March 5, 1946, Churchill spoke after receiving an honorary degree from Westminster College in Fulton, Missouri. Churchill, with Truman in the audience, decried the "iron curtain" that now divided Europe from the Adriatic near Trieste to the Baltic near Stettin (Szczecin).[75] The people behind the new barrier, Churchill asserted, were all subject, in one form or another, not only to Soviet influence but to a very high or increasing measure of control from Moscow. Churchill called for restoring the Allies' wartime cooperation but not for sharing with the U.N. or any other countries information about the atomic bomb. In China, the agreement between Chiang and Mao threatened to break down. Stalin, like Roosevelt, supported Chiang throughout World War II; Mao favored Kim's Communist revolutionaries in Korea as well as Hõ's Viet Minh. In the hope of ending the full-scale civil war between the Nationalists and the Communists that resumed in Manchuria, Truman sent George Marshall to China in December 1945. Although General Marshall's special mission established another truce during January–April 1946, Chiang and Marshall did not succeed in reaching a lasting settlement with Mao. Fighting resumed after the Nationalists ignored the Communists' demand for joint control of Manchuria, and their conflict continued uninterrupted by the U.S.-Nationalist treaty of friendship, commerce, and navigation signed in November. Chiang, reelected president in a questionable vote in October, supported a new constitution in December to reduce abuses while the Communists continued their forceful program of land reform.

At home, the United States faced another wave of domestic-labor unrest. By mid-March, the strikers decreased in number from a high of some 2 million to about 200,000, but, beginning on April 1, 400,000 members of the United Mine Workers walked out. In May, railroad trainmen and locomotive engineers joined the miners on strike. As prices continued to rise, the unions demanded further increases in salaries.

Carl Hayden's Senate subcommittee on Interior's appropriations began its hearings on the USGS budget for fiscal year 1946–47 on May 17. New member Guy Cordon (R–OR) replaced Harold Burton, who left to become an Associate Justice of the U.S. Supreme Court. Cordon made public-land and resource issues his specialty and also chaired the Republican Policy Committee. Wrather protested the House's cuts in funds for topographic mapping when the agency was "about 4 years behind on our domestic program."[76] He reminded the Senators that "[w]e have never had an opportunity to prosecute mapping on a scale commensurate with national needs. We have merely picked at the job. The appropriations have usually been adequate to meet only the highest priority work. It is possible to anticipate map needs by consultation with the interested agencies, State and Federal, and a priority system can be worked out to complete the maps most immediately needed for such developments as the Columbia River or the Missouri Basin. Yet," he continued,

> **we are obliged to wait until the job is around our neck and then turn heaven and earth to meet the demand in time. Map making takes time, particularly map making with the very rigid specifications of the Survey.[77]**

“As a result of past laxness,” Wrather recalled, “we found ourselves at the beginning of war in what might have been a disastrous situation if the threat of invasion had materialized.”[78] The Topographic Branch employed as many as 650 people per year during the war, including those paid with transferred funds, and now required $5 million to support the needed permanent staff of 1,000.

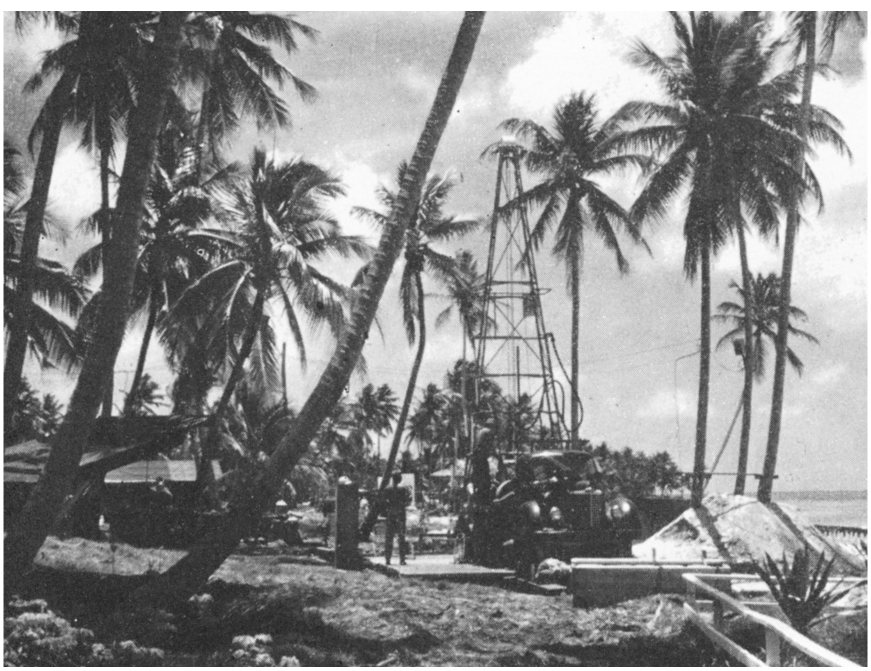
The Senate subcommittee, always more sympathetic to the Nation’s need for topographic mapping than the House subcommittee, responded to Wrather’s plea by recommending the full amount requested by the USGS for fiscal year 1946–47, but its members discussed only briefly the other items in the agency’s budget. For geologic surveys, the committee urged the full sum requested, but it approved for water-resources investigations only $2,888,000, or $112,000 less than asked for. The subcommittee did recommend large increases for classifying lands and leasing minerals, and another $662,000 in response to a supplemental request by the USGS to provide for rehabilitating its printing presses. The Senate agreed with its subcommittee’s decisions, but, in the final bill for USGS appropriations, the two houses more or less split their differences on funding for water-resources investigations, land classification, and mineral-leasing supervision. They allowed only $3 million for topographic surveys, of which $400,000 was available only for cooperative work with the States and municipalities and $2 million for geologic surveys. As enacted on July 1, 1946, the bill provided nearly $2,499,000 (including a transfer of base) for water-resources studies, of which $1,620,000 could be used only for cooperative work. The total direct appropriation of almost $9,709,000[79] for the USGS for salaries and expenses during fiscal 1946–47 amounted to nearly 74 percent of the requested sum. Supplemental appropriations, funds transferred from outside sources, and miscellaneous repay amounts enabled the agency to draw on about $18,633,000 during 1946–47. Principal transfers included the War Department’s $3,349,000; some $2,706,000 from States, counties, and municipalities; the Bureau of Reclamation’s nearly $1,989,000; about $242,000 from the State Department; and more than $224,000 from the Navy Department.

As Congress debated the appropriations bills in mid-June 1946, Bernard Baruch, as the United States’ chief representative to the United Nations, presented the U.S. proposal for an International Atomic Development Authority. Robert Oppenheimer served as Baruch’s scientific adviser, but the ambassador relied on General Groves’ opinions. The U.S. plan outlawed the manufacture of nuclear weapons, required the dismantling of existing atomic bombs, and recommended sharing scientific and technological knowledge about them. The proposed Authority would ensure the full exploitation of the peaceful uses of atomic energy and provide countries with security against surprise attack by violators of the weapons ban. The plan would be effected in stages, so that the new agency’s control mechanisms operated fully to demonstrate their effectiveness before the United States disposed of its existing nuclear weapons, accepted a prohibition on the manufacture or use of new weapons, and turned over to the Authority all U.S. scientific and technological knowledge of atomic energy.

Truman had an alternate plan. In January, Secretary of State Byrnes appointed a committee, including Under Secretary Dean Acheson as Chairman, Vannevar Bush, James Conant, General Groves, and former Assistant Secretary of War John J. McCloy, to recommend to the President what U.S. policy should be in regard to the proposed international control of atomic energy.[80] Acheson convinced TVA Chairman David Lilienthal to lead a Panel of Consultants that included Oppenheimer and three executives from industry. They recommended an international authority having control of the investigation and use of uranium and thorium, conducting experimental studies of atomic explosives, and developing atomic energy for electric power and other industrial uses.[81] Radioactive materials could be used as biological tracers or in small nuclear reactors that produced only low power levels; denaturing uranium and thorium would render them unusable for the known methods of making effective nuclear weapons. The Acheson-Lilienthal report,[82] released by Secretary Byrnes on March 29, suggested making the U.N. agency subject to vetoes by Security Council members. Five days after Baruch introduced his scheme, the Soviet Union, whose nuclear-weapon program struggled to catch up with U.S. achievements, responded by proposing a plan without international control of atomic energy.

The United Nations Atomic Energy Commission (UNAEC), established on January 24, 1946, evaluated the American and Soviet nuclear plans; in July, the United States exploded at a Pacific atoll two "Fat Man" plutonium-implosion bombs of 23 kilotons each to test the effects of nuclear weapons on warships. The Joint Chiefs of Staff established an Army-Navy Subcommittee, chaired by General LeMay, to select U.S. as well as Axis warships, to decide how best to locate the vessels with regard to hazards and risks, to determine what they would carry, and to arrange for logistical support. LeMay wanted General Groves to lead the tests, named Operation Crossroads, but the JCS and President Truman chose Vice Admiral William H.P. Blandy, the Deputy Chief of Naval Operations for Special Weapons, to direct Army/Navy Joint Task Force One. Bikini Atoll and its 240-square-mile lagoon, located east of Enewetak in the northern Marshall Islands, became the site for three planned nuclear tests. Navy Secretary Forrestal and Acting Secretary of War Kenneth C. Royall, previously Patterson's Under Secretary, urged Truman to authorize the tests; he agreed on January 10, provided they were unbiased. Five days later, the President insisted that the United States be the U.N.'s sole trustee for Bikini and the remainder of Pacific Islands formerly held by Japan.

Robert Oppenheimer, and a number of other atomic scientists, some of whom petitioned Truman to prevent dropping the bombs on Hiroshima and Nagasaki and then endorsed the McMahon bill, protested the Bikini tests as an unscientific and unnecessary but to no avail. Truman, convinced by Forrestal and Byrnes that the tests were required for national defense, agreed to delay them until the Council of Foreign Ministers completed their latest meetings in Paris. On March 25, 4 days after the USAAF established the Strategic Air Command (SAC), the Tactical Air Command, and the Air Defense Command, the President appointed an



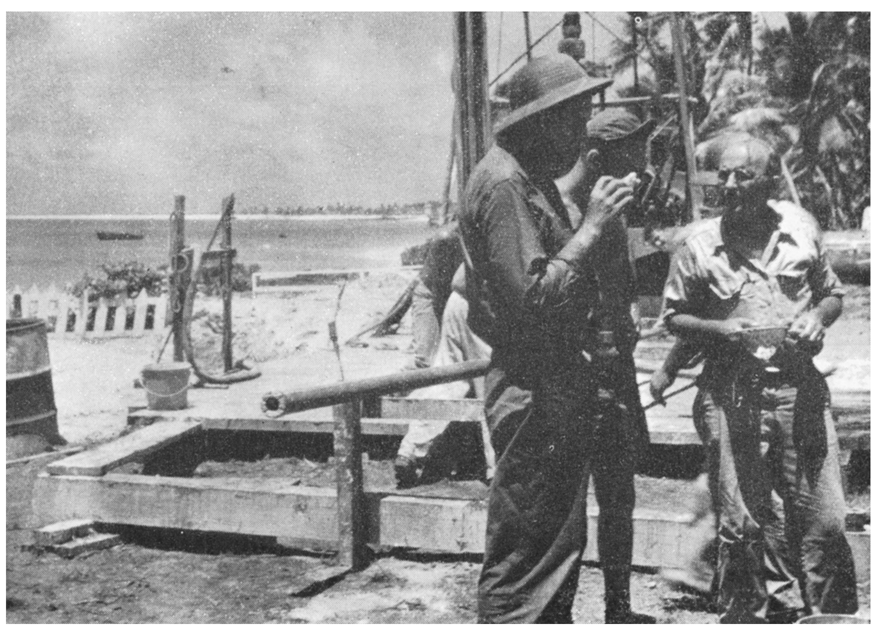
This "1500 Holemaster" rotary drill rig and its crew were supplied under contract to the U.S. Navy by the George E. Failing Supply Company. USGS and Navy scientists advised crew members as they completed three shallow and two deep holes on Bikini Island in 1947. Evaluations of the fossils and sediments in cores from these holes formed part of the scientific resurvey that followed biological and geological investigations done in 1946 before atomic tests were conducted during Operation Crossroads at the Marshall Islands' Bikini Atoll in the west-central Pacific Ocean. (Photograph from Schultz, 1948, pl. 4 [upper half].)

Evaluation Committee for the Atomic Bomb Tests, chaired by Senator Carl Hatch and including Karl Compton but not James Conant, who refused to participate, or Oppenheimer, who resigned. Baruch told the UNAEC on June 14 that successful tests at Bikini would bolster the United Nations and promote international law, and invited each UNAEC-member nation to send two observers.

Navy Secretary Forrestal joined Admiral Blandy in his flagship *Mount McKinley* along with W. Stuart Symington, the former Surplus Property Administrator and now the Assistant Secretary of War for Air; Brigadier General Kenneth Nichols, who represented General Groves; and other invitees. Other observers of the tests of two of the seven operational weapons then in America's nuclear arsenal included a Soviet physicist and Major General Semen P. Aleksandrov, a Soviet geologist who led uranium exploration in Beria's bomb project. In Test Able, on July 1, a B–29-delivered bomb burst nearly 520 feet above the lagoon. In Test Baker, on July 25, the second device exploded 90 feet below its surface. The bombs combined to sink or damage many of the 92 anchored and fully loaded U.S. capital ships, cruisers, destroyers, submarines, large transports, and landing craft and the 1 German and 2 Japanese combat vessels that America received as war reparations. Twenty-two of the 95 test vessels were lost and the others irradiated to dangerous or lesser degrees.

About 42,000 military and civilian personnel, among them some 550 scientists, participated in Operation Crossroads.[83] Commander Roger R.D. Revelle, Director of the Scripps Institution of Oceanography (SIO) but on active duty with the Navy since 1941, led Crossroads' oceanographic and geophysical studies of Bikini's physical environment and its biota. The investigations included a seismic-refraction survey of the atoll, its lagoon, and the waters surrounding the Marshalls. Specialists participating in the investigations represented the SIO, the Woods Hole Oceanographic Institution (WHOI), the Army Engineers' Intelligence Division, the Naval Ordnance Laboratory, the USGS, the Smithsonian Institution, and several universities.

The USGS contingent in Crossroads included Assistant Chief Geologist Harry Ladd, William Rubey, Joshua Tracey, Parker Trask, the University of Rochester's J. Edward Hoffmeister, the Colorado School of Mines' J. Harlan Johnson, Cornell's John W. Wells, and Kenneth O. Emery, of the University of Southern



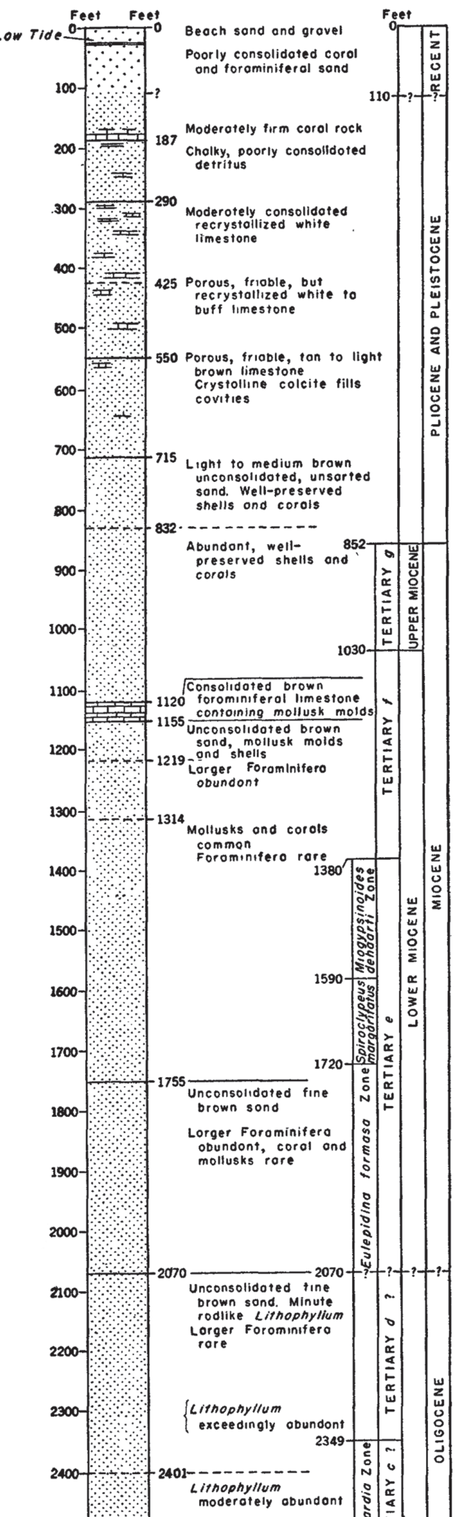
Oceanographer Roger Randall Dougan Revelle (1909–91, at left) and geologist Harry Stephen Ladd (1899–1982, at right) are shown examining fossils from one of the deep wells drilled on Bikini Island during the scientific resurvey in 1947. Cores returned specimens of calcareous algae, corals, foraminifers, and mollusks. Commander Revelle (U.S. Naval Reserve) was on leave from Scripps Institution of Oceanography and had been the first chief of the Office of Naval Research's Geophysics Branch. Revelle had led the oceanographic and geophysical studies during Operation Crossroads at Bikini Atoll in 1946. Ladd, as USGS Assistant Chief Geologist for Basic Sciences (1946–49) led Crossroads' geologic studies, organized the Pacific Geologic Mapping Program, funded by the Army Engineers, and began deep drilling on Bikini in 1947, in part to test the Darwin-Dana theory of atoll formation. (Photograph from Schultz, 1948, pl. 4 [lower half].)

California (USC). Ladd had just completed a 6-months' evaluation tour of the agency's work in the Pacific—in Japan, the Philippines, Guam, and Okinawa—when Nolan and Bradley assigned him to manage the geologic portion of the pre-explosion studies for Crossroads. Ladd and Tracey studied the surface geology of Bikini's islands and reefs, Emery looked at the subsurface geology, and WHOI oceanographer Charles C. Bates concentrated on the atoll's beaches. Hoffmeister (who earlier worked with Ladd on Fiji's geology and coral reefs), Wells, and Johnson collected and analyzed Bikini's corals and calcareous algae.

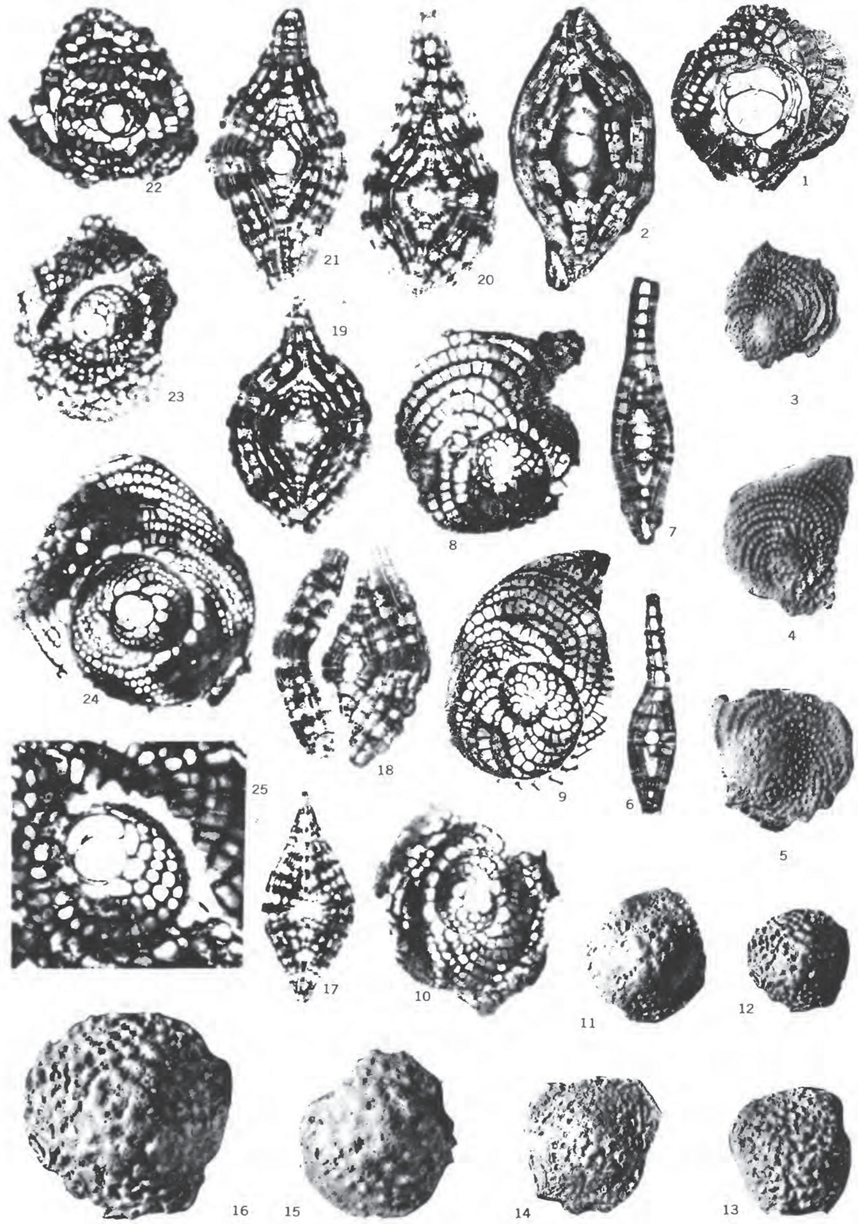
On July 15, 1947, Ladd and Tracey returned to Bikini for a 6-week resurvey of the effects of the 1946 explosions, shock waves, and fallout on the atoll and surrounding waters. Geologist Gordon G. Lill had succeded Revelle as head of the Geophysics Branch of the new Office of Naval Research (ONR) and now served as a consultant to military research and development. Lill accompanied Ladd and Tracey and extended Emery's work. Ladd and the other geologists supervised the rotary drilling, by industry personnel aided by Seabees, of five test wells on Bikini Island to provide a greater understanding of the atoll's geologic history, produce a more accurate base for the seismic studies and the ONR–USGS aeromagnetic survey later in 1947, and test the Darwin-Dana theory of reef development in response to ocean-bottom subsidence.

Drilling on atolls began early in the 1830s with a shallow excavation by an auger operated by the crew of a British merchant ship. Early in 1840, a party from Commander Edward Belcher's HMS *Sulphur* reached a depth of 45 feet during a 2-month boring on Bow (now Hao) Island in the Pacific's central Tuamotus (now in French Polynesia).[84] Charles Darwin, influenced by Charles Lyell's ideas about coral rims and submerged volcanic craters in the initial volume of Lyell's "Principles of Geology" of 1830, studied several atolls in the Pacific and Indian Oceans while accompanying Captain Robert FitzRoy's round-the-world survey in HMS *Beagle*.[85] In April 1836, the ship's dredges at South Keeling Island (probably now South Island [Pulau Atas] in Australia's Territory of the Cocos Islands) recovered no live corals below 120 feet, where light penetration limits the depths to which shallow-water corals, and their zooxanthellae (algal symbionts), can flourish. A Sydney newspaper's account of Darwin's new concept of atoll development in turn swayed James D. Dana, the Yale geologist-zoologist accompanying Navy Lt. Charles Wilkes' U.S. Exploring Expedition.[86] In 1840–41, Dana examined reefs in the Fiji group and Funafuti, Tarawa, Makin, and other atolls before his ship left for Hawaii. Analyses published by Darwin in 1842 and by Dana in 1849 proposed a multistage development of atolls in which coral growth kept pace over millions of years with the sinking of the sea floor beneath volcanic islands. Later in the 19th century, John Murray (who participated in the global voyage of HMS *Challenger* during 1872–76), Alexander Agassiz, Reginald Daly, and William Davis added their ideas to the debate about the origin and history of atolls. Ladd and Hoffmeister favored Agassiz's antecedent-platform theory as the causal mechanism for coral upgrowth rather than the Darwin-Dana idea of ocean-bottom subsidence, sea-level fluctuations, stable-island solution, glacial-control, or other explanations.[87]

As only deeper wells could test the Darwin-Dana model and the alternatives, Darwin continued to hope "that some doubly rich millionaire" would fund borings "in some of the Pacific and Indian atolls, and bring home cores for slicing from a depth of 500 or 600 feet."[88] No magnate stepped forward, but, in the 1890s, Oxford's geologist-paleontologist William J. Sollas suggested to the Royal Society of London (RSL) that it sponsor such a boring. The RSL formed a Coral Reef Committee, chaired by Sollas and including University of Sydney geologist T.W. Edgeworth David, that chose Funafuti as the site, with drilling funded by academic, commercial, government, and private benefactors. In 1896, Sollas' party drilled to 105 feet. David led a new team in 1897; its 25-ton, coal-powered,



◀ This stratigraphic section of drill hole 2B, the deepest of the five wells drilled on Bikini Island in 1947, ended at a depth of 2,556 feet in what Harry Ladd and his colleagues termed Oligocene(?), or possibly upper Eocene, reef sediments. That depth exceeded by 1,140 feet the deepest well in the Pacific, the one drilled by the Japanese on Kita-daito-jima in 1936, but the core record from Bikini hole 2B left unconfirmed the Darwin-Dana model of coral reef development. (From Emery, Tracey, and Ladd, 1954, fig. 35; see also Ladd, Tracey, and Lill, 1948.)



These large foraminifers were recovered from marine sediments from hole 2B drilled on Bikini Island in 1947. Figures 10–25 include external views and median and transverse sections of specimens of *Spiroclypeus margaritatus* (Schlumberger). These marine protozoans, with multichambered endoskeletons known as "tests," occurred in the faunal zone between 1,590 and 1,720 feet, whose sediments were assigned to the lower Miocene. The petroleum industry depended on data from foraminifers and other microfossils to determine the relative ages and correlations of rock and sediment samples from well cores. (From Cole, 1954, pl. 206; figures 1, 2, 6–10, and 16–24 originally shown at × 20; figures 3–5 and 11–15 at × 10; and figure 25 at × 40.)

diamond-drilling rig, owned and operated by New South Wales, reached 698 feet. In 1898, David's teammates extended the main boring to 1,114 feet but without encountering bedrock. The drillers at Funafuti recovered 384 feet of cores—mostly coralline, foraminiferal, and algal deposits in reef limestones overlying dolomitic limestones—assigned later to the Pleistocene and Holocene Epochs. The corals' well-known shallow-water and reef-forming nature—some of them still lived at Funafuti—confirmed subsidence when the core records and analyses appeared in the RSL report in 1904.[89]

Subsequent drilling elsewhere in the Pacific also did not reach basement rock. In 1936, the Japanese completed a hole to a depth of 1,416 feet on Kita-daito-jima (North Borodino), an island in the Daito-jima group some 200 miles east of Okinawa and 70 miles north of the Tropic of Cancer. The Japanese well descended through dolomitic limestone into mostly Miocene-age reef limestones without reaching bedrock. Neither did Ladd's five drill holes on Bikini in 1947 reach basement, but well 2B bottomed out "at 2,556 feet in [Oligocene] unconsolidated fine sand,"[90] when the crew ran out of drill pipe. The accompanying aeromagnetic survey, by Fred Keller, Jr. (of the USGS), and Leroy R. Alldredge and W.J. Dichtel (from the Naval Ordnance Laboratory [NOL]), used a Navy PBY–5A Catalina seaplane reconfigured for a tail-cone magnetometer by the Naval Air Modification Unit (renamed the Naval Air Development Center in 1947) at Johnsville, Pennsylvania. A note in *Science* for May 17, 1945, recommended using for oceanographic surveys the twin-engine amphibian, often used in Allied long-range maritime attack, patrol, reconnaissance, rescue, and supply missions. The Catalina's crew flew 8,300 miles of traverses at 1,500 feet over Bikini and surrounding waters, including those over adjacent Sylvania Guyot. The magnetic survey mapped basement materials within 5,000 feet of sea level just northeast of Bikini, and researchers estimated that the materials occurred 8,000 feet below the atoll, but, like the interpreters of the drilling results, they left the exact nature and depth still to be determined.

Major organizational changes continued throughout the USGS during the fiscal year that began on July 1, 1946, especially in its work in Alaska as the Territory assumed increasingly greater importance in the postwar world. On February 3, just 10 days before Ickes resigned, his article "Let's Open Up Alaska!" appeared in *This Week*. Ickes appealed therein for greater use of the Territory's "vast natural resources to replace some that we have expended so open-handedly during the war." Developing the Territory and populating it by "veterans and former war workers" would provide "a settled Alaska at the coming crossroads of the airways of the world." Ickes called for a Federal program to pave the way in the Territory by classifying its lands, studying opportunities for immigration, settlement, capital investment, and employment, while building roads and other infrastructure "to assure that Americans who accepted the challenge of Alaska would have a reasonable assurance of success."[91]

On May 17, as the Senate subcommittee began hearings on the USGS budget, Wrather announced that as of July 1, the Alaskan Branch's topographic-mapping facilities, commitments, and funds, all part of the Branch since its founding in 1903, would be transferred to the Topographic Branch. Wrather expected the shift to "greatly facilitate preparations for meeting our extensive mapping commitments for the immediate future" and "to carry out administration, research, and field operations with maximum coordination and economy" by standardizing all USGS photogrammetric and map-compilation procedures and equitably deploying "trained personnel and equipment." In ending the mini-USGS in Alaska that now employed some 270 persons (nearly all full time), Wrather ordered the Chief Alaskan Geologist to "act as coordinating official for integrating Alaskan topographic mapping activities with other functions in Alaska," and "assist in determining and appraising other Alaska map needs" and "in establishing schedules and priorities"[92] for surveys. On July 22, Wrather made the Water Resources Branch responsible for water-resources studies in Alaska and placed land-classification activities in the Territory in the Conservation Branch. He promised that geologic activities in Alaska would go to the Geologic Branch as soon as he established the "position of advisor and consultant to the Director on Survey affairs regarding the Territories and Island Possessions."[93] Nine days later, the 79th Congress and the President agreed to appropriate $975,000 for a geophysical institute at the University of Alaska to recognize the results of contributions by its geophysicists to the war effort, its "unique location," and the "necessity for indefinite continuation of geophysical [exploration and] research in the Arctic in the postwar period"[94] for both military and civilian purposes. The institute's director would be nominated by the university's president, chosen by the university's regents, and approved by the NAS' president.

Geologist John Calvin Reed ([Sr.] 1905–93) began working for the USGS in Oregon in 1930 but shifted to mapping mineralized areas in the Alaska Railroad belt in 1931. He returned to Alaska in 1936, participated in and supervised strategic-minerals investigations there, became Assistant Chief Alaskan Geologist in 1944, and succeeded Philip Smith as Chief in 1946. During 1946–53, Reed served as Director Wrather's Staff Scientist for Territories and Island Possessions and as Wrather's deputy on the Navy's Operating and Advisory Committees for Naval Petroleum Reserve No. 4. Reed, also a Commander, U.S. Naval Reserve, retired as Staff Coordinator in the Director's Office in 1960 and became Executive Director of the Arctic Institute of North America. (Photograph, May 1949, from the USGS Denver Library Photographic Collection as Reed, J.C. [Sr.], 849; see also Reed, J.C. [Sr.], 1980, p. 66.)

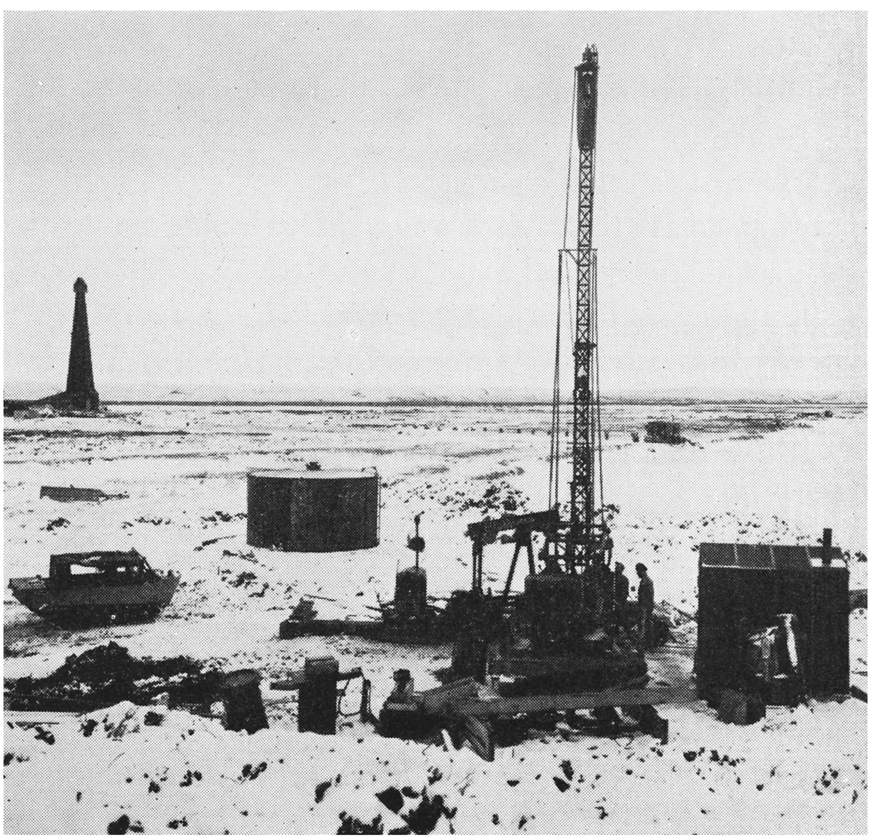
USGS geologic activities in Alaska passed formally to the Geologic Branch on September 27, 1946, when Wrather appointed John Reed (Sr.), formerly Philip Smith's deputy and now Acting Chief Alaskan Geologist, as the Director's Staff Scientist for Territories and Island Possessions. The new slot and Reed's selection for it reflected the USGS' greater concern for its role in the Department of the Interior's increasing activities abroad, as overseen by the DoI's Committee on Foreign Cooperation. Wrather named Robert E. Fellows as Reed's alternate, and Bill Bradley made Fellows also responsible for supervising general geologic mapping and studies of mineral resources within Alaska. Wrather thought that Reed, who led the Branch during the 7 months since Philip Smith's resignation, "knew more about Alaska than anyone else in the Survey"[95] except Smith. Wrather asked Reed to "recommend, advise, and consult on the formulation of Survey policies and the initiation of programs." In addition, Reed would "act as administrative deputy of the Director's Office in giving advice and recommendations to the Branch Chiefs on the planning and direction of projects," "establish and maintain liaison with other Federal agencies, Territorial offices, and municipal and commercial organizations and individuals," and "coordinate the work of the Branches."[96]

Earlier in 1946, Reed accompanied Wrather to Alaska to look at ongoing work in Naval Petroleum Reserve No. 4 (NPR–4) and elsewhere in the Territory. The Navy transferred nearly $118,000 to the USGS for mineral-resource studies by the agency in Alaska during fiscal year 1945–46, more than twice the amount provided during the previous year. USGS studies during the 1945 season gathered initial data on stratigraphic-facies changes within NPR–4. Ground-based gravimetric surveys helped to "localize areas for core drilling and seismography [electrical resistivity and seismic-reflection] work."[97] Cores from drill holes that reached depths of 580 feet at Cape Simpson and 1,816 feet at Umiat (test well 1 in 1945) disclosed oil-bearing sands and shows of oil and gas in addition to providing information on lithology, stratigraphy, and structure. Permafrost, not expected to occur below 130 feet, extended to nearly 600 feet in one of the test wells. To develop NPR–4's potential production in peacetime of 10,000 barrels per day, from estimated reserves of up to 500 million barrels, and to assure its use in a war or other national emergency, Secretary Forrestal, Assistant Secretary for Air John L. Sullivan, and Captain William Greenman agreed on September 21, 1945, to continue contracts for exploration, geophysics, photography, drilling and maintenance, geologic studies by the USGS, and air and sea transport by the Navy. They knew that completing the multiyear exploration of NPR–4 might cost more than $8 million and developing discoveries requiring production of 100,000 barrels every day to be economically viable might need more than $150 million.[98]

On December 4, 1945, Commodore Greenman, who received his single star on November 2, Wrather, Lewis MacNaughton, and Seabee Captain Bart Gillespie, later project manager for Arctic Contractors, testified in a special hearing held by the House's Committee on Naval Affairs. The committee's members reapproved the project and recommended to the Committee on Appropriations that it provide funds sufficient to carry on the program by negotiating a contract with a competent civilian contractor rather continuing to use the Seabees. At Greenman's request for "an advisory group of eminent specialists in petroleum development," Assistant Secretary Sullivan established on January 4, 1946, "an operating committee to develop policies and provide plans for Pet 4 [NPR–4]."[99] The NPR–4 committee, including Greenman, Wrather, MacNaughton, and a representative of Arctic Contractors, met during the next day. For work during 1946, they recommended continuing contract operations at the Barrow and Umiat base camps (including completing the latter's airstrip), finishing the drilling at Umiat and Cape Simpson, continuing the seismic work in the latter area and beginning it over the Meade-Inaru arch and between Simpson and Umiat, conducting a gravity survey at Point Barrow, and providing logistical support to three USGS field parties.

Wrather pointed out to Greenman that the "Navy exploration on the Reserve [also] offered a rare opportunity for conducting research on a variety of Arctic problems" if research specialists from the Smithsonian and other organizations could be attached to USGS field parties. Greenman said "that he would gladly extend any reasonable assistance to such an enterprise."[100]

Between June 1 and September 1, 1946, five USGS geologic field parties in George Gates' new Navy Oil Unit in Alaska operated within NPR–4 and just outside it in locations where the information obtained related directly to advancing the geologic interpretation of conditions within NPR–4. Karl Stefansson led a party that studied and mapped the Umiat anticline, where Umiat test well 1 was reentered and deepened to 6,005 feet and yielded 514 feet of cores. Navy Lt. Richard G. Ray, on detail to the USGS from Commodore Greenman's office, led a second group that examined the area flanking Maybe Creek, a tributary of the Ikpikpuk River. Edward J. Webber's team, including Robert E. Wallace, investigated the Meade River area and the coast at Skull Cliffs. The fourth party, led by Robert M. Chapman, looked at Mesozoic rocks in the region between the Killik and Kurupa Rivers. George Gryc's team studied the Upper Cretaceous sequences east of NPR–4, along the Sagavanirktok River, which emptied into the Beaufort Sea between Prudhoe Bay and Tigvariak Island, and at locales between Ninuluk Creek and the Kutchik River, just south of the Colville River. Additional work by Gates' Unit produced an air-photo mosaic of NPR–4. Studies of well-core and ditch samples, well logs, heavy minerals, macrofossils, microfossils, porosity, and permeability were done in the Fairbanks laboratory. Robert Chapman managed the lab after Robert Black left for Washington to lead the Alaska Terrain and Permafrost Section, one of whose responsibilities involved critiquing the Military Geology Unit's report on permafrost.

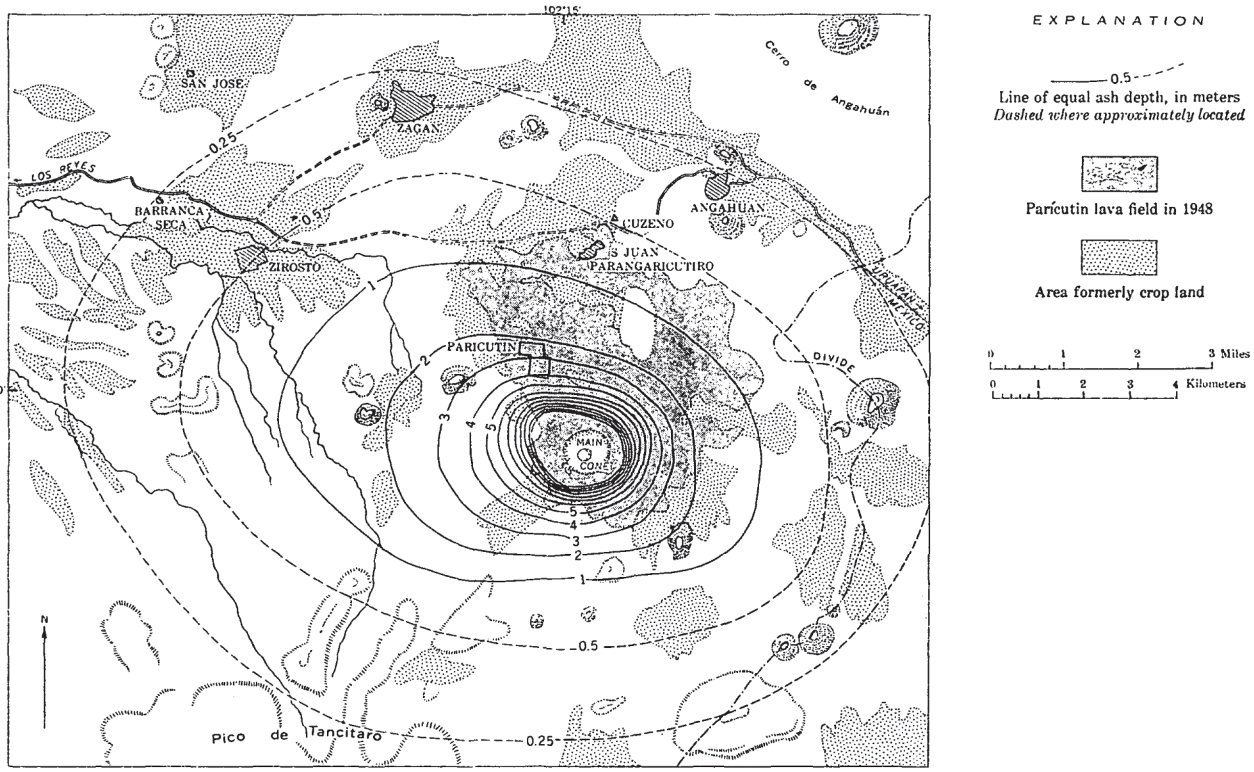


Umiat core test 1 (later Umiat test well 3), shown here in the foreground at right, was drilled in 1946 on the flank of the Umiat anticline near Alaska's Colville River and at the eastern margin of Naval Petroleum Reserve No. 4. The well "penetrated oil sands from 248 to 390 feet" and reached a depth of 572 feet. Pumping tests conducted during September–November 1947 yielded 14–24 barrels of oil per day. Umiat test well 2, in the background at left, was drilled in 1947 to a depth of 6,212 feet, or 207 feet deeper than Umiat test 1 well drilled in 1945–46. Umiat test well 2 penetrated the oil zone between 315 and 745 feet, and permafrost did not extend below 750 feet. (U.S. Navy photograph, October 10, 1947, and quotation from Reed, J.C. [Sr.], 1958a, fig. 37 and p. 77.)

Geologist George Gryc (1919–2008) and his field party 5 used this and similar small boats in 1946 in continuing the USGS exploration program of Naval Petroleum Reserve No. 4 (NPR–4) begun in 1944. Aircraft took Gryc's team to a landing strip on a lake near the headwaters of the Sagavanirktok River and east of NPR–4. The team worked downriver to the Sagavanirktok's delta and Prudhoe Bay. USGS field parties mapping and studying the geology of areas within and around NPR–4 continued the earlier practice of river traverses on Alaska's North Slope. (Photograph from the USGS Denver Library Photographic Collection as Reed, J.C. [Sr.], rjc00872, https://www.sciencebase.gov/catalog/item/51dda8c4e4b0f72b4471e90f.)

USGS airborne-magnetometer surveys of NPR–4 during the field seasons of 1945 and 1946 also added to a greater understanding of the Reserve's geology. Commodore Greenman arranged to have the Johnsville Unit install in another PBY–5A the complete magnetometer system developed by James Balsley's team. Between July 22 and September 14, 1945, Balsley and Homer Jensen began the Special Alaska Magnetic Survey (SPAMS) of NPR–4. Balsley also used the aircraft, crewed by Navy and NOL personnel, to survey known oil-producing structures in Wyoming's Bighorn Basin to gain data that would aid interpreting the results of the NPR–4 survey. Photographs from the aircraft's continuous-strip camera, tied to 1943's trimetrogon records as compiled in 1944, provided ground control; a recording magnetic variometer at Barrow provided the diurnal variation "later used to correct the magnetometer readings." Balsley and Jensen covered "almost all of the Reserve * * * from an altitude of 1,000 feet along north-trending flight lines approximately 2 miles apart." They covered the Cape Simpson area by "additional east-west trending flights," made tests "at an altitude of only 100 feet," and surveyed from 5,000 feet NPR–4's eastern half "at 12-mile intervals."[101] Greenman also arranged for the Air Technical Services Command to install short-range-navigation (shoran) equipment in the PBY–5A and supply personnel to operate it, enabling Balsley's team during March–April 1946 to survey about 9,000 square miles of the coastal waters in the Gulf of Mexico off Louisiana and Texas.

To complete SPAMS, Balsley and Jensen returned to NPR–4 in the Catalina during June 11–August 4, 1946, to cover "about 22,600 square miles, including the western part of" the 37,000-square-mile NPR–4 "and areas east, west, and south of the Reserve." Balsley, Frank M. Byers, Jr., Mary E. Hill, Darwin Rossman, Matt Walton, and Robert E. Thurmond then prepared several magnetic-intensity contour maps, one of which appeared by late August 1946 among those published in USGS Geophysical Investigations Preliminary Map 3. The NPR–4 map depicted, at about 1:725,000 and an isomagnetic interval of 10 gammas, all except 1,000 square miles of the Reserve, from the Meade River-Point Barrow area east to the Colville River and north from Killik Bend to the Beaufort Sea. The NPR–4 map "showed a regional magnetic gradient to the northeast," and one of its magnetic anomalies corresponded closely to the Umiat anticline disclosed by the surface geology. Although Balsley's team found "No consistent correlation * * * between magnetic anomalies and observed geologic structures,"[102] except at Umiat, the combined magnetic-geologic data indicated "a stable axis present [Meade River to Anaktuvuk River] during Late Cretaceous and Tertiary times" and an "anomaly of large areal extent south of Tigvariak Island [some 25 miles southeast of Prudhoe Bay] * * * worthy of further investigation."[103]



This map of Parícutin and the surrounding area in Mexico (originally at about 1 inch = 2.6 miles) shows the area occupied by crops before the initial eruption in 1943, the thickness of the ash deposit of 1946, and the area covered by lava flows in 1948, as compiled by USGS geologist Kenneth Segerstrom. USGS geologist Ray Wilcox, who also monitored Parícutin on site, added these data to his 1959 report that included data from the eruptions of Gunung Kelud (Java, 1919), Hekla (Iceland, 1947), Novarupta-Katmai (Alaska, 1912), Okmok (Alaska, 1945), Quizapú (Chile, 1932), Spurr (Alaska, 1953), and Trident (Alaska, 1952). Wilcox compiled wind-rose diagrams from upper-wind data at Alaska weather stations to demonstrate the importance of wind direction and speed (plus rainfall) in influencing the distribution of ash. He made preliminary predictions of probable falls from some Alaskan volcanoes as part of his initial assessments of volcano hazards. (From Wilcox, 1959, fig. 71, based principally on Segerstrom, 1950, pl. 1.)

On July 8, 1946, Congress and the President approved $9,710,000, of which $9.6 million would be available until July 1, 1950, to support work in the Naval Petroleum Reserves, especially "to drill and equip exploratory wells"[104] in NPR–4. The Navy hired Walter A. English to coordinate all exploration data in NPR–4 and to advise Commodore Greenman. At the fifth meeting of the Operating Committee in Washington during November 6–8, English, Gates, the geologic party chiefs, Balsley, and representatives of Arctic Contractors and United Geophysical discussed the results of their work to date, and FitzGerald "outlined the status of aerial photography of the Reserve and the mapping from those photographs."[105] The 11 wells drilled by Arctic Contractors at Umiat during the 1946 season defined a field of an estimated 100,000 barrels of recoverable crude.

Wrather, while in Alaska with Reed in 1946, met Lt. General Delos Emmons at his headquarters at Fort Richardson, just northeast of Anchorage, to discuss USGS work in NPR–4, the Aleutian Islands, and elsewhere in the Territory. Emmons invited Wrather and Reed to see Okmok on Umnak, guided by Lt. Ray Wilcox. Wrather then arranged with Emmons and Fort Glenn's commander to have Wilcox continue to keep "watch on the eruption as part of his regular duties"[106] at the post. In December 1945, Wilcox had noted "a brief resurgence of activity with a small lava flow and light ash fall [on Fort Glenn on the 16th]," but "it was apparent at an early stage that any large amount of lava would be confined within the caldera."[107] No new pyroclastic flows accompanied Okmok's eruption before it ended on December 31. The increasing volume of actual and projected military traffic in and out of Elmendorf [Air] Field, just west of Fort Richardson, and Ladd Air Field and Eielson Air Field, both near Fairbanks, the airfields and naval bases on the Alaska Peninsula and in the Aleutians, and the strategic position of the Territory contributed to the War Department's growing concern about volcanic and other natural hazards. In October 1945, the Army Engineers asked the USGS to begin systematic investigations of specific volcanoes, among the nearly 80 in that portion of the Pacific's "Ring of Fire," that posed significant threats to bases

This view, looking east, shows Mexico's Parícutin Volcano in eruption on November 7, 1947. Heavy ash covered the year-old lava. USGS, Smithsonian, and other U.S. geologists cooperated with their Mexican colleagues in monitoring and studying the volcano on site during its eruptions in 1943–52. (Photograph from the USGS Denver Library Photographic Collection as Wilcox, R.E., wire0116, https://www.sciencebase.gov/catalog/item/51ddd10be4b0f72b44721c65.)

and other facilities. In addition to the eruptions of Okmok and Tulik on Umnak, significant activity occurred in June 1943 at Kiska Volcano on Kiska (Rat Islands), in June 1944 at Mount Cleveland on Chuginadak (Islands of the Four Mountains), and in 1945 at Pavlof Volcano, northeast of the airfield at Fort Randall at Cold Bay near the tip of the Alaska Peninsula.

Geologists in Gershon Robinson's new unit for Alaskan volcano investigations[108] began field studies in the late spring of 1946, supported by Major General Howard A. Craig, General Emmons' successor as commander of the Alaskan Department, and by funds from the Army Engineers' Intelligence Division. From "1947 to 1955, the Departments of the Army, Navy, and Air Force joined to furnish financial and logistical assistance."[109] Robinson and his colleagues planned preliminary reconnaissances of many of the islands in the Aleutians and the Alaskan Peninsula, concentrating on those with significant Army, USAAF, Navy, and U.S. Coast Guard (USCG) facilities built during or since 1941. Their work centered on Attu and Shemya (Near Islands), Adak (Andreanof Islands), Umnak and Unalaska (Fox Islands), Cold Bay, and Kodiak, but Ray Wilcox was not among them. Wilcox recalled that after his Army discharge, Wrather and Reed asked him "to go back to [the] Aleutians for the Volcano Program, but I begged off. Then they offered me the job at Parícutin. Talk about luck."[110] Wilcox arrived as a "permanent" observer on September 18, 1946. Aided by Kenneth Segerstrom and others, Wilcox tracked Parícutin's activity until he completed his tour there early in 1948 and then transferred to Denver.[111]

Several other USGS geologists and field assistants did join Robinson's program. Robert Coats and his aides briefly examined Adak, Amatignak, Amchitka, Attu, Gareloi, Great Sitkin, Kanaga, Kiska, Semisopochnoi, Shemya, and Tanaga in the Aleutians during the field seasons of 1946 and 1947. Frank Simons, Donald E. Mathewson, and their aides spent the 1946 season investigating in greater detail Great Sitkin, only 20 miles northeast of the bases on Adak. Frank Byers studied tiny Bogoslof Island, north of Umnak, an important landfall long used by navigators in the Bering Sea. Bogoslof Volcano's last eruption began in 1926. In 1946, Byers also led David M. Hopkins, Bernard Fisher, and Kenneth L. Wier in assessing Umnak, during which they mapped Okmok's crater, where cone activity resumed on July 18 and continued for several months, and adjacent parts of the island.

Geological work in the Aleutians, however, proved dangerous beyond the hazards of volcanic eruptions. Fog, williwaws, riptides, and strong currents made hazardous even regular operations from small boats off islands in the chain. On June 22, 1946, Bernard Fisher accompanied an Army Engineer lieutenant and his Aleut boatman to install an aircraft-warning beacon on and study the geology of Ship Rock, an islet a little more than a mile off Fort Glenn in Umnak Pass. They drowned when their craft overturned as they tried to land on the islet.[112] After Wier left Alaska in December to join Harold James' investigation of Michigan's Precambrian iron deposits, Byers continued to study Umnak in 1947. Howard A. Powers, on detail from the USGS Hawaiian Volcano Observatory (HVO), where Gordon Macdonald replaced him on the staff, took charge of the third year's work on Umnak in 1948. George Kennedy and Matt Walton studied Pavlof Volcano in 1946. Howard H. ("Hank") Waldron and seasonal assistant Donald R. Nichols evaluated in 1947 Frosty Peak, also near Fort Randall and its airfield. Military funds continued to aid those efforts.

The Aleutians' natural hazards included earthquakes and tsunamis, as well as volcanic eruptions. Seismic shocks occurred frequently offshore in the Aleutian Trench, and those stronger than Richter magnitude 6.5 could, and some did, generate destructive tsunamis, the huge seismic sea waves the Japanese named "harbor waves" to emphasize that low heights at sea belied their slowing speeds, increasing amplitudes, and decreasing wave lengths when reaching shallow water and beginning to release their energy. Early on April 1, 1946, an earthquake of surface-wave magnitude 7.8 was generated about 15 miles below an epicenter nearly 90 miles south of Unimak Island and spawned tsunamis.[113] One initial wave quickly reached Unimak, rose to a height above 90 feet inshore, and struck Scotch Cap at the island's southwestern tip.[114] There, the USCG operated a 60-foot-tall and steel-reinforced concrete lighthouse built in 1940, on a ledge more than 30 feet above sea level, to replace the older wooden structure that since 1898 had guided ships traveling to and from Nome. The tsunami destroyed the lighthouse, killed the five coastguardsmen who serviced the 80,000-candlepower light, and damaged the direction-finding station located on the plateau above, where the run up strewed debris 115 feet above the sea. The companion lighthouse at Cape Sarichef, on Unimak's northwestern tip, survived to continue to warn ships of the dangers while traversing Unimak Pass until a new lighthouse was built at Scotch Cap.

Other waves generated by the 1946 earthquake traveled at nearly 500 miles an hour southwest toward the Hawaiian Islands. The seismic sea waves reached the volcanic chain within 5 hours, rose inshore to heights of as much as 55 feet, and struck the northeastward-facing coasts of Oahu, Hawaii, and other islands. The surges reached 40 feet above sea level, killed 160 people, injured an additional 160, caused some $25 million in property damage throughout the islands, and devastated Hilo and the Waipio and Pololu Valleys on the main island and Waikolu Valley on Molokai. The U.S. Coast and Geodetic Survey (USCGS) established a tsunami-warning system for the Hawaiian Islands that began operations in 1948. Its network included seismological observatories at Honolulu (headquarters), College and Sitka in Alaska, and Tucson in Arizona and tide stations at Hilo and Honolulu, on Attu and Adak, at Dutch Harbor and Sitka, and on Johnston, Midway, and Palmyra Islands. By rapidly detecting and locating earthquakes, determining if they could cause tsunamis, and, if so, accurately predicting their arrival times, the USCGS intended its new Seismic Sea-Wave Warning System to alert civil and military authorities in Hawaii and in the Trust Territory of the Pacific Islands.[115] The Department of Commerce's Weather Bureau established the Pacific Tsunami Warning Center at Ewa Beach, west of Honolulu, in 1949.

These views of the U.S. Coast Guard (USCG) lighthouse at Scotch Cap on Unimak Island in the eastern Aleutians show the site before (above) and after (below) the magnitude 7.8 Aleutian Islands earthquake and subsequent tsunami of April 1, 1946. The tsunami obliterated the steel-reinforced concrete lighthouse and killed five coastguardsmen. The tsunami struck the Hawaiian Islands about 5 hours later, killing 160 people and causing about $25 million in property damage. In 1948, the U.S. Coast and Geodetic Survey established at Ewa Beach on Oahu the Seismic Sea-Wave Warning System (later Pacific Tsunami Warning Center). (USCG photographs, from National Oceanographic and Atmospheric Administration, National Geophysical Data Center.)

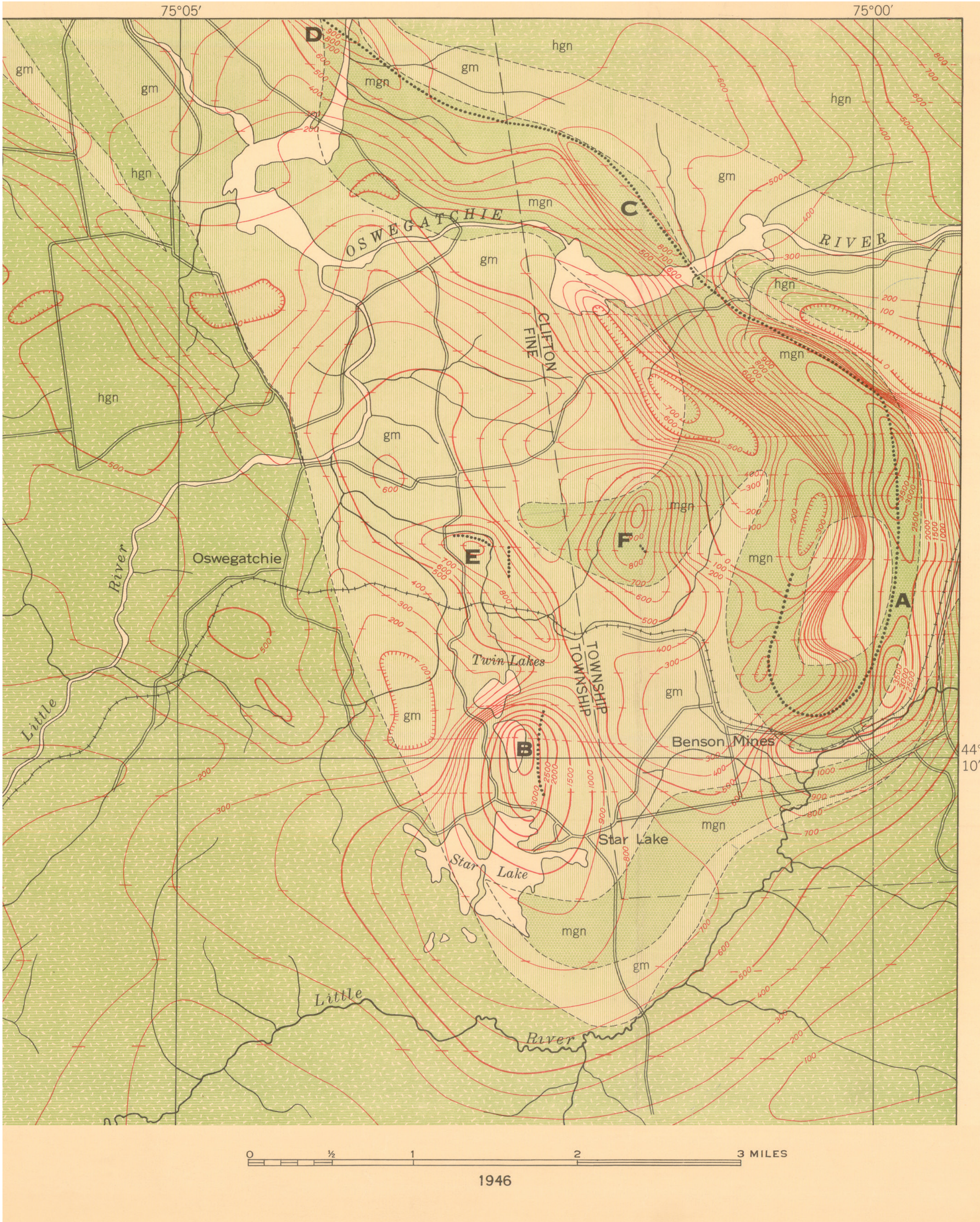
Late in the summer of 1946, as USGS personnel continued their work in Alaska, Secretary Krug appointed a committee to examine the often troubled relationship between the USGS and the USBM. The committee recommended assigning to the USGS the functions of physical exploration for and the evaluation of mineral resources. Krug agreed and ordered the shift, effective July 1, 1947. Reassigning these functions to the USGS required adjusting the agency to merge broad-gage mapping and research on mineral deposits with the two new responsibilities. On July 23, 1946, Congress and the President agreed to amend the act of June 7, 1939, to provide for acquiring and retaining additional stocks of certain deficient or insufficiently developed strategic and critical materials, and encouraging their conservation and development from U.S. sources, to prevent "a dangerous and costly dependence"[116] on foreign supplies during national emergencies when the lack of these resources would detract from the common defense. For these purposes, the new law authorized the USBM and the USGS "to make scientific, technologic, and economic investigations" concerning the "ores and other mineral substances found in the United States or its Territories or insular possessions,"[117] with the goals of determining inadequacies in domestic sources, devising new methods for utilizing low-grade ores, and developing substitutes. In September, Bradley set up a committee of geologists, drawn from the field and administrative staffs of the Geologic Branch, to make specific recommendations.

On October 30, 1946, Acting Secretary Oscar Chapman transferred the USBM's Division of Geophysical Exploration back to the USGS, its home during 1936–42. In the USGS, the ex-USBM Division's "functions, personnel, equipment, property, and office space"[118] became, as of November 15, part of the Geologic Branch's Section of Geophysics.[119] Henry Joesting replaced Balsley (effective March 25, 1946) as Acting Chief of the Branch's expanded geophysics program; the change gave Balsley more time for research. In the Geophysics Section, Joesting and Balsley worked in and from the Army Map Service's building in Washington; Balsley led the section's airborne-surveys unit, while Joel H. Swartz, at the Baltimore office, directed the ground-surveys unit. Joesting's Section received $150,000 for a year's work, of which $105,000 supported magnetometer surveys, but he estimated on August 7 that the Section would require at least $334,000 in subsequent fiscal years.

In other administrative changes within the Geologic Branch, Bradley and Wrather combined the Section of Chemistry and Physics and the Section of Petrology to form a Section of Geochemistry and Petrology on April 30, 1947. They returned Waldemar Schaller and Clarence Ross, at their requests, to full-time research and designated F. Earl Ingerson, who shifted to the USGS from the Carnegie Institution of Washington's Geophysical Laboratory, as Chief of the new Section. Edwin McKnight replaced Charles Park, Jr., as Acting Chief of the Geology of Metalliferous Deposits. Ralph Van Alstine succeeded Josiah Bridge as head of the Geology of Nonmetalliferous Deposits.

The Geologic Branch managed for its activities during fiscal year 1946–47 a total of about $3,114,000, nearly two-thirds of which Congress appropriated directly to the USGS, for salaries and operations by its staff of 446 full-time and 35 part-time members as of June 30, 1946. Three Federal sources—the War Department, the Bureau of Reclamation, and the State Department—supplied $958,000 of the outside funds that totaled nearly $1,114,000. During the 1946 field season, Geologic Branch scientists conducted 45 major metals-related projects, about two-thirds of them on deposits of copper, iron, lead, and zinc that emphasized lead and zinc. To support and extend the ground-based studies of geology and iron deposits in the Lake Superior region resumed by Harold James in the Iron River-Crystal Falls district in December 1945, James Balsley's team began aeromagnetic surveys of several counties in Michigan's Upper Peninsula west of Marquette. Balsley and Arthur Buddington also planned to continue their study of New York's Adirondacks region, augmented by aeromagnetic surveys extending those begun in 1945. Nonmetallic mineral deposits investigated during 1946–47 included fluorspar, pegmatites, and high-alumina clay. Ralph Van Alstine and other Branch geologists continued wartime studies of fluorspar in seven States, many in cooperation with State organizations and the USBM. Investigations of pegmatites containing beryllium, feldspar, lithium minerals, mica, and tantalum, also begun during those years, were now curtailed, but USGS geologists completed reports on these deposits in six States and advanced the remaining reports. Branch geologists also continued field surveys designed to aid the search for new deposits of talc. Some of the $343,000 the Geologic Branch received from the USBR supported five projects—three on major metallic mineral resources, one on nonmetallic mineral resources, and one on construction materials—in the Missouri River Basin as part of Interior's development program.

Early in 1947, the U.S. Atomic Energy Commission asked the USGS to plan a project aimed at increasing the reserves of uranium ore in the United States. In April, as the Senate finally confirmed David Lilienthal as AEC Commissioner, USGS geologists Richard Fischer and Arthur Butler, Jr., submitted a two-part scheme based principally on Fischer's graduate studies at Princeton of sedimentary ore deposits in the Southwestern United States and especially those on the Colorado Plateau. During 1939–45, Fischer led USGS work on vanadium in Colorado and Utah. He also assessed global uranium resources for the OSRD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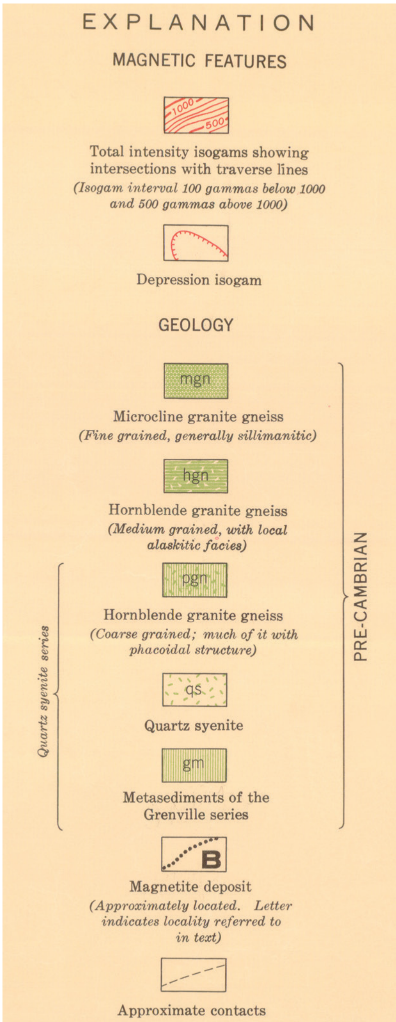
River
Twin Lakes
Benson Mines
Star Lake
Star
Lake
Little
River
A
B
C
D
E
F
hgn
gm
mgn
0
½
1
2
3 MILES
1946



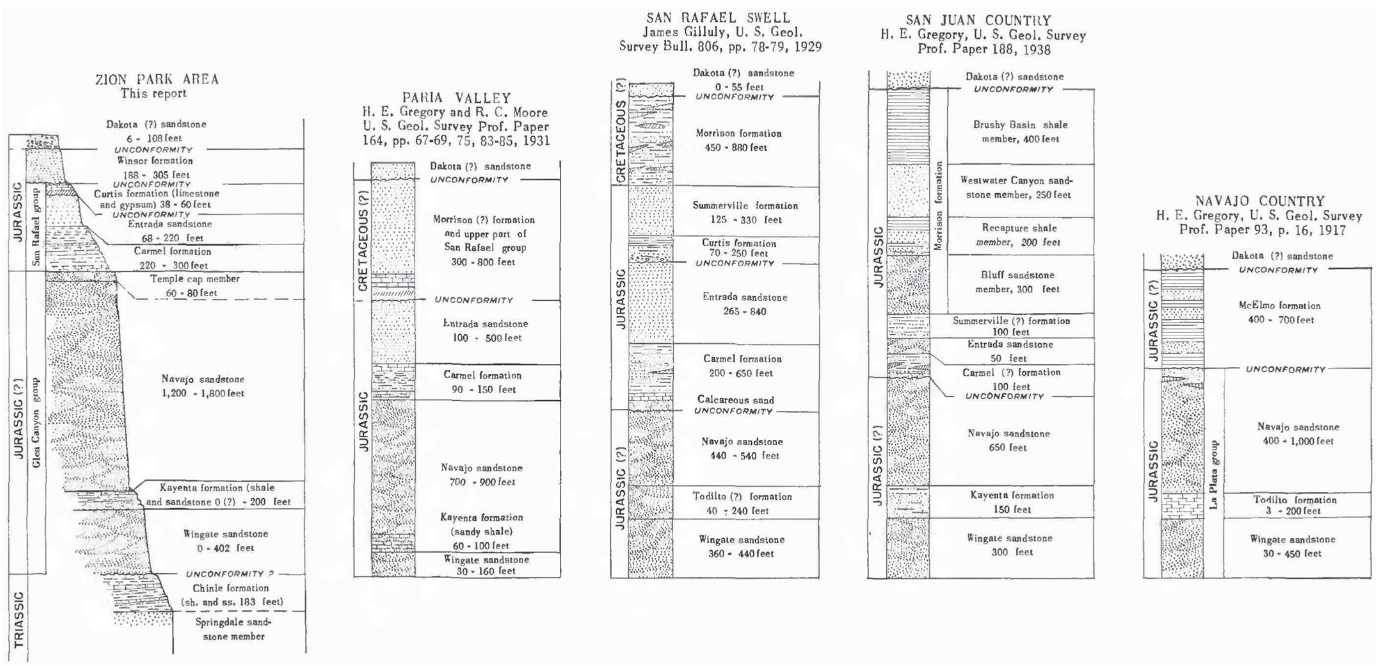
This aeromagnetic map (originally at 1:31,680) shows the total magnetic intensity (in isogams) at an elevation of 1,000 feet above the surface for a portion of the Oswegatchie quadrangle of St. Lawrence County in north-central New York. In May–June 1945, USGS geophysicists James Balsley, Jr., Cleaves Rogers, and Darwin Rossman, with E.M. Canfield of the Aero Service Corporation, conducted east-west traverses, at quarter-mile intervals (for the northern half of the mapped area) and half-mile intervals (for the southern half) of about 3,170 square miles of magnetite-bearing rocks in the Adirondacks of northern New York. William Dempsey (Sr.), Herbert Hawkes, Jr., Mary Hill, and Jack L. Meuschke compiled the magnetic data. Arthur Buddington and Benjamin Leonard provided the geologic base map, by which Balsley's team ground checked their magnetic data. They concluded that the "high-intensity anomalies and strong magnetic gradients" correlate closely "with most of the strong anomalies on the surface" and the "broad magnetic trends" correlated "with regional geological features." Magnetic anomalies shown by symbols on this part of the map include: Benson Mines (A), Twin Lakes (B), Benson Mines Extension (C), Skate Creek (D), Twin Lakes Stream (E), and Anderson (F). The map was the first published in a new series of USGS Geophysical Investigations (GP) Maps. (From Balsley, Rossman, and others, 1946.)

in 1942, contributed to the USGS report to the MED in 1943 that described the vanadium-uranium deposits in carnotitic sandstones on the Colorado Plateau as the only known U.S. occurrences with "significant potential," and emphasized examinations of uranium deposits after May 1944 at the MED's request. For the Army Engineers in 1945, Fischer aided examinations of German ores and their uses and assessed that country's engineering and military geology sites, work, and personnel. Fischer and Butler now suggested a renewed program of exploration to be guided by geologic information already gained and by new field surveys that would be supplemented by Geiger scintillation counters to detect and measure radiation. They expected the contract diamond drilling to yield a ton or more of ore reserve for each foot drilled in areas of significant radioactivity that were not near known deposits.

The Geologic Branch's Colorado Plateau Project, supervised by Richard Fischer, began expanded operations in June 1947 from the Naturita field station, about 60 miles south of Grand Junction. Between June and November, geologists Alfred L. Bush, Frederick W. Cater, Jr., Lawrence Craig, Donald H. Kupfer, and Lorin R. Stieff joined the project. Late in the summer, USGS topographers began mapping 18 quadrangles at a scale of 1:24,000 as bases to facilitate geologic mapping, exploration, and mining operations, as well as topical and other related supporting studies. Those efforts, including drilling, continued through the fall and winter. USGS geologist Lowell S. Hilpert arrived at Grand Junction in March 1948 and directed all drilling exploration for the Colorado Plateau Project to 1954.[120] By the spring of 1948, Richard Fischer's staff, most of them new hires, grew to a total of 30 geologists. The Branch's evaluation of domestic resources of fissionable materials on the Colorado Plateau and elsewhere in the Southwest quickly encompassed fieldwork in 32 States on some 100 uranium minerals in black shales, carbonates, coals, oxides, phosphates, silicates, and other occurrences. Reconnaissance investigations of statewide areas successfully delimited locales that warranted detailed study. Research on the geophysical and geochemical properties of these materials, conducted in the field and the laboratory, yielded refined techniques of exploration and detection. Branch personnel also began long-range research on the properties of uranium and other fissionable materials.

On May 3, 1946, as the USGS continued its studies of domestic fissionable materials, President Truman's Executive order[121] terminated the Petroleum Administration for War (PAW) and transferred its funds, personnel, property, and records to Interior's Oil and Gas Division established by Secretary Krug's order on May 6.[122] Krug, responding to Truman's request for advice to the Army-Navy Petroleum Board, founded within Interior on March 29, 1947, a Military Petroleum Advisory Committee.[123] To chair the new Committee, Krug chose Max W. Ball, who led the USGS Land Classification Board's Oil Section during 1910–16, left the petroleum industry in 1944 to serve as Ralph Davies' special assistant in the PAW, and replaced Davies as head of Interior's Oil and Gas Division when Davies returned to industry 2 years later.

As part of USGS investigations of fuels during fiscal year 1946–47, members of the Geologic Branch continued regional geologic studies in 28 States to advance the intensified search for new supplies of oil and gas, aided by the airborne-magnetometer surveys by Balsley's team, mostly in cooperation with Commodore Greenman's Office of Naval Petroleum and Oil Shale Reserves (ONPR), of some 70,000 square miles over potential oil-producing areas in northern Alaska, Wyoming, New Mexico, and the Gulf of Mexico Coast. In additional collaboration with Greenman's office and with the USBM, Branch geologists reexamined the oil-shale deposits on Naval Oil Shale Reserves Nos. 1 and 3 in western Colorado to appraise the potentials and reserves of these possible substitutes for liquid petroleum. Locating much larger than anticipated resources of shale oil emphasized the need for additional similar work in large, essentially unsurveyed, areas of oil shale



Geologist Herbert E. Gregory (Yale University and USGS) compared this sequence of Jurassic strata in the Zion National Park region of southwestern Utah and northwestern Arizona, shown on the far left of the correlation diagram, with equivalent sections in four adjacent regions in Utah that he, James Gilluly, and Raymond Moore measured and published during 1917–38. Gregory's and related regional correlations in adjacent parts of Utah, Arizona, Colorado, and New Mexico by other USGS geologists became increasingly important by providing regional-framework data after World War II as the USGS expanded its searches for uranium in the Morrison Formation and other Mesozoic strata on the Colorado Plateau. (From Gregory, 1950, fig. 25; for his correlation of Triassic formations between Zion Park and three adjacent regions, see fig. 24.)

throughout the Rocky Mountains and elsewhere. Low-rank coals were investigated as other potential sources of petroleum substitutes. Branch scientists also sought, largely in cooperation with the USBM, new supplies of coking and special-purpose coals in Alabama, Colorado, Georgia, Maryland, and Washington.

Funds from other Federal and State agencies partly supported the Geologic Branch's systematic geologic surveys and some of its special projects. Branch geologists completed maps of 13 quadrangles, depicting about 1,650 square miles, in Massachusetts and Rhode Island, and other areas in Montana, North Dakota, and Wyoming; mapping continued in another 28 quadrangles in these States and in New Mexico and Texas. In smaller scale efforts, they completed the 1:500,000 geologic map of South Dakota and continued work on a similar map of Montana. Special projects included a study of shoreline changes in Massachusetts, where the great storms of 1944–45 damaged much property, and a study of selenium occurrences in South Dakota's bedrock to delineate belts of concentrated amounts of that element poisonous to grazing stock. Edwin B. Eckel recruited Clifford Kaye and other geologists for his Engineering Geology Section, based in Denver. Eckel's geologists made detailed engineering studies of four quadrangles in North Dakota and began work on reservoir sites, landslides, mine waters, and several kinds of subsurface data of special interest to construction engineers. In cooperation with the Public Roads Administration, they also began special engineering soil maps of specific areas and systematic studies of the physical properties of rocks.

In fiscal year 1946–47, members of Eckel's Engineering Geology Section, Van Alstine's Geology of Nonmetalliferous Deposits Section, and other units in the Geologic Division also continued to cooperate closely with the Bureau of Reclamation's engineers, especially in mostly USBR-funded studies of the Missouri River Basin. Donald H. Dow, David Larrabee, and Stephen E. Clabaugh completed in 1945–46 their four-part overview, at 1:250,000, of the Missouri Valley region's minerals, fuels, and construction materials. Larrabee contributed to most of the subsequent preliminary maps, published during 1946–48 at 1:500,000 and at smaller scales, of these commodities in Colorado, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming. The other authors of these maps included Clabaugh; Robert Bryson; Wilbur Burbank; Virginia P. Byers, Frank's wife since 1945; Helen L. Cannon; Frederick Cater, Jr.; Frederick M. Chace; Elizabeth C. Fischer, who married William C. Overstreet in 1955; Elinor L. Fox; Wallace R. Griffitts; Allan Griggs; George S. Hilton; Lyman Huff; Maxwell M. Knechtel; Medora H. Krieger; Edwin McKnight; Virginia Neuschel, Sherman's wife since 1937; Ralph W. Richards; Andrew F. Shride; Helen D. Varnes, David's wife since 1943; and Robert A. Weeks.

Wrather and Bradley expected the activities of the Military Geology Unit (MGU) and its 125 members to terminate at war's end, but the Army Engineers provided funds to expand the MGU's gathering of terrain and related intelligence. In March 1946, Secretary of War Patterson expressed to Interior Secretary Krug "the sincere appreciation of this department for the outstanding cooperation furnished by the Military Geology Unit" and described the MGU's success as "an outstanding example of the feasibility of converting existing competent peacetime groups overnight to important adjuncts of the war effort without altering their administration." Secretary Patterson hoped that the MGU would "continue to function in its specialized field of intelligence, so as to provide peacetime data as well as to maintain a nucleus of personnel as a provision for increased future demands if circumstances should again become acute."[124]

Secretary Patterson's decision led to continued funding by the Army Engineers of the MGU's ongoing work in Japan and Washington and the support of new efforts in the Pacific and elsewhere. At war's end in September 1945, the MGU abandoned its plan to merge its contingent on Oahu with its group in Manila. Half of the Oahu team returned to the United States, and the rest were detailed for duty with the major American ground units assigned to occupy Japan. John H. Wiese and Sherman Neuschel joined Frank Swenson on Okinawa and then accompanied the XXIV Corps in September to Korea, where they briefly examined mineral deposits and supplied advice about construction, transportation, and water supplies in the American zone of occupation before returning to the United States in November. Charles Johnson, Bradley Myers, and John Rodgers went with the 6th Army in September to Japan. There, attached to Engineer battalions, they helped to select quarry sites and locate sand and gravel deposits for airfield and road construction near Sasebo on Kyushu and in the Kyoto-Nagoya-Osaka area on Honshu before reporting in November to the MGU group in Tokyo. Fritiof Fryxell, Morris Austin, John Collins, Allen H. Nicol, Edward Sampson, and Frank Whitmore helped to organize and operate in Tokyo the Division of Mining and Geology, one of five topical divisions in the Natural Resources Section in the General Headquarters of the Supreme Commander for the Allied Powers, and to plan surveys of Guam, Japan (including Okinawa), and Korea.

The Natural Resources Section, established on October 2, 1945, under Lt. Colonel Hubert Schenck, was designed to inform and advise General MacArthur and his headquarters staff on all matters relating to agriculture, fisheries, forestry, and mining and geology in Japan and Korea. Fryxell served in the Natural Resources Section until October 25 and returned to the United States in November. Fryxell carried with him a memorandum of appreciation, from Major General Hugh Casey, now Chief Engineer of the Army's Far East Command, recognizing Fryxell's fieldwork in the Philippines and his leadership as Director of the Intelligence Division's Research and Reports Branch. When Fryxell resumed teaching at Augustana, he agreed to continue on a part-time basis with the MGU. Arthur Spillers, now a Lt. Colonel, directed charcoal production and the other work of the Section's Forestry Division before also returning to America for demobilization. John Collins led the Section's Mining and Geology Division, including the Engineering Geology, Fuels, Metallurgy, Minerals, Mineral Economics, and Water Resources Branches, and its MGU personnel until Thomas Hendricks arrived on December 6.

The work of providing commodities essential to sustain the Japanese people and meet the needs of the occupation forces quickly involved the specialists of the Natural Resources Section and its Mining and Geology Division, augmented by commodity and other geologists, in surveys of fertilizers, coal, and other fuels. The Division gathered basic data on all metals, minerals, and petroleum to supply information on potential exports, imports, and reparations for the Paley Commission and participated in the Section's extensive study of Japanese research in the field of natural resources, particularly during the war years, to prepare comprehensive reports for future use.[125] An OSRD-led census determined that the Japanese sent about 150 geologists to study mineral resources, fuels, and construction materials, but not terrain, on the South Sea islands, in Manchuria, and in northern China. On December 16, 35 Japanese earth scientists, including 9 specialists in economic and mining geology, attended a joint meeting Schenck arranged at the University of Tokyo's Geological Institute, at which Schenck, Hendricks, Ladd, Sampson, and Whitmore presented papers. Quentin Singewald relieved Hendricks in Tokyo in the spring of 1946 when Hendricks joined the second round of the Paley Commission's travels in China. The Division of Mining and Geology also served as a conduit to provide other specialists to the Natural Resources Section, when scientists from other Federal agencies were transferred to the USGS and then sent on military orders to serve in the Section's Agricultural and Fisheries Divisions. The U.S. Department of Agriculture (USDA), as an additional cooperative effort with the USGS, established within the Soil Survey of the Soil Conservation Service, a World Soil Geography Unit at USDA facilities in Beltsville, Maryland. The new Unit, led by Arnold C. Orvedal, functioned as part of the MGU, with funds transferred by the USGS from those the agency received from the Army Engineers, to supply the soils portions of strategic-intelligence reports while also preparing a global-soils map.

Frank Whitmore succeeded Esper Larsen 3d as Chief of the MGU on July 1, 1946. While still based in Tokyo, Whitmore field checked terrain-intelligence reports, located construction materials for airfields and other sites, and compiled information on Japan's wartime gold and silver production. He then spent 2 months surveying landing beaches, ports, and highways in the southern part of Korea on assignment to the Office of the Engineer in the XXIV Corps and participated in field critiquing USGS Strategic Engineering Study (SES) 149 that assessed the peninsula's terrain. Whitmore, as Geologist in Charge of the MGU (later Section and then Branch), inherited a unit of experienced scientists and support personnel, although one significantly reduced in numbers as some members returned to academia and other prewar employers. The MGU continued to generate terrain intelligence for the U.S. military and conduct geologic mapping and engineering-geology field studies almost worldwide. In December 1946, Whitmore announced the MGU's shift "to field investigation, and the peacetime applications of military geology" to gather "first-hand information" on "economic data in occupied countries as a basis for reparations settlements" and "to prepare geologic maps of military areas" in the United States "and abroad for use in military construction work."[126] The USGS and the Army Engineers, he reported, already conducted this research in Japan, Korea, Okinawa, and the Philippines and planned for additional work in other areas of the Pacific region. Charles Johnson noted that field checks were completed for the MGU's terrain-intelligence reports for Korea, Okinawa, Hokkaido, Honshu, Kyushu, Leyte, Luzon, Panay, and Samar.[127]

As of January 13, 1947, Whitmore's unit, restyled the Military Geology Section (MGS), comprised four principal subdivisions. Geoffrey Bodman, Donald Dow, Lincoln Dryden, Fritiof Fryxell, David Gallagher, Montis Klepper, William Putnam, Louis Ray, Edward Sampson, and 17 other specialists in strategic and related studies served in Charles S. Denny's Terrain Intelligence Research Group. Gilbert Corwin, Delos E. Flint, F. Stearns MacNeil, Raymond A. Saplis, and three other specialists formed Sherman Neuschel's Pacific Islands Mapping Group. John Collins, Lowell Hilpert, and seven other specialists served in the Japanese Mineral Resources Survey. James Balsley was the senior member in Special Projects, the fourth group, whose staff also included Arthur D. Howard, Earl Irving, and Joshua Tracey.

During 1946–47, Whitmore's MGS continued its work in the Far East, the conterminous United States, Alaska Territory, and Europe. Members of the large MGS contingent in the Natural Resources Section's Division of Mining and Geology in Tokyo prepared additional terrain reports, reviewed the Japanese literature from 1920 to 1940 about terrain in Japan, and studied some 40 specific mineral commodities, metallurgical plants and processes, potential sites for airfields, construction materials, ports, predictions of volcanism, and water resources of cities and specific areas in Japan and Korea. In Seoul, David Gallagher advised the Director of the Geological Survey of Korea (GSK) and Institute of Mining Technology; he also led a MGS field team that included Montis Klepper, William C. Overstreet, Raymond D. Sample, and their GSK counterparts. They located pyrophyllite used for DDT dust to control the spread of typhus-bearing lice and evaluated southern Korea's coals, gold, tungsten, and other mineral resources. MGS geologists Robert Laurence (in 1946) and then Earl Irving (1946–57), assigned to the General Engineer District in Manila, surveyed construction materials used to aid the rebuilding of the city and those elsewhere on Luzon, studied the groundwater resources of nearby Nichols Field, and cooperated with the Philippine Bureau of Mines to reestablish programs designed to map geology and explore for mineral deposits in the newly independent Republic.

Elsewhere during 1946–47, MGS members prepared four Joint Army-Navy Intelligence Studies of the mineral and water resources and construction materials of Argentina, south-central China, the European part of the Soviet Union, and Turkey. They also completed a large number of Special Reports and Miscellaneous Papers for the JCS, the Army Engineers, and several other organizations. Their efforts included terrain analyses and permafrost studies of four specific areas in Alaska, by Maxim Elias, Robert Wallace, and their colleagues; of clay deposits in the Virgin Islands; of Guam's geology and water resources; of trafficability and airfield sites in westernmost China's Sinkiang (Xinjiang) Province; and of cross-country movement in the Caucasus, as part of a projected global-trafficability map. To help U.S. armored-forces training, the MGS also completed a special terrain-intelligence folio of Kentucky's Fort Knox Military Reservation and vicinity for the Office of the Chief of Engineers. Louis Ray, who served with Esper Larsen 3d as a consultant to the Army's Armor Board, led a ground-studies team that included Arthur Butler, Jr., Charles Denny, Arthur Howland, and Marion Striker. The completed but unnumbered folio included map sheets describing the construction materials, geology (at 1:50,000, with a columnar section on a separate sheet), soils, terrain, and trafficability of the area. The MGS planned a similar study of Virginia's A.P. Hill Military Reservation but, at the Army Engineers' request, shifted to work on a folio about Fort Benning, Georgia, to aid infantry training there. Responding to an appeal from the Engineer Board at Fort Belvoir, Virginia, the MGS also started compiling a training manual for military geology. In Europe, MGS personnel continued fieldwork for a report about Austrian and German oil fields.

The MGS Pacific Islands Mapping Group, later also known as the Pacific Geologic Mapping Program,[128] began operations in April 1946, sponsored by General Casey's office in the Army's Far East Command. Sherman Neuschel, who arrived in Tokyo in December 1946 to lead the new group, reported to Brigadier General Herbert Loper, the Chief of Casey's Intelligence Division. The group's staff, housed initially in Casey's headquarters, later moved to the facilities of the Army Map Service-Far East in one of Tokyo's northern suburbs. The Army Engineers were responsible for constructing and maintaining bases in the western

Pacific, including those on or planned for the former German islands subsequently held by Japan under a League of Nations' mandate.[129] The State Department expressed to the Chief of Engineers its interest in a geological survey of these islands, concentrating on their economic value. Chief of Engineers Eugene Reybold, a Lt. General since April, sought and received for the mapping a delegation of authority on September 27, and an approval on October 3, from the War Department's General Staff. Reybold retired on September 30; Lt. General Raymond Wheeler, who attended the Japanese surrender ceremonies at Singapore, replaced Reybold on October 4. Existing funds, General Wheeler decided, would cover the new group's efforts; he transferred them under the agreement with the USGS for fiscal year 1945–46 and continued the work as part of the understanding for fiscal 1946–47 signed on August 28, 1946.

Harry Ladd suggested that long-term geologic mapping of the islands of the Western Pacific, with emphasis on the mandated islands, be conducted in two phases. Initially, the Army Engineers would provide $600,000 for and supervise the new group and its program, but then USGS appropriations would provide $1 million each year for the next 10 years. The program would produce military geology studies for each island or group of islands, with maps at scales of 1:25,000 or 1:50,000, published by the Engineers. To the program's primary geology and soils components would be added botanical, climatological, hydrologic, marine-geology, and mining studies; some of them would be published by the USGS. In January 1946, Ladd arrived in Tokyo on his tour of inspection. He discussed his scheme with General Loper and other officers on General Casey's staff before visiting Okinawa, Guam, and several of the other targeted islands, and participating in Operation Crossroads. While Ladd traveled, General Wheeler asked the War Department, through General MacArthur, to implement the mapping program. Casey and Loper approved continuing the group's initial work on Okinawa.

MGS personnel in Japan compiled from the literature a preliminary special report on the mineral resources of the former mandated islands, but the USGS did not have sufficient geologists in the Far East to conduct the island-mapping program. Thomas Hendricks placed a note in the Army's *Pacific Stars and Stripes* asking geologists in uniform in the Pacific to request their service discharges in Japan and then join the demonstration project on Okinawa, now being developed as a principal American military base. USAAF Major Warren F. Fuller and 2d Lieutenants Harold W. Burke and Gilbert Corwin and Army 2d Lts. Delos Flint and Raymond Saplis did so. Corwin also arranged to drive Ladd around Okinawa. In April 1946, initial field-party chief John Rodgers, Burke, Flint, and Fuller began mapping Okinawa's 454-square-mile area and its manganese, sulfur, and other mineral deposits. In September, Saplis and Corwin joined the USGS team based at Naha. By January 1949, geologists McClelland G. Dings (also chief), Maxim Elias (also chief), Samuel S. Goldich, Stearns MacNeil (also chief), Allen Nicol, and Henry S. Sharp served on Okinawa. Clarence S. Coleman, Roy W. Simonson, Carl H. Stensland, Edward H. Templin, Joseph H. Vaden, and Raymond Zarza investigated the island's soils and forests while detailed from the World Soil Geography Unit. The combined resident team completed its report on the reconnaissance and detailed mapping of Okinawa during May 1949.

While MGS fieldwork continued on Okinawa, Josiah Bridge, Acting Chief of the Geologic Branch's Geology of Nonmetalliferous Deposits Section, and Arthur Piper, still leading the Ground Water Division's Pacific Coast operations, spent 6 months from April 1, 1946, looking at the mineral resources and water supplies of the Western Pacific islands formerly mandated to Japan. Their work formed part of an economic-appraisal expedition for the Navy by the U.S. Commercial Company, a subsidiary of the Reconstruction Finance Corporation. The MGS' work in Micronesia expanded to the Palaus and to Yap in 1947, and the MGS' special report on Guam's geology and water resources appeared that year. Charles Johnson and

Samuel Goldich gave special attention to the bauxite deposits on Babelthuap (now Babeldaob). Johnson then started studies on Yap and other islands, aided by Preston Cloud, Jr., Collins, Corwin,[130] Julia Gardner, Arnold C. Mason (also chief), and Henry Sharp, until work ended in November 1948. USDA soils scientists Paul O. Elmquist, Ralph C. McCracken, Roy Simonson, and Edward Templin participated in these surveys.

While mapping continued on West Pacific islands, the Geologic Branch expanded southward the geographical frontiers of its studies, this time to Antarctica. James Balsley and Arthur Howard, both still with the Military Geology Section's Special Projects Group, participated in the U.S. Navy's Operation Highjump on and over the southernmost continent during December 1946–February 1947. Earlier in 1946, the Navy's Operations Frostbite and Nanook, the latter led by Captain Richard H. Cruzen, began America's postwar missions in the polar regions by briefly examining portions of the Arctic. The Navy intended its next and larger effort, as Lisle A. Rose described in 1980 in "Assault on Eternity," principally to test men and equipment in another cold environment, to gain information useful for locating sites for airbases and other bases on Antarctica, and to acquire experience for future similar operations on Greenland. The Navy also planned to win its second bitter struggle with the Army over the future of naval aviation, now linked to the proposed national defense establishment. Operation Highjump would show how well the Navy could project power into the southernmost seas to meet cold war threats in those waters and future defense commitments under a proposed new treaty for mutual aid in the hemisphere. Truman attended the signing, at Rio de Janeiro on September 2, 1947, of the Inter-American Treaty of Reciprocal Assistance. The treaty formalized the recommendation in 1945's Act of Chapultepec to consider an armed attack by any nation against one American country as an assault on all of them and to provide the means to respond accordingly.

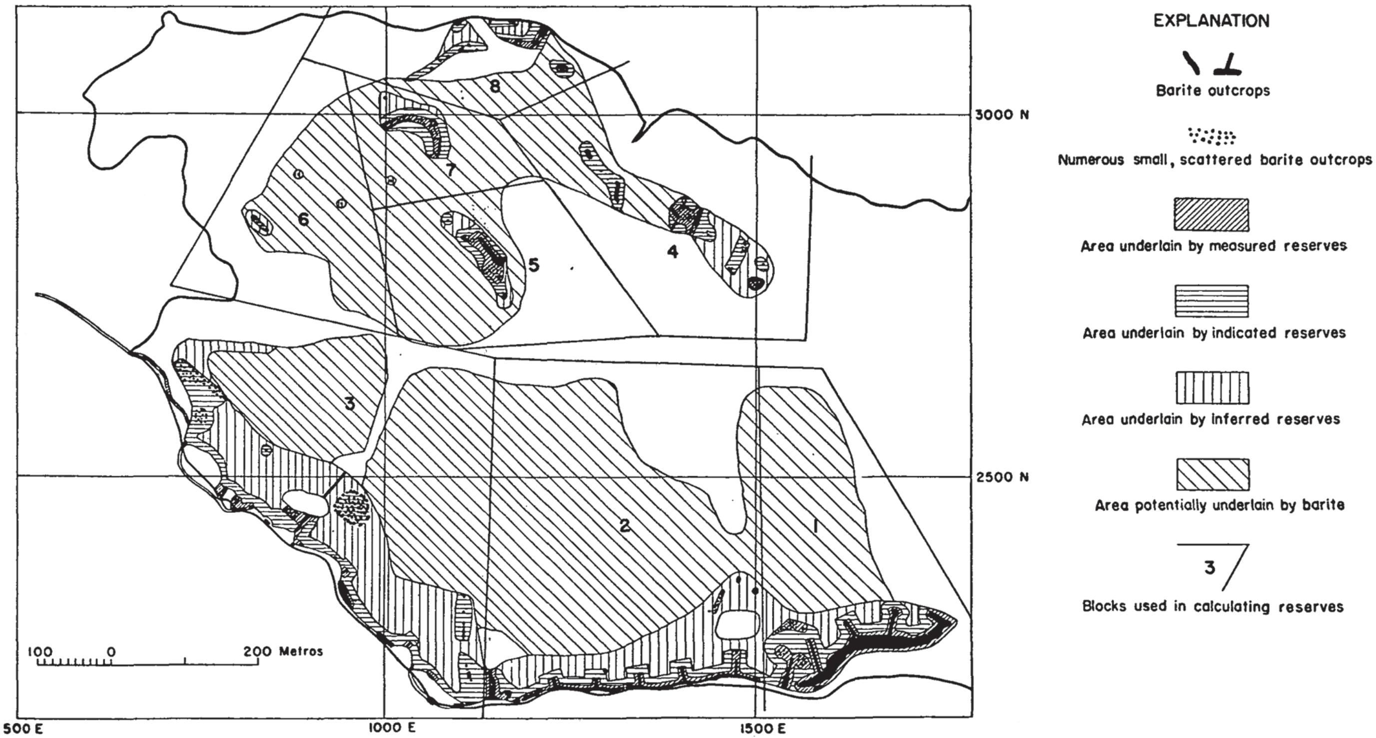
The Navy also intended its Operation Highjump to Antarctica during the austral summer of 1946–47 to increase reconnaissance and mapping coverage of the continent in support of strengthening and expanding the United States' dominion over the greatest possible expanse.[131] During 1907–43, Britain, for itself and for Australia and New Zealand, Chile, France, and Norway, claimed swaths of Antarctica; several of these areas overlapped, and their boundaries remained in dispute. On December 14, 1946, Under Secretary Acheson informed Secretary Forrestal that he approved new, but as before unannounced, claims on Antarctic lands not previously seen by U.S. personnel and those already claimed by other nations. The new paper claims would be placed in brass containers and the time and location of their deposit carefully recorded. The Navy also planned to prospect by air for uranium and other radioactive-mineral deposits, as part of studies of aerology, cosmic and solar radiation, electromagnetic propagation, general geology, geography, hydrography, and meteorology. On August 26, 1946, orders from Secretary Forrestal and Admiral Nimitz, now Chief of Naval Operations, established the Navy's Antarctic Developments Project, led by Rear Admiral Richard E. Byrd (Jr.), the younger brother of Senator Harry Byrd (Sr.) and a veteran of three expeditions to the southernmost continent since 1928–29,[132] and aided by an interagency committee in Washington. Cruzen, now a Rear Admiral, commanded the 4,700 men and 13 warships and support vessels of Task Force (TF) 68; he also led TF 68's Central Group from his flagship *Mount Olympus*. Captain George J. Dufek and Captain Charles A. Bond led, respectively, TF 68's Eastern and Western Groups; like Cruzen, they also were veterans of Byrd's earlier Antarctic expeditions.

As on Byrd's earlier expeditions, civilian scientists accompanied Highjump's Navy and Army personnel, although Admiral Cruzen thought these 24 specialists were superfluous. Paul A. Siple, a biologist turned geographer, veteran of several of Byrd's Antarctic expeditions, and Lt. Colonel in the Army Quartermaster

Corps, participated in Highjump as a scientific adviser to the General Staff's Chief of Research and Development. Howard and half of the scientists accompanied Cruzen's Central Group ships. Delayed by an unexpectedly wide and thick ice pack, Cruzen's ships, led by Coast Guard icebreaker *Northwind*, did not reach the eastern part of the Ross Ice Shelf until January 15, 1947. There, the accompanying Seabees built Little America IV and its landing strip for fixed- and rotary-wing aircraft. On January 23, the Eastern and Western Groups began explorations and overlapping mapping by trimetrogon photogrammetry of coastal regions from six Martin PBM Mariner seaplanes based on the tenders *Pine Island*, stationed off the eastern coast of Marie Byrd Land, and *Currituck*, deployed off the coast of Wilkes Land. Seven days later, Byrd's party, including Balsley,[133] flew into Little America IV in the six-wheel and ski-equipped R4D Skytrains, launched with jet-pack assistance from the new fleet carrier *Philippine Sea*. Admiral Cruzen took his three remaining ships, their crews, and Howard, out of the Ross Sea on February 6.

The first of 28 mapping-sovereignty flights from Admiral Cruzen's Central Group base over coasts and inland began on February 13, 1947, but space on these missions remained at a premium. A week later, Balsley got only a brief notice for his initial flight.[134] He quickly removed his magnetometer from one R4D and tied it down with ropes in another R4D piloted by Major Robert R. Weir. This aircraft, whose eight-man crew also included *New York Times* correspondent Walter Sullivan, flew east from Little America IV toward King Edward VII Land. When the trimetrogon cameras tripped at regular intervals, Balsley marked these events on the magnetometer's paper-roll record to match them to the photographs of strips 20 miles wide by 100 miles long. The R4D crossed the Alexandra Mountains and La Gorce Peak before turning south toward the Rockefeller Mountains and returning over Roosevelt Island to the base. While struggling for higher altitude to clear one of the ranges, Weir suggested that they lighten the load by jettisoning the magnetometer; if so, Balsley replied, they would have to throw him out as well. Balsley's intensity records indicated the locations and approximate depths to igneous or metamorphic rocks with magnetic minerals, confirming some earlier geologic observations on the ground by Laurence M. Gould, who served on Byrd's initial expedition, but the lack of such readings suggested nonmagnetic sedimentary rocks. The next day, as Weir's R4D flew south across the Ross Ice Shelf, Balsley located four new islands near Roosevelt Island, but his records again demonstrated that the magnetometer could not distinguish ice from nonmagnetic sedimentary rock; securing an accurate profile of the land under the ice required gravity and seismic studies. Byrd, Balsley, Sullivan, and the remaining men, but not the R4Ds, left Little America IV in Navy icebreaker *Burton Island* on February 23. Highjump personnel also left behind nearly 70 new U.S. claims to Antarctic territory.

The Geologic Branch, to handle the increasing requests to detail its scientists to work outside the national domain, founded a formal unit for foreign geology. On January 28, 1946, Bradley changed, as of February 1, John Dorr 2d's Committee for Cooperative Investigations Abroad into the Foreign Section. Dorr transferred at his request to field studies of the geology of nonmetalliferous deposits. As Chief of the new Section, Bradley selected William Johnston, Jr., now returned from Brazil. With USGS statutory authority (since 1938) to work in the American Republics, Johnston's geologists used the State Department's auspices and funds in making cooperative investigations during fiscal year 1946–47 of 14 mineral commodities and helping to train younger colleagues in Brazil, Cuba, Mexico, and Peru. The State Department also provided monies for training grants to two Mexican and two Peruvian students of geology. With Foreign Economic Administration funds, Johnston's geologists studied some of Bolivia's tin deposits and continued work on manganese occurrences in Cuba. The Government of Chile requested and financed a USGS reconnaissance of the mineral deposits of its Southern Archipelago and groundwater studies in the northern and central parts of the country.



This geologic map (originally at about 1 inch = 820 feet) shows barite outcrops and the extent of measured, indicated, inferred, and potential reserves of barite distributed in deposits in Cretaceous sedimentary rocks on Ilha Grande in Camamú Bay, southwest of Salvador, in Brazil's State of Bahia. USGS geologist Alfred Bodenlos examined during March and April 1946 the geology and barite deposits of Ihlas Grande and Pequena, at the request of and in cooperation with members of Brazil's Divisão de Fomento da Produção Mineral, and with the sponsorship of the U.S. Department of State's Interdepartmental Committee on Scientific and Culture Cooperation. At that time, barite was used in manufacturing several chemicals, inert fillers, oil-well drilling muds, and white paint. (From Bodenlos, 1948, fig. 3.)

The Topographic Branch's funds available for fiscal year 1946–47 totaled $6,645,000, about 23 percent more than in the preceding year, for its all-full-time staff of about 1,080 persons as of June 30, 1946. George Whitmore's Division of Research and Technical Control, while preparing new and revising existing instruction manuals for field and office procedures, investigated using electronic methods to establish geodetic control for topographic mapping. Whitmore's staff developed an assembly of electrical circuits set up and adjusted as analogs to networks of traverse or level lines, intending that adjusting surveys by electrical control would give results comparable to those found by mathematical corrections but with much less work. The polastrodial, which rapidly determined mechanically the astronomic azimuth of Polaris, the North Star, at any time and from any latitude, reduced considerably routine traverse computations. The staff evaluated, repaired, and, in some cases, redesigned and made available for experimental use or production captured German photographic equipment, including a relatively distortion free and extremely accurate aerial-camera lens. That lens so far surpassed the best lenses manufactured in the United States that arrangements were made with Bausch and Lomb to manufacture copies. Russell Bean and his colleagues also tested a wide range of plotting instruments. In coordination with other Federal agencies and the Bureau of the Budget, Whitmore's staff also made considerable progress in standardizing cartographic procedures and symbols. His Division's Special Map Section continued work on the International Map of the World, as well as transportation maps for the Public Roads Administration and the revisions of State base maps for Connecticut, Delaware, Illinois, Maryland, Massachusetts, New Jersey, Rhode Island, and Wyoming.

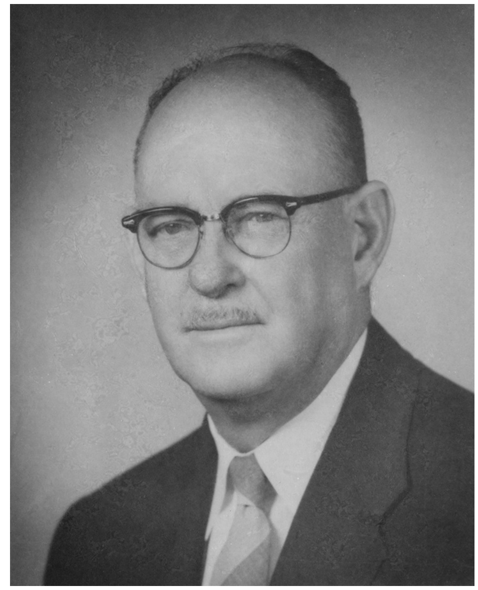
After Gerald FitzGerald's Division of Plans and Coordination reached an understanding with several other Federal agencies regarding their respective spheres of mapping activity, the USGS signed accords with the Bureau of Reclamation, the Coast and Geodetic Survey, the Forest Service, and the War Department. The Army Engineers agreed on October 21, 1946, to continue to support the USGS as the primary domestic mapping agency, under the rubric of utilizing all available

Federal capacity for this purpose before expanding War Department facilities or hiring private firms. The USGS understanding with the USBR, dated January 17, 1947, proposed to eliminate or reduce to a minimum any future special-purpose maps by requiring, whenever possible, that all mapping be done as a direct contribution to the standard-quadrangle mapping of the United States. The USBR would use USGS services in preparing all maps at scales smaller than 1:6,000, preparing specifications for proposed mapping or aerial-photographic projects, and inspecting and testing commercial-contract mapping. The Forest Service, which recently shifted from a policy of mapping irregular areas to one of mapping full quadrangles, agreed to send the material to the USGS for publication. The USCGS and the USGS agreed on March 25, 1947, to consider together devising methods to supply new or additional information on any coastal area of the United States needed by the USCGS in preparing its nautical charts. FitzGerald also reorganized the Map Information Office and broadened the scope of its services. A Survey order, issued on January 2, 1947, set policies with respect to the overall specifications for the accuracy, scales, and contour intervals of USGS standard topographic maps.[135]

On July 1, 1946, the Topographic Branch reactivated its Rocky Mountain Division, with headquarters at Denver and Robert O. Davis temporarily in charge, to provide a "strategically located" operational unit for "much new mapping"[136] in Alaska, Colorado, Montana, and New Mexico. On the same day, all of the Alaskan Branch's topographic mapping activities passed to the Topographic Branch,[137] which founded a Trimetrogon Section, led by John Davidson, to meet the military's continuing demand for aeronautical-chart compilation done by the Alaskan Branch during the war. As "no suitable quarters were available in Denver for the Rocky Mountain unit," Wrather and Michael Straus, now Commissioner of Reclamation, agreed to join their efforts with those of other agencies in seeking congressional support and funds for remodeling buildings in the Remington Arms ammunition plant, built early in World War II about 6 miles west of downtown Denver. Wrather claimed "more space than we needed immediately"[138] in one of the buildings in the proposed Federal Center, to reserve it for use by his other branches. Topographic Branch personnel and equipment occupied a large part of Building 25; the Geologic Branch chose a smaller structure later known as Building 21. On October 1, Davis, who served to Lt. Colonel with the USAAF's Aeronautical Chart Service, was officially appointed the Rocky Mountain Engineer.[139] For the Rocky Mountain Division, Davis now secured Government-surplus office equipment and photogrammetric equipment from the Atlantic Division in Arlington, Virginia, now led by Dallas H. Watson (Albert Pike's former deputy), after Pike's retirement. Also on July 1, as part of a plan to assign the maximum work possible to the four regional divisions (including the Pacific and Central), another Survey order deactivated the Photographic Mapping Section, transferred the drafting and Multiplex units at Clarendon, Virginia, to the Atlantic Division, and shifted the remaining photo-mapping activities to "the Photogrammetry Section of the Technical Staff until such time as these functions can be absorbed by other appropriate units."[140]

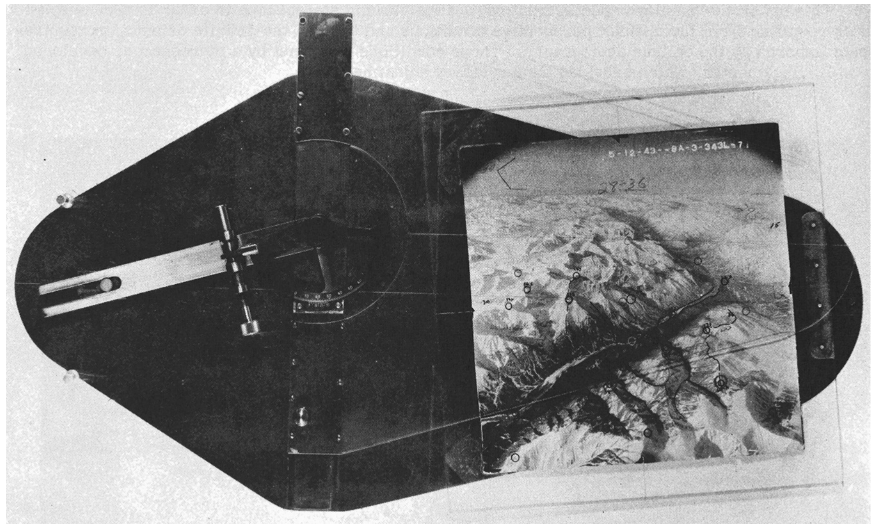
When the war ended, the Topographic Branch resumed large-scale domestic mapping. By the end of fiscal year 1945–46, members of the Branch made field surveys in 35 States, completed mapping 56 quadrangles at a scale of 1:62,500 and 105 quadrangles at 1:24,000, and continued work on an additional 68 quadrangles at 1:62,500 and 109 quadrangles at 1:24,000. They also used photogrammetric methods to make topographic maps of areas covering more than 9,300 square miles and planimetric and base maps of about 10,600 square miles. They also completed a large-scale map of the Naval Oil Shale Reserves Nos. 1 and 3 in Colorado for the Navy Department and continued work on the Snake River in Idaho in connection with Columbia River development.

On May 22, 1947, Krug and Wrather formally advanced Gerald FitzGerald to Chief Topographic Engineer, replacing Thomas Pendleton, whose stroke led



Topographer Gerald Arthur FitzGerald (1898–1981) began serving with the USGS in 1917 and worked in Alaska during most of the interwar years. He led the revisions of Alaskan aeronautical charts before being commissioned as a Major (later Colonel) in the U.S. Army Air Forces (USAAF) in 1942. FitzGerald led the USAAF's Aeronautical Chart Service (1943–45) and earned a Legion of Merit (1946). He returned to the USGS late in 1945, became head of the Topographic Branch's Plans and Program Division in 1946, and succeeded Thomas Pendleton as Chief Topographic Engineer in 1947. FitzGerald and George Whitmore led the Branch's initial postwar reorganization that emphasized improved and new methods of photogrammetry and mapping to increase map production at less cost. FitzGerald retired in 1957. (USGS photograph, Public Inquiries Office 40–13; published in Lyddan, 1983.)

USGS topographer David Landen developed this mechanical topoangulator in 1944 “for use with trimetrogon photogrammetry.” The topoangulator projected “photographic detail into the principal plane for elevation determination” by the transparent-plate projector. A “slide operating parallel to the principal plane of the photograph” actuated the projector and the hairline etched on it. (Quotations and photograph from Thompson, 1958, p. 12 and fig. 10; photograph originally published in Landen, 1945, fig. 4.)



to his retirement on April 1. FitzGerald retained John Staack as his Assistant. George Whitmore’s Research and Technical Control Division included six Sections: Geodesy and Control Surveys (led by Ronald Wilson, whose precision photoalidade helped Charles Fuechsel and David Landen to make practical the trimetrogon-mapping system), Topographic Surveys (Charles Davey), Photogrammetry (Russell Bean), Cartography and Map Editing (Robert L. Moravetz), Special Maps Projects (Oscar Nelson), and Trimetrogon (John Davidson). Robert M. Lyddan’s Plans and Coordination Division comprised four units: Map Information Office (Charles Fuechsel), Plans and Estimates Section (Earle J. Fennell), Production and Control Division (later Section, Roy F. Thurston), and Coordination and Liaison Section (Alfred C. Stiefel). After Staack retired on June 30, Moravetz became FitzGerald’s Assistant Chief, Fuechsel replaced Moravetz, and Jerome O. Kilmartin succeeded Fuechsel.

During fiscal year 1946–47, FitzGerald’s mappers operated in 40 States, in cooperation with 20 of them, the Army Engineers, the USBR, the National Park Service (NPS), and the TVA. They completed coverage of nearly 25,000 square miles, 16,000 of which were mapped at field scales of 1:24,000 or larger. Topographic Branch personnel also finished 45 quadrangles at 1:62,500 and nearly 300 quadrangles at 1:24,000. Published coverage of the conterminous United States at 1:24,000, begun with 3 maps of mining districts (Tombstone in Arizona and Bullfrog and Goldfield in Nevada) in 1906 and 2 urban-area sheets (of Venice and Watts in the Los Angeles Basin) in 1924, remained at 4.8 percent. Work continued at year’s end on an additional 75 quadrangles at 1:62,500 and almost 400 quadrangles at 1:24,000. For the Army Engineers, Branch topographers mapped several areas and established field control for others. The USBR provided the Branch with nearly $720,000 for a major effort to support the USBR’s work in the Missouri River Basin, of which less than 10 percent was covered by topographic maps suitable for water development or other engineering studies. For these purposes, USGS topographers mapped large areas in Montana, Nebraska, North Dakota, and Wyoming. Branch members also completed, at 1:31,680, the resurvey of Massachusetts and revised 55 quadrangles in California’s San Joaquin Valley. For the NPS, they continued mapping Jackson Hole National Monument in Wyoming.

The Topographic Branch’s Trimetrogon Section completed 628,000 square miles of entirely new compilation and another 800,000 square miles of chart revisions in practically every part of the world during 1946–47. Members of the Section made additional studies to determine the feasibility of the method for small-scale mapping of unmapped expanses of the Western United States and aided the mapping of Bikini Atoll for Operation Crossroads. They also planned to generate maps of parts of Antarctica, by using the trimetrogon photographs the Navy took during Operation Highjump, as soon as sufficient ground control became available. Highjump aircraft flew 64 reconnaissance missions over an area estimated to be as much as 700,000 square miles, but they mapped only a tenth of that total, far less than planned, and generated few maps. The lack of oxygen equipment for the R4Ds, without which the planes could not fly above 10,000 feet, and the paucity of geodetic control on the ground prevented prompt use of the operation's 70,000 trimetrogon-photogrammetric records.

During the second Antarctic Developments Project (Operation Windmill[141]) in 1947–48, USGS topographic personnel, flying in Navy HU 35–1 helicopters from the icebreakers *Burton Island* and *Edisto* of Task Force 39, supplied some of the needed geodetic data for selected geographic features. As Under Secretary of State, Robert A. Lovett continued Acheson's policy about extending U.S. territorial claims; a dozen new markers were dropped from Windmill aircraft. Windmill's geologist Earl T. Apfel, of Syracuse University, also served part time with the USGS. Apfel, operating from *Burton Island*, collected and returned nearly 3 tons of rock and mineral specimens from locales along the continent's eastern and western coasts. During the same austral summer, a civilian expedition, led by Captain Finn Ronne, of the U.S. Naval Reserve (USNR) and under contract to the ONR's Geophysics Branch, continued its second year of operations from his *City of Beaumont* in Marguerite Bay on the Antarctic Peninsula.[142] In June 1947, Ronne proposed a 10-year program for U.S. mapping and claims, hoping its results would assist an international settlement of all national claims in Antarctica. Ronne's 1946–48 expedition mapped by air nearly 1.2 million square miles, 50 percent of which was seen for the first time, and claimed some 250,000 square miles. As part of the expedition's scientific work, Robert L. Nichols, a Tufts professor who worked part time with the USGS, studied the geology and geomorphology of the area around Marguerite Bay.

Hydrologist Carl Gustave Paulsen (1887–1961), who joined the USGS in 1913, served as Chief of the Surface Water Division (1931–39) and then Assistant Chief Hydraulic Engineer (1939–46). On March 1, 1946, Paulsen succeeded Chief Hydraulic Engineer Glenn Parker, who had died suddenly on February 12. Paulsen made the Divisions of the Water Resources Branch work more harmoniously and effectively. He led the initial postwar reorganization of the Branch, during which a new generation of Division Chiefs took office. Paulsen retired in 1957 and then served part time as the Delaware River Master. (USGS photograph, Public Inquiries Office 50–13 [1a]; published in Ferguson and others, 1990, frontispiece.)

With the reorganizations of the Geologic and Topographic Branches well underway in 1945–46, Wrather and Nolan turned their attention to improving the administration and work of the Water Resources Branch. There, they faced two principal problems—the proliferation of local offices and a lack of harmony between two of its four main units. In 1928, only 2 years after Congress limited the Topographic Branch's expenditures on its cooperative projects with the States and municipalities to 50 percent of the total of the funds spent by the USGS and the States and municipalities for this work and specified the Branch's dollar amount, the legislators also applied the same restrictions to the Water Resources Branch's appropriation. The funding model required the Water Resources Branch to continue its liaison offices in each State, and suboffices in the larger States, "many situated in localities where they could not be advantageously used by the other divisions [branches]," but the growing demand for groundwater studies required establishing even more of these local offices. Wrather also found that the surface-water and groundwater units "were not working together harmoniously." Philosophical and personal disputes between Chief Hydraulic Engineer Glenn Parker and Oscar Meinzer, Chief of the Ground Water Division, enhanced the units' differences in method, equipment, and personnel. Parker favored providing water data without interpretations; Meinzer, whose own investigations and those of his staff combined geology and engineering, promoted such assessments and encouraged their publication. Nathan Grover, the former Chief Hydraulic Engineer recalled to service with the Branch in 1942, agreed with Wrather's analysis of the problem "in all essential details."[143] The Director's meeting with Parker and Meinzer failed to improve the situation. Wrather planned to make a change after the appropriations hearings in the spring of 1946, but Parker died suddenly on February 12.

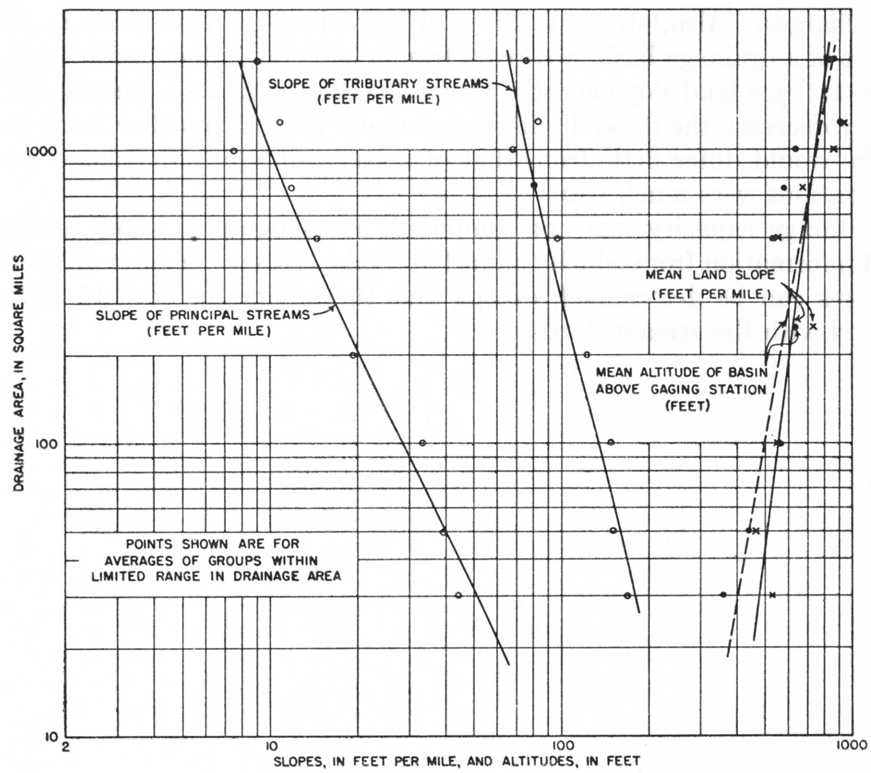
Hydrologist Albert Nelson Sayre (1901–67) joined the USGS Ground Water Division in 1929. Wartime service with the USGS Military Geology Unit and other civilian organizations took him to El Salvador, the Pacific, and a landing with Army units on Leyte in the Philippines. Late in 1945, Sayre began supervising all Ground Water Division operations west of the Mississippi River. Sayre succeeded Oscar Meinzer as Chief of the Division in December 1946, and continued his predecessor's emphasis on scientific geohydrology as the Division tripled its staff size. Sayre retired in 1959 to return to research. (Photograph from McGuinness, 1970.)

Carl Paulsen, Parker's deputy and Acting Chief of the Surface Water Division after Rudolph Kasel died in June 1945, took over as Chief Hydraulic Engineer on March 1, 1946. Paulsen worked to improve Branch cooperation with other Federal agencies and the States. "He and Meinzer got along well together, which paved the way for greatly improved relations between the services." Wrather, Nolan, and Paulsen arranged for "a series of regional conferences,"[144] in which Wrather or Nolan participated, to promote better understanding and cooperation between two of the four divisions. Paulsen strove to make all of the Branch's units work as one. On July 22, Paulsen received responsibility for all water-resources investigations conducted in Alaska. The Water Resources Branch's transition from war to peace proved less abrupt. Months before the war ended, a large number of requests arrived for investigations of the availability and chemical quality of water for civilian needs in connection with flood control, industrial installations, inland navigation, irrigation, municipal supplies, and power production. Greatly increased use of water during wartime, population shifts following the establishment of new industries in areas previously rural or thinly settled, expansion of existing industries, and the need for increased power, as well as larger production of agricultural commodities, offered the Branch a multitude of new challenges and responsibilities.

Replacing retirees during the fall of 1946 brought forward a new generation of Division managers in the Water Resources Branch, like those in the Geologic and Topographic Branches, largely by promotion from within the ranks. On September 17, Paulsen passed the leadership of the Surface Water Division to Joseph V.B. Wells, the District Engineer in Louisville, Kentucky, since February 1940. William Collins retired at the end of September 1946, and S. Kenneth Love, who supervised field studies in several States, succeeded Collins as Chief of the Quality of Water Division on October 1. Adrian H. Williams, recently transferred from work in Montana, became Love's principal assistant. Meinzer, now 70 and the "Nestor" of groundwater hydrology, retired at the end of November. Nelson Sayre, then supervising these studies in the States west of the Mississippi, replaced Meinzer as Chief of the Ground Water Division on December 1. Royal Davenport continued to lead the Division of Water Utilization, which absorbed the duties and responsibilities of the Division of Power Resources after Albert Horton died in April 1945.

Wrather and Paulsen's additional administrative changes also affected coordination, planning, and control within Interior and the Director's Office, as well as the Water Resources Branch. Krug's Secretarial order of September 26, 1946, established a Pacific Northwest Coordination Committee,[145] composed of representatives from the USGS, the Bonneville Power Administration, and six other agencies, including Interior's new Bureau of Land Management (BLM).[146] On July 16, the 79th Congress and President Truman founded the BLM by consolidating the functions, funds, and staffs of the General Land Office, the Grazing Service, the Oregon and California Railroad Revested Lands Administration, the Alaska Fire Control Service, and other units, as recommended by Secretary Ickes in January and now part of Reorganization Plan No. 3. On November 13, Wrather and Paulsen made Arthur Piper, then at Portland, a new Staff Scientist in the Director's Office and the "adviser and consultant to the Director on Survey affairs in the Pacific Northwest and coordinator of Survey activities in that region."[147] Paulsen also confirmed Parker's decision, just before he died, to detail George E. Ferguson, Florida's District Engineer since 1940, to the Chief Hydraulic Engineer's staff in Washington, where Ferguson began planning a reorganization of the office's staff aimed at improving the administration of the Branch's expanding programs.

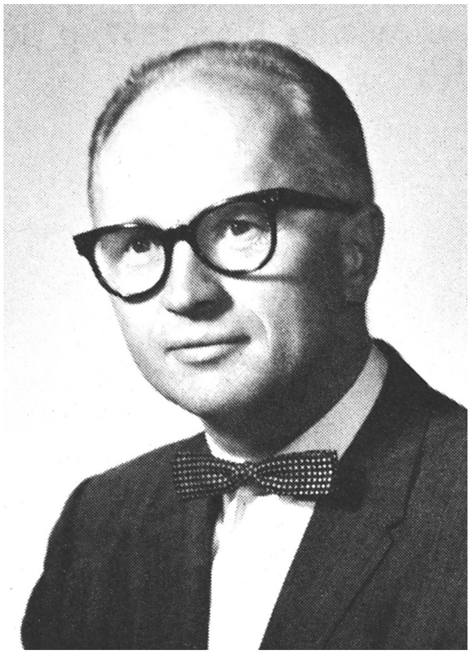
For fiscal year 1946–47, the Water Resources Branch managed slightly more than $6,366,000 in total funds, an increase of about 19 percent over the preceding year, for salaries of and operations by its staff of 1,040 full-time and 2,500 part-time employees, a significant rise from the total of 765 people employed at the end



This graph shows the "general variation in stream slopes and altitude in relation to size of drainage basin." Walter Langbein and his USGS colleagues measured 240,000 miles of streams and counted about a million contours shown on 1:62,500 topographic maps that depicted 145,000 square miles in 340 drainage basins in the northeastern United States. They also counted about 1 million contours and translated them into land and channel slopes. "The divergent trends of the lines showing the principal channel slope and average land slope" indicated that the slope ratio of the basins analyzed tended "to decrease with increase in drainage area." Their study was part of USGS efforts to segregate and evaluate the causative factors in river floods. The results indicated that "none of the topographic factors [in these basins] are unique, but each reflects a condition that also influences the others." (Quotations and graph from Langbein and others, 1947, p. 143 and 125 and fig. 52.)

of fiscal 1943–44. Of the new sum, Congress appropriated nearly $2,589,000, or 41 percent, directly to the USGS; the States and municipalities contributed about $1,936,000, or 30 percent, for cooperative investigations; and some $1,841,000, or 29 percent, came from other Federal agencies. During the year, Branch personnel worked out of more than 100 field offices, one or more of which was located in nearly every State and in the Territory of Hawaii. Members of the Surface Water, Ground Water, and Quality of Water Divisions participated in the Missouri River Basin program, drawing on the $804,000 transferred by the Bureau of Reclamation. Secretary Krug's order of May 31, 1946, established a Missouri Basin Field Committee,[148] led by Glenn Sloan, coauthor of the Pick-Sloan plan for the Basin, and including representatives from the USGS and six other Interior Department agencies. Interior's Water Resources Committee supervised the Field Committee, which represented the Department on the Missouri Basin Inter-Agency Committee that the Federal Inter-Agency River Basin Committee established on March 29, 1945. The Missouri Basin Inter-Agency Committee included representatives of the Agriculture, Interior, and War Departments and the Federal Power Commission (FPC) and the Governors of Missouri, Montana, Nebraska, and Wyoming. In the Missouri Basin, members of the Water Resources Branch collaborated in installing 55 new gaging stations, expanding studies to cover areas in 24 localities with problems related to groundwater or to changes in groundwater conditions arising from reservoir construction or irrigation, measuring the sediment content of surface waters at 44 regular and 7 special stations, and testing the chemical quality of water at 13 regular and 63 other stations.

Members of the Water Resources Branch's units also continued their regular activities. By the end of the fiscal year, the Surface Water Division operated nearly 5,220 gaging stations; some 230 of them in cooperation with other Federal, State, county, and municipal agencies. Division personnel established seven initial gaging stations in Alaska and planned a gradual expansion of the Territory's fledgling system. Members of the Division installed a two-way radio station at the gaging station on the Colorado River at Lees Ferry, Arizona, to make information about river



Hydrologist Charles Edward Jacob (1914–70) earned an M.Sc. in Civil Engineering (Hydraulics) from Columbia University in 1936 and then joined the USGS. In studies on New York's Long Island and in Texas and Florida, he used differential equations and other mathematical techniques in analyzing the permeability, storage transmissibility, and drawdown of groundwater, especially from elastic ("leaky") aquifers. Jacob led the Water Resources Branch's Section of Ground Water Hydraulics before resigning in 1947 to enter academia. In 1961, he founded C.E. Jacob & Associates as an international consulting firm. (Photograph from Titus, 1973.)

flow available promptly for use in administering the Colorado River Compact and for operating Federal projects such as Hoover Dam. They also began a program, in cooperation with the Public Roads Administration and several State highway departments, to work out better procedures for obtaining and utilizing streamflow records in solving hydraulic and hydrologic problems connected with highway structures. Interstate compacts for the allocation among the States of the waters of interstate streams required the Division to establish and operate gaging stations on the Colorado, Belle Fourche, and Republican Rivers, the Rio Grande, and Costilla Creek, as negotiations continued for similar agreements for the Arkansas and Bear Rivers. Division personnel also continued investigations for the allocation and control of waters along the U.S.-Canadian boundary and made special studies for the International Joint Commission, particularly those relating to the Columbia River Basin and Sage Creek in Montana. They also continued work along the U.S.-Mexican boundary, as required by 1944's water treaty between the two Republics.

Members of the Ground Water and Quality of Water Divisions participated in investigations in some 350 projects scattered through nearly every State, Hawaii, and Puerto Rico. They prepared nearly 200 formal reports and answered several thousand requests for information on groundwater conditions in all parts of the country. By the end of 1946, Charles Jacob published a method for analyzing data on interference from the pumping of several wells, developed a physical basis for Theis' 1935 equation, defined the storage coefficient, and analyzed radial flow in an elastic, or "leaky," artesian aquifer.[149] Jacob resigned to lead the Department of Geophysics at the University of Utah in 1947, the year he published the details of his drawdown test to determine the effective radius of artesian wells.[150] The Quality of Water Division established two new field laboratories—one at Salt Lake City to serve as a regional laboratory for both Federal and State interests in a large area of the West and the other at Philadelphia to handle a portion of the State cooperative program in Pennsylvania. The Division's laboratory staff analyzed the chemical quality of more than 11,000 water samples, continued its program for measuring sediment in streams, and operated facilities for analyzing sediment at Philadelphia and Albuquerque, and at Dickinson in North Dakota, Lincoln in Nebraska, Norton in Kansas, and Worland in Wyoming.

At war's end, the four Divisions of Harold Duncan's understaffed Conservation Branch continued to be fully occupied by their regular activities. The increase in the Branch's work during the war did not end with the advent of peace. In the fall of 1945, Harold G. Barton replaced Duncan as Chief of the Branch's Oil and Gas Leasing Division at the time its work increased yet again. The production of minerals from public and Indian lands continued at wartime rates, but the output of oil and gas actually increased to meet industrial and civil needs during the Nation's return to a peacetime economy. Director Wrather convinced Secretary Krug not to transfer the Conservation Branch to the USBM or the BLM, as sought by the directors of those agencies. Wrather argued that doing so would require congressional modification of "the [scientific] classification of the public lands"[151] mission in the legislation that established the USGS in 1879. The Conservation Branch's work on the unitization of oil and gas fields, Wrather added, also was so integrated with its land-classification and mineral-leasing responsibilities "that they could not be easily disentangled. The enforcement of the conservation laws had been tactfully handled," he believed, "and amicable relations existed with the oil producers." As "practically the entire force * * * had been raised in the Survey," Wrather concluded, they "did not wish to leave it."[152] At the end of fiscal year 1945–46, that force numbered 220 full-time and 5 part-time employees, a net increase of only 15 since the end of fiscal 1944–45. The Conservation Branch received about $1,076,000 from all sources in fiscal 1946–47.

On July 22, 1946, the Conservation Branch also received responsibility for all land-classification activities conducted in Alaska.[153] Although hampered by an abnormal turnover of personnel, John Northrop's Mineral Classification Division accelerated its work pace and disposed of nearly 14,300 public-land cases during fiscal year 1946–47, a 16-percent increase over 1945–46; however, the number of cases it received grew by 53 percent. For agencies concerned with disposing of acquired Federal lands, the Division's staff determined the potentialities for fissionable materials of some 2,330 parcels, a 240-percent increase, in practically every State, Territory, and U.S. possession, as required by the Executive order[154] of March 4 and the Secretarial order[155] of April 19, 1946. The Division also established a new field headquarters in New Mexico. As fiscal 1946–47 progressed, Benjamin Jones' Water and Power Division and other Branch units expanded their work in the Missouri River Basin to meet the needs of the Army Engineers and the Bureau of Reclamation. On June 10, 1947, Acting Secretary Chapman, whose activities in formulating policy increased as Krug's interest waned, authorized Director Wrather, without prior approval, "to classify public domain lands as power sites valuable for power purposes and to modify or revoke such classifications."[156] Members of Barton's Oil and Gas Leasing Division supervised nearly 10,900 oil and gas properties, a 20-percent increase, on the public lands in 22 States and Alaska; more than 5,660 leaseholds on Indian lands, a 13-percent increase; the Rio Vista gas field for the War Department; and the 21 properties under lease in Naval Petroleum Reserve No. 2 in California, where production yielded nearly $895,000 in royalties, a 19-percent increase. Personnel in Howard Smith's Mining Division supervised mineral production whose value totaled nearly $73,744,000, a 10-percent increase, from which the U.S. Treasury, the Reclamation Fund, the Indian beneficiaries, and the States received more than $2,439,000 in royalties.

While Wrather dealt with internal and external challenges, the debate within the U.S. Government about taking a hard line versus a soft line toward the Soviet Union came to an end. Hardliners James Byrnes, James Forrestal, Averell Harriman, and Admiral William Leahy, joined later by Dean Acheson and General Dwight Eisenhower, Army Chief of Staff since November 1945, prevailed in the fall of 1946 over General Lucius D. Clay (Sr.), George Marshall, Robert Patterson, Henry Stimson, and Henry Wallace, who recommended a gentler approach. Late in March 1945, Roosevelt decided that Harriman, the U.S. Ambassador in Moscow since 1943, was right in thinking that Stalin had broken every promise he made at Yalta, yet the President still hoped for American-Soviet cooperation in the U.N. and elsewhere in the postwar world.[157] By early in 1946, Truman's own experiences as President led him to agree that the United States could not trust the Soviet Union. The Council of Foreign Ministers, convening again in Paris, agreed on terms on July 4 and called a meeting of representatives from 21 nations to consider drafts of the treaties for Axis satellite nations. Commerce Secretary Wallace remained an outspoken advocate of continued cooperation and trade with, and loans to, the Soviet Union. Truman dismissed Wallace on September 20, just 2 days after ordering him to end his foreign-policy comments. As Wallace's successor, Truman appointed Harriman; after leaving Moscow late in January, Harriman represented the United States in London before beginning to serve as Secretary of Commerce on October 7. Acheson, as Acting Secretary of State, announced on October 1 that the United States would keep its occupation forces in Korea south of the 38th parallel until Soviet troops evacuated the northern half of the peninsula and the Allied Powers formed a free government for the unified country. Shortly thereafter, the peace conference at Paris broke up after agreeing only on minor issues.

At home, President Truman continued to try after 1945 to secure a single Federal agency to support scientific research and education, but, as Merton England recorded, Truman wanted it in a form that he could fully accept. In January 1946, Isaiah Bowman and Vannevar Bush discussed with Senators Kilgore, Magnuson, and Elbert Thomas how they might best modify the legislation to ensure approval by Congress and the President. On February 21, Kilgore and Magnuson, joined by Fulbright, Thomas, and other Senate colleagues, introduced a bipartisan compromise bill to establish a National Science Foundation. The measure called for an advisory National Science Board (NSB) appointed by the President, who also would appoint an Administrator after considering candidates recommended the NSB.[158] The Administrator would be required to consult the NSB on issues of budget, policy, and program. The NSB also would make recommendations to the President and Congress independent of the Administrator and approve all appointments to the Divisional Scientific Committees, whose chairs also would serve on the NSB. Although the compromise bill included some items not wanted by Bowman's Committee Supporting the Bush Report, its members recommended that the Senate's Committee on Military Affairs favor the bill and, when it did so, asked the whole Congress to enact it. The AAAS Council also voted overwhelmingly to support the Kilgore-Magnuson bill and appointed a special committee, chaired by James Conant, and including biophysicist Detlev W. Bronk (Director of the University of Pennsylvania's Johnson Foundation for Medical Physics), Ernest Lawrence, and geologist Howard A. Meyerhoff (the AAAS' Executive Secretary), to aid its passage. Conant drafted and sent a letter of support to all the Senators other than the bill's sponsors.

Delayed by debates about the extensions of the Selective Service Act of 1940 and the Office of Price Administration and the proposed atomic energy agency, the Kilgore-Magnuson bill passed the Senate on July 3, 1946, and went to the House's Subcommittee on Public Health, of the Committee on Interstate and Foreign Commerce. Meanwhile, Representative Mills revised and reintroduced his bill in the subcommittee on May 15 and held hearings during May 28–29, at which Bowman, Bronk, Bush, Edward U. Condon, Jewett, Secretary Patterson, and others testified. On July 16, the subcommittee reported out Mills' second bill, 2 weeks after the Secretaries of War and the Navy established a Joint Research and Development Board (JRDB). Bush chaired the new JRDB, also composed of two members each from the Army and Navy. Lloyd V. Berkner, an electrical engineer and Bush protégé who led the Navy Board of Aeronautics radar and electronics-materiel groups during 1941–45, served as the JRDB's Executive Secretary. The JRDB's committees included one for Geophysical Sciences and another for Geophysical Exploration, the latter chaired by Sidney Paige. On July 19, the Mills bill reached the Committee on Interstate and Foreign Commerce. Its members promptly tabled the measure when they decided they lacked the background and the information to defend their rejection of the Kilgore-Magnuson compromise in favor of Mills' revived bill. Meyerhoff, in announcing the legislative "homicide"[159] in an "obituary" in *Science* on August 2, the last day of the 79th Congress, placed the blame for the demise squarely on Bush and his supporters for the "political blunder which has cost science at least a year of life for the National Science Foundation." Meyerhoff decided that "The moral of 19 July is simple":

> **Only in a reasonable show of unity, achieved by some compromise, can scientists expect political results.[160]**

Although Truman continued to admire many of the prescriptions for a national foundation in "Science—The Endless Frontier" and the bills derived from it, he decided that Vannevar Bush's biases, and his influence on the legislative process in 1945–46, made imperative another Executive-sponsored report on this issue.[161] The President tried to have the second report ready for evaluation and legislative action during the 80th Congress. On October 17, 1946, Truman issued an Executive order that required economist John R. Steelman, former Director of

War Mobilization and Reconversion and now the President's special assistant for labor issues, to review current and proposed scientific research and development conducted or financed by the Federal Government. To assist Steelman, Truman issued an Executive order on October 17 that established an interdepartmental President's Scientific Research Board[162] (PSRB) to begin operating in November and named Steelman as its Chairman. The new PSRB's 15 members included the Secretaries of Agriculture, Commerce, Interior, Navy, and War; the Administrators of Federal Loans, Federal Security, and Federal Works; the OSRD's Director; the Chairmen of the AEC, the Federal Communications Commission, the NACA, and the TVA; the head of the Veterans Administration; and the Secretary of the Smithsonian. J. Donald Kingsley, former Deputy Director of War Mobilization and now program coordinator at the White House, acted as the Board's Executive Secretary. Chemist Lyman Chalkley, a veteran of the Office of Production Management (OPM) and the Board of Economic Warfare (BEW), and Bush's assistant in the OSRD since 1943, served as the PSRB's Scientific Advisor. Each of the Board's members designated one full-time person from his staff or agency as an alternate. On December 26, 1946, USGS Assistant Director Thomas Nolan began serving as Krug's representative on the PSRB's Board of Alternates, with Edward Condon and Carroll Wilson.

In establishing the PSRB, Truman emphasized that

> **[n]ational security and the development of the domestic economy depend upon the extension of fundamental scientific knowledge and the application of basic principles to the development of new techniques and processes. The Nation has a vast reservoir of war-accelerated technological development which must be applied speedily and effectively to the problems of peace—stepping up productivity in both industry and agriculture, creation of new farm and factory products and advancement of medical science. Fundamental research, necessarily neglected during the war, must be resumed if scientific progress is to continue.[163]**

Truman directed the PSRB to investigate and report on "the current and proposed scientific research and development activities conducted or financed"[164] by the Federal Government, including their content and balance, their administration and costs, the type and number of scientists employed and the conditions under which they worked, policies in respect to research contracts, national scientific resources in terms of people, money, and facilities, and the training of scientific personnel. In particular, Truman requested a careful inquiry into the current shortage of scientists. The Federal Government, he stipulated, would continue to play an important role in all areas of research, but the share of the national income that could be devoted to research had definite limits. The President's order laid the groundwork for a general plan designed to ensure that Federal scientific research would "promote the most effective allocation of research resources between the universities, the research foundations, industry, and the Federal Government" so that they might be "used most effectively in the national interest." "There must be no duplication, overlapping or inefficiency," Truman stressed, "to hamper Federal research. In view of the current level of Federal expenditures, our research activities must be conducted with minimum expenditures consistent with the essential objective of a Federal program."[165]

As Truman founded his President's Scientific Research Board, campaigns continued for the midterm elections. Republican candidates for the 80th Congress used "Had enough?" as an effective weapon against the President. On November 5, the Grand Old Party won enough races to control both chambers for the first time in 16 years.[166] As Samuel Rayburn's successor as Speaker of the House, Republicans elected Joseph W. Martin, Jr., a conservative from Massachusetts, a former minority leader, and another skillful political technician. Maine's Wallace H. White, Jr., led the Republican majority in the Senate, but he did so in name only. Senators Arthur Vandenberg and Robert Taft, both, like Martin, opposed to the New and Fair Deals, shared the real responsibilities for party leadership. Vandenberg, who replaced Tennessee's Kenneth McKellar as President of the Senate pro tempore, handled foreign affairs, while Taft dealt with domestic issues.

Truman presented his State of the Union Message to the new Congress and to television cameras on January 6, 1947. He advocated a balanced budget, a streamlined military establishment, and international control of atomic energy.[167] Truman also called for improvements in labor-management relations, strengthened antitrust laws, national health insurance, "a fair income"[168] for farmers, aid to veterans, an aggressive program for constructing homes, and new progress in civil rights. On the following day, Truman announced the resignation of Secretary of State Byrnes and the appointment of General Marshall to succeed him. Marshall named George Kennan to lead a new Policy Planning Staff on May 7.

On January 21, 1947, hearings began in the 80th Congress on the bill providing Interior with appropriations for fiscal year 1947–48. The measure proposed an appropriation of $295 million for the Department and nearly $18,105,000 for the USGS in fiscal 1947–48, the latter sum almost double the direct appropriation received for fiscal 1946–47. Secretary Krug, making his initial appearance before the House subcommittee, assured the Representatives that a committee was examining his Department's programs to determine priorities and bureaus' programs to ensure they contained no conflicts of interest or duplication of effort. The total amount Krug requested caused consternation among some of the legislators. Ohio's Robert F. Jones, Jed Johnson's successor as the subcommittee's chairman, and Benton Jensen welcomed Ivor D. Fenton (R–PA) and Lowell Stockman (R–OR). Democrats Michael Kirwan and William Norrell were joined by Albert A. Gore (Sr., D–TN). Jones quickly observed with amazement that in 1938 and 1939 Interior's appropriations were, respectively, only $132.7 million and $129.7 million. Now, Jones continued, the Bureau of Reclamation alone asked for $145.7 million! Ohio's irrepressible Kirwan, now the ranking minority member on the subcommittee, seemed less alarmed by the larger numbers. On February 3, when Wrather and his principal managers arrived to discuss the USGS budget request, Kirwan declared that he could not understand why they came with a request for so small a sum. In 1938, Secretary Ickes requested an amount for the agency that equaled about 1.3 percent of the DoI's budget. Now the USGS asked for only 0.87 percent of Interior's budget. Kirwan wondered why the agency was not keeping up with the rest of the Department.

In April, Interior's managers also submitted a draft for a bill to provide permanent substantive legislation to support USGS activities that were authorized each year in the annual appropriations bills, because items in the appropriations act must conform to the language of the USGS establishing legislation or they would be subject to point-of-order objections. This effort derived from proposals, reported in January by Krug's coordination committee, to examine the bureaus' contemplated programs, try to eliminate conflict and (or) duplication, determine emphasis and priority, and provide the greatest degree of mutual support. It also reflected the ongoing congressional debate about establishing a national foundation for science and the proposal in May 1946 by Senator Carl Vinson (D–GA), past Chairman of the Committee on Naval Affairs, that led to the founding on August 1 of the Office of Naval Research.[169] The ONR and its civilian Advisory Committee were intended "to plan, foster, and encourage scientific research"[170] to maintain the Nation's naval power and preserve its security. Harold Bowen, now a Vice Admiral and the Navy's Chief of Research and Inventions, became the ONR's Chief and so served until November 1. Bowen's Army equivalent was the Director of Research and Development, a new General Staff (G–6) slot. Physicist Alan T. Waterman, long on loan from Yale to the NDRC and then to OSRD's Office of Field Service, began serving as the ONR's Deputy Chief and Chief Scientist. The ONR's Advisory Committee included Bronk, Arthur and Karl Compton, DuBridge, and six other members.

Interior's draft bill for appropriations in fiscal year 1947–48 contained six sections about the USGS. The initial part of section 1 reproduced the USGS original block-funded legislation, enacted on March 3, 1879, except for setting the Director's salary at $10,000 to gain congressional authorization to classify the position as a Professional and Scientific grade 9 (P&S–9 or P–9). The second part of section 1 made clear the reenactment would not repeal or qualify laws since enacted regarding classification of the public domain or investigations of mineral resources. Section 2 of the draft made specific provision for topographic surveys, chemical and physical research, and water-resources investigations. Section 3 provided permanent substantive support for the transfer of funds from other Federal agencies. Section 4 furnished support for cooperative investigations with State and local government agencies, as authorized in the legislation enacted in the 1920s, and proposed cooperation with the Carnegie Institution of Washington, the Smithsonian Institution, and other nonprofit organizations. Section 5 provided for publication and library exchange. Section 6 supplied authorization for contracting some phases of the work. No section, however, addressed the problem of statutory authorization for USGS work outside the national domain to end its dependence on detailing agency personnel to other departments. The Committee on Appropriations reported the bill favorably, but the House took no further action on the measure.

The total funds requested by Interior for the USGS for fiscal year 1947–48 included $8.5 million for topographic surveys, $3,135,000 for geologic surveys, $250,000 for mineral-resources work in Alaska, $3.75 million for water-resources investigations, $350,000 for classifying lands, $748,000 for supervising mineral leasing, and $150,000 for printing and binding. Wrather hoped "to complete the detailed geologic mapping of the United States within the next 30 years," but he reported that it was "only 10 percent mapped at the present time."[171] The estimate for USGS topographic surveys in fiscal 1947–48, nearly three times the current appropriation, would fund the initial step in the third 20-year program proposed by the USGS since the 1880s to complete, after Director Powell's failure by 1894 and Congress' unwillingness to fund the Temple Act of 1925, the larger scale mapping of the United States. Gerald FitzGerald believed the sum represented only one-fiftieth of what would be needed overall. The War Department's recognition of the USGS as the prime domestic mapmaking agency and its proposal to appropriate to the agency the funds for strategic mapping explained part of the increase over the fiscal 1946–47 monies. Would sums be saved by restricting topographic mapping to areas requested by the War Department? FitzGerald pointed out that what the War Department wanted for fiscal 1947–48 alone would cost $48 million, a request already scaled down. For USGS geologic surveys, the Bureau of the Budget approved $3,135,000, nearly 1.6 times the amount appropriated for fiscal 1946–47. House subcommittee members asked if more results could be obtained for the money provided by concentrating geologic surveys on smaller areas rather than all over the country. Chief Geologist Bradley reminded the legislators that nature spread mineral resources countrywide, which meant his program must be planned and executed nationally. Pressed to state which of the requested increases in funding—for metals, fuels, or other studies—was the most important, Bradley declined; they were all the top priorities of a long list. When Chairman Jones inquired if "Your song is 'All or nothing at all'?"[172] (the title of Jack Lawrence and Arthur Altman's 1940 hit), Bradley wasted no words in replying "Yes."[173] In response to the USGS request for a sum about 1.5 times the original appropriation for water-resources studies in fiscal 1946–47, the legislators asked if some reimbursement plan could be worked out whereby the agency could charge private industry for benefits received, but it could not be done.

The House Committee on Appropriations reported out its version of Interior's appropriations bill on April 21. The Representatives set Interior's funding at $156.5 million, or about 53 percent of the requested amount, and recommended that the USGS be given some $9,113,000, or 50 percent of the budget request. Within those totals, however, the House proposal contained uneven cuts. The committee reduced the recommendation for topographic surveys to just $3 million, an amount equal to the 1946–47 appropriation, and that for geologic surveys to $1,690,000, or $310,000 less than the total in 1946–47. The legislators suggested $2,578,680 for water-resources studies, a sum only a little less than the amount approved for the previous year, but then they added a proviso that none of these funds could be used for groundwater investigations. They also cut monies requested for land classification and mineral-lease supervision, respectively, by 49 and 31 percent. Some of the members of the committee explained these reductions by reminding the USGS that the war ended nearly 2 years earlier. Despite this fact, they continued, the committee encountered stubborn and continued resistance in trying to reduce the appropriations for the agency. Although the amount recommended in the bill remained very substantially in excess of prewar appropriations for the USGS, these members of the committee felt that they had made a step in the right direction in trying to limit funds for the agency to what they termed a normal peacetime level.

The Interior Department made no attempt to hide its dismay over the committee's report, which again provoked subcommittee chairman Robert Jones. He complained that Secretary Krug's condemnation of the bill reminded him of a singer, in what he termed Truman's anti-inflation production, stepping up to the footlights and warbling "for all, or nothing at all," while the chorus of New Deal spenders tiptoed and kicked their way across the stage. Jones' expansion of his earlier exchange with Bradley during the hearings evoked an image worthy of a USGS Pick and Hammer Club show, but the discussion in the House made it clear that Jones' view did not represent the sentiments of all members of his subcommittee. Jones charged that only four of the seven members of the subcommittee tried to hold the line against the inflationary movement in Interior, whereupon John J. Rooney (D–NY) retorted that the majority was trying to wreck the Interior Department. Kirwan and Gore also disassociated themselves from the committee's action. Clair Engle (D–CA), a lawyer and reclamation enthusiast sometimes known as "Congressman Fireball" for his colorful and outspoken speech, observed that all of his colleagues realized that the strictest economy should be practiced in Government operations. But care should be exercised, Engle continued, to ensure that the committee insisted on true rather than false economy. The Government, he emphasized, wasted large sums during the war to obtain information in a desperate hurry because earlier investigations by its agencies proved insufficiently extensive. We should not, Engle warned, allow that situation to occur again. The House nonetheless voted for the appropriations recommended by its subcommittee.

Secretary Krug appealed to the Senate subcommittee, now chaired by J. Chandler ("Chan") Gurney (R–SD), to restore the House's cuts in the Interior Department's budget. Gurney's fellow Republicans on the subcommittee included holdover Guy Cordon and two newcomers—Idaho's former Representative Henry C. Dworshak, newly elected to fill a death vacancy, and William F. Knowland of California. Democrat Carl Hayden was now the subcommittee's ranking minority member.

Krug told Gurney's subcommittee that the House's action would "require abandonment of some essential services which have been rendered by the Survey for as long as a half a century, and the cessation of a large volume of work, some of it already in part completed, which is of vital importance not only to industry but to the security of the country." Public-land classification and mineral-leasing supervision were "functions which the Survey has been performing for many years by specific mandate of Congress."[174] Royalties from these activities increased from about $9.5 million in 1938 to the more than $14 million estimated to accrue in 1947. The savings of $200,000 in appropriations for these purposes would result in a reduction of about $1.1 million, or 10 percent, of the approximately $11 million in revenues from the public lands that went to the reclamation fund, State school funds, and the Federal treasury. Krug also pointed out that the U.S. Government, in planning irrigation and water-control projects, continued to be one of the chief beneficiaries of the USGS groundwater surveys that the House thought should be made by States, counties, and municipalities. The work should be done, he added, by a Federal agency, as "underground pools and streams are no more respecters of political boundaries than are surface lakes, pools, and streams." The cuts, Krug continued, would diminish the value of the surface-water investigations that needed to be continued because the results would lack data from groundwater studies. Reductions in the appropriation for geologic surveys would require abandoning some 30 projects, would result in the loss of the $750,000 already invested in them, and might "delay for years any progress toward the discovery of new reserves of badly needed minerals." As for topographic mapping, the Secretary said the USGS speeded up its mapping program at the request of the War Department, which remained anxious to have the program completed in 20 years. "Under the leisurely program provided by the House," Krug predicted, "we shall be lucky to have this work performed by the year 2020."[175]

Senator Milton R. Young (R–ND) was one of the witnesses who encouraged the Senate subcommittee to support the USGS budget, especially the funds for its water-resources program. Young attested that Lee Rogers, president of Lane-Western in Minneapolis, carried a lot of weight in the House, but Young thought that Rogers' company remained in disrepute in North Dakota. Nathan T. Veatch, president-elect of the American Water Works Association, Donald O. McBride, Secretary and Manager of the National Reclamation Association, and Rogers himself also appeared before the legislators, who added letters from State Geologists and other officials. The Senators voted to restore the full amounts for USGS geologic and topographic surveys and voted for increases of $106,000 for classifying the public lands, $215,790 for supervising mineral leases, $46,320 for water-resources investigations, and $90,500 for publications. They also suggested that the House's proviso that no funds for streamgaging be used for groundwater studies be changed to the more innocuous requirement of the preceding year that these funds could not be used to drill wells to supply water for domestic use.

In approving USGS appropriations for fiscal year 1947–48, the House yielded to the Senate on the level of funding for streamgaging and determining the U.S. water supply, public-lands classification, and mineral-lease supervision. The two bodies agreed on $3 million for topographic surveys, $2.3 million for geologic surveys and $389,000 for printing, binding and related costs of publication; the last sum represented a $53,000 reduction from fiscal 1946–47. The final proviso about streamgaging funds also reflected a modified compromise—"no part of the funds appropriated * * * shall be used for the payment, directly or indirectly, for the drilling of water wells for the purpose of supplying water for domestic use"—but one to which the USGS did not object. Congress directly appropriated a total of more than $10,091,000 for USGS salaries and operations for fiscal 1947–48. The legislators also authorized the USGS to "acquire by transfer without exchange of funds, for two years beginning July 1, 1947, from the War Department, the Navy Department, or the War Assets Administration, equipment, materials, and supplies of all kinds, with an appraised value of not to exceed $500,000 from the surplus stores of these agencies."[176]

While Congress debated the level of funding for Interior and the USGS, the Nation's impasse with the Soviet Union remained unresolved. On December 26, 1946, the Soviet Union and Poland abstained from the general approval of an American plan for far-reaching nuclear control and inspection by the United Nations. On February 18, 1947, the Soviets proposed amendments opposing the degree of international control recommended in the report approved 2 months earlier. The Soviets vetoed subsequent attempts by the Security Council to agree on an atomic controls plan. Finally, on March 5, the Soviet Union rejected the United Nations Atomic Energy Commission's report. The Council of Foreign Ministers arranged, and Secretary Byrnes signed before resigning in January, peace treaties with Bulgaria, Finland, Hungary, Italy, and Romania that made territorial adjustments and provided reparations. By their provisions, the Soviet Union received Bessarabia, northern Bukovina, and Finland's Petsamo area and nickel mines, its Porkala, Rybachiy, and Karelian Peninsulas, and significant reparations. The ministers made no progress on permanent settlements with Austria and Germany. From March 10 to April 24, Secretary of State George Marshall and British Foreign Secretary Ernest Bevin met with Soviet officials in Moscow, but they could not agree on the type of government for Germany. The United States and Britain favored a federal form, but the Soviet Union preferred a more centralized arrangement. Britain and the United States refused the Soviet demand for $10 billion in reparations from Germany. The two powers noted with dismay that Soviet influence on or control over the governments of Eastern Europe continued to grow, as did Soviet interference in the internal affairs of Greece and Turkey, Iran, and other Middle Eastern countries. On February 21, 1947, the British Government officially informed the U.S. State Department that internal economic difficulties would force Britain, also looking forward to the end of its troubled U.N. mandate in Palestine since 1920, to suspend economic and military aid to Greece and Turkey as of March 31. In 1946, French troops had withdrawn from their mandates in Syria and Lebanon, and the British had remade the autonomous Transjordan of 1921, two-thirds of their Palestine mandate, as the independent Kingdom of Jordan.

President Truman, responding to these challenges, laid down the general lines of a policy for containing the Soviet Union in his special message to a joint session of the 80th Congress on March 12. Truman asserted that

> **it must be the policy of the United States to support free peoples who are resisting attempted subjugation by armed minorities or by outside pressures. I believe that we must assist free peoples to work out their own destinies in their own way. I believe that our help should be primarily through economic and financial aid which is essential to economic stability and orderly political processes.**[177]

The President did not mention the Soviet Union by name, but he followed his statement of principle by asking for $400 million in aid to Greece and Turkey, the two countries most immediately menaced by Soviet expansion. On April 16, Bernard Baruch claimed that America already was in a cold war.[178] The principle of flexible containment of Soviet expansion, formulated in part by George Marshall and published in "The Sources of Soviet Conduct" by "X" (George Kennan) in the July issue of *Foreign Affairs*, became known as the Truman Doctrine. Kennan again warned his readers that the Soviet Union, which naturally viewed containment as encirclement, remained confident that history was on its side. He continued to recommend a protracted policy of patient, staunch, and watchful containment of Soviet expansionism[179] but one without unnecessary histrionics, gestures, or threats. The Soviet system, Kennan asserted, likely would decay from within, and so containment came to include all counter-force measures short of war while waiting for the demise. On April 23, the Senate formally endorsed aid to Greece and Turkey, to maintain "their national integrity and their survival as free nations,"[180] and the House agreed on May 9. Truman signed the aid bill into law on May 22.

International affairs, particularly those in Eastern Europe, continued to demand Truman's attention during the remainder of 1947. On June 5, the United States ratified peace treaties with Bulgaria, Finland, Hungary, Italy, and Romania. Twenty days later, a U.N. commission reported that Albania, Bulgaria, and Yugoslavia supported guerilla warfare in Greece. On July 29, the United States proposed a resolution to accept the commission's findings and implement its recommendations. Although the Soviets blocked approval by the Security Council, the General Assembly passed the measure on October 21 long after Secretary Marshall presented another American response. On the day official peace began with the five European countries, Marshall received an honorary degree from Harvard. In return, he assured the audience that U.S. policy was directed against chaos, desperation, hunger, and poverty, and not against nations or philosophies. U.S. policymakers hoped to revive a worldwide effective economy that would enable political and social circumstances to arise and support free institutions. Marshall declared that it would not be efficient or proper[181] for the U.S. Government unilaterally to draw up a program designed to put Europe on its feet economically and suggested instead a joint program, agreed to by most, if not all, European nations, recipients of more than $11 billion in U.S. aid since 1945. The United States also secured an international agreement promoting the growth of global trade by reducing tariff and other barriers when 23 countries signed in Geneva on October 30, 1947, the General Agreement on Tariffs and Trade (GATT) and promised to continue negotiations at future biennial meetings.

British Foreign Secretary Bevin and French Foreign Minister Georges Bidault met with Soviet Foreign Minister Molotov to discuss drawing up a European recovery plan along the lines suggested by Secretary Marshall. Molotov, on orders from Stalin, walked out and damned Marshall's plan as an imperialist plot to enslave Europe. Unfazed, representatives of 16 nations met in the Marshall Plan Conference at Paris during July 12–15, 1947. On September 22, they reported that Europe's needs during the next 4 years would require an additional $16 billion to $24 billion in aid. The Soviet Union and its European satellites refused to participate in the European Recovery Program and instead formed their own mutual-assistance system. Stalin ordered his Communist leaders throughout Europe to redouble their efforts to seize power before the Marshall Plan could begin its restorative work. He also directed Deputy Foreign Minister Andrei Y. Vyshinsky, the Soviet representative at the United Nations, to begin an offensive in that forum. In the U.N. General Assembly on September 18, Vyshinsky attacked Americans as warmongers. On October 5, Moscow announced the formation of the Communist Information Bureau (Cominform), to coordinate, from its Belgrade headquarters, the activities of the Communist parties of Bulgaria, Czechoslovakia, France, Hungary, Italy, Poland, Romania, the Soviet Union, and Yugoslavia. Stalin planned to use the Cominform as part of his efforts to block the Marshall Plan. On December 17, Truman responded by signing an act to "promote world peace and the general welfare, national interest, and foreign policy of the United States by providing aid," initially up to $150 million via the Reconstruction Finance Corporation (RFC), to Austria, China, France, and Italy "to alleviate conditions of hunger and cold and prevent serious economic retrogression."[182] One clause therein required that petroleum and petroleum supplies furnished to the recipient countries be obtained from sources outside the United States, "to the maximum extent practicable," and delivered "by the most economical route from the source of supply."[183]

In the Far East, the bitter struggle continued between Communists and Nationalists for the control of China, the fate of Korea remained undecided, Japan received a new constitution, and India and Pakistan won their independence as Dominions in the British Commonwealth. On January 29, 1947, the United States ended its efforts at arbitration in China, and Marshall criticized both Chiang and Mao for failing to reach a lasting agreement. Nationalist successes in the north peaked in March, and during that month Nationalists also captured Yan'an, the Communists' capital since the end of their "Long March" to Shaanxi Province. General Albert C. Wedemeyer knew conditions in China, from long service there, better than most persons in the Truman administration, but Wedemeyer's mission in July and August fared no better than Marshall's. In reporting to Truman on September 9, Wedemeyer attacked the use of force by the Communists, as well as the economic policies and widespread corruption of the Nationalists. By year's end, Mao's forces completely controlled Manchuria and also advanced on Yan'an. Nearby Korea remained divided between the American and Soviet zones of occupation after the failure of a joint commission to agree on a unified democratic government for the peninsula. In Japan, where General MacArthur served as the occupation's proconsul, the Allied constitution for the country provided for democratic reform, political parties, labor organizations, women's suffrage, and a for-defense-only military establishment. In India, Louis Mountbatten, now Earl Mountbatten of Burma and Attlee's new Viceroy (later Governor General), offered on June 3 the British Government's plan for separate Hindu and Muslim nations (India and Pakistan, respectively). Jawaharlal ("Pandit") Nehru, Mohandas K. ("Mahatma") Gandhi's principal aide in the long and mostly nonviolent struggle after World War II by the Indian National Congress for independence from Britain, became India's Prime Minister. On the same day, Pakistan began its existence under the leadership of Mohammed Ali Jinnah, leader of the Muslim League, as Governor General, and Liaquat Ali Khan as Prime Minister. Pakistan received less territory (in separate halves) for its large population of Muslims in the northwestern and eastern parts of the former British India. Both India and Pakistan claimed Kashmir.

In the Pacific, the United States assumed responsibility for the U.N. trusteeship of the Pacific islands formerly occupied by Japan. Truman's Executive order of July 18 provided an interim government,[184] under the Secretary of the Navy, for the U.N. Trust Territory of the Pacific Islands (TTPI), when, on the same day, Congress authorized the President to approve the trusteeship agreement for the former League of Nations' mandate.[185] The TTPI, established on April 1 and approved unanimously by the U.N. Security Council on the following day, encompassed some 3 million square miles of ocean and 96 islands totaling 687,000 square miles in the Carolines, the Marshalls, and the northern Marianas, inhabited by more than 50,000 people. The U.N.'s Trusteeship Council monitored all such territories, but the United States held veto powers over any political changes in, access to, or operations on these strategic trusteeship islands. The United States also joined Australia, Britain, France, The Netherlands, and New Zealand in signing an agreement in Canberra on February 6, 1947, that established a South Pacific Commission "to encourage and strengthen international cooperation in promoting the economic and social welfare and advancement of the non-self-governing territories in the South Pacific," in accordance with the U.N. Charter, and to help maintain "international peace and security." On January 28, 1948, Congress approved "[n]ot more than $20,000 annually" for U.S. membership and participation in the Commission.[186]

President Truman did not ignore pressing military and civilian domestic issues that included the reorganization of the Federal Government, Presidential succession, business-labor relations, discrimination in Federal and other hiring practices, and concern about the loyalty of public servants. On July 7, 1947, Congress and Truman established a Commission on Organization of the Executive Branch of the Government,[187] chaired by former President Herbert Hoover, to recommend improvements in economy and efficiency in and improved service by the executive branch. The President, the Senate's temporary president, and the House's Speaker each chose four members, two from their branches and two from private life. Dean Acheson, who resigned as Under Secretary of State on June 30 to return to his law practice, served as the Hoover Commission's Vice Chairman. Navy Secretary Forrestal, U.S. Civil Service Commissioner Arthur S. Flemming, financier Joseph P. Kennedy, Sr., and three chairmen of congressional Committees on Expenditures in Executive Departments also served as commissioners. Subsequent legislation provided $750,000 for salaries and expenses,[188] and authorized "the temporary or intermittent services of experts or consultants or organizations."[189] The Commission established 18 task forces to evaluate: (1) personnel, with Vannevar Bush, Senator Byrd, and David Lilienthal; (2) supply; (3) records management; (4) statistical agencies; (5) departmental management; (6) fiscal, budget, and accounting activities; (7) national-security organization, with 13 members, including Robert Patterson, and chaired by Ferdinand Eberstadt; (8) foreign affairs, chaired by Harvey Bundy, with Henry Stimson as his adviser; (9) Post Office; (10) revolving funds and business enterprises; (11) water resources projects; (12) natural resources, including Isaiah Bowman and Homestake Mining's president Donald McLaughlin; (13) agricultural activities; (14) regulatory commissions; (15) medical services; (16) public welfare; (17) public works; and (18) lending agencies.

Later in July, Congress and the President acted to change the order of Presidential succession and to improve the armed forces. On July 18, the Presidential Succession Act revised the 1886 law to make the Speaker of the House third in succession to the President and Vice President, after the "removal, resignation, death, or inability"[190] of both. On July 26, Congress passed and Truman signed an act to "promote the national security" by placing all branches of the armed services under a National Military Establishment led by a Secretary of Defense, establishing or confirming the subordinate Departments of the Army, Navy, and Air Force, and correlating the new National Military Establishment's activities "with other departments and agencies of the Government concerned with the national security."[191] Forrestal and Eberstadt, Forrestal's friend and adviser since their years together as Princeton students before World War I, proposed this arrangement in 1945 to oppose George Marshall's and many generals' scheme for a defense department dominated by the Army and its Air Forces. Truman nominated and the Senate confirmed Forrestal as the new but reluctant Secretary of Defense as of September 17. Forrestal's service secretaries included Kenneth Royall (Army), John Sullivan (Navy), and W. Stuart Symington (Air Force). The new law created a Central Intelligence Agency (CIA) that evolved during 1942–47 from the Office of Strategic Services, the Assistant Secretary of War's Strategic Services Unit, and the National Intelligence Authority's Central Intelligence Group. The statute established a formal Joint Chiefs of Staff of four members, with a Joint Staff; a National Security Council (NSC), composed of the President, Vice President, Secretaries of State and Defense, the Chairman of the JCS, and the CIA's Director; a War Council of the service secretaries and chiefs to advise the Secretary of Defense; a National Security Resources Board (NSRB), chaired by a civilian; a Munitions Board, with a civilian chair; and a Research and Development Board, also chaired by a civilian, to replace Vannevar Bush's Joint Research and Development Board. The Federal Bureau of Investigation (FBI) remained responsible for domestic intelligence and security.

As the Office of the Secretary of Defense began its operations, the reconversion of the Nation's industries to peacetime operations was virtually complete, but their relations with labor continued to pose problems, as did questions concerning the loyalty of Federal employees and ensuring equal civil rights to all Americans. On April 1, 1947, bituminous-coal miners again walked out. In response, the 80th Congress passed, over Truman's veto, a bill on June 23 to "amend the National Labor Relations Act."[192] The new law, better known as the Taft-Hartley Act, significantly affected business-labor relations by eliminating the closed shop, permitting the States to enact right-to-work laws, requiring union leaders to affirm that they were not members of the Communist Party, and allowing employers to sue unions for contract violations and damage. The law also required 60 days' notice for ending contracts, stopped employer collection of union dues, banned political contributions by unions, established a Federal Mediation and Consolidation Service, and authorized 80-day cooling-off injunctions for strikes that endangered the Nation's health or safety. Despite Federal seizure of the mines and extensive mediation between owners and unions, the coal-miners' strike continued until December 1. On March 21, Truman signed an Executive order[193] authorizing the Attorney General and the FBI to investigate the loyalty of all Federal employees and dismiss any found disloyal, an action that led to similar programs outside the Government. Earlier that month, Krug's Secretarial order established an Interior Department Loyalty Board[194]; its three members investigated the backgrounds of all employees and new hires. On July 26, the President's Committee on Civil Rights, established by Executive order,[195] reported its findings in "To Secure These Rights."

As the new fiscal year began on July 1, 1947, USGS dependence on outside finances rose above 50 percent for operations by and salaries of its staff of 3,320 persons. The direct appropriation of about $10,091,000, the largest sum yet received, represented an increase of nearly $382,000, or about 4 percent more than the similar funds provided for fiscal 1946–47. The direct appropriation for fiscal 1947–48 was some 54 percent of the USGS request, and the direct and supplemental appropriations actually received ($10,176,000) made up more than 45 percent of the total of the $22.4 million eventually available to the agency. Of the more than $12 million the USGS received from other organizations, about $11 million came from four sources. The National Military Establishment provided nearly $4 million, mostly from the Army; States, counties, and municipalities shifted some $2.8 million; and the AEC and the USBR each transferred about $2.1 million.

In fiscal year 1947–48, Bill Bradley's Geologic Branch managed about $5,568,000, an increase of some $2,454,000 from 1946–47. The nearly $2.14 million transferred from the AEC to fund the search for uranium-bearing deposits and related projects formed the major portion of the growth in Branch funds. Transfers from the USBM and the USBR fell by a total of $136,000, but military sources, especially the Army Engineers, and the States, counties, and municipalities provided modest increases. Continuing reorganization, aimed at using its staff and funds more effectively and efficiently, yielded three additional Branch changes during the year. On July 15, 1947, Wrather and Bradley reassigned Hugh Miser[196] to Bradley's Special Research Staff to serve as their adviser in fuels geology, conduct fieldwork in the Mid-Continent region, and aid the revision and preparation of State geologic maps. Carle Dane succeeded Miser as Chief of the Fuels Section. Edwin Goddard returned to succeed Don Carroll as head of the Geologic Information and Reports Section.

In other managerial and organizational changes within the Geologic Branch, Thomas Hendricks took over the Trace Elements Unit from Frank Stead, who shifted to lead the TEU's technical planning and development. An AEC–USGS conference on July 28 confirmed the TEU's role as Bradley's coordinating group for AEC-funded work by five of the Branch's Sections—Geology of Metalliferous Deposits, Geology of Nonmetalliferous Deposits, Fuels, Geochemistry and Petrology, and Geophysics—using the AEC's funds of $850,000 for personal services, $1 million for equipment, and the remainder for other expenses. The TEU's new name, the Trace Elements Planning and Coordination Office (TEPCO), reflected its increased responsibilities, funding, operations, and staff, which grew from 12 to several hundred people during 1947–48. On August 1, Wrather and Bradley also abolished the Geology of Metalliferous Deposits Section and the Geology of

Nonmetalliferous Deposits Section and transferred "their functions, personnel, records, and equipment" to the new Section of Mineral Deposits. They gave the new Section's two units, Mineral Investigations and Mineral Resources, additional responsibilities, respectively, for "physical exploration by sampling, trenching, drilling, and such other exploration, except geophysics," and "continuing evaluation of the nation's mineral resources and preparation of systematic reports thereon."[197] That Survey order returned to research former Section Chiefs Edwin McKnight and Ralph Van Alstine and appointed Olaf N. Rove, who shifted from the WPB to the USGS in 1946, to lead Mineral Deposits.

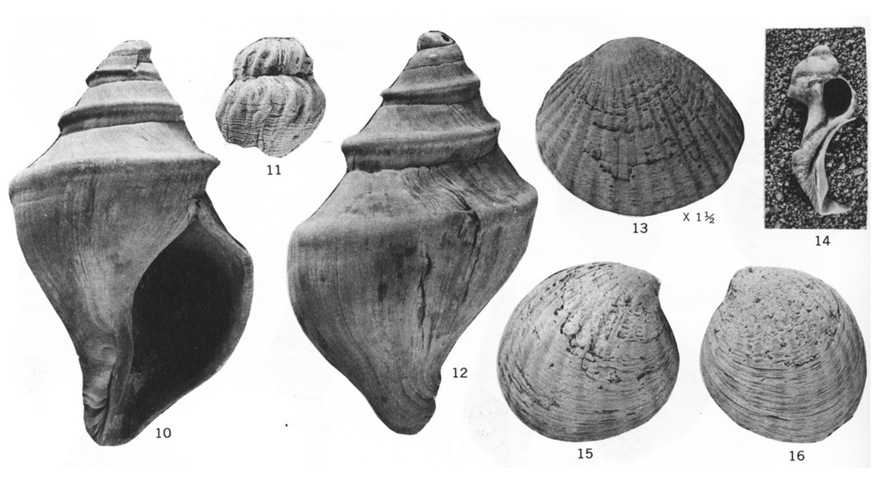
With significantly increased funds and under managers old and new, members of the Geologic Branch began or continued work on mineral deposits, geochemical prospecting, and regional studies, marked by the increasing use of photogrammetric aids. Branch geologists undertook 71 separate investigations of mineral deposits in 28 States—24 of these studies covered copper, lead, and zinc, and 15 others dealt with deposits of iron and ferroalloy minerals. They began an intensive study of uranium in phosphate deposits in Florida, Idaho, Montana, and Utah, gave considerable attention to the geology of pegmatites as sources of beryllium, feldspar, mica, tantalum, and lithium minerals, and continued investigations of alunite, bentonite, fluorspar, magnesite, mercury, potash, talc, and granites. Work also included five new exploratory drilling projects, one each in Arizona, Colorado, Idaho, New York, and South Dakota, of which three were completed. As U.S. reserves of aluminum and its ores now seemed sufficient for projected needs, the Branch devoted less time to work on that commodity, but estimates began to change after Reynolds Metals introduced aluminum foil on September 16, 1947. Geochemical prospecting for mineral deposits in Arizona, Colorado, New York, Tennessee, Utah, and Wisconsin involved new rapid analytical tests developed for use in the field. Branch geochemists also began greenhouse experiments to grow plants in soils containing known concentrations of copper, lead, and zinc to obtain background data on plant behavior in mineral-deposit environments. Regional studies were made in 19 States to delineate new areas with geologic relations favoring occurrences of oil and gas; they ranged from detailed surface studies of the stratigraphy of the Coast Ranges to subsurface correlations of samples, cuttings, and cores from deep wells in Florida, and from investigations of oil-bearing formations in Texas to detailed, bed-by-bed, correlations of New York's black shales. The USGS published 19 maps and charts of fuel-related investigations in Alabama, Colorado, Georgia, Mississippi, Montana, New Mexico, Ohio, Utah, Virginia, and West Virginia. Map sales from this program reached a total of 90,000 copies; to make the information more promptly available, the USGS set up sales offices at Billings, Casper, Denver, Los Angeles, and Tulsa.

During fiscal year 1947–48, Paul Averitt and other Geologic Branch scientists also began the long-needed reappraisal of U.S. coal reserves, aided by the statutes of 1941 and 1947 that permitted Federal inspections of coal mines. They nearly completed a study and computation of available data on Montana's coal reserves, now important as a potential source of synthetic fuels, and an accompanying coal-resources map of the State. Bill Bradley and Carle Dane expected the Montana investigation to serve as a pattern for similar studies in other States. In conjunction with the USBM's investigations, the USGS published a preliminary report on the geology and reserves of coking coals in the Paonia field in Colorado, while fieldwork continued on that State's Durango field, thought to contain coking coal, and North Carolina's Deep River coal field. Late in the fiscal year, fuels geologists also began the long-needed investigations of the Pacific Northwest's coals in Washington's Lewis and Thurston Counties. New investigations of the geology and structure of Pennsylvania's anthracite fields commenced with a study of a part of the Western Middle anthracite field.

During the year, USGS geologists continued work in the Missouri River Basin, planned for similar studies in the Columbia River Basin, and began investigations on the Continental Shelf in the Gulf of Mexico. They conducted six field projects in the Missouri River Basin during 1947–48 as part of Interior's development program. During 1946–48, the USGS issued maps, at 1:500,000 or 1:750,000, showing the occurrences of sand and gravel, construction materials, deposits of metallic and nonmetallic minerals, and other raw materials in areas of the Missouri River Basin in Colorado, Montana, Nebraska, North Dakota, South Dakota, and Wyoming. Plans also were completed for studying the geology and construction materials in and around Denver and San Francisco and on part of Puerto Rico (in cooperation with its water authority). Other plans included a 20-year effort in the Columbia River Basin, based on the programs of Federal construction agencies, and similar long-range investigations in other areas. Branch geologists continued an experimental gravity survey and program of oceanographic studies, begun in June 1947, on the Continental Shelf in the Gulf of Mexico, as commercial drilling for petroleum continued off Louisiana and Texas, where operations began in Black Duck Bay in 1917. The Branch's program, largely financed by the Office of Naval Research, was carried out in cooperation with the ONR and Woods Hole Oceanographic Institution.

The Branch's program for mapping the conterminous United States at 1:62,500 continued to produce during fiscal year 1947–48 only one-sixth of the 400 quadrangles needed each year to complete by 1980 the mapping of the remaining 12,000 quadrangles. Wrather called for a new plan to increase mapping output, one that would combine and better utilize the resources of the Federal and State Governments, academia, and industry. As a first step in securing this cooperation, the USGS completed bibliographic indexes to all published geologic maps in each State. Wrather also emphasized that geologic mapping helped to develop new concepts about the nature of crustal motion, the formation of glacial deposits, and the geological processes involved in soil development.

USGS geologists also extended their studies of Alaska's mineral resources during fiscal year 1947–48, for which Congress provided $250,000 in direct appropriations and the Navy transferred $173,000, principally to support work in NPR–4. On March 28, 1947, George Gates, Walter English, and three representatives of Arctic Contractors met in Los Angeles to discuss the whole program in NPR–4 and offer advice to the Operating Committee before it met in Washington. The group recommended expanding seismic-shothole drilling by adding shallow-core wells to recover fossils for stratigraphic correlation, conducting gravity and seismic investigations of the magnetic-anomaly areas to determine their significance, and drilling the Fish Creek seepage west of the Colville Delta. English told



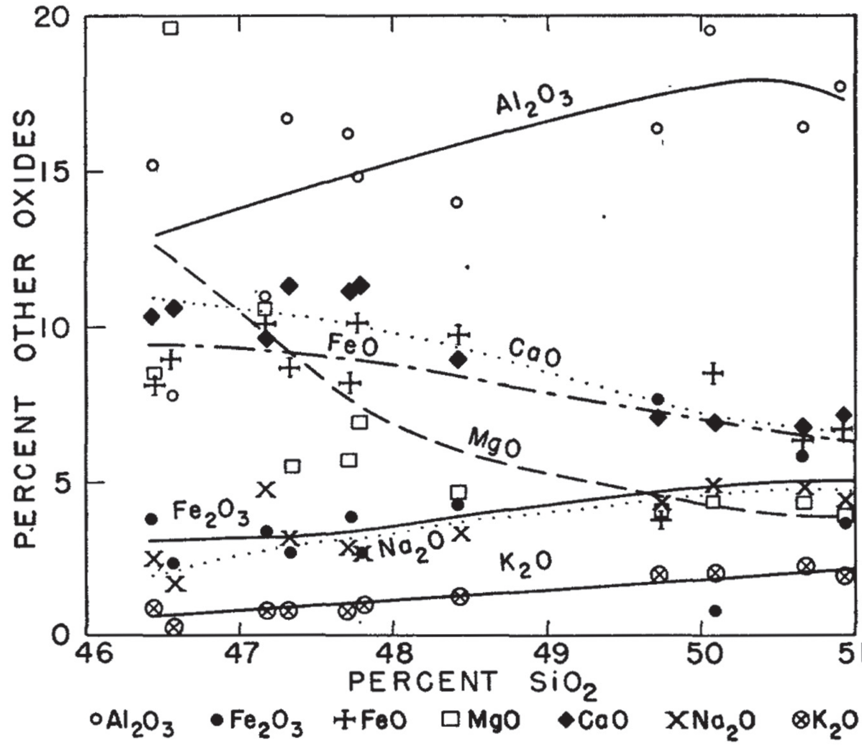
Geologist L.J. Barksdale, while serving with the USGS Navy Oil Unit, collected these specimens of the pelecypod *Cardita* (figs. 13, 15, 16), the gastropods *Buccinum* (fig. 11), *Neptunea* (figs. 10, 12) and *Volutopsius* (fig. 14), and other fossil mollusks from exposures of the Gubik Formation along the Meade River during the exploration of Alaska's Naval Petroleum Reserve No. 4 in 1944–53. USGS paleontologist Stearns MacNeil, in identifying, dating, and correlating the late Cenozoic marine invertebrates from this and other formations at Carter Creek, Ocean Point on the Colville River, and elsewhere on the North Slope, extended his investigations of Cenozoic marine faunas that began with studies of coastal-region strata in the conterminous United States. In subsequent years, MacNeil analyzed marine invertebrate fossils from the oil-bearing strata in the Gulf of Alaska Tertiary Province. (From MacNeil, 1957, pl. 14 [part]; figures 10–12 and 14–16 originally shown at × 1; figure 13, at × 1.5.)

Commodore Greenman about the group's increasing interest in "the northern and northeastern portions of the Reserve as being the most hopeful" and gave "his opinion that the funds allotted were not sufficient to attain fully the major objective of [the] Pet-4 [exploration program]—to determine the oil possibilities of the Reserve." Greenman decided that "basic investigations should emphasize * * * geologic structural features that could be drilled before the spring of 1949" to "have some oil wells to justify to Congress the need for additional funds."[198] Greenman immediately ordered that the Umiat test well 2 be drilled to about 3,000 feet, for a projected cost of $260,000. When Greenman, English, Colonel O.F. Kotick of the Army-Navy Petroleum Board, William Wrather, Lewis MacNaughton, and the rest of Operating Committee convened for their sixth meeting on April 15, George Gates oversaw the reports of progress and plans by his USGS Navy Oil Unit's geologists and geophysicists—Robert Chapman, George Gryc, Fred Keller, Jr., Thomas G. Payne, Karl Stefansson, and Edward Webber. Gryc noted the Army's promise to complete by June the trimetrogon and vertical photography required by the field parties.

Gates' reconnaissance by air of specific parts of NPR–4 in June modified the committee's directions for the seismic, gravity, and geological surveys. Gryc, Stefansson, Raymond M. Thompson, Webber, and Charles L. Whittington led the five parties, each with at least two geologists, in NPR–4 during the 1947 season. The Navy funded four of George Gates' five field parties, and the USGS financed Gryc's team as the fifth group. Working east of NPR–4 in the Shaviovik-Canning Rivers region, Gryc's party discovered oil-bearing sands and decided that "older rocks to the east pitching under the flatter terrain to the west," not change "in direction of fold axes in the mountains," caused the "great bend of the north front of the Brooks Range."[199] During the season's work, team members increased their understanding of the regional geology and located a large basin of deltaic-type Tertiary deposits underlying the flat Arctic Plain in the northeastern part of the Reserve. The oil seeps at Fish Creek and Cape Simpson indicated source beds. Oil-bearing sands, Payne, believed, would be limited largely to shoreline belts within the deltaic basin. Payne's explanation of stratigraphic "facies changes * * * subsequently was very useful in planning the program."[200] As part of the exploration effort, Simpson test well 1 was drilled to 6,094 feet, Umiat test well 2 was drilled to 6,212 feet, and core-test wells were completed at Barrow, at two sites between the Ikpikpuk and Oumalik Rivers, at Sentinel Hill, and at Skull Cliff. The Army Engineers supported the Navy ships of the Barrow Expedition 1947 and supervised the installation of a subsidiary station and tower at Skull Cliff and a monitoring station at Barter Island, as part of a long-range navigation (loran) system based in northern Canada. In September, members of the Senate's Committee on Interstate and Foreign Commerce and the House's and Senate's Committees on Public Lands toured NPR–4. By the end of December, the USGS completed 75 percent of its 1:48,000-scale planimetric maps and 60–95 percent of the Army Map Service's 1:250,000-scale sheets for Barrow, Umiat, and Wainwright, but to finish them, the USGS needed complete vertical-photographic coverage.

In Hawaii, in November 1947, the Hawaiian Volcano Observatory[201] returned to the USGS, its home during 1924–35 before it was transferred to the National Park Service. Earlier in 1947, after Wrather again visited Alaska, Harry Ladd, returning from Bikini, interrupted Wrather's brief vacation in Honolulu with a request to join him "for a trip to Mauna Loa." "The trip, though unexpected," Wrather recalled, "came at an opportune time" because "[t]he Survey expected to take over the Volcano Observatory from the National Park Service and I wanted to discuss the situation with Mr. [Francis R.] Oberhansly [Oberhansley], Superintendent of the Hawaii National Park." Oberhansley met Wrather and Ladd at the Hilo airport and took them on a tour of the big island, accompanied by Gordon Macdonald and Howard Powers. At the HVO, still led by Ruy Finch, they enjoyed

The percentages of the principal oxides compared to those of silica in this diagram of the composition of andesitic lavas from Mauna Kea on Hawaii showed that "most of the curves are very similar to those from Haleakala Volcano" to the northeast. Geologists at the USGS Hawaiian Volcano Observatory collected samples of lavas new and old as part of their geochemical and geophysical studies and monitoring of activity by the islands' volcanoes to increase their understanding of eruptions and their ability to predict them. (Quotation and graph from Macdonald, 1949, p. 83 and fig. 1.)



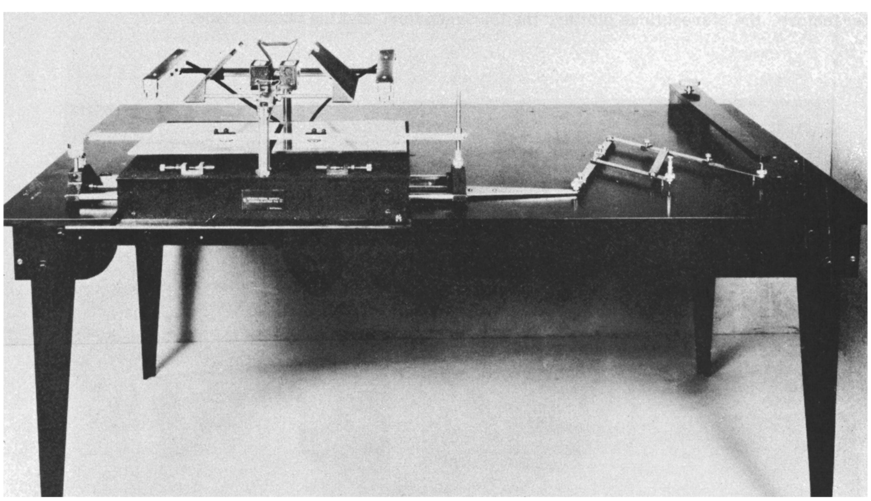
"a long session with" Thomas Jaggar, who lived near Volcano House. This trip, Wrather believed, gave him his "first comprehensive understanding of the volcano problem as is it concerned the Survey." On returning to Honolulu, Wrather, guided by Chester L. Wentworth, of the city's Board of Water Supplies, and other hydraulic engineers who "were interested in both the Survey's water program, and in an effort to secure new topographic maps of the Islands," looked at the city's water system and "the underground facilities of the Navy at Pearl Harbor."[202] Max H. Carson, the Water Resources Branch's District Engineer in Hawaii since 1924; groundwater geologist Dan A. Davis, who succeeded Carson in 1951; and geologist and hydrologist Doak C. Cox, who left USGS strategic-minerals investigations in 1946 to lead the Hawaiian Sugar Planters Association's water research and development, arranged for Wrather to view the progress of some of the Water Resources Branch's projects and related activities on Oahu and Kauai.

The advent of fiscal year 1947–48 also marked a new high in funds for the USGS Topographic Branch and the reestablishment of the Board on Geographic Names. On July 25, 1947, the day that Congress and the President agreed on USGS appropriations for the new fiscal year, they also revived the Board, originally founded in 1890, to "provide a central authority for standardizing such names among the Federal departments."[203] To support Branch operations in 1947–48, Chief Topographic Engineer Gerald FitzGerald managed a total of about $7,708,000, an increase of about $1,063,000 from fiscal 1946–47. Of this sum, $3 million came from the direct appropriation, more than $2.6 million in transfers from the National Military Establishment (74 percent of which came from the Army Engineers), nearly $1,076,000 from the Bureau of Reclamation, and some $713,000 from States, counties, and municipalities. The USGS also completed formal agreements with the Army Engineers, the USBR, and the USCGS. By these accords, the USGS would provide, insofar as possible, for all their map needs. If the three agencies found it necessary to undertake any special mapping, they agreed to prepare these maps to standard specifications so that the USGS could use them as well. Members of Ronald Wilson's Geodesy and Control Surveys Section completed developing the electrical-survey-net adjuster for the routine adjustment of leveling nets and transit-traverse surveys. They also extensively field tested two commercially designed instruments that continuously measured elevation while being carried in automobiles or trailers traveling at 10 to 15 miles per hour.

Russell Bean's Photogrammetry Section completed repairing and evaluating nearly all the former German equipment, placed most of it in use, and continued to prepare several designs for new projectors and plotting instruments. The basic principles for one of these new instruments, the Kelsh plotter, were developed outside the USGS by 1943 and were based in part on German equipment designed before 1935. In 1934, Harry T. Kelsh, the stereoplotter's inventor, joined the Cartography Division of the USDA's Soil Conservation Service, where he quickly became involved in photogrammetry and devised and tested an improved slotted-template method of map control. As head of the Division's Survey Section in the USDA's complex at Beltsville, Kelsh continued to "develop a simplified, economical plotter capable of projecting full-size images at large magnification."[204] At Russell Bean's suggestion, Charles Davey, James Buckmaster, and Joseph P. Burns went to Beltsville to see Kelsh and the 1946 version of his prototype plotter (of 1945) and its contact-sized diapositives. Kelsh, anxious to leave the SCS, agreed to work half time for the USGS if the agency would help him to design and build an improved and commercially viable plotter. Burns joined the Kelsh team's effort to design and develop standard and wide-angle plotters, while Buckmaster worked on improving the Multiplex. Construction began on an improved graph rectifier that would convert the record charts from airborne-magnetometer surveys to a more usable form.[205]

One of the Topographic Branch's regional units also conducted experimental work during fiscal year 1947–48. Over a 10-day interval late in 1947, engineers in Robert O. Davis' Rocky Mountain Division used a helicopter to carry a payload of 200–250 pounds on each of 24 round trips, traveling a total of about 650 miles, from Cañon City to mountaintop stations and other high stations in nearby parts of Colorado. The Division then chartered three helicopters for work in Alaska during the summer of 1948.

The Topographic Branch's reorganization plans called for ensuring that field offices performed all possible production steps. Installing additional equipment and transferring or hiring additional personnel increased the work capacity of the Rocky



USGS topographer Richard O. Mahan developed in 1942 a "comparatively simple stereoscopic mapping instrument" as a plotter to use "ordinary contact prints of [7-inch by 9-inch or 9-inch by 9-inch vertical] aerial photographs." The Mahan plotter enabled "plotting on a constant scale and appropriate tilt correction" but, unlike the Multiplex, did "not provide refinements such as correction for lens distortion." The "adaptable, low cost, and accurate" Mahan plotter remained in use through the 1940s. (Quotations from Thompson, 1958, p. 14 and fig. 12; see also Van Camp, 1945, figs. 1, 2.)

Mountain Division's headquarters in Denver. Plans also were completed for a new building at the Central Division's headquarters in Rolla. Each field office received a copy of "Topographic Mapping by Photogrammetric Methods," a training film for employees and a briefing vehicle for visitors and other interested groups. During fiscal year 1947–48, Topographic Branch engineers mapped nearly 36,000 square miles in 38 States and Puerto Rico. Mapping in Alaska, by topographers now sent from the Denver office, involved projects in the south-central part of the Territory at Homer, near Cantwell and Healy along the Alaska Railroad, and to the southeast in the Stikine River Valley north of Wrangell. The Branch published a new 1:5,000,000-scale base map of Alaska in 1947. One topographer advised the U.S. Air Force (USAF, the former Army Air Forces) while it and the Navy secured vertical photography of priority areas. The Trimetrogon Section surpassed its previous record by completing more than 700,000 square miles of entirely new compilation and revising nearly 800,000 square miles already covered. In another significant change in Branch operations, its personnel prepared for multicolor photolithography 226 of the 240 maps edited for publication, which marked a major shift away from engraving.

Carl Paulsen's Water Resources Branch received about $6,738,000 for its operations in fiscal year 1947–48, a sum just $372,000 more than in 1946–47. Of this total, Congress directly appropriated $3,110,000, States, counties, and municipalities supplied nearly $2,027,000, and the remainder came from other Federal sources—about $690,000 from the USBR, slightly more than $586,000 from the Army Engineers, and some $106,000 from the State Department.

From the Water Resources Branch's more than 100 principal offices, its personnel conducted investigations in nearly every State and in the Territories of Alaska and Hawaii. Members of Joseph Wells' Surface Water Division operated some 6,000 gaging stations, nearly 800 more than in the previous year, throughout the States and Territories, some of them in conjunction with interstate compacts or in accordance with international-treaty obligations. The Division expanded its gaging program in Alaska, begun with 7 stations in 1947, to 35 sites. Division personnel experimented with a new snowmobile, developed and fabricated in cooperation with the Soil Conservation Service, for making winter observations in remote mountain areas. They also completed the laboratory observations, begun in 1946–47, on the effect of backwater on river discharge and began analyzing the data. Groundwater investigations in nearly 400 projects were conducted in almost every State, Alaska, Hawaii, and Puerto Rico. In Arizona, members of Nelson Sayre's Ground Water Division used geophysical methods to locate supplies of underground water in critical areas where previous efforts by private interests proved unsuccessful. In North Carolina's Piedmont area, statistical studies of the yields of wells in relation to several factors developed criteria for selecting well sites that could be applied over the entire area from Pennsylvania to Alabama. Stuart Schoff spent a month during October–November 1947 in Kuwait evaluating available data to try to locate sources of potable groundwater; he thought prospects were very poor, but his recommended sites in previously unexplored locales were not tested by drilling. Employees of Kenneth Love's Quality of Water Division analyzed the chemistry of some 17,500 samples, many in cooperation with 13 States. The Division established two new field laboratories: one was in Schuylkill Haven, Pennsylvania, and the other was in Columbus, Ohio, the latter to serve Federal and State interests throughout the lower Ohio River Basin. Division personnel increased substantially the extent and scope of their sediment-measuring activities by collecting at least daily at 69 stations, and intermittently at 72 additional sites, on streams in the Brandywine, Schuylkill, Missouri, Washita, Colorado, and Rio Grande Basins.

Harold Duncan's Conservation Branch received nearly $1,043,000 to support its work during fiscal year 1947–48, a loss of about $33,000 from the previous year. The $9,000 increase for mineral leasing did not offset a decline of nearly $43,000 in direct appropriations and USBR transfers for land classification. Branch personnel acted on more than 28,900 cases involving the disposal of Federal lands or the exercise of the Government's right to explore for and produce minerals from lands under Federal jurisdiction, an increase of nearly 50 percent over the previous year. They also determined the potential for fissionable source material of more than 3,700 parcels during the 5 months prior to Truman's Executive order of December 5, 1947, that required reserving to the United States the lands that contained uranium, thorium and similar materials.[206] The Conservation Branch detailed one of its geologists to the Department of Justice for the entire fiscal year for work with the proceedings in the case of the *Confederated Bands of Ute Indians* v. *United States*. On public lands, the Branch supervised nearly 13,440 oil and gas properties, an increase of 19 percent over the preceding year. Branch personnel approved 41 new unit plans; 55 percent of the petroleum, 62 percent of the natural gas, and 80 percent of the gasoline and butane obtained from the public lands during the year were produced under endorsed unit agreements. Branch members continued to monitor, on the Navy's behalf, operations under lease in NPR–1 and NPR–2, where production generated royalties of nearly $1.1 million to be added to the almost $294,000 from production in the Army's Rio Vista gas field. They also oversaw operations on 956 mining properties that produced coal, fluorspar, lead, phosphate, potassium, sodium, and zinc. The record production of potassium in fiscal 1947–48 exceeded for the first time the royalty value of coal output.

On August 7, 1947, Congress and the President, through the Acquired Lands Leasing Act,[207] extended the 1920 Mineral Leasing Act's provisions to all acquired-land minerals and, with few exceptions, the minerals acquired by Federal agencies. The management of the disposition and use of minerals on all U.S. lands thereby passed to the Interior Department in an effort to ensure a coordinated Federal policy and program. Eastern-coal producers and the oil industry, looking to the future generation of synthetic fuels from coal, showed more interest during fiscal year 1947–48 than in previous years in acquiring western coal lands. Members of the Conservation Branch's Mining Division cooperated with the National Petroleum Council in selecting sites for producing petroleum from solid fuels. Using 500 million tons of bituminous-coal and lignite reserves would require 50 million to 75 million gallons of water each day but would yield an estimated 50,000 barrels of oil daily for 30 years, or a little more than 1 barrel per ton of solid fuels. To the military authorities, the Committee recommended 15 sites—5 in North Dakota, 4 in Montana, 2 each in Colorado and Wyoming, and 1 each in Alaska and New Mexico.

Kirtley F. Mather's assessment of petroleum available now and in the future, presented at the British Association for the Advancement of Science's meeting in Dundee, Scotland, on August 29, 1947, suggested that U.S. coals and oil shales could provide 2 billion barrels of synthetic crude per day for 1,000 years, provided costs were borne, and that British coals could generate a similar volume for hundreds of years. He said nothing about the cost of repairing, or at least mitigating, mining's adverse effects on the environment or water needs. Mather, who worked part time with the USGS during 1911–45, now provided these estimates, based principally on industry data, within the greater context of evaluating the decline in America's proved reserves of petroleum and the rise in production from them in the decade since 1936. He noted that U.S. reserves comprised 30 percent of the world's total, but U.S. production accounted for 60 percent of global production. Mather, echoing Harold Ickes, suggested that "if present trends continue, 10–20 years from now the United States will be a 'have-not nation.'"[208] The Soviet Union, Kuwait, Iran, Iraq, the Arabian Peninsula, and the East Indies then would be "haves," but the United States, Britain, and The Netherlands now either controlled or influenced the reserves of the last five of these six countries or areas and U.S. interests in South American reserves rose to 75 percent.

Mather recommended continued exploration for petroleum combined with maximum production, better recovery, efficient use, and the development of solar, nuclear, and other sources of energy. Mather thought that "world petroleum reserves are quite adequate to meet world needs for half or three-quarters of a century to come" but only if they were used well with "almost complete freedom for distribution of the oil and its products from regions of supply to all parts of the world, regardless of political boundaries." Like Charles Leith and others in the immediate postwar years, Mather felt that "mineral interdependence in the modern world * * * should be thoroughly comprehended by every person concerned with international relations."[209] Leith, now retired, continued to serve on the AEC's Combined Development Agency (founded in 1944 as an Anglo-American effort to secure increased supplies of uranium and thorium), the National Military Establishment's Research and Development Board, the National Security Resources Board, and the National Research Council's Minerals and Metals Advisory Board. In a symposium on "Present Trends and International Implications of Science," sponsored by the National Academy of Sciences and held in Philadelphia during October 1946, Leith again emphasized the importance of the growing number of bilateral and regional agreements on mineral resources. He hoped these arrangements would evolve into a system "of mineral supply by international agreement, either for industry or for security, [which] will tie up the world's mineral resources in a way that would be an effective deterrent to war."[210]

On August 6, 1947, one day before Truman signed the extended-leasing bill, he vetoed another measure intended to establish a national science-research foundation, even though he continued to think it was needed to help pioneer new courses in meeting America's needs. In the 80th Congress, Senator H. Alexander Smith (R–NJ) chaired the bill's parent subcommittee. Smith, favoring Vannevar Bush's version of the science foundation, helped to revise the Kilgore-Magnuson compromise measure in 1946. On February 7, 1947, as Merton England recorded, Smith introduced his own bipartisan bill, based principally on the Magnuson version and cosponsored by Cordon, Fulbright, Magnuson, and two other Senators. Smith's version, and similar bills introduced in the House, included a board of 48 (later 24) part-time members, each appointed by the President for an 8-year term, and a 9-member executive committee that would choose a full-time director whom it would control and supervise. Representatives from some 75 organizations met in Washington on February 23, formed an AAAS-sponsored Inter-Society Committee for a National Science Foundation, and elected its executive committee, chaired by Cornell's president Edmund M. Day and including Isaiah Bowman and psychologist and OSRD-veteran Dael Wolfle among its 8 other members. Smith ignored the new Committee's recommendations. During the Senate's debate on the Smith bill during May 14–18, opponents defeated amendments allowing the President to appoint the foundation's director and restoring the social-sciences and geographic-distribution-of-funds components, but they accepted an increase of the foundation's public-health activities, including cancer research (the House added poliomyelitis). On July 22, the conference version of Smith's bill passed Congress and went to the White House. James E. Webb, Director of the Bureau of the Budget since July 1946, had warned Bush earlier, and did so again on August 1, that Truman would veto the measure, which the President had discussed with Smith, if it did not give him greater Presidential authority over the foundation.

"With deep regret," Truman vetoed the Smith bill because the measure contained provisions representing "so marked a departure from sound principles for the administration of public affairs"[211] that the proposed national science foundation "would be divorced from control by the people to an extent that implies a distinct lack of faith in democratic processes." The proposed organization, and its two layers of part-time boards, was "so complex and unwieldy that there is grave danger that it would impede rather than promote the Government's efforts to encourage scientific research." Truman believed that the legislation also would deprive him "of effective means for discharging his constitutional responsibility"[212] by establishing an "Interdepartmental Committee on Science"[213] composed of representatives from the departments and agencies responsible to the President whose chairman, not appointed by or responsible to the Chief Executive, would direct the foundation. Truman thought that the bill's principles, if applied Governmentwide, would yield "utter chaos." He asserted "that our traditional democratic form of government" could properly administer "a program for encouraging scientific research and education."[214] Vannevar Bush thought Truman's insistence on appointing the foundation's director, who would report to the President rather than the National Science Board, would make the NSB primarily an advisory body.[215] As the foundation would work closely with the universities, Bush believed, this would lower both confidence and resistance to political pressure. Bush, although failing for a second year to achieve an OSRD-like foundation, did not join Smith, the legislators, and the scientists who denounced Truman for a solely political decision.[216]

Bush's Research and Development Board, of the National Military Establishment, now was served by a policy council, a full-time staff led by Lloyd Berkner, and six committees. James Conant chaired Bush's Atomic Energy Committee, Hartley W. Rowe led the Aeronautics Committee, and Karl Compton chaired the Guided Missiles Committee. Julius A. Stratton, an electrical engineer and physicist at MIT and Rad Lab veteran, who now directed the Research Laboratory for Electronics, led the Board's Electronics Committee. Geophysicist Roland F. Beers chaired the Board's Geophysical Sciences Committee; he had led in Dallas the Geotechnical Corporation (1936, later Teledyne-Geotech) and Beers and Heroy (1946) and also had advised the NRC, the ONR, and the USGS. Charles H. Behre, Jr., an economic geologist at Columbia University who worked part time for the USGS during 1921–45, led the Geographical Exploration Committee. Merton England noted that Bush, despite losing influence with Truman, still respected him as a leader and looked forward to a successful bill for a national science foundation. So did the President, who closed his message by asking Congress to "reconsider this question" and enact a sound law "early in its next session."[217]

"Science and Public Policy," the four-part report of the President's Scientific Research Board (chaired by Steelman, Assistant to the President since December 12, 1946), appeared shortly after Truman's veto. Truman's subsequent Executive order consolidated economic stabilization, war reconversion, and related Federal functions in a new Office of Temporary Control, and the President made Steelman liaison to and coordinator of the policies and programs of all Federal agencies. "A Program for the Nation," the initial volume of the PSRB's report, echoed "Science—The Endless Frontier" by its beginning assertion:

> **The security and prosperity of the United States depend today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival.[218]**

Steelman's PSRB urged Congress and the President to act in eight principal areas of concern. First, the PSRB's report called on the legislators and Truman to consider increasing "our annual expenditures for research and development as rapidly as" permitted by increases in facilities and trained personnel, so that by "1957 we should be devoting at least one percent of our national income" to such work "in the universities, industry, and the Government." Second, the report also asked that in the next decade greater emphasis be placed on basic and medical research, total expenditures for research and development be doubled, funds for medical research be tripled, and expenditures for fundamental research be quadrupled. Third, the PSRB recommended Federal support of "basic research in the universities and nonprofit research institutions at a progressively increasing rate, reaching an annual expenditure of at least $250 million by 1957." Fourth, the PSRB called for "a National Science Foundation * * * to make grants in support of basic research, with a Director appointed by and responsible to the President * * * and advised by a part-time board of eminent scientists and educators,"[219] of whom half would be from outside the Federal Government and half would be from within it. As the PSRB's fifth and sixth exhortations, it asked for Federal programs of assistance "to undergraduate and graduate students in the sciences" and "to universities and colleges" for "laboratory facilities and scientific equipment" as integral parts of general programs of "national scholarship and fellowship" and "aid to education." Seventh, the PSRB proposed establishing a Federal committee, "composed of the directors of the principal Federal research establishments," to assist in coordinating and developing "the Government's own research and development programs," to be aided by a review unit in the Bureau of the Budget and a White House staff member responsible for overall liaison. Eighth, the PSRB urged that "every effort be made to assist in the reconstruction of European laboratories as part of our program of aid to peace-loving countries" whose terms required "the maximum contributions toward" restoring "conditions of free international exchange of scientific knowledge."[220]

On December 18, 1947, William T. Golden, who assisted David Lilienthal at the U.S. Atomic Energy Commission (AEC), added a ninth consideration by suggesting to Truman that he appoint his own scientific adviser as well as a scientific advisory committee.[221] Six days later, an Executive order established the Interdepartmental Committee on Scientific Research and Development (ICSRD) "to further the most effective administration of Federal scientific research and development." Representatives of the "Departments of Agriculture, Interior, Commerce; the Army, Navy, Air Force, and the National Military Establishment; the Federal Security Agency; the AEC; the National Advisory Committee for Aeronautics; the Veterans Administration; and the Smithsonian Institution"[222] made up the ICSRD. The President would designate annually the ICSRD's Chairman, who might occasionally establish specific-study subcommittees that could include persons from outside the Federal Government or from agencies not regular members of the ICSRD. On December 26, another Executive order terminated the OSRD, effective December 31, but provided for completing its liquidation through the National Military Establishment.[223]

To aid the international exchange of scientific knowledge, Congress and the President already had approved two measures. On July 1, 1946, they provided for U.S. participation in the United Nations Educational, Scientific and Cultural Organization (UNESCO). On August 1, just before founding the AEC, they established "An American Bridge to World Science"[224] by amending 1944's Surplus Property Act while enacting the bill introduced by Senator Fulbright. To increase scientific communication, reduce parochialism, increase research potential, and contribute to a stable and peaceful world, the new law enabled the use of foreign currencies or credits from such disposals to fund "studies, research, instruction, and other educational activities"[225] abroad by U.S. veterans and other citizens and those by foreign citizens in American schools in their countries or in the United States. To administer these exchange programs, the Fulbright Act also established a 10-member Presidential Board of Foreign Scholarships, to which Truman appointed General Omar Bradley, Ernest Lawrence, Vassar's new president Sarah G. Blanding, and others from academia and government. By the beginning of fiscal year 1947–48, Congress and Truman authorized nearly $138 million in foreign cash or credits for these purposes and divided the sum among 21 participating countries. Australia, Austria, Belgium, Britain, Burma, Nationalist China, Czechoslovakia, Denmark, Egypt, Finland, France, Greece, Hungary, Iran, Italy, The Netherlands, New Zealand, the Philippines, Poland, Siam, and Turkey each received sums that varied between $20 million for Britain, China, and Italy and $500,000 for Turkey. The Philippines gained its independence on July 4, 1946, as promised by the United States, which retained the 99-year leases on military bases in the new Republic as negotiated on March 14.

Steelman and the other members of the President's Scientific Research Board now staked out an even larger role for science and technology in foreign relations. For a world where many nations still suffered "from extreme poverty due to the war's destruction" and "totalitarian ideas still dominate several areas and continue to impede progress toward a world society of free peoples,"[226] the PSRB's report stressed that

> **[it] is to our national interest to make a maximum effort to restore the conditions of free international cooperation among scientists which existed before parts of the world came under totalitarian domination. It is equally important to our interest, as part of the plans for reconstruction of the devastated countries of Europe and Asia, for us to lend every possible aid to the re-establishment of productive conditions of scientific research and development in all those countries willing to enter whole-heartedly into cooperation with us.[227]**

Chapter 6.
Replenishing the Research Capital, 1947–1950

> **We must concurrently carry on scientific investigations whose economic benefits cannot be immediately reflected in the balance sheet. It has been abundantly demonstrated that the pure or basic science of today is the applied science of tomorrow. We must develop by painstaking research methods the techniques for the discovery of new mineral deposits.[1]**
>
> **—William E. Wrather**

The treaties signed in 1947 to end hostilities in World War II ensured that 1948 would be for the United States a year of official peace as well as a Presidential election. As part of his campaign, Truman promptly set out his domestic agenda. The President, in his State of the Union Message to Congress on January 7, 1948, set five goals for the Nation. America should secure the essential human rights for all its citizens, protect and develop its human resources, conserve and use its natural resources to contribute more effectively to public welfare, raise the standard of living for all its citizens by strengthening the economy and sharing more widely its products, and achieve "world peace based on principles of freedom and justice and the equality of all nations."[2] To do so, Truman emphasized, required overcoming the problem of inflation that threatened the realization of all of these goals. He called for a national health program, increased support for education and farmers, the conservation of natural resources, and raising the minimum wage from 40 to 75 cents an hour.

On February 2, Truman sent to the 80th Congress a special message on civil rights,[3] urging the legislators to pass measures to ensure more effective statutory protection of the right to vote and to end poll taxes, establish a Fair Employment Practices Commission with authority to stop discrimination by employers and labor unions, end inequity in interstate travel, and act on claims by Americans of Japanese descent confined against their will during the war years. When Congress did not act, two Executive orders[4] on July 26 banned discrimination in Federal hiring and in the armed forces. Unfortunately for women and minorities who were not Federal employees, no President held the authority to end the statutory and informal prejudice and bias elsewhere in American society and especially in the "Jim Crow" Southern States. Wartime service and demographic and related changes during the conflict that increased public awareness of these difficulties and efforts to end or at least reduce them now began to yield limited and slow but cumulative results. In the Northern States, where laws prohibited segregation, State and municipal courts long supported private restrictive covenants that established and maintained segregated urban neighborhoods by prohibiting ownership or occupancy of real estate by specific racial or ethnic groups. In four cases before the U.S. Supreme Court in 1948, the Justices struck down the State and municipal courts' enforcement of these agreements by holding them discriminatory and illegal under the Constitution's 5th and 14th Amendments and the Civil Rights Act of 1866.

Like the President in 1948, the Republican-dominated 80th Congress in its second session continued to wrestle with problems in the Federal domestic programs, including providing support for basic as well as applied science; the

European recovery and the growing cold war remained their principal challenges abroad. On January 12, Truman announced that the budget for the new fiscal year would show a surplus of $4.8 billion of projected receipts over estimated expenditures; he suggested applying the surplus to reducing the national debt. The President requested a total budget for fiscal year 1948–49 of $39.7 billion, of which $11 billion, or $279 million more than in fiscal 1947–48, would go to national defense; $7 billion to international activities and finance; and $1.6 billion to natural resources. The budget provided "for basic mapping and investigations only as part of a long-term program," including an increase from $10 million in 1947–48 to $15 million in 1948–49 "for the basic surveys and mapping of the Geological Survey." Expenditures by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) "for limited exploration and development, mostly for strategic and critical mineral supplies," Truman added, "will continue in 1949 at a slightly increased level. Since these efforts cannot result in the discovery of resources for all foreseeable requirements," he concluded, "we must supplement them by stockpiling materials likely to become deficient."[5]

For the Interior Department in its centennial year, the Truman administration's budget requested nearly $443.5 million, an increase of some $202.5 million more than the appropriation for fiscal year 1947–48. Interior expected its revenues during the coming fiscal year to rise by $5.2 million to a total of $107.6 million. Interior's proposed budget included $16 million for salaries and operations by the USGS, or some $5.9 million more than provided during the previous year but less than the $22.1 million requested by the USGS from the Bureau of the Budget. The USGS asked for $6.58 million for topographic surveys, more than twice the appropriation for fiscal 1947–48. The USGS intended the new sum to cover the $2.2 million required for its surveys of militarily strategic areas, monies formerly supplied by transfers that included $1.9 million in 1947–48, from the Army and its Engineers. The USGS also expected an increase in cooperative funds from States, counties, and municipalities. The USGS wanted $2,988,000 for geologic and mineral-resource surveys and mapping, $400,000 for work in Alaska, $3,496,700 for investigations of water resources, $425,000 for classifying lands, $710,000 for mineral-leasing supervision, and $768,000 for printing and binding. The USGS expected to add to its direct appropriations about $12 million from other Federal and nonfederal sources.

The House appropriations subcommittee on Interior began hearings on its budget on February 16, 1948. Iowa's Benton ("Ben") Jensen, often a harsh critic of Interior and the USGS, succeeded Ohio's Robert Jones as chairman after Jones resigned on September 2, 1947, to join the Federal Communications Commission. Chairman Jensen, after a 7-week trip with subcommittee member Ivor Fenton to inspect Interior's activities nationwide, looked more favorably on the Department than did Jones. As Julius Krug was unavoidably absent, Jensen read the Secretary's opening statement into the record.

Director William Wrather, in his remarks to the House subcommittee on March 15, again "stressed the importance of basic scientific investigations within the Geological Survey"[6] and pointed out the agency's continued development and expanded use of the airborne magnetometer and geochemical methods as effective exploration tools for locating concealed mineral deposits. Part of the proposed increase in direct funds for topographic surveys would expand research toward modernizing mapping techniques. Wrather also emphasized two of the agency's continuing problems—difficulty in hiring adequately trained scientific and technical employees and the present spending limit on personal services in the District of Columbia. "We are already decentralized to the point where the Survey is largely a field organization,"[7] the Director explained, and although the agency must perform most of its professional activities outside Washington, vital administrative and staff functions must be conducted there. He urged the subcommittee to approve the proposed increased expenditures for personal services in the Capital. If Congress endorsed the USGS request for increased direct funding for fiscal year 1948–49, Wrather and John L. Ramsey, the agency's Budget Officer, said that the expanded budget would provide for 1,400 full-time jobs. USGS regular (permanent) employees in the Capital and in the field rose from a postwar low of some 2,500 persons in fiscal 1945–46 to about 3,320 people in fiscal 1947–48. The increased staff would be more than 3,820 regular (full-time) and some 2,370 part-time (seasonal and other) employees by January 31, 1949, but Ramsey explained that most of the latter group would read water gages and wells.

In responding to Jensen's queries about the requested funds for topographic surveys, Chief Topographic Engineer Gerald FitzGerald emphasized his Branch's continuing efforts to conduct more economical and efficient operations, but he reminded Jensen that some 50 percent of the Nation remained unmapped at currently usable scales. During the last 2 years, USGS topographers concentrated their work on mapping the Missouri River Basin and on special areas selected by the Army. To improve coordination in federally sponsored mapping, the USGS recently formed agreements with the Army and its Engineers, the Bureau of Reclamation, the Coast and Geodetic Survey, and the Forest Service "to provide, insofar as possible, all their map needs."[8] Accepting this responsibility, FitzGerald cautioned, placed a larger burden on the USGS and made it necessary for the agency to seek a staff of sufficient size and talent to accomplish the task. As one measure of the Topographic Branch's efforts toward economy and modernization, FitzGerald reported that it was "using helicopters, not in Alaska but in the West, under a contract to determine how much we can cut our over-all field costs."[9] After Robert O. Davis, Earle Fennell, and other USGS topographers met with representatives of Bell and Sikorsky, the agency requested bids for a 1-month project in Colorado to transport men and equipment in the field. An aircraft company in St. Louis won the contract and began operating, from the Royal Gorge Airport at Cañon City, a Bell Model 47B, the new, four-seat, fully enclosed helicopter known as the "Sioux" in the Army version. The helicopter successfully supported operations at triangulation stations at elevations of up to 10,200 feet above sea level and, subsequently, additional mapping in the Paradox area. Representative William Norrell, whose experience in the oil and mining industries gave him a better appreciation than some of his legislative colleagues of this innovation's importance, suggested that "the Nation could afford a helicopter for your Department."[10]

Fenton, who began the subcommittee's evaluation of the funds requested by the USGS for geologic surveys, agreed with Wrather that topographic mapping and finding new mineral deposits "are inseparable."[11] The USGS significantly reduced the total of funds requested for strategic-minerals investigations after the agency received advice to drop most of these studies at the war's end and return to the peacetime program. In view of the worsening international situation, Chief Geologist Wilmot ("Bill") Bradley suggested that the USGS should restore its work on strategic and critical minerals; the agency, he added, would offer a "sizable item" in its "next budget submission."[12] Wrather then agreed with Fenton that these studies should have "very high or the highest priority"[13] and reported continuing the USGS wartime practice of assigning one or more geologists to each of the important mineral commodities.

In assessing the USGS energy-resources program, Michael Kirwan noted the shortage of oil during the past year and asked Wrather why he thought it occurred. The Director cited as one factor "the prodigious increase in the consumption of oil by new users and in new uses," in home heating, by industry, and in private and public transportation. Wrather had expected a post-war "breathing spell" that would allow the petroleum industry to "take stock" and perhaps cut back on production to "get on an even, sound footing again." Instead, "consumption and production are going up and up and up." The United States now used nearly 6 million barrels per day, a total higher than the war's peak rate. Wrather, in words eerily reminiscent of his response to Senator Patrick McCarran in May 1943, while trying to explain wartime shortfalls, recalled that

> **[i]n my own experience, I have seen the daily production in this country expand five fold. I remember when in 1919–20 the daily oil production first passed 1,000,000 barrels a day. Today it is 5,300,000 or 5,400,000 barrels a day.[14]**

As part of the USGS response to this problem, the USGS request for increased funds for continued investigations of Alaska mineral resources included nearly $15,000 for petroleum-related studies. Only 43 percent of the Territory's lands were mapped at reconnaissance scales; of that area, just 11,000 square miles were covered at scales sufficiently large for a sketchy appraisal of its petroleum potential. The same held true for part of the Goodnews Bay platinum-mining district, one of two provinces in western Alaska, of whose 12,000 square miles only one-sixth was adequately mapped. Alaska produced minerals worth $904.5 million between 1880 and 1945, but only 0.3 percent of the Territory was mapped well enough to evaluate these resources. Most of the remaining appropriation would go to geologic mapping in and investigations of nonfuel minerals in Alaska, but, with coal now increasingly important, $22,000 would fund coal-resources studies. The agency's request also contained a new item of $12,000, to replace Navy funds, for geophysical and related studies in the Aleutians "to determine whether there is any active movement in the islands, and to find out whether it is possible to determine the periodicity of the volcanoes; how often they are apt to erupt." The USGS tabulated all available historic records from the Aleutians to try to determine if "there is any periodicity that is to be counted on with any assurance."[15]

The USGS also asked for an additional $600,000 for coal investigations as part of geological surveys in the States. Norrell, wishing to reassure his colleagues that the USGS did not compete with water-well drilling or other industries, queried the increase for coal studies. USGS work had increased since the war due to the greater demand for its services, Wrather reminded the subcommittee, and the agency's program reflected pressures for particular types of work. No USGS operations duplicated those of private enterprise and would not do so in the future, "if we can help it."[16] The country should look to its coal, Wrather suggested, in trying to solve the oil problem. Funds were required to begin a 10-year program of appraising the Nation's coal resources at a total cost of $12.5 million. Although the amount of coal-derived energy peaked just before World War I, and petroleum took coal's place since then, Wrather believed that "we are about to see a reversal of these relationships."[17] The change would not be sudden or disruptive, but it was becoming increasingly difficult and costly to find each new oil field, and so more money and time would have to be spent on the search. Advanced techniques of converting coal into liquid and gaseous fuels comparable to petroleum and natural gas would enable the synthetics to compete with petroleum in the foreseeable future. The chemical industry's increasing use of coal as a raw material also created an even greater demand for this resource. The most recent comprehensive estimate of U.S. coal resources was 20 years old, Wrather asserted, and subsequent developments showed that it might be flawed.

Wrather pointed out the need to press on with the search for new deposits of minerals for security in times of emergency and to provide low-cost sources for industry. The gross value of mineral production had risen from $1 billion to $12.4 billion since 1900, as the number of mineral commodities on the market increased from 56 to 150. The strategic list now held 51 of these minerals, and 34 of them were in the vital A group. Stockpiling continued to be an essential activity, but Wrather also emphasized the necessity of discovering new deposits, facilitated by the newer exploration techniques. He tried to impress on the subcommittee's members, as did Walter Mendenhall during the energy crisis of the 1920s, that it took time to search for, find, and develop mineral deposits. Arizona's San Manuel copper deposit, some 30 miles northeast of Tucson, was known in 1943 but it would not be ready to produce for the market for another 5 years and it would take a full generation to mine. Yet San Manuel contained only enough copper to supply U.S. requirements, at 1947's rate of consumption, for 2 years, and the United States produced only a little more than half the copper it used. "In order to supply our own needs," the Director concluded, "we must find the equivalent of a San Manuel copper deposit every 2 years, a new southwest Wisconsin zinc field every 1½ years, a new Adirondack iron district every 6 or 7 years, and so on for a long list of other minerals."[18]

The USGS budget for geologic surveys included new wording specifying the printing of geologic reports. One of the most critical problems facing the USGS, Wrather noted, involved the agency's inability to publish promptly "the results of investigations and mapping."[19] In 1938 and 1940, respectively, amounts equal to 9 and 10 percent of the appropriations were available for publication. Thereafter, the percentage dwindled rapidly until in 1948 publication funds represented only 3.5 percent of the appropriation. That loss forced the USGS to place on its library's shelves most of the results of its investigations, rather than publishing and distributing them to the public. Some of this backlog, Wrather indicated, might be reduced if Congress authorized the agency to use some of its operating funds and (or) increased funds for printing and binding, including the topographic and geologic maps printed in the USGS' own plant.

At the end of the USGS hearings, Chairman Jensen, in a mellow mood, complimented but also cautioned the Director. "Dr. Wrather," Jensen observed, "it is a pleasure to have you and your staff come before the [sub]committee. We always get the information we seek. Although we may not agree with you and give you all the money you want, we nevertheless like the way you carry on your Department."[20] "I want to furnish you a sufficient staff," Jensen emphasized earlier, "I know this committee does, and I know the Congress does, and I know the American people do, too," before adding phrases reminiscent of some turn-of-the century and subsequent legislators. "But I also know that the Congress and the people and this committee just simply do not want the Geological Survey to get in the same rut that some other departments of Government have gotten into because of the overstaffing of the departments." "I hope," Jensen added, "the Geological Survey never gets in that rut because of the very nature of your work, in particular, which is so important. * * * I feel you have done a good job, and I am a little afraid, if we give you these extra 1,400 men, or a majority of them, that you might get the bureaucratic fever that the rest have."[21]

Secretary Krug, testifying before Jensen's subcommittee on April 29, 1948, the day Jensen introduced a stockpiling bill, remained reluctant to advocate increased-personnel expenditures by any of Interior's bureaus because he deeply desired to effect economies in the Department. When Krug personally looked into the programs of the USGS and the USBM, he found both agencies hesitant to ask for the additional funds required for their programs "because of the difficulty of getting the people to do the work." "Yet they are hopelessly behind a minimum schedule to meet our critical needs," Krug explained, "and the period it will take to catch up is a shocking thing to me. If I were to give priorities in our programs—and I am not trying to say what you should cut—I would like to say, please don't cut these two agencies that are directly related to expanding our mineral resources."[22] Only 10 percent of the United States, Krug later emphasized, was mapped geologically at scales adequate for mineral-resources evaluations. That level of completion placed the Nation, Krug observed ruefully, slightly behind Algeria's coverage but just ahead of Poland's.

The House subcommittee's immediate reaction to Krug's verbal plea was mixed, and its report proved disappointing. Jensen's subcommittee, impressed by the value of USGS work in support of national defense and preparedness, approved an increase in the total requested by the USGS, but it was only $881,000 more than the sum appropriated for fiscal year 1947–48, or just 15 percent of the requested raise. The House did allow the USGS to expend operating funds for publishing its reports rather than continuing to require a separate line item for this purpose. Action on Interior's budget then moved on June 1 to the Senate subcommittee, where Kenneth S. Wherry (R–NE) replaced "Chan" Gurney as chairman. Wherry's subcommittee more than doubled the House's increase to 37 percent of the requested amount, bringing the total appropriation to $13,924,000. The conference committee compromised on a total of $13,027,000 for the USGS for fiscal 1948–49.[23] Of this sum, $237,350 would be used for salaries and expenses,[24] $4,350,000 for topographic surveys, $2,625,000 for geologic surveys, $325,000 for Alaska mineral resources, $3,496,700 for water-resources investigations, $300,000 for classifying the public lands, $690,000 for supervising mineral leasing, and $602,950 for publications; the sum also included a cooperative advance of $400,000 to be "returned to the Treasury not later than six months after the close of the fiscal year 1949 out of reimbursements received from the cooperating agencies."[25] The House and Senate also compromised on the higher limit of $4,750 for attendance at scientific meetings and authorized the USGS "to contract for the furnishing of topographic maps made from aerial photographs, or for the making of geophysical or other specialized surveys."[26]

Truman signed the bill for Interior's appropriations for fiscal year 1948–49 on June 29, 1948. The new law provided the usual transfer funds of $19,500 for stationery supplies; deficiencies legislation, enacted on June 23, 1949, furnished an additional $700,000 for increased pay costs.[27] Transfers from other Federal agencies and funds from States, counties, municipalities, and miscellaneous sources increased the total funds available to the USGS during fiscal 1948–49 to just under $26,712,000, a gain of $4.3 million, or about 19 percent, from the previous year. To this total, States, counties, and municipalities contributed nearly $3,486,000, while about $9,223,000 of the $10,062,000 transferred by other Federal agencies came from seven principal organizations—$3,931,000 from the U.S. Bureau of Reclamation (USBR), $2,602,000 from the U.S. Atomic Energy Commission (AEC), $1,524,000 from the Department of the Army, $517,000 from the Department of the Air Force (as renamed in September 1947), $329,000 from the Navy Department, nearly $243,000 from the Department of State (DoS), and $77,000 from the Tennessee Valley Authority (TVA).

The appropriations statute for fiscal year 1948–49 also authorized the USGS to "acquire from the Department of National Defense or from any disposal agency of the Government without reimbursement or transfer of funds, one aircraft for replacement only; including engines, parts, accessory, and flying equipment."[28] In 1900, Senator Henry C. Lodge (Sr., R–MA) asked a colleague if he doubted "that in time, as the Coast Survey has extended onto the land and become geodetic, the Geological Survey would extend onto the water and get a navy?"[29] In 1948, the USGS still lacked blue-water vessels but now Congress and the President enabled the agency to begin its own air force by searching for a larger plane to replace the Navy's Beech SNB–1 to continue airborne geophysical surveys. In 1949, the USGS acquired a Douglas C–53D Skytrooper delivered to the U.S. Army Air Forces (USAAF) in 1943 and then combat-flown in Europe during 1944–45. The USAAF then leased the C–53D to American Airlines, which operated the aircraft under Civilian Registration Number N19924, before it was transferred to the USGS, was repainted, and began flying magnetic surveys for the agency. In 1955, the U.S. Air Force (USAF) transferred a C–47 (N19950) to the USGS.[30]

As the USGS budget for fiscal year 1948–49 passed through congressional review and modification, the world became increasingly more complex and dangerous as two European nations continued to try to regain control of their former colonies, conflict less than outright combat grew in other regions, and armed disputants in one area began open warfare. In Indochina, the French and the non-Communist nationalists, both the Buddhist majority and the Catholic minority, recognized the independence of Vietnam (Cochin China), within the French Union, in March 1948. They combined to establish an anti-Communist Republic of Vietnam in June under Bao Dai, the former Emperor of Annam, with Ngô Dình Diêm as his deputy. In the north, the French struggled to reimpose their government throughout the country by defeating the Viet Minh, although Hõ Chí Minh's forces grew ever stronger as they continued to operate as guerrillas from their rural bases. In the East Indies, Mohammed Hatta and Achmed Sukarno declared the Republic of Indonesia (Java, Madura, and Sumatra) on August 17, 1945, but The Netherlands refused to recognize the change, and Dutch and British troops clashed with those of the new nation. Negotiations during February–November 1946 produced the Chierbon Agreement in March 1947 for a United States of Indonesia (the Republic, plus Borneo, the Celebes, the Moluccas, and the Sunda Islands) as an equal part of The Netherlands, but significant differences remained and war resumed in July 1947. The United Nations (U.N.) Security Council sponsored a cease-fire and a committee to resume negotiations that led to a second agreement in January 1948 that also dissolved into renewed fighting.

War and disputes continued or began elsewhere in Asia, in Europe, and in the Middle East. Mao's forces gained the upper hand in China's civil war. Korea remained divided, and the low-level conflict grew between the regimes in the north and south halves of the "Land of the Morning Calm." Britain, continuing to grant independence to her colonies, completely freed Burma (Union of Burma, later Myanmar) in January 1948, and made Ceylon (now Sri Lanka) a self-governing unit of the Commonwealth in February. Independence did not guarantee peace. Violence between Hindus and Muslims in India and border clashes, especially in Kashmir, between India and Pakistan, went on before and after a Hindu fanatic killed Mohandas Gandhi in Delhi on January 30 and Mohammed Jinnah died in September. In Europe, the Soviet Union continued to oppose the European Recovery Program's successful operations, and it began to restrict the West's access to Berlin. In the Middle East, Britain gladly ended its difficult and costly occupation of Palestine, under U.N. mandate, and the Muslim-Jewish struggle there flamed into open war.

The Zionists' intention to recreate and repopulate Israel within its historic Biblical lands and the military response promised by Arab rulers made war in the Middle East almost inevitable.[31] The British Government sent its plan for Palestine to the United Nations in February 1947, nearly 30 years after Britain's Balfour Declaration promised to establish there a national home for the Jewish people but without affecting the civil and religious rights of non-Jewish inhabitants. The U.N. General Assembly then sent to Palestine a Special Committee to evaluate the British and other plans for partition, a concept Truman approved early in October 1946. In August, the U.N.'s Committee recommended dividing Palestine into a Jewish state, with an equal number of Jews and Arabs, a 100-percent Arab state, and an internationalized Jerusalem. The U.N. General Assembly approved the plan in November. The Anglo-American Committee's report in 1946 asked that Palestine take in 100,000 more Jews from Europe and recommended neither partition nor independence. The U.N.'s Committee feared additional violent acts by Arab and Jewish fanatics, like the latter's explosive device that destroyed Britain's headquarters for Palestine in Jerusalem's King David Hotel and killed nearly 100 Arab, British, and Jewish people on July 22, 1946. Instead, the Committee suggested establishing a single Arab-Jewish state under U.N. trusteeship before the British mandate ended on August 1, 1948.

In response to the U.N. General Assembly's approval of its Committee's plan for Palestine, delegations from the Arab countries walked out. Prince Faisal, representing Saudi Arabia, also took the U.S. affirmative vote as a personal affront. In 1945, Faisal signed the U.N. Charter in San Francisco and made a second visit, during July 31–August 1, to Washington, where Acting Secretary of State Joseph Grew assured the Prince that Truman, then at Potsdam, would honor Roosevelt's promises to King Ibn Saud. When Crown Prince Saud visited Washington by invitation in January 1947, principally to request a $50 million loan for economic development in the Kingdom, Secretary James Byrnes promised that the United States would support its independence, territorial integrity, and security and the application of the U.N. Charter but would oppose any British-backed "Greater Syria." When the Security Council failed to endorse the General Assembly's plan, Palestine lapsed into renewed chaos. Britain declared in December that its troops would be withdrawn by the end of its mandated occupation, now scheduled for May 15, 1948.

On May 14, 1948, as the last British military units left Palestine, David Ben-Gurion, head of the Jewish Committee, declared Israel's independence according to the U.N.'s plan. The United States and the Soviet Union immediately recognized Israel in fact. The United States provided no official and little real aid to Israel, aside from a few advisers and other volunteers, but it acknowledged Israel and Transjordan (later Jordan) in law on January 31, 1949. The Arab League, founded, in part as an anti-Zionist organization, by Egypt, Iraq, Lebanon, Saudi Arabia, Syria, Transjordan, and Yemen in March 1945, quickly moved to destroy Israel. Truman, who favored independence for Arabs as well as Jews, decided not to send U.S. troops to make and enforce a peace in Palestine. Truman, with a large Jewish constituency at home but only a tiny Arab one, did not, in the end, fully make good on Roosevelt's pledges, but Truman did continue to inform Ibn Saud by letter and to support Saudi Arabia, to which the President twice sent his personal physician and a medical team to treat the ailing King.

Armies from five members of the Arab League invaded Israel. The Israelis, although aided by their single command and internal lines, repelled with difficulty the 42,000 Egyptian, Iraqi, Lebanese, Syrian, and Transjordanian troops,[32] of which the most effective were the 10,000 in Transjordan's British-trained and British-led Arab Legion. Another 50,000 Palestinians, in less organized local units, provided some aid to the Arab regulars. The Israeli army regulars and reserves, including some veterans of the British 8th Army, numbered nearly 33,000 and had weapons for another 30,000; two terrorist groups held 4,000 more. As Israeli forces grew in strength, professionalism, and confidence, they began offensives. In April 1948, the Israeli army captured Haifa and Jaffa, but it did not retake East Jerusalem from the Arab Legion. In the south, Israeli forces defeated the Egyptians, to whom, like the Syrians, the Soviets furnished arms.

As fighting continued in Palestine, Zionist terrorists assassinated the U.N.'s Swedish negotiator Count Folke Bernadotte on September 17. American Ralph Bunche, Bernadotte's assistant, replaced him and negotiated a temporary armistice in February 1949 and a formal one in May, which received British, French, and U.S. support in 1950, the year Bunche received the Nobel Peace Prize. By the agreement, Israel comprised an area more than 50 percent larger than the country depicted in the U.N. plan and included nearly 80 percent of the former British Palestine mandate, but more Israelis than Arabs paid with their lives for these changes. When Jordan annexed 2,000 square miles of the West Bank, in the area west of the Jordan River, Palestine disappeared entirely into Israel, Jordan, and Egypt, which kept the Gaza Strip and the El Aija area in the Negev Desert. The Palestinian diaspora, their "catastrophe," during 1947–49, displaced more than 700,000 of the original 1.3 million Arabs in the region. Some 400,000 of these people fled to Jordan's West Bank lands, another 150,000 left for Egypt's Gaza enclave, and an additional 150,000 immigrated to Lebanon and Syria. The U.N. established a Relief and Works Agency for Palestine Refugees in the Near East. Some of the Arabs who remained on their lands within the new democracy chose to become Israeli citizens. Jewish immigration to Israel, especially from Arab countries, resumed and the new country's economy soared.

The major oil-producing Arab countries did not enlist their petroleum resources in the struggle to overwhelm the Israelis during the 1948–49 war, as historian Daniel Yergin noted, but the importance of the Middle East's oil continued to grow, as predicted by Everette DeGolyer's team in 1944. America's petroleum exports last exceeded her imports in 1947. In that year and in 1948 as Yergin recorded, U.S. and British oil companies retained or gained control of most of the Middle East's petroleum,[33] which, except for Iran's, represented just 6 percent of the world's supplies. In Saudi Arabia, Socal (later Chevron) and Texaco (as Caltex) began building in 1947 the Trans-Arabian Pipeline (Tapline), championed earlier by Secretaries Harold Ickes and James Forrestal. To reduce risk and recover part of their investments, the two companies sought additional partners. In view of Ibn Saud's demand that Aramco remain wholly American, and with the King's approval, Socal and Texaco sold 30 percent of Caltex to Standard of New Jersey (later Exxon) and another 10 percent to Socony-Vacuum (later Mobil). Aramco's now four companies signed a joint agreement on March 12, 1947, the day Truman announced aid to Greece and Turkey as part of his "Doctrine," and they completed the merger in December 1948. Meanwhile, Gulf and Royal Dutch/Shell agreed to divide equally during the next 10 years the profits of the Kuwait Oil Company, a consortium joined in reconstructing the Iraq Petroleum Company, and the Anglo-Iranian Oil Company signed a 20-year contract with Standard-Jersey and Socony-Vacuum. Ibn Saud, who might have canceled his Aramco concession, did not. The King continued to view Hashemite Iraq and Jordan, and Arab Communists, as greater threats than Israel. He needed Aramco's royalties for his own and other uses and sought mutual-defense treaties with the United States and Britain. Ibn Saud also convinced some of the Arab League's member nations that Aramco's revenues strengthened Saudi Arabia and thus enabled that country to increase indirect aid to the Arab cause.

As Arabs fought Israelis in 1948–49, the United States continued trying to contain the Soviet Union in accord with the Truman Doctrine by all actions, short of war, "to support free peoples who are resisting attempted subjugation by armed minorities or by outside pressures."[34] The Soviets, although faced with enormous domestic difficulties following the war's devastation, devised and applied a foreign policy that advanced their own nationalist and Communist influence. Starting in mid-February 1948, the Soviets helped to overthrow the government of Czechoslovakia, purged it, nationalized its banks and industries, and established forced-labor camps. To carry out the Soviet-opposed Marshall Plan, the 80th Congress and President Truman approved the Foreign Assistance Act on April 3, 1948. Title I, the Economic Cooperation Act, provided for European and other international economic collaboration as part of continuing American efforts to "promote world peace and the general welfare, national interest, and foreign policy of the United States through economic, financial, and other measures necessary to the maintenance of conditions abroad in which free institutions may survive and consistent with the maintenance of the strength and stability of the United States."[35] The new law provided for "promoting industrial and agricultural production in the participating countries; * * * furthering the restoration or maintenance of the soundness of European currencies, budgets, and finances; and * * * facilitating and stimulating the growth of international trade * * * by appropriate measures including reduction of barriers which may hamper trade."[36] The statute established the Economic Cooperation Administration (ECA), headed by an Administrator appointed by the President, advised by a National Council and a Public Board, and represented abroad by a special representative of ambassadorial rank and ECA missions in each country. Additional titles covered the International Children's Emergency Fund, provided up to $275 million in assistance to Greece and Turkey, and capped aid to China at $338 million.

Truman appointed Paul G. Hoffman, the president of Studebaker Motors since 1935, to lead the ECA, and the Senate confirmed him on April 7, 1948. Congress furnished $4.3 billion for the initial year, and later $17 billion in all, for the European Recovery Program run by the ECA, which began operating independently of the DoS in the following summer. Several West European nations responded in part by signing a treaty in Brussels on March 17 that established a 50-year economic, military, and social alliance between Belgium, Britain, France, Luxembourg, and The Netherlands, to expand 1947's Benelux agreement among Belgium, The Netherlands, and Luxembourg. The Marshall Plan participants met in Paris and, on April 16, founded the Organisation for European Economic Co-operation. Two days later, the Christian Democrats overwhelmingly defeated the Communists in Italy's national elections. On May 7, a congress of European nations, led by Winston Churchill, met at The Hague to plan for a European Union, in which (West) Germany might play a role. The Western Powers began West Germany's economic recovery in December 1946, when Secretary of State James Byrnes and Foreign Minister Ernest Bevin signed an agreement that fused the American and British zones of occupation as "Bizonia," but France and the Soviet Union refused invitations to join them. Subsequent actions to rehabilitate West German industry culminated in June 1948 in an agreement by representatives of the United States, Britain, France, and the Benelux countries to encourage international control of the Ruhr, link West Germany to the Marshall Plan, draft a constitution for the now two Western zones, and establish for them a military security board and a stable currency.

The Soviet Union responded to these actions in several ways in different parts of the international arena. The Soviets improved their foreign exchange in December 1947 by devaluating the ruble by 10 to 1. By February 1948, they made several parallel economic moves in their occupation zone in Germany. On March 18, the Soviets recalled their advisers from Yugoslavia and then expelled Marshal Tito's country from the new Cominform, producing a potential gap in the Iron Curtain. When Tito denounced the Cominform and Yugoslavia's treaty with the Soviets, Albania withdrew from the Yugoslavian coalition. In August, the Soviet Union ended all consular relations with the United States. The Soviets, building on treaties signed earlier in 1948, established on January 25, 1949, the Council for Mutual Economic Assistance (Comecon) as a response to the Organisation for European Economic Co-operation. By 1950, Comecon included Bulgaria, Czechoslovakia, Hungary, Poland, and Romania; Albania and East Germany joined later. In Germany, the Soviets withdrew from the Allied Control Council on March 20, 1948, and began interfering 2 weeks later with traffic on the previously approved rail and road routes to and from West Berlin. On June 24, six days after the Western Powers established the new West German mark, the Soviet Union denied the Western Powers all access by land and water to the city in an attempt to starve the West Berliners and force the Allies to surrender control of their sectors.[37] Pavel and Anatoli Sudoplatov later asserted that Stalin also ordered the blockade to prevent Truman from authorizing the use of U.S. atomic bombs in China in an attempt to halt the continued advances of Mao's Communist forces and save at least a part of the country for Chiang's Nationalists.[38] On June 24, as Soviets began blockading Berlin, Truman signed the Selective Service Act,[39] to replace the 1940 statute that expired on March 31, 1947, and reestablished registration for all U.S. male citizens between 18 and 25. The new law restricted active service to those more than 19 years old and limited their active-duty service to 21 months. Britain passed its National Service Act, for males 18 to 26 years old, in December. Truman ordered to Germany 60 B–29 bombers, not yet equipped to carry nuclear weapons, and escorting Lockheed F–80 jet fighters.

Pending resolution of the crisis, the Western Powers also responded with Operation Vittles, a massive airlift of food, fuel, and other supplies to West Berlin initially ordered by General Lucius Clay (Sr.), General Eisenhower's postwar deputy and now the military governor of Western Germany and commander of U.S. forces in Europe. On June 28, 1948, Truman approved a full-scale operation to bring relief, via the three major airfields in West Berlin, to the city's more than 2 million residents. Major General Curtis LeMay, now commanding the U.S. Air Forces-Europe, planned and guided Vittles, before taking over in October, as a Lt. General, the Strategic Air Command. Major General William H. Tunner, who oversaw the Allies' wartime airlift over the Himalayas to China, succeeded LeMay as head of the Combined Airlift Task Force. Deliveries by American C–47s and four-engine C–54s, and British transports, flying in good weather and bad, rose from 80 tons on June 26 to more than 5,500 tons on September 18. The Allies closed their zone to traffic from the East in February 1949, and the Soviets ended their blockade in May. By the time the airlift ended on September 30, Allied aircraft had delivered more than 2.3 million tons of cargo[40] in 277,000 flights but at a cost of more than 320 deaths among the crews and an expenditure of more than $200 million.

As the Soviets reevaluated their increasingly ineffective blockade of Berlin and the West's counter effort to halt the eastward flow of its goods, their influence remained strong in the Far East, except in Japan. Mao's Communist troops continued to advance against Chiang's Nationalist forces on all fronts in China during 1948, even though aid from the United States since the end of World War II now topped $2 billion. Some of Chiang's best units were destroyed in combat; his surviving troops could not overcome the results of continued corruption in government and inflation nationwide. The Communists, aided by their ever-increasing heavy artillery, recaptured Yan'an in March. They declared a North China People's Government on September 1, as troops led by Lin Piao (Biao) neared Mukden (Shenyang).

The adjacent Korean Peninsula also remained divided and chaotic.[41] On November 14, 1947, the U.N. General Assembly recognized Korea's claim to independence and then aided plans for peninsula-wide elections to establish a national government and arrange for the withdrawal of all occupation forces. The Soviet Union announced on January 23, 1948, that the U.N. Temporary Commission on Korea, operating from Seoul since January 8, would not be allowed to enter the Soviet-controlled northern half of the peninsula. In Pyongyang, Kim Il Sung and his supporters claimed the entire country, boycotted the U.N.-supervised elections on May 10 of a national assembly for the U.S.-occupied south, and refused to send invited representatives when the rightist-dominated assembly convened on May 28. That assembly established on August 15 the Republic of Korea (ROK, or "South Korea") and chose as its president conservative Syngman Rhee (Yi Sung Man), Korea's provisional-government leader since the 1920s, who opposed the U.S. offer to seek a U.N. trusteeship for the Korean Peninsula. In response, Kim founded the Democratic People's Republic of Korea (DPRK, or "North Korea"), with himself as premier on September 9. Rhee's government agreed on December 10 to accept economic aid from the ECA and the War Department. Two days later, the U.N. General Assembly recognized Rhee's regime in Seoul and formed a second commission to try again to unify the two Koreas. Soviet troops completed their withdrawal from North Korea on December 25, but they left a group of military advisers who would significantly outnumber their American counterparts when the U.S. garrison left South Korea.

On November 23, 1948, as the Soviet forces neared the end of their occupation of North Korea, President Truman approved the revised statement from the National Security Council (NSC) that outlined U.S. objectives and measures to counter Soviet threats to American security. In May, Truman asked Secretary of Defense Forrestal to prepare a defense budget for fiscal year 1949–50 that would not exceed $15 billion. The Soviet's blockade of Berlin on May 24 caused Forrestal and the Joint Chiefs of Staff, believing this level inadequate, to urge the President and the NSC on July 10 to prepare an evaluation of future risks, specific U.S. objectives, and how to achieve the latter. Three draft statements, derived principally from three existing papers by George Kennan and his Policy Planning Staff at the State Department, were merged as NSC–20/4, which Truman approved. NSC–20/4, among recommendations for aims and means in American domestic and foreign policy, called for developing "a level of military readiness which can be maintained as long as necessary as a deterrent to Soviet aggression" and provide "an adequate basis for immediate military commitments and for rapid mobilization should war prove unavoidable."[42]

During 1948, Truman and Congress also faced continuing and significant problems in domestic affairs, especially economic uncertainties fueled by the results of strikes during April–July in the coal, railway, and steel industries. When the Truman administration took action to stop the walkouts by invoking the Taft-Hartley Act, cooling-off interval negotiations led to a third round of postwar increases in wages. The raises included a cost-of-living adjustment in the agreement between General Motors and the United Auto Workers. Responding to the repeated unrest in the coal industry, Interior Secretary Krug, who discontinued the Coal Mines Administration on October 25, 1947, established on May 14, 1948, the National Bituminous Coal Advisory Council,[43] including representatives of the coal companies who met with him on January 27 in Washington. Krug and Under Secretary Oscar Chapman also moved quickly to increase the regional organization of Interior's operations in the Pacific Northwest and Alaska. On May 18, Krug revised the Pacific Northwest Coordination (Field) Committee,[44] composed of representatives from the Bonneville Power Administration, the Bureau of Indian Affairs (BIA, the renamed Office of Indian Affairs), the Bureau of Land Management (BLM), the USBR, the Fish and Wildlife Service (FWS), the National Park Service (NPS), the USBM, and the USGS, and revoked his order that originally established the group in September 1946. Truman's special message, on May 21, 1948, to Congress about Alaska included statehood among its recommendations for the Territory and its 94,000 residents. On July 1, Krug founded an Alaska Field Committee,[45] led by the Assistant Secretary responsible for Alaskan affairs and including representatives from the Alaska Railroad, the Alaska Road Commission, the BIA, the BLM, the FWS, the NPS, the USBM, and the USGS, to meet in Juneau. In 1949 and 1950, Krug and Chapman, Krug's successor as Secretary, began similar field committees for the Colorado-Great Basin (headquartered in Los Angeles), the Missouri River Basin (at Billings, Montana), and the Southwest (in Albuquerque) and named a Northeast Field Staff (in Boston).

During fiscal year 1948–49, the USGS increased its searches for and evaluations of mineral deposits and developed new geophysical and geochemical techniques for those purposes. In addition, the agency undertook new investigations to meet the needs of fast-growing industrial areas, highway construction, and provision of water supplies, as well as those to solve problems attendant on the construction of large dams for irrigation, power development, and flood control. To aid this work, the USGS made significant changes in administration and operations before July 1, 1948, and the agency continued similar modifications during fiscal 1948–49. Wrather established "a fifth [administrative] division [within the Director's

Office] to handle all the 'housekeeping' functions" in the USGS and prevent unnecessary fiscal statements, complaints about unpaid bills, personnel matters, and other issues from reaching his desk "when they should have been stopped at lower levels."[46] On May 10, a Survey order abolished the position of Chief Clerk,[47] established in 1881 and filled on an interim basis since the retirement of the last incumbent on June 30, 1947. The directive also transferred the Division of Map Reproduction, the Division of Accounts, and the Section of Correspondence and Records to Julian Sears, the Administrative Geologist.

Wrather's next Survey order, issued on June 25, 1948, restored the post of Executive Officer, discontinued since 1894, but placed it on the Director's staff (of 78 persons) to have the selectee serve as "an advisor and consultant to the Director and his associates and to the heads of the scientific and engineering branches in problems of business management."[48] This order appointed Glendon J. Mowitt, Executive Officer of the U.S. Railroad Retirement Board in Chicago, as USGS Executive Officer to provide a more objective analysis of how best to centralize accounting, job classification, personnel actions, housing, storage, purchasing, and mail and messenger services. His duties reflected those of Wilbur C. Irving, whom Bradley appointed as the Geologic Branch's Executive Officer during fiscal year 1946–47 to succeed Assistant Chief Geologist Joe Peoples. Wrather made Mowitt responsible for six business and service units: Accounts; Budget; Correspondence and Records; Field Equipment, transferred from the Topographic Branch in December; Map Reproduction; and Personnel. The order also changed Julian Sears' title from Administrative Geologist to Staff Geologist in the Director's Office to enable him "to devote himself more fully, as a scientific consultant and advisor to the Director, to problems of technical planning and coordination," while continuing to serve as Acting Director when both Wrather and Nolan were absent from Washington at the same time. Sears' new avatar marked the agency's "return to the original concept underlying the designation of successive field geologists as Administrative Geologist to assist the Director in various problems requiring a knowledge both of professional objectives and operations and of controlling laws, regulations, and policies."[49]

On January 1, 1949, as part of the Federal Government reorganization and by Wrather's order of December 15, 1948, the USGS abandoned its long-time usage for its administrative and programmatic units; USGS Branches became "Divisions" and their subordinate Divisions or Sections were renamed "Branches."[50] Wrather's order authorized two exceptions to these changes. The Atlantic, Central, Rocky Mountain, and Pacific Divisions of the Topographic Branch became Regions of the Topographic Division. The Geologic Branch's two topical Divisions were abolished, and their constituent Sections were restyled Branches in the Geologic Division.

For fiscal year 1948–49, Bill Bradley's Geologic Branch (Division) drew on directly appropriated funds of nearly $3,145,000 and total transfers of about $4,098,000, for a total of about $7,243,000 for its staff of nearly 530 persons. Other Federal agencies provided some $3,975,000, including nearly $2,554,000 from the AEC, about $885,000 from the National Military Establishment (mostly from the Army and its Engineers), $363,000 from the USBR, and $142,000 from the DoS. States, counties, and municipalities contributed $123,000. One "manager" in the USGS Pick and Hammer Club's annual show, on March 16, 1948, ruefully observed that outside money, shortages of quality geologists, plus some onboard "you oughta fire," and requests by "the brass" for ever more maps overcommitted the Geologic Branch and would bring a future reckoning. Adopting "I Cain't Say No" from "Oklahoma!," the 1943 musical by Richard Rodgers and Oscar Hammerstein 2d, he pleaded:

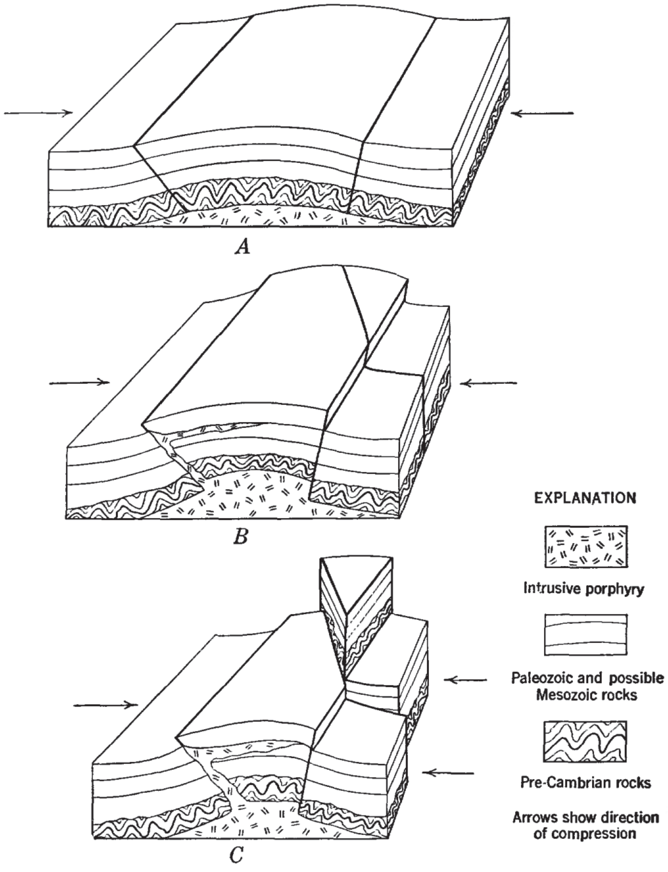
I'm just a man who can't say "No";
Can't seem to say it at all;
When I'm approached by Strauss or Krug,
Royall, or Lilienthal.

* * * * *

I CAN'T SAY NO.[51]

On December 31, 1948, Wrather approved Bradley's recommendation for the formal appointments on January 1 of Harold Bannerman and Harry Ladd as Assistant Chief Geologists[52] and ended, as required by Wrather's order, the Division of Economic Geology and the Division of Basic Sciences established by Bradley when he became Chief Geologist. Staff Geologist Stephen Capps, on detail to the Military Geology Section since the fall of 1948, died on January 19, 1949, leaving Foster Hewett, Hugh Miser, William G. Pierce, and William Rubey as the principal advisers in Bradley's office. During the second half of fiscal year 1948–49, the Geologic Division contained 12 Branches. Bannerman oversaw Mineral Deposits, the Trace Elements Planning and Coordination Office (TEPCO), Geology of Fuels, and Alaskan and Foreign Geology. Ladd remained responsible for Engineering Geology, General Geology, Paleontology and Stratigraphy, Geochemistry and Petrology, Military Geology, Geophysics, Geologic Information and Reports, and the Library.

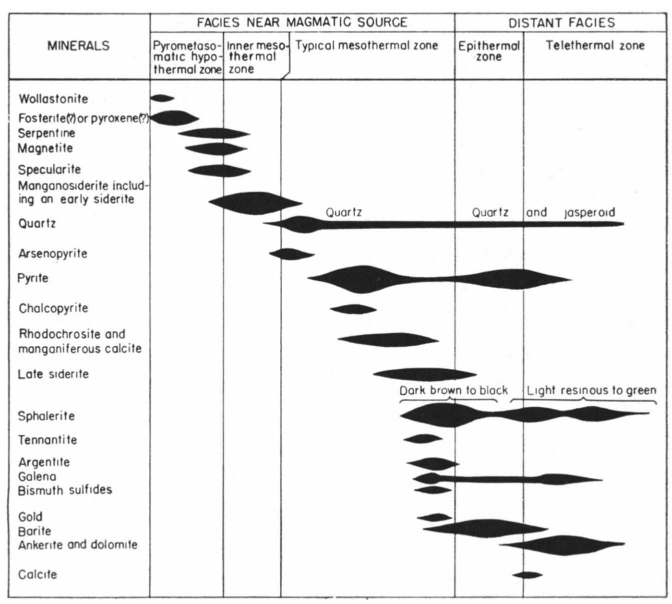
During fiscal year 1948–49, geologists in Olaf Rove's Mineral Deposits Section (Branch) conducted mapping and mineral-resource investigations and increased their emphases on searches for and evaluations of mineral deposits. At the request of the National Security Resources Board (NSRB), the USGS joined other Federal agencies in resuming studies of several strategic minerals. The



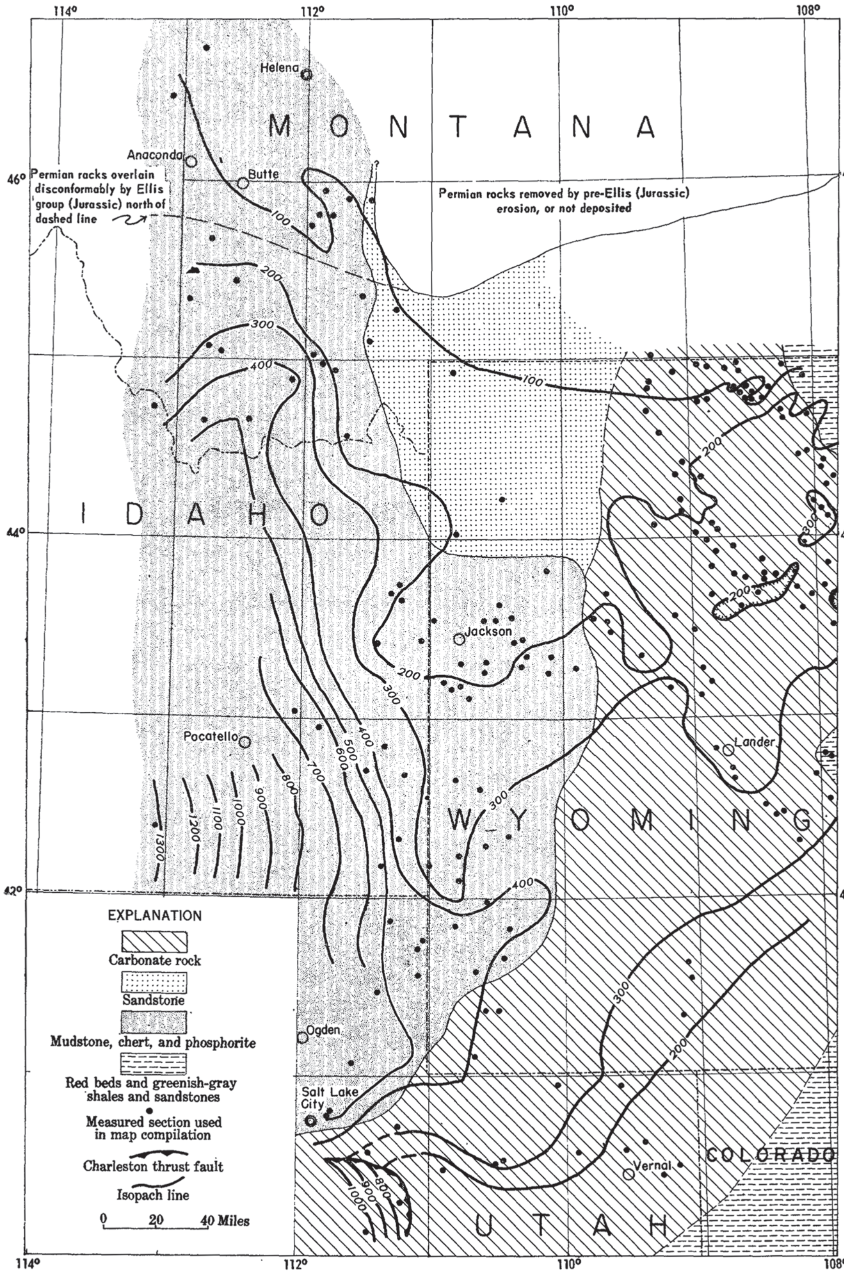
This figure, looking north, shows the sequence of major tectonic and intrusive events in three intervals during the Mesozoic and Cenozoic in the Leadville mining district and the western slope of the Mosquito Range in Colorado, as determined by USGS geologist Charles Behre, Jr., during his investigations in 1928–35 of the area's geology, ore deposits, and tectonic activity. The oldest-to-youngest sequences (shown from top to bottom) include the following: *A*, a typical Laramide (Late Cretaceous) upfold; *B*, a Late Cretaceous–early Tertiary sequence of movement along fractures from flatter thrust faults (Mosquito or Sawatch Ranges) to the west and steeper reverse faults (Front Range) to the east, followed by the intrusion of porphyritic magma and then mineralization; and *C*, continued compression (early Tertiary), especially in the northeast, producing faults oriented oblique to the major regional features. (From Behre, 1953, fig. 62.)

USGS also provided information to the ECA and published a guide for apprais-ing national mineral resources. Branch geologists completed 6 of the 45 field projects underway and began 2 new efforts. On July 15, 1948, David Gallagher, having completed his preliminary reports on Korea's mineral resources, relieved Richard Fischer as chief of the Colorado Plateau Project. Gallagher led three units—Geology, under Fischer; Engineering, headed by Norman E. Ebbley, Jr.; and Administrative, led by Helen J. Butcher—that appraised for the AEC the uranium resources of an area of 40,000 square miles. The Branch's Geochemical Prospect-ing Unit, while developing prospecting methods based on chemical studies of soils, vegetation, and water, conducted field experiments in ore searches in mining areas in Arizona, Colorado, New Mexico, Utah, and Wisconsin. When results proved encouraging, the mining industry began to try these techniques elsewhere. Vincent McKelvey's team continued its work on the Phosphoria cyclical marine-sedimentary sequences and their phosphate deposits in the West by mapping areas, sampling rocks and fossils for petrologic and paleontologic studies, measuring stratigraphic sections, determining facies relations, and making regional correlations. These efforts, building on their earlier work and on mapping and studies by Joseph T. Pardee and his USGS colleagues before the war, also were designed to produce a genetic model of depositional environments and their subsequent alterations.[53] The discovery of more than 15 million tons of iron deposits in New York, at a cost to the Federal Government of $150,000 (or about 1 cent per ton), followed an 8-year study by the USGS and demonstrated to industry the value of these investigations as aids to exploration.

Wrather and Bradley aided the work of the AEC-funded Trace Elements Program during fiscal year 1948–49 by establishing a new committee and reorga-nizing the Trace Elements Planning and Coordination Office. On February 23, 1949, they had established a Trace Elements Planning Committee "to consider and propose new lines of investigation of sufficient merit and scope to further the major aims" of the program. John Rabbitt chaired the new committee, whose members included Arthur Butler, Jr., Ralph Cannon, Jr., Thomas Lovering, Vincent McKelvey, Lincoln Page, and William Rubey. Bradley asked the committee to advise him and TEPCO. On June 24, 1949, Wrather and Bradley recast TEPCO, effective July 1, by designating Hubert D. Keiser as its Chief to replace Thomas Hendricks. They also transferred the functions and staff of Frank Stead's Technical Planning

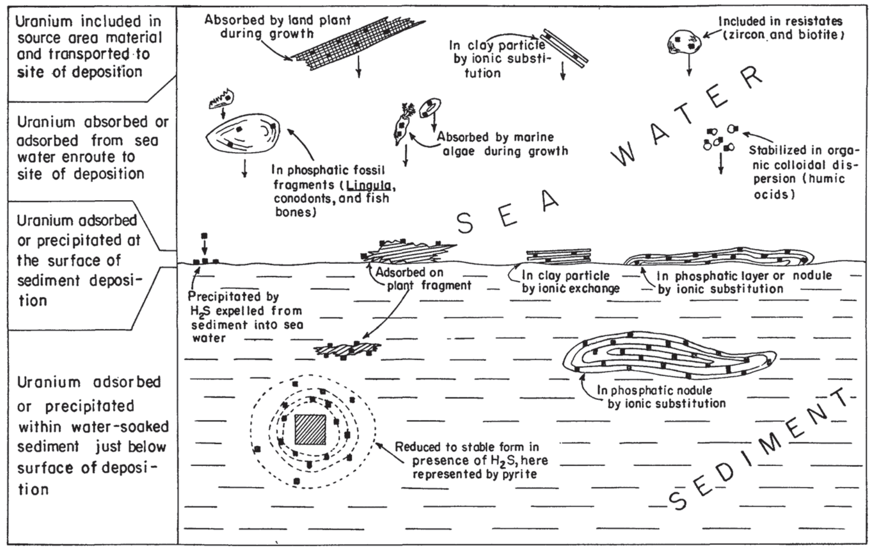


This figure shows the extent (in horizontal length of dark shapes) and timing (in vertical spacing of shapes) of Late Cretaceous–early Tertiary mineralization near to or far from the magmatic intrusions in the Leadville mining district and the western slope of the Mosquito Range in Colorado. Charles Behre, Jr., in his investigations during 1928–35, discerned an inner-to-outer sequence of five thermal "zones," each distinguished by its suites of minerals and grouped in "near" (three zones) and "far" (two zones) mineralization facies. USGS geologist Franklin Emmons began in 1879 the agency's studies of the region's geology and minerals. Knowledge gained was increased by the subsequent work of John D. Irving, Gerald Loughlin, and Charles Behre, Jr. Wartime responsibilities delayed Behre's publication of his investigations. (From Behre, 1953, fig. 63.)



This map (originally at 1 inch = 58 miles) portrays the four dominant rock types and thicknesses (isopach numbers represent thicknesses in feet) of the Phosphoria Formation (Permian) and age-equivalent rocks in the study area occupying parts of five Western States. USGS studies of the western phosphate field, principally the portion in Idaho, Montana, and Wyoming, began in 1910 and continued intermittently thereafter through World War II. These investigations resumed in 1947 for the U.S. Atomic Energy Commission's Raw Materials Division and the Missouri Basin Inter-Agency Committee. Fieldwork by a USGS team led by Vincent McKelvey concentrated on the area of the dark shale-phosphorite-chert facies of the Phosphoria Formation and its contained uranium. (From McKelvey and others, 1959, fig. 2.)

and Development Unit and the functions and field personnel of the Technical Operations Unit and the Technical Plant Development Unit to the Mineral Deposits Section (Branch). Wrather and Bradley also established a Reconnaissance Group, led by Lincoln Page, to investigate domestic sources of radioactive raw materials and reassigned Interior's personnel within TEPCO but kept unchanged the Analysis and Reports Unit managed by Butler. Wrather and Bradley asked Keiser, Olaf Rove, and Wilbur Irving to work out the coeval transfer of funds, property, and records required for these moves. Wrather and Bradley also authorized TEPCO, when preparing the annual budget request to the AEC, to call on the Geologic Division's operating Branches "to draft the estimate and narrative justification of the portions of the program for which they have operating responsibility, and to furnish such other data as may be necessary for preparation of a consolidated budget statement and determination of fund allocations to the respective Branches."[54]



This diagram shows the common organic and inorganic associations of uranium (black squares) in seawater and sediment and the methods of absorption, adsorption, and precipitation by which the emplacement of "uranium in marine black shales may have been localized and incorporated." Of the five types of materials genetically associated with the uranium, those vegetal and phosphatic "probably account for more than 90 percent of the total amount of uranium" in, respectively, the Chattanooga Shale of the Midwest and the Phosphoria Formation of the northern Rocky Mountains. Extensive regional searches by USGS scientists for uranium throughout the United States during 1944–54 included field and laboratory studies of these Paleozoic marine black shales and their origins. (Quotations and diagram from Swanson, 1960, p. 4 and fig. 2.)

Paul Averitt and other geologists in Carle Dane's Geology of Fuels Section (Branch) continued their comprehensive examination of the Nation's coal resources with two closely integrated programs in 1948–49. Regional appraisals of coal reserves provided data on minable-coal thickness, overburden, and data reliability for the reserves in individual beds. Detailed studies and mapping in selected areas yielded specific information needed to facilitate mining or locate new sources. These studies also produced fundamental geologic data upon which to base adequate resource estimates. Montana's coal reserves were reappraised by county, coal rank, and bed thickness; similar evaluations began of coal reserves in Michigan, New Mexico, and Wyoming. Fuels geologists also started detailed mapping of coal deposits in New Mexico's San Juan Basin, Colorado's Durango and Trinidad fields, Wyoming's Spotted Horse field, Washington's Lewis County, and Kentucky's Leslie County. They also completed a detailed map of Montana's Coalwood field and published maps of Alabama's Coosa field, North Carolina's Deep River field, and Oklahoma's Haskell County coal area, in cooperation with that State's Geological Survey, and prepared a similar report on occurrences in Oklahoma's Le Flore County. Exploratory drilling began in parts of Colorado's Yampa field, where large areas remained in the public domain as potential sources of good-quality coal. Branch geologists completed plans for a new coal-geology laboratory at Columbus, Ohio, to be led by paleobotanist and microscopist James M. Schopf of the USGS, who was interested in the origin of coal.

The Fuels Section's (Branch's) investigations of oil and natural gas during 1948–49 continued to provide, as rapidly as possible, the stratigraphic data—about source beds, reservoir rocks, vertical and lateral changes, and regional structure—and other basic information for the Nation's petroleum provinces that promised new discoveries. The USGS published 16 reports in the preliminary series of oil and gas charts and maps, of which by the fiscal year's end more than 115,000 copies had been distributed, including 25,000 of them in 1948–49. The Branch's 30 ongoing projects involved similar studies in 19 States—Alabama, Arkansas, California, Colorado, Florida, Georgia, Kansas, Kentucky, Michigan, Montana, New Mexico, New York, Ohio, Oklahoma, Oregon, Utah, Virginia, West Virginia, and Wyoming. Branch geologists also continued their detailed investigations of the rich deposits in Colorado's Parachute Creek-De Beque area, adjacent to Naval Oil Shale Reserves Nos. 1 and 3, and, in cooperation with the Navy, published a detailed study of these two areas to aid more reliable estimates of potential reserves of oil. Viewing the Fuels Branch's expansion, writers of the Pick and Hammer Club's annual show, on April 8, 1949, predicted an "Ironic Curtain." To 1934's tune of "Don't Fence Me In," by Cole Porter and Robert Fletcher, cast members concluded that it was

No earthly use–
To complain, when the Dane
Begins to reach for more terrain.
Now we have heard that the Branch has a prime ambition:
When Industry is fu-eled by atomic fission.
The A. E. C. will make a very fine addition.
They'll fence me in.[55]

On September 29, 1948, Acting Director Julian Sears approved Bradley's recommendation to abolish the Geologic Branch's Alaskan Section and its Foreign Section and combine the two units' functions, staff, and funds in a new Section of Alaskan and Foreign Geology,[56] headed by William Johnston, Jr., Chief of the Foreign Section. With the continuing sponsorship of the State Department, USGS work on mineral deposits abroad now formally included the training of foreign nationals. Eight months earlier, on January 27, Truman signed the Information and Educational Exchange Act "to promote the better understanding of the United States among the peoples of the world and to strengthen cooperative international relations." The new statute provided for, under the DoS' direction, "an information service to disseminate abroad information about the United States, its people, and policies."[57] The law created advisory commissions on information and on educational exchange "to formulate and recommend * * * policies and programs."[58] The statute established "an educational exchange service to cooperate with other nations in * * * the interchange of persons, knowledge, and skills; * * * [nonmilitary] technical and other services; * * * [and] developments in the field of education, the arts, and the sciences."[59] For these purposes, the act authorized participation, at the request of the Secretary of State, by U.S. citizen-specialists and the use of the service, facilities, and personnel of Federal agencies. The law also enabled agencies, with the Secretary's approval, to order, purchase, and rent materials and equipment, make contracts, and pay the travel and daily expenses (up to $10) of foreign citizens during training and study. Mutual national or scientific interest, or the industrial needs of other countries, determined the nature and scope of the studies.

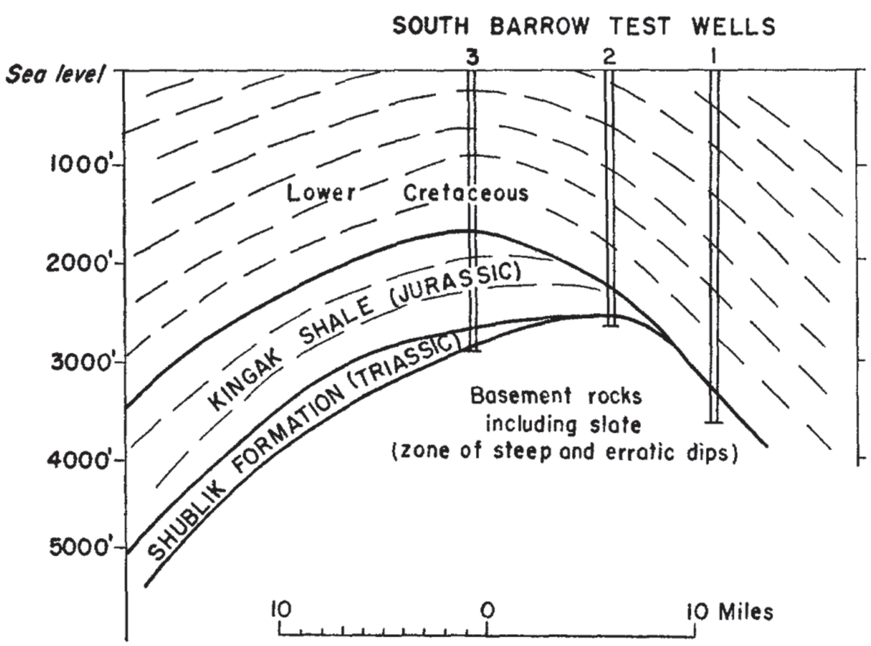
The Foreign Geology Unit's projects ranged from initial reconnaissance studies in underdeveloped areas to detailed investigations of those partly developed, and researchers sought to discover wholly new deposits, to extend reserves of known occurrences, and to locate new deposits in developed mineralized areas. During fiscal year 1948–49, USGS geologists completed studies in Mexico of manganese at Talamantes in Chihuahua, optical-calcite deposits nationwide, tin placers in San Luis Potosí, antimony deposits at Soyatal in Querétaro, and lead-zinc occurrences at Zimapán in Hidalgo. They also finished examinations of Brazilian barites at Camamu Bay near Bahia, tungsten occurrences in north-central Chile, and groundwater investigations in Haiti and Panama. John Dorr 2d and Philip Guild, aided by Charles Park, Jr., and two other colleagues, continued their work on the Minas Gerais iron deposits in Brazil. George C. Taylor, Jr., completed his studies of Chile's groundwater and surface water. Earl Irving, as chief of party, extended his investigations of mineral resources in the Philippines. Other geologists briefly examined mineral deposits in Afghanistan and Peru. The unit designed the second phase of its program to train promising young scientists and technicians from countries with less developed mineral areas. Their parent organizations, more often than not, also needed additional scientific, technical, and administrative experience, including reviews of practices and procedures in long-range planning for countrywide geological surveys and mapping. In fiscal 1948–49, 10 such trainees from 6 foreign countries served their USGS internships with field parties and in the Washington, D.C., laboratories.

The staff of the Alaskan Unit of the Alaskan and Foreign Geology Section (Branch) investigated metals, nonmetals, and fuel resources in Alaska during fiscal year 1948–49. Intending to serve the best interests of the Territory, the USGS asked for support to significantly increase the existing geologic-map coverage of Alaska at reconnaissance scales, now at 49 percent, and detailed scales, now at less than 1 percent. Robert Fellows, who had served as Acting Chief of the Alaskan Section since its establishment in 1946, returned at his request to fieldwork in the Territory, and Pemberton L. Killeen replaced Fellows in Washington as Acting Assistant Chief of the new unit's activities in Alaska. The Survey order of September 29, 1948, also confirmed Bradley's memorandum of April 22 that designated George Gates as "geologist in charge of the section field office which is to be established in San Francisco this fall."[60] In Alaska, members of the new combined unit continued studies in the Juneau gold belt, the mineralized areas of the central Kuskokwim region, and the Willow Creek mining district. They completed fieldwork on the copper, gold, molybdenum, and tungsten deposits of the northwestern Chichagof area and the high-grade limestone deposits of Heceta Island, west of Prince of Wales Island, undertaken to obtain partial coverage of the extensive belt of limestone in southeastern Alaska. New investigations began in Mount McKinley (now Denali) National Park (and Preserve), in the Juneau-Chichagof area, and on the southern portion of Prince of Wales Island, an area known to contain mineral deposits of potential significance. USGS scientists now believed that more than 250,000 square miles of Alaska might hold petroleum deposits, but of that total, only 11,000 square miles had been adequately mapped. Don Miller and other geologists continued their assessments of the petroleum possibilities in the Gulf of Alaska, finished those on the Alaska Peninsula's Iniskin Peninsula, and began studies from the Iniskin north to Tuxedni Bay to delimit additional specific areas favorable for oil accumulations that warranted further detailed work. Investigations by fuels geologists continued in the Kenai and Nenana coal fields of south-central Alaska, and they completed a report on the reserves of the Kenai's Homer district that summarized the results of nearly two decades of investigations.

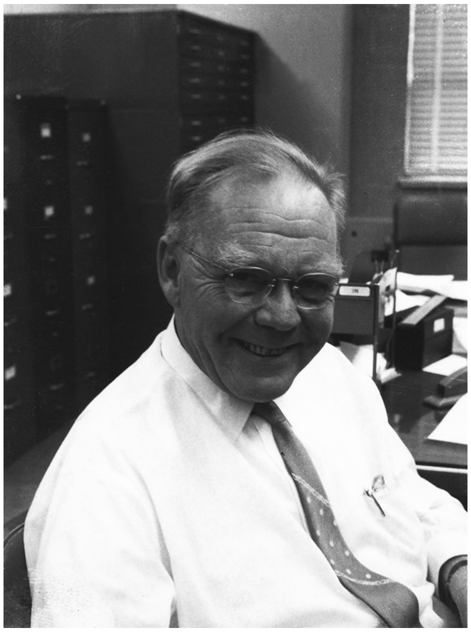
In Alaska north of the Arctic Circle, the USGS began its fifth year of continuous work in Naval Petroleum Reserve No. 4 (NPR–4). Members of the Operating Committee for NPR–4 had met in Washington for their eighth session on April 20, 1948. Those attending included Commodore William Greenman, who retired on January 1 but was still the Director of Naval Petroleum and Oil Shale Reserves (DNPR); Colonel O.F. Kotick, now Greenman's Deputy Director; John Reed (Sr.), representing Wrather; Lewis MacNaughton, for DeGolyer and MacNaughton; and Walter English. Other attendees included representatives of Hoover, Curtice, and Ruby; Arctic Contractors; United Geophysical; the Navy; and the USGS. The executive branch and the House Committee on Armed Services approved a long-range plan "for five more operating seasons after 1948 at an estimated cost of $28 million with an initial appropriation of $15 million."[61] The program for 1948 included a plan to extend Simpson Test Well 1 to 7,200 feet to penetrate the Lisburne Group (of Paleozoic age), if present, or to reach basement rocks. Two seismographic lines would extend (1) from the existing Simpson-Ikpikpuk line to pass north of Teshekpuk Lake and (2) from Fish Creek southwest to link with the Simpson-Ikpikpuk line. The committee recommended conducting "an experimental test of color aerial photography for use in geologic interpretation" and placing "temperature cables in all core holes and shotholes deeper than 125 feet" to gather data "on permafrost as it affected seismic and other activity."[62]

During 1948's field season, the USGS operated three geologic field parties in NPR–4, the first two of which used Navy funds. Edward Webber's Party 1, including Robert L. Detterman and William W. Patton, Jr., restudied the Chandler River before Webber shifted to areas south of the Colville and before Detterman and Patton transferred to Karl Stefansson's Party 2 to help map structure and measure sections in Lisburne Group exposures near Chandler Lake. Charles Whittington's Party 3, with Edward G. Sable and USGS financing, worked far east of NPR–4, beginning at the Okpilak River and moving westward to Lakes Peters and Schrader, to gain information "useful in interpreting conditions in and near the Reserve." Thomas Payne prepared "a progress report on the evaluation of the oil possibilities of the major stratigraphic units"[63] in NPR–4. Drillers completed the Simpson well to a depth of 7,002 feet in rocks older than the Lisburne Group. Drilling on the first of two test wells on the South Barrow structure was stopped at a depth of 3,553 feet after yielding stains of light oil just below 3,000 feet.

As the USGS continued work in Alaska during fiscal year 1948–49, the Section (Branch) of Engineering Geology, proceeding cautiously under Edwin B. Eckel's leadership to determine its proper scope, reached maturity. The report of the Hoover Commission's Task Force on Natural Resources, by highlighting the lack of existing data on topography, geology, hydrology, and soils in planning major Federal construction activities, indicated the significance of engineering geology for the Geologic Division. Branch members carried out 17 projects in 11 States, Alaska, and Puerto Rico. A device originally designed to rivet plates to damaged hulls of ships seemed to be a useful tool in field measurements of the engineering properties of rock by gaging quickly and accurately the toughness, the porosity, and even the weight per cubic foot of dry and water-saturated rocks. Geologists hoped that additional work with the device might eventually eliminate the need for some of the more costly laboratory tests on rock used by construction engineers. Frank E. Byrne, who had worked part time for the USGS as part of the Missouri River Basin Project and other projects, led a team's investigations of construction materials in northern Kansas. Byrne's group completed, in cooperation with the Kansas Highway Commission, mapping 17 counties by the end of fiscal 1948–49 and published, or made available to interested Federal and State agencies, reports on most of them. Their maps, at a scale of 1:62,500, showed all of the rock units in the counties, plus overburden and other unconsolidated materials, and described their use for concrete aggregate, road material, riprap, and other construction purposes. During the year, the USGS also signed a cooperative agreement with the



This stratigraphic section shows three South Barrow test wells and the northward beveling of Jurassic strata in the Barrow area of Naval Petroleum Reserve No. 4 (NPR–4). Exploration in NPR–4 during 1944–53 did not find economically viable oil pools, but drilling in the South Barrow area's structural "high" discovered locally useful deposits of natural gas. Production in 1949 from South Barrow test well 2, completed to a depth of 2,505 feet, totaled "30,124,000 cubic feet of gas," mostly methane. Using that gas, which represented an estimated 20-year supply, "would save about $275,000 a year in fuel oil." (Quotations from Reed, J.C. (Sr.), 1958a, p. 108; section from Tappan, 1955, fig. 7.)



USGS geologist Edwin Butt Eckel (1906–89), the oldest son of USGS geologist Edwin Clarence Eckel, joined the agency in 1930. E.B. Eckel investigated mineral deposits in the Western United States, concentrating after 1938 on mercury ores. In 1942, he helped to organize the USGS Military Geology Unit; he served as its Assistant Chief during part of 1944. Eckel's investigation of underground facilities in Western Europe for the Army Engineers led to the founding of the USGS Engineering Geology Section (later Branch) in 1944; his service as its Chief (1944–62) produced a growing emphasis on landslides and their hazards. During those years, Eckel also worked in Paraguay and the Caribbean, and on Colorado's mineral resources, before shifting to nuclear-test investigations in Nevada in 1956. (Photograph, 1961, from the USGS Denver Library Photographic Collection, Portraits, in the "Last Name E–F" folder.)

Army Engineers for surveys along Washington's Snake River for detailed geologic maps of a section 80 miles long by 3 miles wide, within which the Engineers expected to build several large power and navigation dams. The Army Engineers needed detailed knowledge of the rock conditions in the river strip, not only for planning the dams and powerplants but also in relocating many miles of railroads and highways. USGS geologists then planned to expand the area covered by preparing standard geologic maps at 1:62,5000 with subsurface interpretation for four quadrangles to also contribute to the industrial development likely to follow river development.

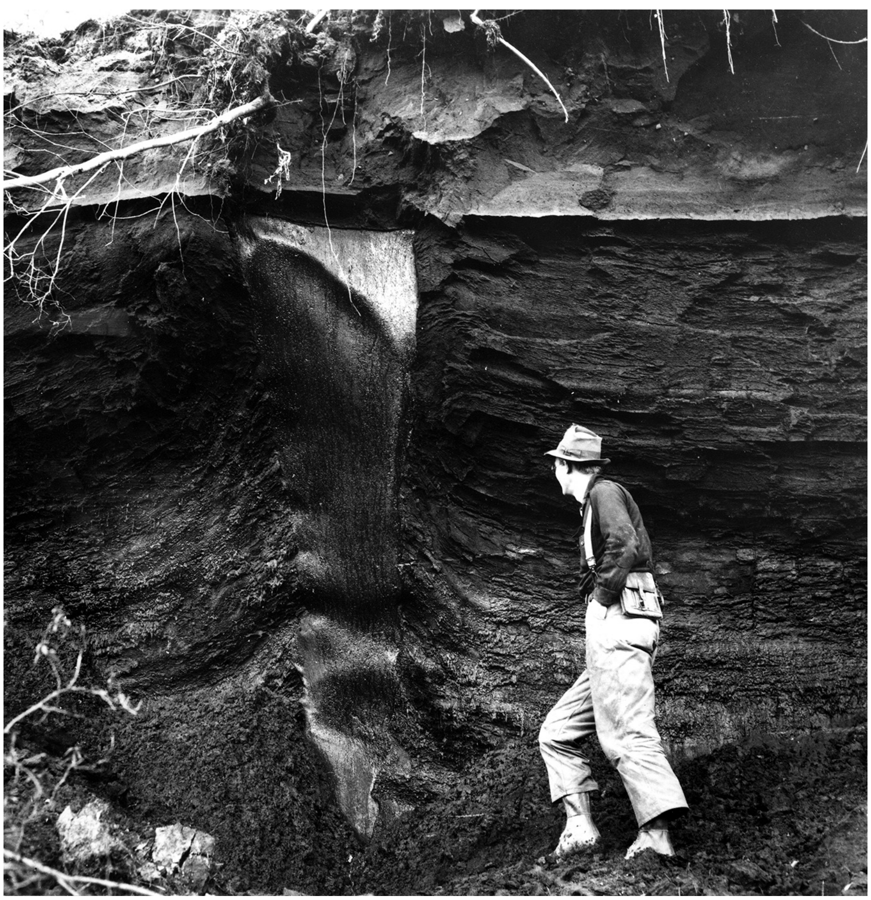
On February 5, 1948, Wrather and Bradley transferred John Hack to the Chief Geologist's staff[64] to help program planning, changed the name of Hack's Section (Branch) of Areal Geology to General Geology, and appointed Charles Hunt to lead the renamed unit from Denver. Arthur E. Granger, who worked on strategic minerals in the Basin and Range and in the Wasatch Mountains, succeeded Hunt as Regional Geologist at Salt Lake City. Carl Dutton (Madison), Robert Laurence (Knoxville), and Albert Weissenborn (Spokane) continued as the other Regional Geologists. The General Geology Section's staff continued to prepare geologic-quadrangle maps, compile State geologic maps, and prepare State indexes to published geologic maps. The 1:500,000 geologic map of Idaho, completed in 1947 by Clyde Ross and James D. Forrester, continued to be distributed. Branch geologists drew near to finishing similar maps of Montana and Oklahoma, issued 10 State indexes to published maps, and published a report on a detailed survey in Rhode Island.

Planners in the General Geology Section (Branch) expected that most of the 35 field projects in progress at the end of the fiscal year would be continued throughout fiscal year 1949–50. These projects included those of Ruy Finch's Hawaiian Volcano Observatory (HVO),[65] which had returned on December 27, 1947, to the USGS after having been managed by the National Park Service since its transfer from the USGS in 1935. Plans were made to integrate the HVO's applied and basic studies to the Branch's research program that already included investigations of volcanoes and related phenomena on the Colorado Plateau, the Aleutians, the Alaska Peninsula, and the Pribilofs. Thomas F.W. Barth used military funds to map and examine St. Peter and St. Paul Islands in the Pribilofs during the 1948 field season. With Frank Byers, Barth also studied volcanism on Akun and Akutan Islands, between Unalaska and Unimak, in the Aleutians. Bradley and Hunt expected all of these studies to produce data that would aid predictions of eruptions and some types of earthquakes. In addition to their application to forecasting these geologic hazards, the volcano-research program's results were considered essential to reaching a greater understanding of hydrothermal and many other kinds of mineral deposits and applying the knowledge gained to assist further exploration.

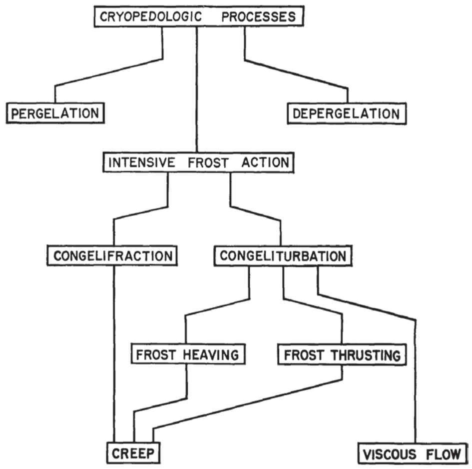
In the laboratories of Earl Ingerson's Geochemistry and Petrology Section (Branch) during fiscal year 1948–49, modification of the flame-photometer method made possible rapid and accurate quantitative determinations of alkali metals in rocks and minerals. Branch geologists developed geochemical-prospecting methods to determine minute amounts of various elements, including copper, lead, molybdenum, nickel, vanadium, and zinc. They designed and tested a chromograph, a new and simple device for making semiquantitative spot tests. The chromograph enabled rapid field analyses that were sufficiently accurate to determine minute traces of copper and nickel. The results could be preserved as a permanent record that eliminated the delay and expense of sending samples to the laboratory and enabled the fieldwork to be immediately concentrated on promising areas. USGS geochemists expected the chromographic method to be important not only in prospecting for ores but also in agricultural studies of soils. Improved spectrographic methods of analysis became the mainstay of the search for beryllium.

USGS standards aided commercial laboratories to improve their analytical results. The geochemical laboratory's staff also identified and studied samples that required special techniques using chemical, optical, spectrographic, and X-ray methods and differential thermal analysis. The laboratory increased its X-ray powder patterns to more than 4,000 films, by which nearly all naturally occurring materials could be identified quickly. The lab's staff described seven previously unknown minerals, three of them new uranium compounds.

In fiscal year 1948–49, the Military Geology Section (Branch [MGB]), still led by Frank Whitmore, Jr., continued terrain-intelligence operations in Washington, D.C., and elsewhere in the conterminous United States, studies of permafrost in Alaska, investigations in Europe, and geologic surveys in the Far East and on the Pacific islands. The MGB's group in the Nation's Capital produced for the Army Engineers 13 comprehensive and 24 special reports on various aspects of military geology. In 1948, the group added analyses of construction materials, mineral resources, water resources, and possible sites for airfields in Eastern Canada, the Caucasus, the Trans-Urals, and Turkey to the earlier reports prepared for Joint Army-Navy Intelligence in 1946 and 1947 about Argentina, south-central China, and the European part of the Soviet Union. For the Army European Command's Campbell Project in Heidelberg, MGB geologists finished terrain and other composite analyses of airfield and road construction, climate, coasts, drainage, groundwater, landforms, mineral resources, rock types, seasonal variation in ground, soils, trafficability, underground installations, and vegetation on 1:1,000,000 maps of Albania, Austria, Bulgaria, Czechoslovakia, Estonia, Finland, Germany, East Prussia (Kaliningrad) and Poland, Latvia, Lithuania, Romania, and Yugoslavia. Maxim Elias summarized German wartime experiences with underground installations,



This photograph shows a ground ice wedge "in permafrost exposed by placer mining near Livengood about 50 miles northwest of Fairbanks," Alaska. In postwar years, USGS geologists continued studies of permafrost in Alaska, begun by Siemon Muller and his colleagues in the Military Geology Unit during World War II and expanded by them to other Arctic areas. They studied a number of cryopedologic processes, including creep, frost heaving and thrusting, and viscous flow, in assessing the hazards of constructing airfields, buildings, roads, and other facilities on and in permanently frozen ground. (Photograph by Troy L. Péwé, September 1949; from the USGS Denver Library Photographic Collection as Ferrians, O.J., foj00003, https://www.sciencebase.gov/catalog/item/51dc43e1e4b0f81004b7b363; published as fig. 9 in Ferrians and others, 1969. Quotation from caption.)



USGS scientists David Hopkins and Robert Sigafoos used this chart to summarize their investigations of the scope of and interrelations among cryopedologic processes, as part of wider studies of vegetation patterns as related to permafrost on the Seward Peninsula in Alaska. They defined cryopedologic processes as all those "involving intensive frost action or perennially frozen ground." Pergelation and depergelation encompassed "the formation and decay of perennially frozen ground." Congelifraction (splitting) and congeliturbation (churning or stirring) were processes of intensive frost action and the "geomorphic processes dependent upon repeated cycles of freezing and thawing." (Quotations from Hopkins and Sigafoos, 1951, p. 53; chart from fig. 17.)

and three MGB geologists joined the European Command's Engineer Division, as special consultants, to extend work begun in 1947 by Frank Reeves. Special reports included analyses of the mineral resources of the Soviet Union and its satellites, the geology and terrain suitability of potential sites for seismic arrays in China, West Germany, Hokkaido, India, and Mongolia (and in Colorado, Maine, and New York), mineral resources in the northern Ryukyu Islands, and occurrences of asbestos, ceramic and refractory materials, graphite, iron, molybdenum, and tungsten in Korea.[66]

In domestic studies, members of the MGB began to prepare a military geology folio of the 6th Army area, where Brigadier General Garrison Davidson, who had returned from Europe, served as Chief Engineer during March 1946–September 1947 before becoming Chief of Staff to General Mark Clark, when Clark returned from command in Austria, and then to Lt. General Albert Wedemeyer, after Clark took command of Army Field Forces in October 1949. MGB staffers also completed gathering field data for the Branch's Folio 2 about Fort Benning in Georgia, planning to finish it during fiscal year 1949–50, and studied possible sites for explosive tests in Colorado, Maine, and New York. In Alaska, Robert Black, Troy L. Péwé, and William L. Barksdale examined permafrost and other terrain features of St. Lawrence Island, the Seward Peninsula, Umiat on the Colville, the Yukon and Kuskokwin Rivers, and the Fairbanks area.

As part of the MGB's efforts in the Far East and the Western Pacific, Frederick S. Blach continued his reports on the water supplies and installations of urban areas in Japan and Korea. By 1950, Blach completed water-supply analyses of nearly 30 cities in Japan and 4 in Korea, including Inchon, Pusan, and Seoul. For the Natural Resources Section of General MacArthur's headquarters in Japan, MGB geologists completed studies of the sources of East Asia's coal and bauxite and compiled a 1:15,000,000 map of the Trust Territory of the Pacific Islands' mineral resources.[67] In the Pacific Geologic Mapping Program (now directed by Sherman Neuschel), Gilbert Corwin, Charles Johnson, and other MGB geologists finished fieldwork during July 1948–July 1949 on Yap, in the Palaus, and on Okinawa, while Preston Cloud, Jr., led a team that began a study of Saipan. Cloud also directed the initial phases of mapping and studies on Guam and Saipan, aided principally by Harold Burke, Dan Davis, Charles Johnson, and Robert George Schmidt. Burke left Saipan in July 1949 to lead Charles Johnson, Harold G. May, and Carl Stensland in mapping adjacent Tinian's geology and soils.

During fiscal year 1948–49, the staff of Henry Joesting's Geophysics Section (Branch) conducted airborne and ground geophysical surveys, by electrical, geothermal, gravity, magnetic, radioactivity, or seismic methods, in connection with geological surveys in many areas of the conterminous United States and in Alaska Territory. The Geophysics Branch's headquarters moved from the Army Map Service's (AMS') building to the Interior Department's building early in April 1949. By then, James Balsley, who led the Branch's Airborne Surveys Section, had flown in magnetometer surveys beyond both polar circles. Mary ("Mimi") Hill, who married USGS geologist John D. Strobell, Jr., that same month, had been a member of Balsley's crews since April 1945. Recognizing the Section's geophysical feats aloft, the USGS Pick and Hammer Club burlesqued these "Flying Sorcerers" in its annual show for 1948. To the music of "The Daring Young Man on the Flying Trapeze," the players applauded the changes since

Geophysics was tied to the ground—
In the days before Jim Balsley happened around;
But now that a comf'table plane has been found,
The doodlebug's took to the air.
*** * * * ***
They fly over oil fields; they fly over mines;
They fly till the maps have been covered with lines.

* * * * *

It picks up the bed rock; it spots every vein;
It picks up the subway, and sometimes a train.
What Mimi's recorded, poor Jim must explain,
As the doodlebug doodles along.

* * * * *

It flies through the air with the greatest of ease,
Recording pulsations that nobody sees;
But plot up the curves and you'll have all the keys
To geology 'way down below.[68]

During fiscal year 1948–49, Balsley's team covered nearly 30,900 square miles in 10 States and increased its aeromagnetic-map production some twentyfold by further systematizing and standardizing data compilation, increasing the staff assigned to this work, introducing a training program for new employees, and continuing cooperative surveys. In 1947, the USGS and the Missouri Geological Survey had combined their talents to identify an anomaly at Pea Ridge, whose iron ores the St. Joseph Lead Company later developed. In Pennsylvania during 1948, William B. Agocs and his colleagues from Philadelphia's Aero Service Corporation identified for Bethlehem Steel Company the Grace Mine anomaly in the area previously overflown by Balsley's team in a general survey. Core drilling tested one anomaly near Morgantown in Berks County, Pennsylvania, and discovered Cambrian iron ore at a depth of more than 1,520 feet on December 19, 1949. Members of the Branch's Ground Surveys Section, managed by Joel Swartz from the Baltimore office, used the Hotchkiss Superdip to help identify another anomaly at Pine Swamp near Warwick in Chester County, Pennsylvania. They also made 12 gravimetric and electrical surveys in seven States and in Alaska. An experimental electrical survey in southwest Colorado detected uranium-ore bodies in that area. Other electrical surveys, in cooperation with groundwater geologists of the Water Resources Branch (Division), determined the depth and extent of water-bearing beds and gravel deposits in several localities. The results led to reductions in the drilling required for testing those sources.

During fiscal year 1948–49, the Topographic Branch (Division) remained organized to serve seven principal functions—plans and estimates, production control, geodetic surveys, photogrammetry, topographic surveys, cartography and map editing, and map information—and geographic operations. Chief Topographic Engineer Gerald FitzGerald continued to depend on the principal staff and associates he appointed in 1946 and 1947. On January 1, 1949, the Topographic Division's Washington office included two staff Branches (formerly Divisions)—George Whitmore's Research and Technical Control and Robert Lyddan's Plans and Coordination—and two special operational Sections—John Davidson's Trimetrogon and Oscar Nelson's Special Map Projects. All other operations continued being supervised by the four Division (Regional) Engineers—Dallas Watson, Atlantic at Arlington; Daniel Kennedy, Central at Rolla; Robert O. Davis, Rocky Mountain at Denver; and Conrad Ecklund, Pacific at Sacramento. Kennedy, who served with the Army Map Service during World War II, began his managerial tour on July 1, 1948, replacing Carl Sadler, who retired at the then-mandatory age of 70 after 46 years with the USGS.

For fiscal year 1948–49, the Topographic Division received almost $9,323,000, including about $4,932,000 in direct appropriations, an increase of more than $1.6 million from fiscal 1947–48, for its staff of 1,413 persons. Nearly $3,523,000 of this total came from other Federal agencies, while States, counties, and municipalities provided $850,500. Although the USBR increased its transfers by almost $1.4 million and the Navy doubled its input to nearly $60,000, these gains did not offset the expected reductions of nearly $1.8 million from the Army and $138,000 from the Air Force. The offsetting increases in direct appropriations to the USGS for its topographic mapping now exceeded funds from all other sources by more than $1.4 million, restoring to more than 50 percent USGS control of its topographic-mapping program, including its expanding domestic segment, for the first time since fiscal 1941–42. Acting Director Thomas Nolan, in a memorandum dated December 6, 1948, issued a policy statement for the USGS national topographic-mapping effort. The agency, Nolan noted, had completed standard quadrangle maps for about half the United States but the increasing demand for greater accuracy and larger scales generated a recent revaluation of these sheets. This assessment found that less than 25 percent of the United States and its territories and possessions was adequately mapped for present use. Nolan emphasized that

> **[in] the interest of national defense, the Armed Services have urged the Geological Survey to submit to Congress a program to complete the topographic map of the country in twenty years.[69]**

In response, the USGS had promised to try, with available funds and by coordinating efforts with other mapping agencies, to establish a priority schedule each year that would best serve the country's military and industrial needs. Twice before, in the 1880s and the 1920s, the USGS had pledged but failed to finish mapping the Nation within the following 20-year interval. Those shortfalls followed the results in the early 1890s of Director Powell's failed policies and programs and Congress' refusal to provide more than the first-year's funds for the Temple Act of 1925. To make good on its third promise, the USGS would need better planning, increased funding each year, a larger staff, and improved instruments and methods.

Topographic Branch (Division) personnel mapped in 44 States, Alaska, and Puerto Rico during fiscal year 1948–49. They continued work toward the mapping of some 2,400 quadrangles, helped in Alaska and the Rocky Mountain States by helicopters that transported men and instruments to triangulation stations in continuing experiments to gain easier and quicker access to high and (or) rugged terrain. The USGS, having proven the value of helicopters and portable radiotelephones as aids to mapping in Colorado,[70] chartered three of the former for work in Alaska during the summer of 1948. One helicopter, based at Pelican on the northwest part of Chichagof Island, covered about 1,000 square miles in southern Alaska in taking field parties to 260 stations at elevations of 3,500 to 4,500 feet above sea level. The other two, based in Fairbanks, helped field parties establish geodetic control at elevations up to 9,000 feet for an area of some 2,500 square miles in the Territory's interior. During the 1949 field season, the surveyors used Wallace and Tiernan altimeters, acquired from military sources, to establish supplemental vertical control and tested these instruments by reading them at every 100-foot change in elevation as they carried them up and down the mountains. In Washington, Division topographers completed more than 80 sheets at 1:62,500 and 320 quadrangle maps at 1:24,000. Of the 650 maps reviewed and forwarded for reproduction, 625 were prepared for multicolor photolithography. The Trimetrogon Section continued mapping and charting operations for the Air Force. During fiscal 1948–49, the Section's staff completed entirely new photo compilations for more than 538,000 square miles and cartographic compilations for 118,000 square miles; they also photorevised charts depicting nearly 226,000 square miles.

The Topographic Branch (Division) continued to plan during 1948–49 for future mapping needs and operations. Topographic Division managers and their planning staffs integrated analyses of map requirements submitted by 15 Federal agencies, via the Bureau of the Budget (BoB), with special requests received from map-using State agencies and other sources in preparing the Division's mapping program for fiscal year 1949–50. They exchanged information on mapping programs with Interior's field committees and merged information about topographic needs received from these committees with the other mapping requests. The Division established new programs in Iowa, Kentucky, Minnesota, and Tennessee. Military requirements and civilian requests for increased map coverage led the Division to step up its program in Alaska, where its long-range program coordinated its efforts with the National Military Establishment, civilian agencies, and Interior's Alaska Field Committee. With support from the Air Force and the Navy, the Division acquired photographs of about 59,000 square miles in Alaska (including 14,000 square miles in NPR–4) that were suitable for standard mapping. At the request of the Governor of Hawaii, the Division also took preliminary steps toward revising some of the maps of the Territory that had been completed two or three decades earlier.

The Topographic Division's staff engineers continued research and development, seeking to improve existing equipment and to design new instruments for the field and office. Morris M. Thompson joined this group when Russell Bean requested Thompson's services with Bean's Photogrammetry Section in Washington. Thompson and William A. Radlinski knew that "Russ Bean was not a prolific author. He encouraged those of us who worked for him to do most of the writing, but we were writing about *his* ideas."[71] Bean's staff engineers completed the polastrodial, and topographers began using it in the Atlantic region. Other field operations tested two commercial elevation meters, and extensive experiments determined the relative speed and economy of several new or improved methods of measuring distances for transit traverses. Division staffers continued to keep up with new developments in the use of shoran so that this electronic method of measuring distances could be applied to control surveys as soon as advancements in its technique attained the required precision.

After Harry Kelsh transferred to the USGS from the Soil Conservation Service (SCS) in 1948, he and other staff engineers in the Photogrammetry Section redesigned the Kelsh stereoplotter to incorporate the use of wide-angle photography and to eliminate the "huge lamp houses" that illuminated "the entire diapositive area" but "gave off unbearable heat." Russell Bean's research team used "swinging compact light sources and a cam arrangement for continuous adjustment of principal distance."[72] Bean's team continued to improve the now-patented Kelsh plotter, and contracts were let for the purchase of 12 wide-angle units. They also worked on the Twinplex, a stereoplotter that used twin Multiplex-type projectors, which Bean began developing in 1945 to increase accuracy and economy in mapping operations. Bean designed the double-projection Twinplex to use "low-oblique, wide-angle photography * * * aligned either along the flight line for precision mapping, or transverse to the flight line for reconnaissance mapping." This plotter used "two unrectified diapositives, corresponding to the two exposures made at one camera station."[73] In addition to the work on the two stereoplotters, a commercial firm successfully duplicated a captured German lens that was nearly distortion free; the Topographic Division expected its future use to influence significantly all of its mapping activities.

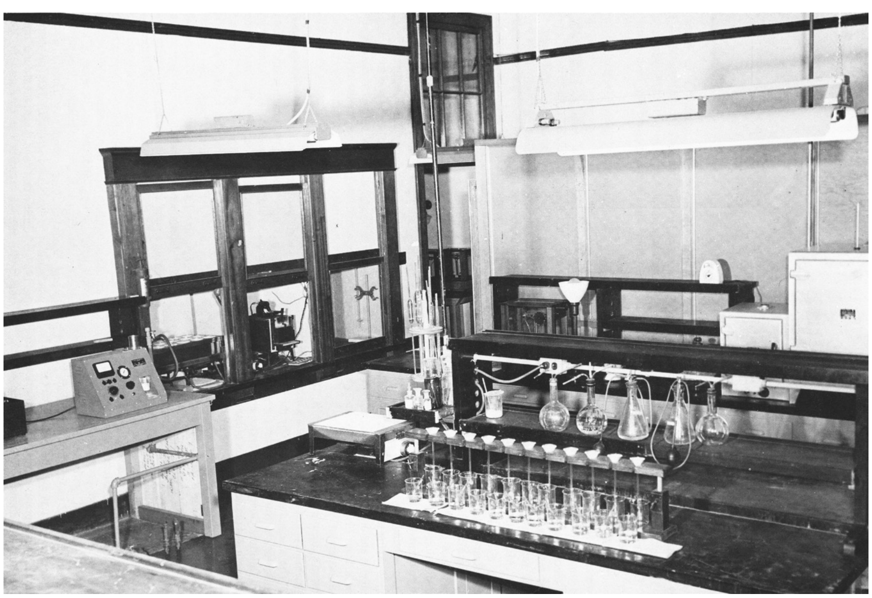
By April 3, 1948, Chief Hydraulic Engineer Carl Paulsen established a Water Utilization Committee as the last step in reorganizing the Water Resources Branch (restyled as a Division on January 1, 1949). The new Committee was founded to aid in planning and preparing reports on the water resources of specific areas to improve integrated field performance. Royal Davenport continued as Chief of the Technical Coordination Division (later Branch; the former Water Utilization Division) and its three Sections—Research, Reports, and Technical Control. George Ferguson remained in charge of the Program Control Division (Branch) and its three Sections—Field Relations, Fiscal Control, and Interagency Relations. The Field Equipment Division (Branch) included a Water Resources Section. The four units of the Business and Clerical Section handled fiscal, personnel, and procurement matters and also mail and files. The leaders of the three program Divisions (later Branches)—Joseph Wells (Surface Water), Nelson Sayre (Ground Water), and Kenneth Love (Quality of Water)—also continued to report directly to Paulsen, whose "friendly, considerate, and quietly aggressive leadership," Wells observed, had gained "the loyalty of the key personnel in all the Branches" and brought "really for the first time * * * all of the segments of the Division together to work as a unit."[74] Henry C. Beckman coordinated the all-Branch effort in the Missouri River Basin, still funded principally by the Army Engineers and the USBR, and he also represented the USGS on Interior's field committee for that basin. Beckman's efforts, aided by Bruce R. Colby, Roy E. Oltman, and other Division members, continued as a principal example of this new internal cooperation. Colby and Oltman published their analysis of discharge and runoff in the Missouri River Basin in 1948 and began looking at trends in its climate-runoff relations.

John Cederstrom, Robert Follansbee, Fred Klaer, Jr., Philip E. LaMoreaux, Stanley W. Lohman (Kenneth Lohman's younger brother), Harold Peterson, Joseph F. Poland, George H. Taylor, Charles Theis, and Harold Thomas were among the hydrological engineers and geologists who led the geographic-district offices of Water Resources' units during fiscal year 1948–49. While investigating the Grand Junction artesian basin in Colorado, Charles Jacob and Stanley Lohman measured pressures with Lohman's unique "ink-well"[75] mercury gage to test Jacob's new mathematical theory for determining the storage and transmissibility coefficients from variations in the discharge rate of wells flowing at constant drawdown.

The Water Resources Division (formerly Branch) received for the salaries of and operations by its 1,255 employees, as of January 1, 1949, about $8,688,000 from direct original, deficiency, and supplemental appropriations, transfers, and repay funds during fiscal year 1948–49, an increase of almost $2 million from the previous year. Of the total monies, Congress and the President supplied more than $3.7 million. Nearly $2,362,000 of that sum was available only for cooperative work with States, counties, and municipalities, whose contributions surpassed $2.5 million. The remaining $2,455,000 in transfer funds, about $853,500 more than in fiscal 1947–48, came principally from other Federal agencies. The USBR shifted almost $1.1 million, $815,000 of the military's $830,000 came from the Army Engineers, the State Department provided slightly more than $100,000, the TVA supplied about $77,000, and the AEC transferred almost $48,000. The nearly $4,967,000 in outside funds now represented 57 percent of the Division's total monies.

Joseph Wells' Surface Water Branch included four Sections—Annual Reports, Field Standards, Research, and Special Reports and Investigations. During fiscal year 1948–49, the Surface Water Branch operated about 6,200 streamgaging stations, some 200 more than in the previous year. The Branch expanded its laboratory and shop facilities to seek new or improved equipment for measuring streamflow and, like the topographers who sought better mobility and access to field sites, further tested and improved the snowmobile. Arthur Frazier returned to Paulsen's organization in November 1948 to lead Surface Water's Equipment Development Laboratory in Columbus, Ohio, founded in 1947 to continue improving streamgaging equipment. The Division continued to contribute studies to the commissions for the international-water compacts with Canada and Mexico, and those for the interstate-compact commissions for the Belle Fourche, Cheyenne, Colorado, Pecos, and Republican Rivers, the Rio Grande, and Costilla Creek. On June 30, 1948, the Water Pollution Control Act declared that it would "be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States" in this effort. Congress also would "support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment," and "provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs."[76] The new law encouraged interstate cooperation, consented to negotiation and entry into interstate-water compacts by two or more States (pending congressional approval), authorized the Justice Department to sue polluters, and approved Federal "surveys, studies, investigations, research, and experiments," under the direction of the Surgeon General, "with regard to the control of water pollution."[77] The statute also established a Water Pollution Control Advisory Board, chaired by the Surgeon General and including representatives from the Army, Agriculture, and Interior Departments and the Federal Works Agency plus six persons appointed by the President. On October 11, representatives of Arizona, Colorado, New Mexico, Utah, and Wyoming signed the Upper Colorado River Basin compact,[78] which Congress and the President formalized on April 6, 1949. By June 30, the Branch's streamgaging program in Alaska, which began with 7 stations in 1947, expanded to 35 stations, and plans called for an additional 20 stations during fiscal 1949–50. The Branch established a district office at Juneau and a field office at Palmer.

Nelson Sayre's Ground Water Branch also comprised four Sections—Ground Water Geology (led by Victor Stringfield), Ground Water Hydraulics, Technical Reports, and Utilization and Equipment.[79] Investigations by specialists in the Ground Water Branch during fiscal year 1948–49 indicated no overall depletion of the Nation's groundwater resources, but they demonstrated that conditions were critical in southern California, Arizona, Texas' High Plains, and many other areas, including some in the humid East. Work in western North Carolina revealed important and hitherto almost unmapped groundwater supplies in thin alluvial deposits along streams in the Piedmont and mountain areas; these studies also suggested the probable existence of similar occurrences in other States. Geophysical studies supplemented test drilling in Champaign County, in west-central Ohio, by locating and outlining the course of a buried-valley deposit of water-bearing gravel undisclosed by surface topography and too costly to identify by drilling. Branch engineers developed a new way of determining flow in steeply inclined and fractured rock strata beneath a blanket of saturated glacial deposits in one of Michigan's iron-mining districts. At Louisville, Kentucky, they analyzed mathematically the way water can be made to flow from rivers to nearby wells. The Branch issued



Cooperative efforts by the USGS, States, and academia succeeded in establishing in 1946 this water-quality laboratory in the Chemistry Building at Oklahoma A&M (later State) College (later University) in Stillwater. Increasing agricultural, industrial, and urban demands on and the contamination of U.S. water resources during and after World War II made water-quality studies increasingly important. The consortium moved this laboratory to a new location in Stillwater in 1952 and then, with the USGS District office, to Oklahoma City in 1954. (From Ferguson and others, 1990, p. 258.)

a map of southwestern Louisiana showing the varying thickness of its freshwater-bearing sands, which helped to outline the problem of saltwater encroachment then threatening the irrigation of rice and sugarcane fields.

In the West, an investigation near the AEC's plutonium plant at Hanford, Washington, demonstrated the geologic and hydrologic factors that limited the disposal of radioactive-waste products through infiltration basins. Other groundwater investigations showed the extent to which the safe yield of the area in California southwest of Los Angeles had been exceeded and the extent to which saltwater advanced inland from the coast. Research continued on the mechanics of unsaturated flow above the water table, including a study of the forces affecting lateral movement of water in the capillary fringe. Branch engineers, increasingly influenced by an analysis of the conduction of heat in solids[80] published in Britain, also developed improved laboratory equipment for determining the permeability of water-bearing rocks. John G. Ferris applied Charles Theis' formula and the image methods to locate hydrologic boundaries.[81] Ferris's chapter on groundwater, in Chester O. Wisler's and Ernest F. Brater's "Hydrology," became a standard reference.[82]

The Branch's continuing studies abroad included work in Chile, Haiti, Panama, and Greece. George C. Taylor, Jr., who completed in January 1948 a 1.5-year study of groundwater in 26 basins and valleys in northern Chile for the State Department and the Chilean Development Corporation, conducted similar work in the arid lowlands and other parts of Haiti, during September 1948–March 1949, with Haitian engineer-geologist Remy C. Lemoine, and then in the rangelands of central Panama, during April–May 1949. Howard F. Haworth supervised the well-drilling operations in Greece, during February 1948–January 1950, by 25 rigs furnished by the U.N. Relief and Works Agency that secured water supplies for many locales on the mainland and on adjacent islands.

Kenneth Love's Quality of Water Branch included three Sections—Chemical Quality, Physical Quality, and Technical Reports. Walter Langbein and three of his colleagues continued to serve at headquarters as Love's senior technical staff. Branch analyzers determined the chemical quality of 37,500 water samples during fiscal year 1948–49.[83] The extent and scope of the Branch's sediment-measurement activities increased slightly when its staff collected and analyzed more than 71,000 samples. To handle more intensive investigations of sediments, the Branch established two new field offices at Riverton in Wyoming and Tucumcari in New Mexico and a field-research center at Minneapolis. The USGS helped the AEC to select some 40 sites nationwide for evaluation to participate in an extensive program of developing and testing nuclear reactors. The AEC then narrowed the choice to two locations—one near Fort Peck, Montana, and the other in Idaho's Snake River Basin. Late in 1948, Arthur Piper and Raymond Nace examined and reported on the basin between Arco and Idaho Falls. The AEC provided $137,000 for the first year, fiscal 1949–50, of a decade-long study by Nace and his colleagues of the geology and hydrology of the Idaho site. The AEC "soon asked Nace to choose a site for the experimental breeder reactor." During construction, the "AEC distorted the Survey's proposals," and Nace's site "later became the burial ground"[84] for radioactive waste.

The managers of the four principal Divisions (Branches) in Harold Duncan's Conservation Branch (Division)—John Northrop's Mineral Classification Division, Howard Smith's Mining Division, Harold Barton's Oil and Gas Leasing Division, and Benjamin Jones' Water and Power Division—continued to serve during fiscal year 1948–49. The Conservation Division received nearly $1.1 million for fiscal 1948–49, all but $77,000 of which came from direct appropriations to support salaries and operations by its staff of about 200 persons. A Secretarial order, signed by Assistant Secretary C. Girard ("Jebby") Davidson on December 30, 1948, clarified the responsibilities of the Bureau of Land Management and the USGS for "the collection of, and accounting for rentals and royalties under the mineral leasing acts, and other acts providing for the leasing or development of Federal mineral lands or interests, including lands transferred to the Department of the Interior for prospecting and development." The Secretarial order required specific supporting duties from the BLM and the USGS. In addition to supplying promptly the Conservation Division with information necessary for complying with its responsibilities, the BLM would "maintain accounts, collect and deposit filing fees, bonus payments, commissions, and rentals on all applications and permits and licenses, lease sales and nonproducing leases except nonproducing leases in producing unitized areas." The BLM also would answer inquiries in respect to the status of these entities and "maintain a control account over the individual accounts maintained by the Geological Survey." In addition to advising promptly the BLM about complying with its responsibilities, the USGS would notify the BLM "at the time when the operating status of a lease changes as to production or non production."[85] The USGS also would maintain accounts, prepare bills and receive collections for rentals and royalties, and deposit immediately with the BLM's regional administrators the receipts from individual producing lessees and nonproducing lessees in producing unitized areas. The USGS would as well provide them with collection schedules and a monthly statement of bills for and periodic proofs of the correctness of these accounts, answer questions about their status, and review and report any delinquencies.

During fiscal year 1948–49, the Conservation Division's staff acted on nearly 25,000 cases involving disposal of Federal lands, a decrease of about 14 percent compared to fiscal 1947–48; the change was due chiefly to decreased demands during regionalization of the BLM in the early part of the year. As of June 30, 1949, the Division supervised 1,050 properties for the production of coal, oil shale, phosphate, potassium, silica sands, sodium, and sulfur, as well as many other commodities. Transfer of the BLM's functions of preparing statements and receiving collections for rents and royalties due the United States on production from federally owned land broadened the Conservation Division's responsibilities. Potassium production continued to increase and for the second year in a row exceeded in royalty value the coal produced from the public lands. Prospecting for potash in New Mexico during the year disclosed additional valuable deposits. The USGS predicted a total income for the fiscal year of more than $3 million from mining rentals, royalties, and bonuses. The Division also supervised more than 21,270 oil and gas properties on the public lands, an increase of 58 percent from 1947–48, and nearly 6,400 leaseholds on Indian lands; revenue from these operations almost reached $8 million. Truman's Executive order of April 20, 1949, again enlarged California's Naval Petroleum Reserve No. 1 by adding to it another 2,280 acres.[86] Production royalties from the 272 active wells on NPR–2 totaled $982,000.

As the Federal Government conducted its operations during the summer of 1948, both major political parties held their national nominating conventions. Republicans convened in Philadelphia on June 24, the day the Soviets began blockading Berlin, and renominated Thomas Dewey for President and selected California's Governor Earl Warren as their candidate for Vice President. Dewey developed a large lead in the public preference polls before July 15, when the Democrats also met in Philadelphia and nominated Truman for President. The Democrats chose Kentucky's Alben W. Barkley, the Senate majority leader during 1937–47, as Truman's running mate, after Associate Justice William O. Douglas decided to remain in the U.S. Supreme Court. Southern delegates protested the civil-rights plank in the Democratic platform by walking out of the convention. Those "Dixiecrats" nominated for President South Carolina's Governor J. Strom Thurmond, an enthusiastic advocate of States' rights, white supremacy, and racial segregation. Henry Wallace decided to campaign as a Progressive and that perennial third party nominated him on July 24. Harold Ickes, still bitter over his dismissal, suggested that Truman should retire rather than be defeated, but Truman believed and said that he and Barkley would win.

Truman, calling the Republican-dominated 80th Congress a do-nothing assembly and the worst in U.S. history, ran against the legislators almost as much as opposing Dewey. Truman traveled some 31,000 miles by train, in Roosevelt's *Ferdinand Magellan* coach, as part of his nationwide whistle-stop campaign, during which he proposed halving the defense budget for fiscal year 1949–50 due to continued concerns about deficits and inflation. On August 16, to "aid in protecting the Nation's economy against inflationary pressures,"[87] the President signed an anti-inflation Joint Resolution that authorized the Federal Reserve System to use consumer-credit controls during the rest of the fiscal year to curb installment buying, but the economic recession continued through the fall. On November 2, Truman defeated Dewey by about 2,136,000 votes and received 303 of the 531 electoral votes,[88] disproving the front-page headline, "Dewey Defeats Truman," in the *Chicago Daily Tribune*. Dewey's 189 electoral votes easily outpaced Thurmond's 39 electoral ballots, all from 4 States in the "Solid South," a loss made good by large Democratic majorities from urban black voters in the North. Wallace won no electoral votes, although he polled just 12,000 popular votes less than Thurman's total of some 1,169,000 ballots. The Democrats also regained control of Congress; in the 81st Congress, the Democrats would have a 92-seat majority in the House and a 12-seat advantage in the Senate.

Truman promptly presented programs to attain his foreign and domestic goals. In reporting to the 81st Congress about the State of the Union on January 5, 1949, 2 days after the legislators took their seats, he planned "to encourage free states and free peoples throughout the world to aid the suffering and afflicted in foreign lands, and to strengthen democratic nations against aggression."[89] At home, the President asserted,

> **[e]very segment of our population and every individual has a right to expect from our Government a fair deal.[90]**

In calling for this "Fair Deal," the President asked Congress in his State of the Union Message, supplemented by his Economic Report on January 7, to help generate a budget surplus and reduce the national debt by raising taxes; authorize increased contributions to Social Security and selective control for prices, wages, and the allocation of materials; continue regulation of bank and consumer credit and rent and export controls; support the production of steel and other critical commodities and develop the Nation's natural resources; increase the minimum wage to 75 cents per hour and supports for farm prices; stimulate the economy; provide slum clearance and more low-rent housing; aid local schools; extend health coverage; repeal the Taft-Hartley Act; and enact improved civil rights for minority citizens. Truman's budget message on January 10 predicted expenditures in fiscal year 1949–50 of $41.9 billion, $1.7 billion more than in fiscal 1948–49, but an income of only $41 billion. He asked Congress to provide the additional funds and eliminate the $873 million shortfall by passing new legislation to raise taxes by up to $4.8 billion. Of the $14.3 billion for national defense, Truman promised to give priority in allocations to the Air Force and the Reserves. Although funds for international affairs and finance would fall by $600 million to $6.7 billion, Truman asked Congress to continue to support European recovery and to supply additional aid to Greece, Nationalist China, South Korea, and Turkey. In return, he would request only funds sufficient to keep the other active armed services at current levels.

The United States did not need to rearm, the President concluded, but it should help its allies to do so. The budget's domestic portion included a plea for an energy policy emphasizing conservation of petroleum resources and encouraging commercial development of synthetic liquid fuels from coal, lignite, and oil shale, via methods developed in USBM facilities.

Having refined domestic policy, Truman, at his inauguration on January 20, focused his address on foreign policy. "Each period of our history has had its special challenges," the President recalled, and those "that confront us now are as momentous as any in the past. Today marks the beginning not only of a new administration, but of a period that will be eventful, perhaps decisive, for us and the world."[91] Without specifically mentioning the Soviet Union, he drew a clear line between communism and democracy. Truman declared that "the actions resulting from the Communist philosophy are a threat to the efforts of free nations to bring about world recovery and lasting peace."[92] "In the coming years," he continued, "our program for peace and freedom will emphasize four major courses of action," later termed "points." The United States, the President vowed, would first "continue to give unfaltering support to the United Nations and related agencies" and "search for ways to strengthen their authority and increase their effectiveness." Second, the Nation also would continue its "programs for world economic recovery," keep its "full weight behind the European recovery program," and reduce "the barriers to world trade" and increase its volume. Third, the United States would "strengthen freedom-loving nations against the dangers of aggression" by forming by treaty a new "collective defense arrangement" among the nations bordering the North Atlantic; the treaty would be "within the terms of the United Nations Charter" and would complement the Inter-American Treaty of Reciprocal Assistance signed in Rio de Janeiro in 1947. That pact formalized the recommendation in 1945's Act of Chapultepec to consider an armed attack by any nation against one American country as an assault on all of them and provide the means to respond accordingly. On January 13, 1949, Truman had sent to the Senate the Organization of American States' Charter that was signed in Bogotá on April 30, 1948, by representatives of 21 countries. The United States also would "provide military advice and equipment to free nations which will cooperate with us in the maintenance of peace and security."[93]

Truman, as the fourth point of his inaugural address, called for "a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas." "The material resources which we can afford to use for the assistance of other peoples are limited," he continued, "But our imponderable resources in technical knowledge are constantly growing and are inexhaustible."[94] Joining other countries in distributing knowledge and technology, and fostering capital investment, Truman believed, would counter disease, hunger, and poverty by helping people to help themselves. The President hoped that "these four major courses of action" would "help create the conditions that would lead eventually to personal freedom and happiness for all mankind."[95] Although Truman had rejected Forrestal's request of December 1, 1947, to increase the defense budget for fiscal year 1949–50 to nearly $17 billion, the President signed on July 2, 1948, the National Industrial Reserve Act that provided for "a national reserve of machine tools and industrial manufacturing equipment * * * for immediate use to supply the needs of the armed forces in time of national emergency or in anticipation thereof"[96] and a 15-member Review Committee appointed by the Secretary of Defense. Congress provided $5 million for the expenses of the Federal Works Agency in carrying out the provisions of the law during fiscal 1948–49.

As Truman faced these and other foreign-policy issues early in his second term, ill health led both Secretary of State George Marshall and Secretary of

Defense James Forrestal to resign. When Marshall left office on January 7, Under Secretary Dean Acheson replaced Marshall, and James Webb left the Bureau of the Budget to serve as Acheson's Under Secretary. In 1948, Marshall recommended against providing further aid to Chiang's Nationalists as Mao's forces continued to make gains in Manchuria and in northern and central China. Tientsin (Tianjin) fell on January 15, 1949. When Peiping (Beijing) followed 6 days later, Chiang resigned as president. In February, the United States withdrew the last of its protocol-duty troops from China. The Communists then offered to reach a peace, but, on April 20, the Nationalists rejected demands that included a Mao-led coalition cabinet to govern all of China and trials of Chiang and other "war criminals." Shanghai fell on May 15 and Canton (Guangzhou) followed on October 15.

As the Nationalists' military situation on the mainland continued to deteriorate, their new supreme council, founded on July 16 and led by Chiang, began planning to finish a mass exodus to Taiwan, where Sherman Neuschel completed a military geology reconnaissance. The United States on August 5 suspended all aid to Nationalist China, which the State Department claimed had lost the confidence of its troops and people. On October 1, Mao, as Chairman of the Central Committee, and Zhou Enlai (Chou En-lai), as Premier and Foreign Minister, proclaimed the People's Republic of China (PRC). The Soviet Union and its satellites immediately recognized the new government. India also recognized the PRC, as did Britain on January 6, 1950. Some 2 million Nationalists withdrew across the Formosa Strait to Taiwan, leaving some forces on Matsu, Quemoy (Jinmen), and two other island groups off mainland China's coast between Shanghai and Amoy (Xiamen). The Quemoy garrison repulsed a landing by forces of the People's Liberation Army in October. On December 8, the U.N. called on all member states to respect mainland China's political integrity. Two days later, Chiang flew from Chengdu to Taiwan; he resumed the presidency of the relocated Republic of China on March 1, 1950. After declaring a continuing emergency and securing control of the local population by using harsh methods, Chiang introduced a few of the reforms he had promised while still on the mainland. The "loss" of the Chinese mainland, and Hainan Island in May 1950, gave Republicans another international issue to use against the Truman administration, but the mainland's unification lessened China's internal inflation, continued its land reform, and introduced some equal rights for women along with multiyear economic plans in the Soviet style.

During these military and political changes in China,[97] the Truman administration became involved in an interservice dispute about how best to defend the United States. The pressures of producing a balanced-force military under continuing requests for budgetary restraints, while all three services squabbled over funds and turf, led to Secretary Forrestal's resignation on March 3, 1949. His successor, Louis A. Johnson, took office on March 29. Johnson promoted the President's goals of unifying the services in fact and reducing their yearly expenditures below $15 billion, from Truman's $14.3 billion to about $13.5 billion to cut deficits and fight inflation, but the Secretary's personality and tactics alienated some of his supporters and enraged many of his enemies. In the struggle for strategic domination in the National Military Establishment (later the Department of Defense), Johnson favored the Air Force and its new intercontinental bomber, the Convair B–36 Peacemaker, a huge aircraft powered by six pusher-piston engines enabling it to carry a single 5-ton atomic bomb for 10,000 miles (without refueling) at a top speed of 300 miles per hour (mph) and a maximum altitude of 35,000 feet. The B–36D, with four turbojets added to its powerplant, reached a maximum speed of 435 mph and entered service on August 19, 1950. The Air Force initially tested in December 1947 the Boeing B–47 Stratojet, a smaller, swept-wing aircraft powered by six turbojets, and began developing in 1948 the larger, eight-turbojet, B–52 Stratofortress.

On April 21, 1948, Forrestal assigned primary responsibility for defending the United States to the Air Force, but he promised the Navy that it would continue to control naval aviation. In January 1949, the Hoover Commission's Task Force on National Security, chaired by Ferdinand Eberstadt, also rejected merging naval aviation with the USAF. Some Navy officers wanted to ensure control of naval aviation by adding a strategic capability to its tactical resources. McDonnell FH–1 Phantom twin-jet fighters had operated successfully from *Franklin D. Roosevelt*, and the Navy had modified Lockheed P2V Neptune patrol bombers for operations from *Roosevelt* and *Midway*. Now the Navy began developing its own carrier-capable strategic bomber, the North American AJ–1 Savage, a swept-wing, three-engine (two pistons and one jet) aircraft, to carry a single atomic bomb for 1,000 miles. Johnson followed advice from General Omar Bradley, Army Chief of Staff since February 1948; General Dwight Eisenhower, formerly the informal head of the Joint Chiefs of Staff (JCS) and president of Columbia University since June 1948; and General Hoyt S. Vandenberg, the Senator's nephew, who succeeded Carl Spaatz as Air Force Chief of Staff in April 1948. All of them thought the Navy's strategic aspirations a wasteful duplication of the Air Force's mission. Johnson, without contacting Secretary of the Navy John Sullivan and Admiral Louis E. Denfeld, Chief of Naval Operations (CNO) since December 1947, canceled Navy Day for 1949. On April 23, after only 6 days' construction, Johnson also "sank" the 65,000-ton supercarrier *United States*. Funds thus saved went to purchase additional USAF bombers.

Secretary Sullivan responded by resigning in May, but CNO Denfeld led an admirals' "revolt," principally a verbal and paper mutiny.[98] Those testifying before Carl Vinson's House Committee on Armed Services in October included William Blandy, who led Crossroads in 1946; Omar Bradley, the first formal Chairman of the JCS since August 1949; Clifton B. Cates, Marine Corps Commandant since January 1948; Louis Denfeld; Ernest King; Chester Nimitz; Arthur W. Radford, who commanded the Pacific Fleet and also served as High Commissioner of the U.S. Trust Territory of the Pacific Islands; Raymond Spruance; John Sullivan; Stuart Symington; and Hoyt Vandenberg. The Navy officers opposed the increasing loss of their funds, ships, and roles. They also opposed the $615 million Congress tacked on to the administration's budget request for the Air Force to produce even more B–36s, thought by the admirals to be vulnerable to jet fighters. Francis P. Matthews, Sullivan's successor as Navy Secretary and, like Johnson, another of Truman's political cronies, asked Truman to transfer Denfeld, and the President approved the request on October 27. Denfeld and Blandy retired, rather than accept reassignment and demotion, but Radford returned to his posts in the Pacific.

Vice Admiral Forrest P. ("Ted") Sherman, as Nimitz recommended, succeeded Denfeld as CNO on November 2, 1949. Sherman opposed an independent Air Force but worked with its Major General Lauris Norstad, Forrestal, and Symington to draft the plan for a defense department and contributed to the Truman Doctrine; he did not join the admirals' "revolt." As CNO, Sherman supported cooperation between the services, but he thought carriers essential to ensure control of the seas and wanted far more of them than the eight funded for fiscal year 1949–50. Johnson also differed with Acheson on U.S. policy towards China and began courting Republicans to try to gain their Presidential nomination in 1952. After Symington resigned as Air Force Secretary on April 18, 1950, to protest less-than-requested budgets, Johnson threatened to leave as well when Truman nominated as Symington's successor Thomas K. Finletter, who favored a larger Air Force and chaired the President's Air Policy Commission in 1947. The Commission, advised by General James Doolittle and other experts, recommended in January 1948 an American counteroffensive force of 70 air groups, or 12,000 planes, by the beginning of 1950. The report also called for greater support for naval aviation but predicted, as had Generals Groves and LeMay, that the Soviets would not have an atomic bomb before 1953. Truman called Johnson's bluff, as he did with Harold Ickes in 1946, and the Senate quickly confirmed Finletter on April 24, 1950. Johnson did not resign and Truman did not request his departure. Symington took over the National Security Resources Board from John Steelman, the NSRB's Acting Chairman since December 10, 1948.

The 80th Congress had been reluctant to provide funds for basic research for the common defense and general welfare, but the 81st Congress proved somewhat more understanding and generous. Although Southern Democrats and other conservatives in the new Congress failed to support the major points of Truman's "Fair Deal" domestic program, the legislators increasingly accepted the importance of natural resources in the national economy and national security. At the request of the NSRB, Krug chaired an Interior committee that looked at the availability of supplies of 16 strategic and critical metallic and nonmetallic materials derived from minerals. These commodities included asbestos, bauxite, bismuth, cadmium, chromite, cobalt, copper, industrial diamonds, iron, lead, manganese, mica, nickel, tin, tungsten, and zinc. On October 9, 1947, the Krug Committee's report, "Natural Resources and Foreign Aid," warned that if a future conflict interrupted foreign supplies of these minerals, the United States would run out of asbestos, bauxite, copper, and nickel within 6 months. Supplies of cadmium, cobalt, industrial diamonds, lead, and manganese would last up to 12 months; bismuth, chromite, mica, and tin for 1–2 years; and tungsten and zinc for 2–4 years. Only iron would last for more than 4 years. An equivalent number of other vital materials derived from minerals, including columbium, corundum, graphite, kyanite, steatite talc, and tantalum, also remained in short supply, and, for them, the United States was increasingly dependent on sources in the Eastern Hemisphere. Alan Bateman, Elmer Pehrson, and their colleagues in academia and government warned, in the style of Charles Leith, that the Soviets planned to control the resources of Eurasia and adjacent areas before striking for world dominance. The United States now relied on the Soviet Union for some 30 to nearly 60 percent of its imports of chromite, manganese, and platinum, a dependence discounted by George Kennan and his planning group at the State Department.

To solve these recurring mineral problems, Krug's team recommended establishing a long-range policy, under a single coordinating agency, for increasing research, domestic exploration and production, imports (while improving infrastructure in the source countries), and stockpiling and for developing alternate sources and substitutes well before any Soviet embargo. The Krug Committee's report, as well as those by the House Select Committee on Foreign Aid, the Nourse Committee, and the Harriman Committee, influenced the appropriation for the Marshall Plan in 1948 and the definition of one of the recovery program's goals—decreasing America's mineral dependence through exchange, repay, and trade. Now the Senate Committee on Interior and Insular Affairs and the House Committee on Public Lands held joint hearings in search of an improved policy for the conservation, development, and administration of the Nation's natural resources. Representatives from a number of Federal agencies participated in these sessions, and their organizations submitted reports on internal problems. Following the hearings, the committees' chairmen asked the senior specialist in natural resources at the Library of Congress' Legislative Reference Service to reappraise natural-resources policies and programs and submit proposals for needed changes and improvements. The discussions and the review generated the filing in House committees of two bills, in September 1949 and January 1950, intended to provide, respectively, for programs for comprehensively and adequately collecting basic data about natural resources and accelerating the surveying and mapping of the United States, its Territories, and its possessions. Both bills were amended and reported favorably to the whole

House in July 1950, but the Representatives took no further action. While bills were being prepared, Truman, recognizing that natural-resource problems were increasingly of worldwide concern, suggested that the United Nations sponsor a Pinchot-like conference on the conservation and utilization of these resources. Secretary Krug and Under Secretary Chapman played leading parts in planning for the meeting, and many officials of the Interior Department participated in its sessions, held under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO), at Lake Success, New York, during August 17–September 6, 1949.

The Hoover Commission's reports influenced those efforts by Congress and the Interior Department. On January 13, 1949, the Commission began transmitting to the legislators the reports (appendixes) by its 18 task forces that the Commissioners received in October and November 1948. These documents included the Task Force on Natural Resources' report on "Organization and Policy in the Field of Natural Resources." The natural-resources group recommended organizational changes to establish "a consolidated Water Development Service" (to include some of the BLM's functions plus some of those in the Army Engineers, the Bonneville and Southwestern Power Administrations, and the Federal Power Commission) and "a consolidated Forest and Range Service" (to include the Forest Service plus some functions elsewhere in the U.S. Department of Agriculture (USDA) and in the BLM). The group also recommended decentralizing both of the new Services and organizing them regionally "by river basins where practicable,"[99] in a partial return to John Powell's innovative but unrealized concept; dividing the Fish and Wildlife Service; transferring some Federal agencies' functions to the USBM; and reestablishing "the General Land Office as a record-keeping and title-holding agency for public lands."[100] In 1879, Clarence King, Powell, and other reformers in the National Academy of Sciences (NAS) and Congress did not succeed in so confining the GLO.

In another return to past unsuccessful efforts, the Hoover Commission's Task Force on Natural Resources proposed to replace the Interior Department by uniting, in a new Department of Natural Resources, the proposed new agencies for Water Development, Forest and Range, Fisheries, and Wildlife, with the existing USGS, USBM, NPS, and GLO. The task force recommended continued Federal ownership of the public domain. Its members also urged modernizing the mining location and patent laws, and leasing statutes, to facilitate discovery and exploitation; aiding private enterprise in commercial fisheries, nonpublic forests, and mineral leases; strengthening Federal-State cooperation in water-resource development; increasing emphasis on recreational values; rectifying legislation conflicts in land use and water development; and making "more adequate provision for the collection of basic data with respect to water, land, and mineral resources."[101] The Task Force especially regretted "the lack of adequate hydrologic data" on "precipitation, run-off, stream flow, etc."[102] that had led to the failure of dams, overextension of irrigation systems, and excessive filling of reservoirs by sediment. Until dependable data could be gathered on the availability of water for "navigation, flood storage, irrigation, water supply, and power development,"[103] the Task Force's members opposed the creation of future valley authorities like the TVA.

The Task Force on Natural Resources' report also called for more intensive exploration of the public domain to provide "a more adequate supply of a long list of minerals to support and strengthen our industrial economy and to ensure our national security." The USBM and the USGS, while continuing to share major Federal responsibility for achieving these goals, now worked "under a coordinated program without objectionable duplication" due to attention and efforts by Wrather, Nolan, and Hewett and their USBM counterparts. The major programs of the USBM and the USGS had not been invaded significantly by any of the 25 other

Federal agencies also concerned with mineral-resources issues that called regularly for services by these two bureaus.

> **The scientific and technical work performed by these two agencies is of a high order and of real value to the Nation. They are now headed by able men who command the respect of the mining and metallurgical professions. Continued support and steady maintenance of their current activities are certainly warranted, but expansion is hardly needed except to meet calls for technical service from other organizations such as the Atomic Energy Commission for special statistical and economic investigations, and for the expanded hydrological investigations recommended elsewhere in the report.[104]**

The Task Force recommended giving the USGS and the USBM "adequate support to continue energetically their work" toward gaining "improved knowledge of the occurrence of mineral deposits * * * and more refined techniques for testing areas for them." Repeating lessons recently learned, the members urged the Federal Government and private enterprise to make greater progress in the "necessarily slow" efforts "to make the best use of the mineral resources and to provide against disastrous lack of critical materials." They also encouraged the legislators to recognize or remember, especially when considering budget requests, that the two agencies needed to keep "personnel and specific projects for adequate periods of time." The report placed minerals and fuels vital to the national economy in three classes. Coal, copper, iron, lead, molybdenum, petroleum, and zinc seemed "in relative abundance within our borders." Bauxite, chromium, manganese, mercury, and tungsten could "be obtained from domestic sources only at considerably greater cost than foreign production and not in adequate quantity or quality to meet the Nation's full needs."[105] Nickel, tin, and other mineral commodities appeared "to be lacking within our boundaries in deposits that offer any hope for significant production."[106] To prevent any additional or future duplication by Federal agencies within or outside Interior, the report recommended consolidation of several functions within the USGS and the USBM to "promote a consistent policy with regards to mineral exploration and development, technical aid to mining and metallurgy, taxes, tariffs, stock piles, and other factors." "All responsibility for mapping, geological study, and exploration for mineral resources on public lands, and for administering all phases of the mining and mineral leasing laws"[107] would go to the USGS, except for the following tasks that would be handled by a reorganized General Land Office: issuing and recording leasing rights; collecting rentals, royalties, fees, and penalties (as determined by the USGS); and interpreting the legal aspects of the mining and mineral-leasing laws, in consultation with the USGS. The USBM's Economic and Statistics Branch (Division) would receive "all responsibility for the collection and economic interpretation of data on mineral resources, mining operations, and the international reserves and movements of metals and minerals"[108] by transferring responsibilities now in the Commerce Department, the NSRB, the Tariff Commission, and other Federal organizations.

During February 9–March 31, 1949, the Hoover Commission submitted to the 81st Congress 22 reports of recommendations for improving the executive branch; the concluding report was transmitted on May 20, 1949. The Commissioners based their suggestions for enhancing the national-security organization largely on the report by Ferdinand Eberstadt's task force, received in November 1948 and sent on to Congress in January 1949. Eberstadt's group, in evaluating the economy and efficiency of the Nation's mobilization programs, considered both the policies for stockpiling strategic materials and the accumulated reserves. They called the stockpile's condition deplorable and urged the Commissioners to consider asking "that full responsibility and authority for formulation of stock-pile policy and its execution be clearly and definitely focused—either in the National Security

Resources Board or elsewhere." The NSRB, they continued, should invite representatives of the AEC and the ECA to the NSRB meetings "when matters that concern them are under discussion," the ECA should "increase its contributions to the stock pile by taking payment for its advances," and the NSRB and the Munitions Board should "have more active civilian and industrial participation in their planning and make fuller use of their civilian advisory committees."[109] The Hoover Commission's report on the national-security organization, from whose preparation and consideration Forrestal recused himself, recommended that Congress act to have "the economic warfare section of the National Security Resources Board develop a comprehensive economic warfare program, aimed at supporting our national security in times of peace as well as war."[110]

On March 15, 1949, the Hoover Commission sent to Congress 15 numbered recommendations and additional suggestions for reorganizing the Interior Department, along with dissenting opinions by Acheson, Forrestal, and four of the other Commissioners on the rejection of the Department of Natural Resources, the transfer of the Army Engineers' civil functions, organization by public works, and other views. A majority of the Commissioners did recommend that Congress authorize for Interior a third Assistant Secretary and an Administrative Assistant Secretary for congressional liaison, finance, management research, personnel, publications, and supply; both posts to be appointed by the President, confirmed by the Senate, and filled from the career civil service. Hoover and his colleagues also urged Congress to thoroughly reorganize Interior by major function, or purpose, to emphasize its mission for developing "subsoil and water resources."[111] They recommended transferring the BIA to a new department for education, Indian affairs, and social security; sending the BLM, except for minerals, to the USDA; and shifting Commercial Fisheries from the Fish and Wildlife Service to the Department of Commerce.[112] Proposed transfers to Interior included flood control and rivers and harbors improvement from the Department of the Army, and public-building construction and community services from the Federal Works Agency. The majority of the Commissioners then recommended five groups of major-purpose assignments of Interior's agencies by services, or functions: water development and use, intended to provide adequate hydrologic data; building construction; mineral resources, including the USBM and the USGS; recreation; and territories and possessions.

In urging a "Better Organization in Mineral Resources Services,"[113] most of the Commissioners followed their task force's determinations in promoting "more extensive geological explorations," "more research into improved methods of mining and recovery," and "more adequate management of the Government relations to title leases, royalties, [and] reservations." After study, they continued, mining laws should be revised, "a center of mineral services" should be established, and some of the 25 agencies that dealt with mineral resources should be consolidated to avoid current "extensive duplication" and to provide "a more systematic source of information and advice."[114] The Commissioners also recommended that the proposed agency for mineral-resources services should provide reports to the Reconstruction Finance Corporation and that RFC's tin smelter at Texas City, Texas, be transferred to the USBM. These recommendations were republished in the proceedings of hearings, held during mid-October 1949, by a special subcommittee of the House's Committee on Public Lands on proposed revisions of the U.S. mining laws. On March 23, 1950, Truman asked Secretary Krug to comment on all these proposals and forward them by April 15 to the Bureau of the Budget's Director. Truman noted that Krug might accomplish some of the reforms by administrative action, if the Secretary considered them practical and necessary, but others might require Executive orders, authority provided by reorganization plans pending in Congress, or new legislation. Where Presidential determinations were needed, Truman asked for Krug's views about the practicality and propriety of the Hoover Commission's recommendations.

On May 26, Under Secretary Chapman, again acting for Krug, sent Interior's comments to Frank Pace, Jr., who succeeded James Webb as the BoB's Director earlier in 1949 after serving as Webb's Assistant Director. Krug, Chapman, and their advisers considered "inadequate" the Hoover Commission's report on Interior, "despite the validity of certain recommendations." In their view, the report denied "one of the most fundamental principles of organization expressed by the Commission: 'The numerous agencies of the executive branch must be grouped into departments as nearly as possible by major purposes in order to give a coherent mission to each Department.'" "Interior," they continued, "is substantially a natural resources agency, the product of evolution and accretion." Some Commission recommendations, like those for water-resources development, "would amplify this role"; others, especially in public-domain management, would detract, but still others "would add completely unrelated construction functions, turning Interior into a hybrid." Krug and his associates suggested the Commission's views lacked sufficient awareness "of the economic and administrative significance of the job to be accomplished by the Federal Government in the field of conservation and development of natural resources."[115]

In supporting the proposed Department of Natural Resources, Krug and his associates urged that Interior, with its present functions intact, should form the new department's nucleus and recommended that it receive the Forest Service's forest functions (except farm forests), the Soil Conservation Service's responsibilities in hydrology and public lands, and the Army Engineers' harbors and rivers functions. These reviewers also recommended regional authority to ensure "that adequate facilities exist for planning and carrying out balanced resource development programs." Favoring the establishment of additional valley authorities, like the one Truman proposed for the Pacific Northwest, they suggested, alternatively, that "coordinated regional development can be assisted measurably through suitable decentralization" of the proposed department's "planning and operating responsibilities."[116] The reviewers recommended statutory authority to enable the President to carry out any reorganization plan. Their responses to each of the Commission's 15 numbered recommendations included the view that the "proposal for the creation of a Minerals Resource Service raises questions which will require further study" now underway. We "wholeheartedly endorse," Krug and his colleagues continued, "the Commission's general objectives" to establish Interior "as the major center of [Federal] mineral resource programs," to be accomplished by creating a Department of Natural Resources, and "to provide for a greater integration of the policy planning and program direction of the Department's mineral activities." Krug promised to formulate draft legislation to "Define and clarify the existing activities" of the USBM and the USGS, to "[b]roaden and make specific the Department's authority relating to the collection, reporting, and analysis of minerals economic data,"[117] and "authorize the Secretary to provide adequate staff and organize the minerals activities * * * to assure the integration of policy planning and program direction."[118]

While the Interior Department completed its review of the Hoover Commission's recommendations, the Commissioners submitted their concluding report to Congress on May 20, 1949. A complete reorganization of the executive branch to enhance its authority, accountability, economy, and efficiency, the Commissioners emphasized, would reduce to 30 the 52 agencies now reporting to the President. For all Federal agencies, they rejected regional management in place of firm lines of authority that passed directly from the chiefs of units to chiefs of sections, branches, divisions, and bureaus. To sharpen managerial tools, the Commissioners suggested changes in the management of buildings, fiscal matters, personnel, recordkeeping, and supplies. Among the Commissioners' recommendations to avoid "conflict, duplication, and overlapping,"[119] they retained their Task Force's ideas of merging water-resource development in Interior (although they harbored no illusions about the difficulty of prying some water responsibilities away from the Army Engineers) and land and forestry management in Agriculture. Interior's responsibility for U.S. territories and possessions would join the ECA, the administration of occupied areas, and other organizations in a new Administration of Overseas Affairs. On June 20, 1949, Truman signed a bill that provided "for the reorganization of Government agencies." The Reorganization Act authorized the President to reform at his pleasure the executive branch "to promote the better execution of the laws," "to reduce expenditures and promote economy, to the fullest extent consistent" with "efficient operation," "to increase [operational] efficiency * * * to the fullest extent practicable," "to group, coordinate, and consolidate agencies and functions * * * according to major purposes,"[120] and to abolish agencies or reduce their number. Proposed reorganizations would be subject to a veto by a majority of all Members of the House or the Senate of any plans "transmitted to the Congress before [the time limitation expired on] April 1, 1953."[121]

The Truman administration accepted wholly or in part more than half the Hoover Commission's 270-plus recommendations in the Commissioners' final report when the administration sent to Congress 35 plans for reorganization. On August 20, 1949, the administration had transmitted eight reorganization plans to Congress; the legislators accepted six of them, including Plan 4 of 1949 that transferred the National Security Council and the NSRB to the Executive Office of the President. During March 13–May 31, 1950, the Truman administration sent to Congress 27 additional plans for reorganization, of which the Senate threw out 6, the House disposed of 1, and both bodies agreed on 20. Of the reforms approved in 1950, Plan 3, effective on May 24, added to Interior the recommended third Assistant Secretary and the Administrative Assistant Secretary.[122] Plan 15, also effective on May 24, transferred the Alaska and Virgin Islands Public Works from the Administrator of General Services to the Secretary of the Interior. Plan 25 (effective July 9) moved the functions of the NSRB to its chairman and established a position for a Presidentially appointed civilian as the Board's vice chairman. Congress and the President had established the General Services Administration (GSAd) on June 30, 1949, "to simplify the procurement, utilization, and disposal of Government property,"[123] as part of its ongoing reorganization, by transferring to the new organization the Bureau of Federal Supply, the Federal Works Agency, the National Archives, and (for liquidation) the War Assets Administration.

In another modification on October 28, the Classification Act of 1949 was intended to "establish a standard schedule of rates of basic compensation" and "an equitable system for fixing and adjusting the rates"[124] for Federal civilian employees. The new law repealed the Classification Act of 1923 and replaced its Professional and Scientific Service grades (PSS–1 through PSS–8), Subprofessional Service grades (SS–1 through SS–8), and Clerical, Administrative, and Fiscal Service grades (CAF–1 through CAF–15) with two new grades—General Schedule (GS–1 through GS–18) and Crafts, Protective, and Custodial (CPC–1 through CPC–10). In the new GS grades, the former SS–1 now equaled GS–1; PSS–1, SS–6, and CAF–5 shifted to GS–5; PSS–2, SS–8, and CAF–7 became GS–7; and PSS–8 and CAF–15 became GS–15. The new statute based yearly salaries in the GS and CPC classifications on employees' grades and their lengths of service within each grade, the latter tied to a six-stage sequence of potential in-grade step increases that depended principally on efficiency ratings. The new act applied to most Federal departments and agencies, except the AEC, the Central Intelligence Agency (CIA), the TVA, and other organizations already covered by existing laws.

While the Hoover Commission deliberated, the House's Interior subcommittee began considering, on January 26, 1949, the Department's request for appropriations of $616.7 million for fiscal year 1949–50. Krug estimated that Interior's net revenues for the year would increase by more than $3 million. The larger budget proposed for the USGS, he explained, would enable the agency in "three significant areas" to expand "some urgently needed projects" in topographic mapping, strategic and critical minerals, and water resources, the last of which "should be expanded to match substantially, on a 50:50 basis, the offerings of the States."[125] Hearings on USGS appropriations for the new fiscal year began on February 2. Representative Michael Kirwan now chaired the House subcommittee, including new member Henry M. ("Scoop") Jackson (D–WA).

The USGS requested $17.9 million in direct appropriations for salaries and operations by its nearly 4,400 permanent personnel during fiscal year 1949–50, an increase of nearly $5 million, and the agency expected $13.5 million from all other sources. The USGS cast its budget in somewhat different terms than it had done since the early results of Director Powell's failed policies and practices had forced Congress to require separate estimates for engraving and printing for fiscal 1887–88 and complete line itemization of all budget requests beginning with those for fiscal 1888–89. Most of the subsequent mandatory categories of salaries, topographic surveys, geologic surveys, streamgaging, classification of lands, supervision of mining and oil and gas leases, preparation of illustrations, and printing and binding now were restyled by the USGS. These items, which appeared initially in the annual report of funds available for fiscal 1948–49, included topographic surveys and mapping, geologic and mineral-resources surveys and mapping, water-resources investigations, classification of lands, supervision of mining and oil and gas leases, and general administration. The new language of printing and binding and purchase of reprints replaced the old line items for the preparation of illustrations and for printing and binding. Wrather, in testifying before the House subcommittee, explained that the BoB was instituting a Governmentwide policy "to make the operating funds available for publication of the results."[126] The item for preparing illustrations shifted to salaries, while the amounts for printing and binding went to water-resources investigations and salaries.

Wrather, in presenting justifications for the restyled specific items in the requested budget, continued his firm line on the request for increases in funding even larger than those desired for fiscal year 1948–49. "The Geological Survey is requesting a direct appropriation of $7 million," a 61-percent increase, the Director emphasized, for its topographic program because "The rate of mapping achieved since the 20-year program was proposed in 1946 will result in complete national coverage in about 60 years." "The increased appropriations of the past several years," he continued, enabled the USGS "to completely reorganize and better staff and equip our mapping service" and yielded "a greatly accelerated production of new maps." The "far more efficient organization," and its ability to respond promptly "to a greater work load,"[127] could only finish mapping the Nation within 20 years, Wrather cautioned, if Congress and the President continued to make available gradually increased funds. The $875,000 raise for USGS geologic surveys, to $3.5 million, represented entirely the reintroduced formal request for investigations of strategic and critical minerals within the geologic work. Wrather emphasized the existing shortages for 34 of the 51 minerals still on the strategic list, especially industrial diamonds, nickel, and tin. The USGS also asked for an additional $156,000, to a total of $500,000, for work on Alaskan mineral resources, on its permafrost, and in the Aleutians, and an extra $700,000 for water-resources investigations. The hearing, as it progressed, took on a rather surreal character. Kirwan asked the questions, Wrather replied with long statements, and the other subcommittee members and USGS managers, including Bannerman substituting for Bradley, said very little. The subcommittee and the whole House voted to cut 13 percent from the Interior and USGS requests, reducing the former to $536.2 million, which provided $126.8 million more than in 1948–49, and the latter to $15,513,000, or $2.49 million more than in 1948–49.

The Senate subcommittee began its deliberations on Interior's budget request on May 23, 1949. In calling for restoration of the House's cuts, Secretary Krug urged the Senators to restore the $1.5 million reduction for USGS topographic mapping. Even the full $7 million, Krug observed, "would provide only for a moderate expansion of the over-all mapping program,"[128] while the National Military Establishment, other Federal agencies, the States, and private organizations continued to ask the USGS to complete mapping the Nation in 20 years. The subcommittee, again chaired by Carl Hayden, evaluated the USGS budget on June 7. Wrather asked the subcommittee to restore the five reductions made by the House. Carl Hayden, who had sponsored the Temple Act in 1925, needed no encouragement to support topographic mapping, but Wrather quoted the Hoover Commission's Task Force on Natural Resources in urging the Senators to restore the funds for studies of water resources to obtain the "basic hydrologic data essential to sound planning and construction."[129] A letter from Karl Compton,[130] still a member of the military's Research and Development Board, to Wrather supported his request for the full $60,000 to continue the USGS role in the Joint Aleutian Geophysical Program, to which each of the three services would add $20,000 during fiscal year 1949–50. Wrather promised the subcommittee that the USGS would ensure that the Aleutian program balanced civilian and military needs. Wrather also asked for $40,000 to add a third full-time member to the HVO's staff and support the staff's salaries and work in geochemistry, geology, seismology, and ground surveys.[131]

The House and the Senate, retaining the old line-item usages, agreed to provide $343,000 for salaries and expenses, $5.75 million for topographic surveys, $3.5 million for geologic surveys, $500,000 for mineral-resources investigations in Alaska, $4,125,000 for water-resource investigations, $320,000 for classification of lands, $725,000 for supervising mineral leasing, $725,000 for engraving and printing maps, and the usual $19,500 for stationery supplies. The USGS also listed among its expenditures in fiscal year 1949–50 nearly $34,400 for soil and moisture conservation, drawn from the $2.8 million for salaries and expenses that Interior received that year for its work in the program that began in 1935 when Congress and President Roosevelt established the Soil Conservation Service. Congress continued unchanged the cooperating advance out of the revolving fund and the authorization for contracting for topographic maps made from aerial photographs and for geophysical or other specialized surveys and the prohibition on paying for drilling for domestic-use water wells. As the USGS requested, the legislators raised the limits on the amounts in each programmatic item that could be spent on personal services in the District of Columbia. They also extended for 1 year USGS authority to acquire surplus equipment, materials, and supplies but limited their total appraised value to $150,000.

Congress provided the USGS with a total of $15,988,000 for salaries and operations during fiscal year 1949–50,[132] and Truman signed Interior's appropriations bill into law on October 12, 1949, 9 days after Krug authorized Wrather to "enter into agreements for the acquisition and accept conveyances of lands or interests in lands whenever * * * [they] are to be acquired for administration through the Geological Survey pursuant to any act of Congress."[133] On June 29, 1950, deficiencies legislation added almost $151,000 for increased pay and travel costs,[134] bringing the total of direct appropriations to about $16,139,000 for fiscal 1949–50, an increase of more than $2.9 million from 1948–49. In the final sum of nearly $30,601,000 managed by the USGS during fiscal 1949–50, almost $3.89 million more than the previous year, outside funds fell to 47 percent of the total.

States, counties, and municipalities contributed nearly $4,160,000, while about $9,562,000 of the nearly $10,446,000 transferred by other Federal agencies came from the usual seven principal organizations. These funds included some $4 million from the USBR, nearly $2,710,000 from the AEC, about $1,587,000 from the Army, some $569,000 from the USAF, a little more than $372,000 from the Navy, nearly $232,000 from the State Department, and almost $92,000 from the TVA. Only the DoS reduced its transfer funds, but $34,000 from foreign governments more than made good that loss. Of these outside funds, the Topographic Division received 35 percent, the Water Resources Division took in 32 percent, and the Geologic Division got 27 percent.

In the new fiscal year that began on July 1, 1949, Wrather and Nolan continued forming special committees to advise them about specific ways and means to improve USGS policies, plans, operations, and products. On July 18, Nolan, acting for Wrather, established a Publications Committee to heighten the quality of USGS "published maps and reports, and to secure their prompt issuance" to justify the earlier request to Congress for authority and funds to end, or at least reduce, the backlog of unpublished products. Julian Sears chaired the new Committee, whose members included one representative of each of the four program Divisions—John Northrop (Conservation), John Hack (Geologic), George Whitmore (Topographic), and Walter Langbein (Water Resources). Nolan asked the Publications Committee to make a "broad and intensive study" of "general governmental and bureau policy, scope, review of technical content, format, mode of publication, and procedures for handling" throughout the USGS, "with a view to analyzing present shortcomings and of devising means of correcting them."[135]

On November 17, 1949, Wrather founded a USGS Executive Committee (ExComm), composed of Nolan (chair) and the four Division Chiefs—Harold Duncan (Conservation), Bill Bradley (Geologic), Gerald FitzGerald (Topographic), and Carl Paulsen (Water Resources). Wrather asked the new ExComm to "consider and review internal policy matters affecting the administration of the Survey; interdivisional responsibilities; and major phases of operating programs." He outlined five specific duties and responsibilities. The new group would (1) assign to the Coordination and Management Services Committees "special problems for study and recommendation" and recommend "to the Director approval or disapproval of internal policy matters submitted by" those committees; (2) review and reconcile the administration of operations consistent with USGS policies; (3) consider "major phases of each Division's operating program"[136] to coordinate and integrate them with the Director's major policies; (4) review for the Director all proposed Survey orders; and (5) present their recommendations on external policy matters to the Director at his Staff Conference or separately in written form. Wrather asked the ExComm to meet each Wednesday at 9:00 a.m. and authorized a secretary to take minutes. The ExComm's meetings, he emphasized, would not replace those of the Director's Staff Conference.

In the first half of 1950, Wrather formed a third new committee and revised the charter for an existing group. On January 4, Wrather created a General Staff Committee to replace the Coordination Committee, chartered on June 29, 1949, to establish USGS policy on Interior's Regional Field Committees. The General Staff Committee (GSC), chaired by an individual chosen by the Director, included representatives of each Division and one member of the Director's Office. Wrather gave his newest Committee five principal tasks. First, the GSC would "perform staff work, as assigned by the Director or the Executive Committee" on matters of interdivisional cooperation, coordination, and integration, other than those of management service and publication. Second, it would report to the Director's Office through the ExComm. Third, the GSC would review the reports and programs of the Interior Department and its agencies, prepare comments and recommendations, and assist the USGS representative (Paulsen) on the 12-member Water Resources Subcommittee of Interior's Program Committee, whose 10 members included Wrather, as reorganized by Krug on April 14, 1948, and chaired by Lee Muck. Fourth, the GSC would correspond with the representatives of Interior's field committees and coordinate USGS participation in and provide advice on departmental and bureau policies relating to them. Fifth, Wrather asked the GSC to "reach a reasonable compromise or reconciliation of ideas where differences occur."[137] On May 11, 1950, Wrather formalized the USGS Budget Committee, established by memorandum on December 15, 1948. He asked this Committee, composed of Budget Officer John Ramsey (Chairman) and one member of each Division, chosen by the Division Chief, to consider "budget estimates and related budgetary problems"[138] within the USGS and make its recommendations to the Director through the ExComm.

Wrather, in three Survey orders issued before the end of fiscal year 1949–50, also dealt with other pressing problems by making additional changes in USGS administration, operations, and products. On March 29, 1950, the Director provided a formal policy and procedures for the review and approval of "manuscripts and statements [by members of the USGS] proposed for outside publication or oral presentation." He required all writings "in which the Survey has a proprietary interest" and those bearing authors' titles and USGS affiliation to "be submitted to the Director, and be approved or cleared by him, or his deputy, prior to release for outside publication." "In accordance with generally accepted ethics and amenities," Wrather continued, the writings "should include acknowledgments, and/or citations of official authorizations, when and as appropriate as determined by the Director." He suggested that "the frequently used footnote, 'Published by permission of the Director, U.S. Geological Survey,'" was "one satisfactory form of citation." Abstracts of papers or talks also required Director's approval, unless the abstracts had accompanied a manuscript previously approved for publication. Oral presentations did not, Wrather added, require such clearance. He urged USGS speakers to continue to exercise discretion in "content or tone" while discussing "controversial topics," those that might unjustifiably embarrass the agency or criticize "other persons or organizations," reveal "unsettled or unannounced Department or bureau plans and policies," and prematurely disclose "the results of investigations."[139]

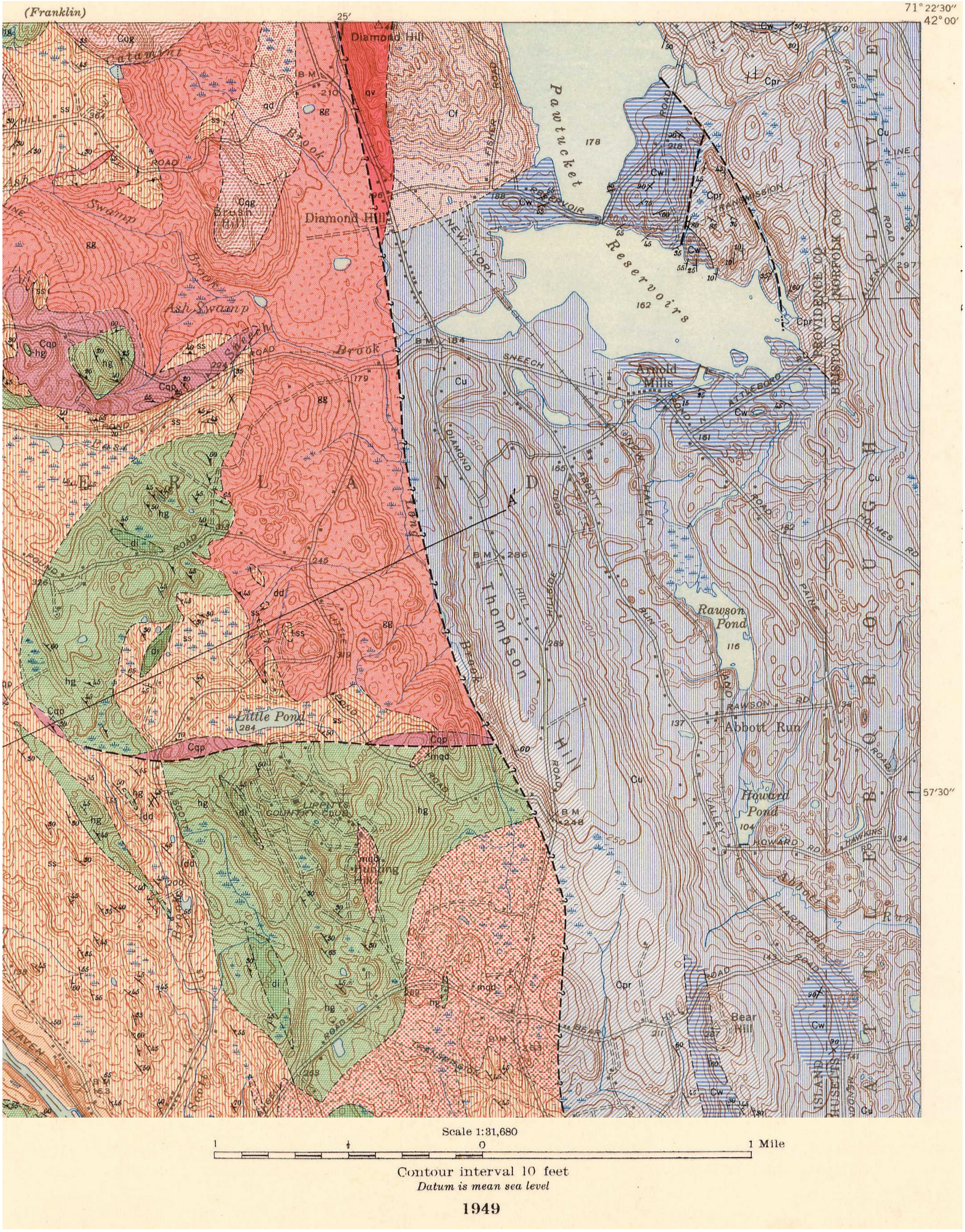
Wrather continued his reorganization by appointing a new personnel officer for the USGS and establishing a USGS committee at Denver. Charles A. King, USGS Personnel Officer, retired on December 1, 1949, after more than 40 years of service with the agency. On April 21, 1950, Wrather confirmed his selection of Willard P. McCornack,[140] who had managed personnel elsewhere in the Federal Government and now was a chemical engineer in the Geologic Division, as Charles King's successor as of April 13. On June 16, Wrather established a Denver Survey Committee[141] to facilitate discussions of problems of mutual interest to the USGS units and to coordinate their operations in the Rocky Mountain region. The USGS Budget Officer, succeeded later by the Management Service Officer, who served as secretary, at Denver, and representatives from each of the program Divisions, chosen by the Division Chiefs, composed the new Committee, whose chairman would be elected annually from among its members. Wrather empowered the Denver Committee to make recommendations for improvement to the Executive Officer and the Executive Committee, who would then forward to the Director their opinion of the proposed changes. On the same day, another Survey order founded "a Denver general office" as a public-information facility, like the one in Washington, to handle the "necessary downtown distribution and orders of maps and reports, both sale and free editions."[142]

Bill Bradley's Geologic Division managed about $8,407,000 in total funds for salaries and operations during fiscal year 1949–50, an increase of some $1,164,500 from 1948–49. To the direct appropriations of nearly $4,071,000, the AEC added more than $2,495,000 in transfers, principally for the uranium-vanadium program. The Army, the Navy, the USBR, the State Department, the USBM, and other Federal agencies combined to provide about $1,667,500, of which $688,000 came from the Army and its Engineers. The ECA and several foreign governments combined to add another $70,600 to the Division's total funds. States, counties, and municipalities transferred $86,000.

Bradley made four significant changes among his Division's planners and managers during fiscal year 1949–50. Robert Bryson replaced William Pierce as one of the four Staff Geologists. In mid-October, Preston Cloud, Jr., succeeded John Reeside, Jr., as Chief of the Paleontology and Stratigraphy Branch (PSB). Reeside, Chief of the PSB since December 1930, returned at his request to full-time research on ammonite stratigraphy and systematics. Wrather, like Bradley, thought Cloud "exceptionally well qualified"[143] to be the new Chief. Cloud revitalized and expanded the Branch by adding full-time staff and consulting specialists in biostratigraphy, enlarging the space in the U.S. National Museum and elsewhere available for their work, and making the results of these studies in basic chronology and evolutionary biology more useful to the Division's mineral and energy programs. Assistant Chief Geologist Harry Ladd, at his request, also returned to research in January 1950. Wrather noted Ladd's craving, suppressed with difficulty since 1943, to resume his studies on the paleoecology and ecology of mollusks. "Henceforth," the Director noted wryly, "Dr. Ladd will be found in the Survey's quarters at the National Museum; happy as a clam."[144] To replace Ladd as Assistant Chief Geologist, Bradley and Wrather selected Esper Larsen 3d, who led the Military Geology Branch during August 1945–August 1946 before returning to research and serving as Chief of the Petrological Investigations Group in Earl Ingerson's Geochemistry and Petrology Branch. A. Williams ("Bill") Postel replaced Edwin Goddard as Chief of Geologic Information and Reports, after Goddard retired. Postel became Acting Geologic Map Editor in June 1949, as the USGS resumed its series of geologic maps of quadrangles, begun as Folios of the Geologic Atlas of the United States (1894–1945), with Geologic Quadrangle (GQ) Maps 1–4 (1949) that displayed, at 1:31,680 with a 10-foot contour interval, the bedrock and surficial geology of two quadrangles—Pawtucket in Rhode Island and Massachusetts and Mount Grace in Massachusetts.

The USGS geologic program carried out under regular appropriations during fiscal year 1949–50 continued to emphasize surveys and appraisal of the Nation's mineral and mineral-fuel resources.[145] The evaluations included preparing reports for several Federal agencies on bauxite and other specific resources. I. Gregory Sohn, an ostracode specialist who had just rejoined the PSB after serving with minerals units since 1942, began compiling a 1:1,500,000 map to show the geology of alumina occurrences in the Columbia River Basin and to summarize his searches for bauxite-rich clays in the Pacific Northwest. Additional studies began of the Nation's current position with respect to copper, graphite, and talc; investigations soon expanded to cover more than a dozen strategic commodities. The Mineral Deposits Branch operated or began some 90 field projects. They included detailed geologic mapping and related studies of mining districts, extending similar investigations into undeveloped but potentially mineralized areas, developing and testing new techniques of finding ore, conducting basic research on mineral-deposit formation, expanding exploration (including drilling) to obtain geologic data and to test structural interpretations and theories of ore concentration, and compiling maps and preparing comprehensive descriptions for broad areas of diverse deposits.

Well over half of the Mineral Deposits Branch's program focused on strategic minerals and emphasized commodities and areas about which the Geologic Division knew the least and on locales that offered the best chances for new and important discoveries plus providing additional information about geologic processes.


(Franklin)
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Reservoirs
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Brush Hill
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Abbott Run
Howard Pond
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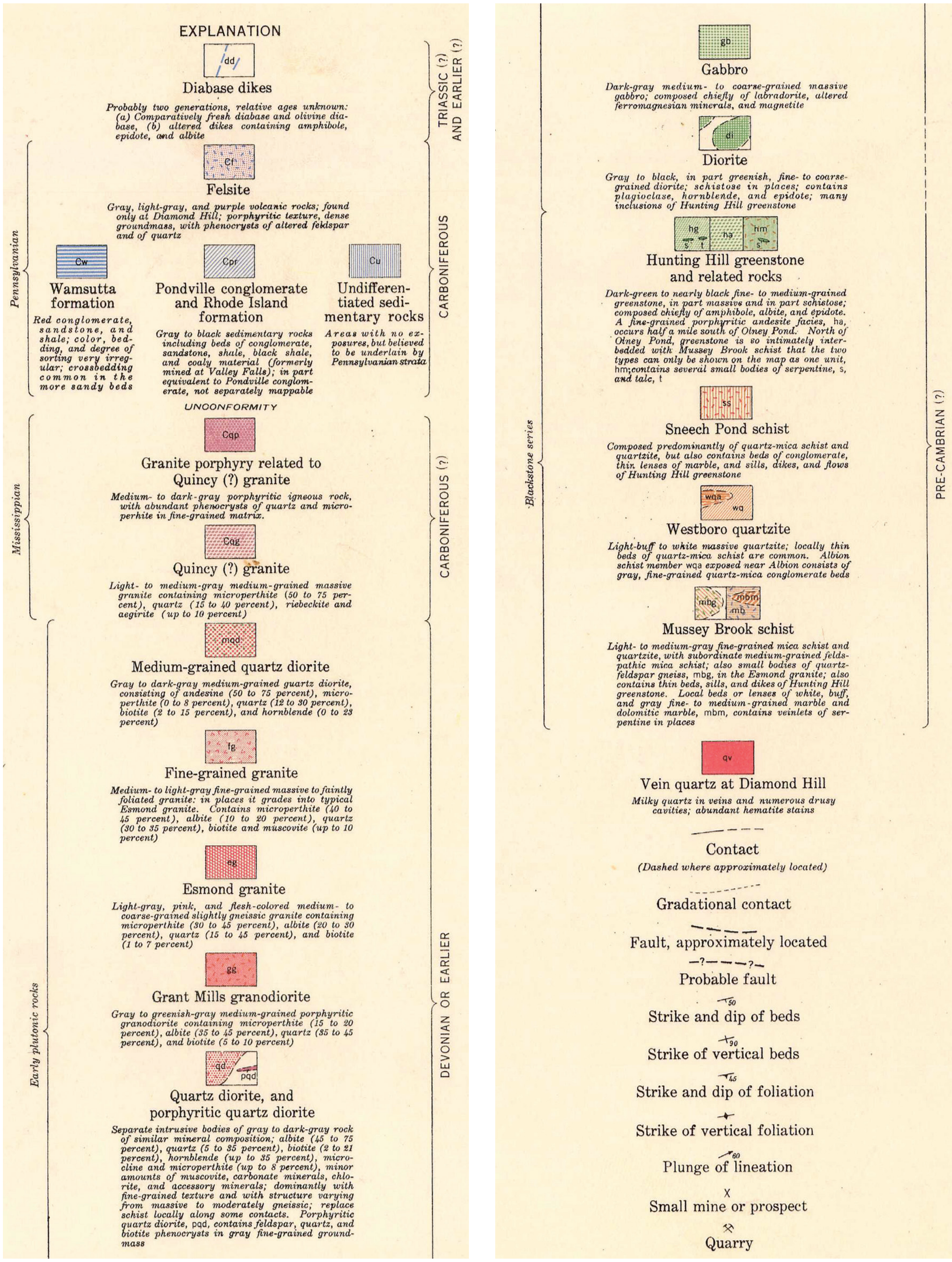
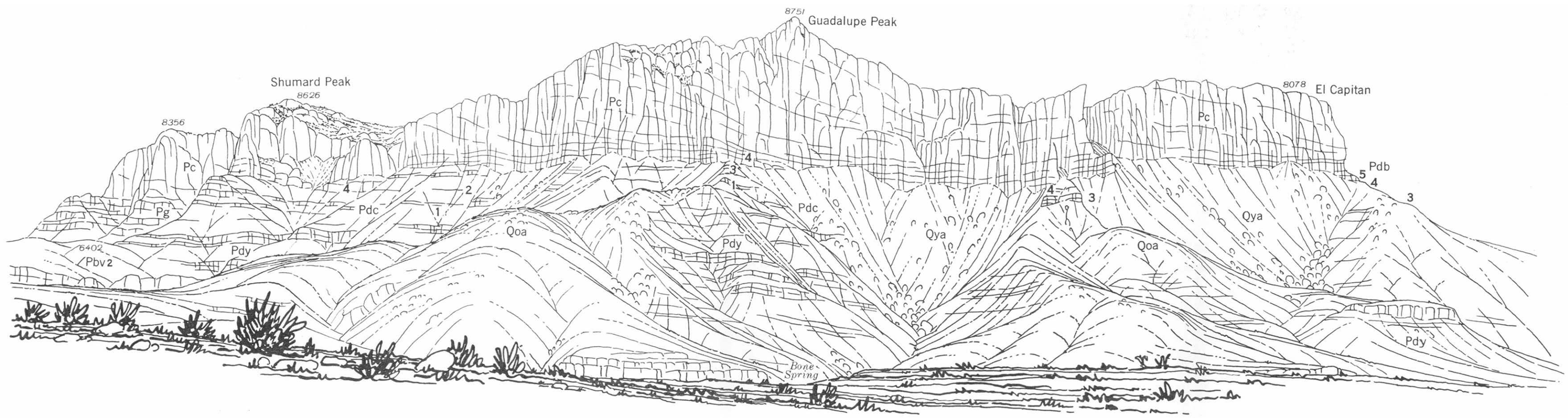


This map (originally at 1:31,680) shows the bedrock geology—Precambrian, Paleozoic, and Triassic rocks—of the northeast quarter of the Pawtucket 7.5-minute quadrangle in Rhode Island and Massachusetts. The map was published in 1949 as USGS Geologic Quadrangle Map 1 (GQ–1) and printed on a once-folded sheet that also contained a title page and a text. The map was accompanied by a geologic section along line *A–A′*. GQ–2 portrayed the Pawtucket quadrangle's surficial (Quaternary) geology; see Chute, 1949. The two Pawtucket quadrangle maps inaugurated the USGS series of Geologic Quadrangle Maps of the United States to replace the agency's smaller scale series of Folios of the Geologic Atlas of the United States (numbers 1–227, 1894–1945). Most subsequent GQ maps appeared at the new standard scale of 1:24,000. (From Quinn, Ray, and Seymour, 1949.)

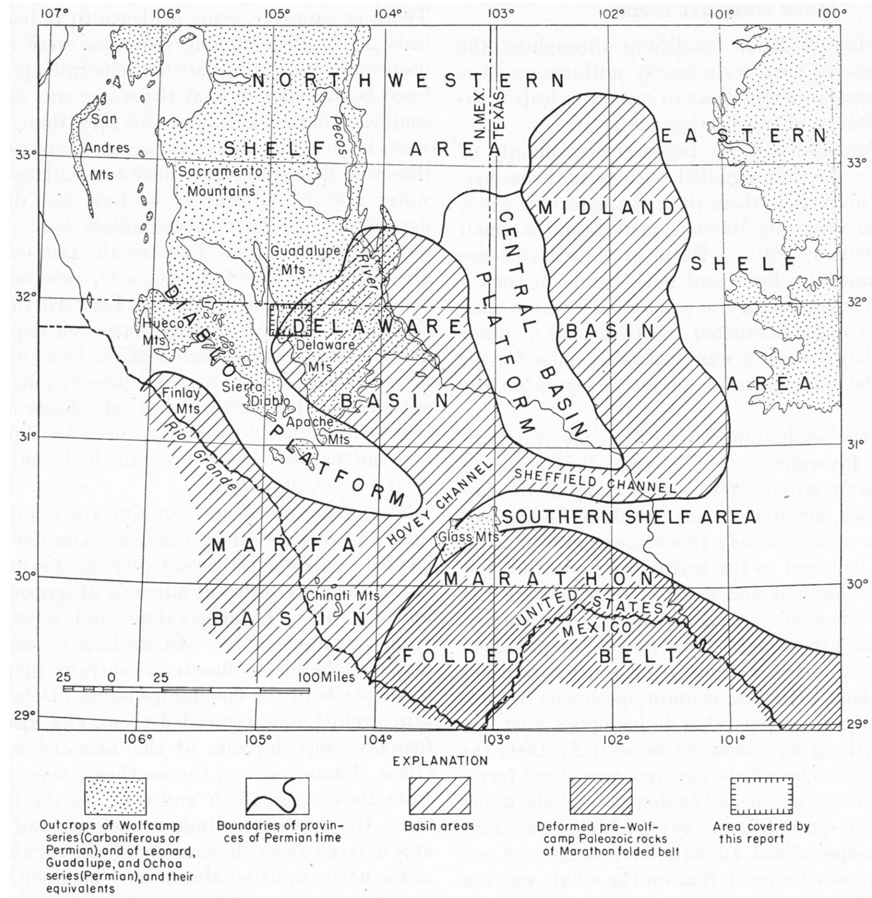


A. EL CAPITAN TO SHUMARD PEAK, LOOKING NORTHEAST FROM RIDGE ON SOUTH SIDE OF BONE CANYON.

B. NORTH SLOPE OF GUADALUPE PEAK TO SHUMARD PEAK, LOOKING NORTH FROM RIDGE ON SOUTH SIDE OF SHUMARD CANYON.

In the late 1930s, USGS geologist Philip King sketched these panoramic views, looking (*A*) northeast from the ridge on the south side of Bone Canyon and (*B*) north from the ridge on the south side of Shumard Canyon, both in the southern Guadalupe Mountains of western Texas. Units in King's stratigraphic sequence shown here included two Quaternary (Q) units: Younger alluvial deposits (Qya) and Older alluvial deposits (Qoa). The sequence also included the following Permian (P) units: Capitan Limestone (Pc); Bell Canyon Formation (Pdb), and its Pinery (Pdb5) and Hegler (Pdb4) Limestone Members; Goat Seep Limestone (Pg); Cherry Canyon Formation (Pdc), and its Manzanita (Pdc3), South Wells (Pdc2), and Getaway (Pdc1) Limestone Members; Sandstone tongue (Pd); Brushy Canyon Formation (Pdy); upper (Pbc2) and lower (Pbc1) divisions of Cutoff Shaly Member of the Bone Spring Limestone; upper (Pbv2) and lower (Pbv1) divisions of the Victorio Peak Gray Member of the Bone Spring Limestone; and Black limestone beds (Pb1). King was the latest of a number of USGS geologist-artists, whose contributions to scientific illustration began with William Henry Holmes' limning of the Grand Canyon and the Lake Bonneville terraces in 1880 for, respectively, Clarence Dutton and G.K. Gilbert. Elevations are in feet. (From King, 1948, pl. 12.)

This view of the southern Guadalupe Mountains of western Texas looks north toward El Capitan (center, elevation: 8,078 feet), which lies in front of and conceals Guadalupe Peak (8,751 feet). To the west, Shumard Peak (8,626 feet) honors Federal geologist George G. Shumard, who set up an initial stratigraphic section here in 1855 while serving with a U.S. Army expedition led by Captain (later Major General) John Pope of the Corps of Topographical Engineers. USGS geologist Philip King correlated Shumard's older lithologic units (1–4) with some of those in his own stratigraphic section completed as part of field studies during 1934–39. In King's youngest-to-oldest upper Paleozoic sequence, Capitan Limestone = 1 (white limestone), Pinery Limestone Member (of Bell Canyon Formation) = 2 (upper dark limestone), Delaware Mountain Group = 3 (yellow sandstone), and Bone Spring Limestone = 4 (basal black limestone). The letters refer to younger (b) and older (a) Quaternary slope (alluvial) deposits. (Aerial photograph by U.S. Army Air Corps from King, 1948, pl. 1.)

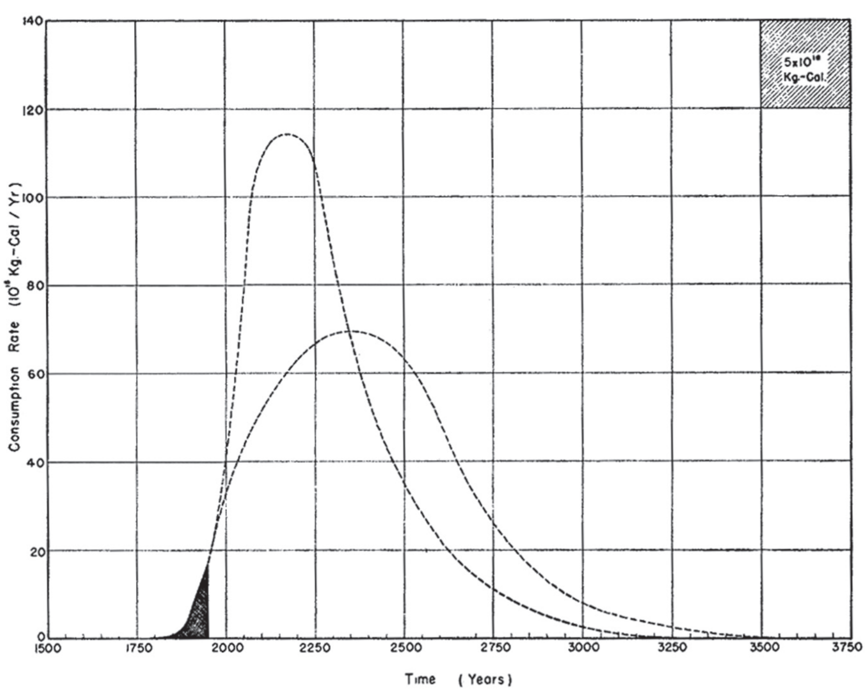


This index map of parts of western Texas and southeastern New Mexico shows the major basins, platforms, shelves, and related paleogeographic features during the Permian. USGS geologist Philip King concentrated on the area (hachured box) between the Delaware and Guadalupe Mountains as part of his investigations of regional geology, depositional provinces, and stratigraphic facies in the upper Paleozoic rocks of the Southwestern United States. (From King, 1948, fig. 3.)

Large-scale exploration for uranium and vanadium, funded principally since 1944 by the AEC, continued on the Colorado Plateau. Only three uranium mines existed on the Plateau before 1948, the year that large deposits began to be found and their products started to reduce the Nation's dependency on shipments from the Belgian Congo and Canada. Branch members worked on other mineral commodities, including chromite, copper, gold, iron, lead, manganese, mercury, silver, and zinc. Nonmetal investigations emphasized phosphate deposits in Florida, Idaho, and Montana; beryllium, mica, and other pegmatite minerals in the Black Hills and in the Rocky Mountain and Eastern States; potash in New Mexico; talc in New York and Vermont; monazite in the Southeastern States; and bentonite and other clays and bauxite nationwide. Diamond drilling in the Wisconsin lead-zinc district disclosed zinc minerals of minable grade in an inactive part of the district and discovered other significant deposits below those previously considered favorable for mineralization.

Other units in the Mineral Deposits Branch continued to support the Branch's fieldwork. Ralph Roberts, brought to Washington in May 1949 as head of the Mineral Deposits Branch's manuscript-processing unit, worked with Julian Sears and their colleagues in improving and extending the series of special maps, especially those in the numbered Mineral Investigations Field Studies (MF) and Mineral Investigations Resource (MR) series.[146] In the separate but related Trace Elements Program, Vincent McKelvey joined TEPCO's headquarters' staff in 1950 as the unit completed installing analytical laboratories at Beltsville and Denver. The unit's new X-ray fluorescence analyzer facilitated easier and more precise determinations of several elements, including cesium, hafnium, niobium, rubidium, tantalum, and zirconium, obtained earlier only with difficulty. Mining companies increasingly drew on geochemical prospecting techniques developed by the USGS. The amount of the agency's service work in geochemistry and petrology increased substantially during the year, as the staff improved its equipment, apparatus, and methods to obtain faster and more accurate results.

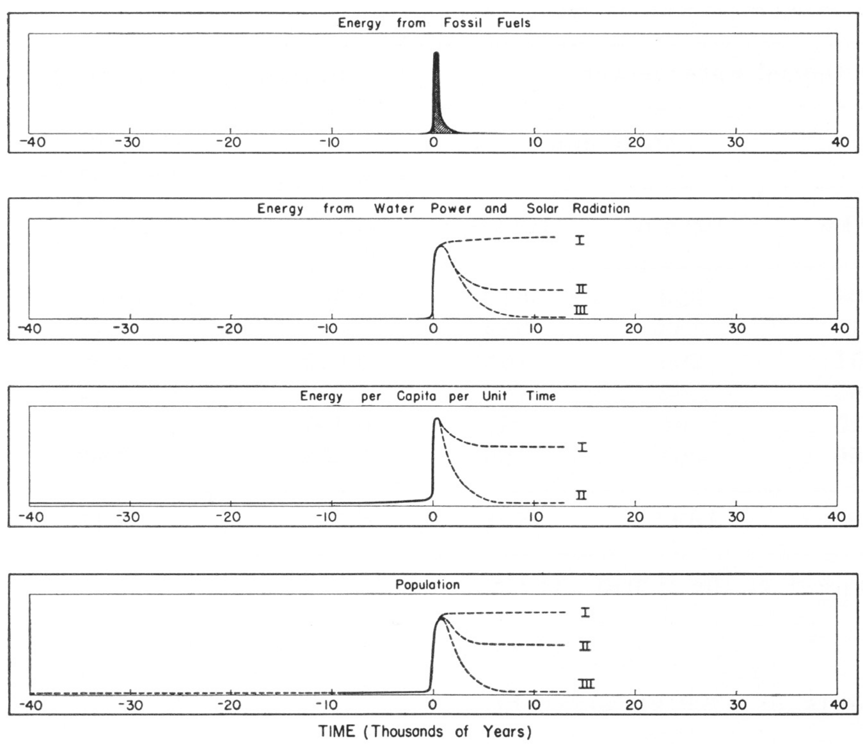
The Fuels Branch directed most of its 54 investigations in 23 States toward acquiring regional data on geologic conditions that continued to aid the search for oil and gas in known and possible producing areas by the petroleum industry. The



Geologist King Hubbert's graph shows the actual rate of the world's fuel consumption between A.D. 1800 and about A.D. 1950 compared with projected consumption at a faster rate (a steeper curve to zero at A.D. 3250) or at a slower rate (a shallower curve to zero at A.D. 3500). "The area under each curve," Hubbert cautioned, "is approximately the same—10 unit squares, each of which represents 5 x 10^{18} kilogram-calories." Hubbert based his projections on existing estimates by Wallace E. Pratt and others of the amount of fossil fuels—coal, natural gas, oil shale, petroleum, and tar sands—originally present in the Earth compared with the amount already consumed. A higher peak in the production curve, Hubbert asserted, would produce an earlier and sharper decline. (Quotations from Hubbert, 1949, p. 107; graph from fig. 6.)

USGS published 15 additional maps and 5 charts in its Oil and Gas Investigations numbered series in 1949–50, and more than 20,000 copies were purchased during the year. Beginning with Oil and Gas Investigations Chart 40, the chart numbers bore the prefix OC; with Map 110, the map numbers added the prefix OM. Branch geologists completed their determinations of the distribution, thickness, and reserves of oil shales in the Eocene Green River sequences in the southern part of the Piceance Creek Basin in northwestern Colorado, and they continued work required in its northern and central parts to finish mapping all these deposits. Amidst USGS, other Federal, and industry efforts to increase the Nation's domestic supplies of oil and gas, came another cautionary declaration that these resources were finite. On September 15, 1948, at the Energy from Fossil Fuels Symposium held in Washington, D.C., as part of the American Association for the Advancement of Science (AAAS) centennial, King Hubbert presented his initial application of bell curves to world consumption and impending exhaustion. "The consumption of energy from fossil fuels is thus seen to be but a 'pip,'" he concluded, "rising sharply [on the chart] from zero to a maximum, and almost as sharply declining, and thus representing but a moment in the total of human history [of the displayed 40,000 years before and 40,000 years after the present]."[147] As a response to the coming crisis, Hubbert recommended stabilizing the human population and developing solar power as one of alternatives to fossil fuels.

For coal reserves, Paul Averitt and his colleagues continued their summary reappraisals by States of all available data on the distribution, attitude, and thickness of beds and the amount of overburden. Detailed geologic surveys, on which depended the accuracy and validity of the estimates of reserves and effective planning for development, began or continued in Colorado, Indiana, Kentucky, Montana, New Mexico, North Dakota, Pennsylvania, South Dakota, Washington, and Wyoming. The USGS published a two-sheet, 1:500,000 map of Montana's coal resources, by John X. Combo, Clifford N. Holmes, and H. Reed Christner. Late in the fiscal year, James Schopf's Coal Geology Laboratory at Columbus began providing paleobotanical and petrological data to increase knowledge about the origin and nature of coals.



King Hubbert added additional perspective by comparing in these four graphs the projected amounts of energy expected from fossil fuels ("a 'pip' * * * representing but a moment in the total of human history") to those from waterpower and solar radiation at three possible rates of use. He then projected the energy used per capita (two possible rate curves in kilogram-calories/day) and population growth (three possible rate curves) during the next 12,000 years of human history. Hubbert, at Shell Development in Houston (1943–63), and later with the USGS, here traced the "sharp breaks in all the foregoing curves to * * * directly or indirectly, the tapping of the large supplies of energy stored in the fossil fuels," whose "release is a unidirectional and irreversible process." (Quotations from Hubbert, 1949, p. 108; graphs from fig. 8. See also Doan, 1994, and Deffeyes, 2001.)

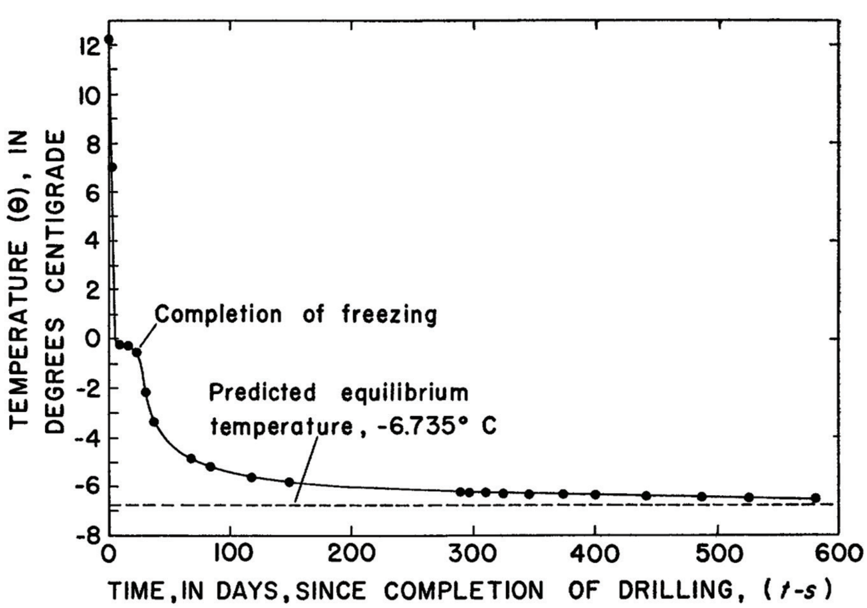
Members of the Engineering Geology Branch continued investigations in selected areas where proposed engineering projects would benefit from the results of surveys of bedrock and surficial formations. Branch geologists mapped areas as part of the Division's overall program of improving the geologic map of the United States but gathered detailed information, such as depth to rock, sources of sand and gravel, and foundation conditions, on specific sites as supplements. Many of these investigations involved ongoing studies in the Missouri River Basin, still funded in part by the USBR and designed to support Interior's development program. Branch geologists also mapped, in cooperation with the Army Engineers, a strip along the Snake River in southeastern Washington that included sites of four dams. In Massachusetts and Rhode Island, they mapped under cooperative agreements with the governments of those States. Coeval investigations in Puerto Rico represented a cooperative effort with the Water Resources Authority of the Territory, which became a Commonwealth in 1952. Geologists also mapped a number of fast-growing industrial areas to provide geologic data pertinent to many types of engineering construction required in these urban areas. Members of the San Francisco Bay project planned to produce 16 geologic-quadrangle maps at 1:24,000 to depict San Francisco, Oakland, and Berkeley. Some of the Bay project's geologic interpretations already proved useful in relocating roads, aqueducts, and sewage tunnels to avoid landslide-prone areas; in finding sources of riprap, bituminous aggregate, and other road materials; in estimating the costs of excavating rock in tunneling; and in analyzing the causes of failure in existing structures in this earthquake-prone area. Branch geologists also mapped parts of other major cities, including Anchorage, Knoxville, and Oregon's Portland. Their research on geologic processes affecting the safety of engineering structures encompassed a study of the landslides along the shores of reservoirs due to changes in the environment that followed the filling of the reservoir and subsequent fluctuations in its water level.

The Military Geology Branch continued comprehensive strategic-intelligence studies for the Army Engineers that produced, during 1949–50, 23 comprehensive reports (10 more than in fiscal year 1948–49) and 25 special reports.[148] These studies included geologic investigations of military areas in the conterminous United States, investigations of the characteristics of permafrost and its effects on military engineering, and studies in the Far East and on the Western Pacific islands. Branch geologists completed field surveys of the construction materials, geology, soils, terrain, and mineral and water resources in the 6th Army's area, and they continued work on the Fort Benning folio. In August 1949, Frank Whitmore invited William E. Davies, earlier a Major of Engineers and the former Chief of the Map Research Department at the Army Map Service, to join the MGB. There, Davies began selecting sites for underground installations in the Eastern United States, especially in the area around Washington. He picked the initial site at Raven Rock (Camp Ritchie) in Maryland. In 1950, Davies completed a preliminary study of the geology and groundwater resources in the Herndon area in northern Virginia, about 20 miles west of the Capital. Coevally, Allan P. Bennison and Charles Milton released a preliminary geological map of Virginia's Fairfax quadrangle, including the Herndon area, and part of the adjacent Seneca quadrangle, at 1:125,000, on a USGS topographic base mapped in 1911–12. In Alaska, studies of terrain and vegetation joined the ongoing permafrost investigations to help solve problems connected with military operations in Arctic and sub-Arctic regions. This work involved a special study at Point Barrow, the selection of airfield sites in six areas throughout the Territory, and field tests by Daniel B. Krinsley, Troy Péwé, and others of the cone penetrometer in areas around Bristol Bay, Fairbanks, Nome, and Yukon Flats. MGB geologists also completed a preliminary report on six industrial sites in the Soviet Union and analogous areas in North America; analyses of terrain, airfield sites, and water supplies in Tibet; terrain in the Pakistan-Kashmir-India area; and underground installations in China, Japan, and Malaya. Members of the Pacific Geologic

Mapping Program continued mapping, at 1:25,000, the engineering aspects, geology and soils of Tinian, conducted rapid reconnaissances of Agrihan, Alamagan, and Pagan Islands in the northern Marianas, and completed a 1:10,000 evaluation of the phosphate deposits and groundwater on Angaur Island in the Palaus.

During fiscal year 1949–50, the Geophysics Branch expanded its program of reconnaissance surveys by air, detailed ground surveys, and research and development to produce increasingly sensitive and precise instruments to record the field data used in analysis and interpretation. Henry Joesting and his headquarters unit had moved from the AMS building to offices in Interior in April 1949. During the subsequent fiscal year, members of James Balsley's expanded Airborne Surveys Section flew 35,000 miles of traverses, compiled 25,000 miles of data, and completed 127 maps released in open file or printed for sale. Balsley hoped the aeromagnetic survey of San Francisco Bay would enable faults to be traced under the bay. Branch mathematicians published theoretical studies on the upward continuation of magnetic total-intensity anomalies that aided in interpreting aeromagnetic surveys. The Ground Surveys Section started testing a portable absolute magnetometer that could measure accurately all components of the magnetic field. The Branch also began a program of magnetic observations with Ruy Finch's Hawaiian Volcano Observatory to gather data on events similar to the striking changes in magnetic intensity that preceded the major eruption of Mauna Loa and provide insights into the geologic processes involved and assist in predicting eruptions. The General Geology Branch decided to continue, in cooperation with the University of Hawaii and the Hawaiian Volcano Research Association, the HVO's quarterly *Volcano Letter*. Seismic instruments installed at the new USGS facility on Adak and other islands in the Aleutians furnished data on the timing, location, and magnitude of earthquakes. Scientists on Adak, like those at the HVO, focused their efforts on obtaining information on volcanic processes to aid in predicting events. Temperature and resistivity measurements by geophysicists in the permafrost area at Point Barrow also were applied in other engineering projects within and outside Alaska.

On August 24, 1949, Truman signed a bill that provided $70 million to the Federal Administrator of General Services to sponsor "a [5-year and matching funds] program of useful public works for the development of the Territory of Alaska," as Ickes had advocated in 1946. Congress designed the Alaska Sales Act, sponsored by Alaska's Delegate Edward J. ("Bob") Bartlett and its Governor Ernest



This graph records the cooling, at a depth of 595 feet, of South Barrow test well 3, in Naval Petroleum Reserve No. 4 (NPR–4), after the completion of drilling on August 23, 1949. USGS geologists Arthur H. Lachenbruch and Max C. Brewer studied this well as part of their investigation of the long-term temperature effects of drilling wells in the permafrost of NPR–4. They deployed evenly spaced electric-resistance thermometers (thermistors) from the surface to 595 feet in well 3. Mathematical analysis of the data gained explained the major features of the cooling curves and the consistent secular changes that occurred in ground temperature "at all depths from 75 to 275 feet." They estimated that conduction produced a decrease from 20°C to 0.1°C in their 6 years of observations. Another 50 years, they predicted, would be required to reach 0.01°C. (Quotation from Lachenbruch and Brewer, 1959, p. 73; graph from fig. 29.)

Gruening, both Democrats, "to foster settlement and increase the permanent residents * * *, stimulate trade and industry, encourage commercial commerce and private investment, develop Alaskan resources, and provide facilities for community life."[149] The new law authorized the sale by public auction of public-land tracts of up to 160 acres previously reserved for commercial or industrial use. In 1948 and 1949, as the Nation's interest in Alaska continued to climb, the USGS received a growing number of public and private requests for information about the Territory's geology and mineral resources. Demand for USGS data, gathered since 1895, on Alaska's gold-bearing areas, long the mainstay of the Territory's mining industry, remained high, while interest increased in coal, petroleum, and natural gas, other metallic and nonmetal minerals, and, to a lesser degree, oil shale. Work continued on exploratory geologic mapping and reconnaissance studies of mineral resources in the lower Kuskokwim and Glacier Bay regions; coal investigations in the Kenai Peninsula field and in the Nenana field north of the Alaska Range; petroleum studies in the Bristol Bay, Iniskin-Chinitna Peninsula, Katalla, and Yakataga areas of southern Alaska; and reconnaissance searches for fissionable materials. Gruening also helped the members of Seattle's Chamber of Commerce and other special-interest groups to convince Secretary Symington not to move Boeing's factory from Everett, Washington, to Wichita, Kansas, out of range of current Soviet bombers. Instead, Gruening and others promoted planning and funding for constructing a radar-based Distant Early Warning (DEW) Line across northern Alaska and Canada to alert and guide the growing numbers of jet interceptors controlled by the North American Air Defense (NORAD) Command's headquarters at Colorado Springs.

The sixth season of fieldwork by the USGS in Alaska's NPR–4 began in June 1949. In February, Commodore Greenman and Edward W. Beltz, the new chief of exploration, visited Fairbanks and then operations at Barrow and elsewhere in the Reserve. Greenman and the Operating Committee held their 10th regular meeting in Washington during April 12–13. George Gryc "summarized the status of geologic information on Pet 4 [NPR–4] and adjacent areas and announced the completion of a geologic map of northern Alaska,"[150] with stratigraphic and structure sections, facies diagrams, and a text that included the results of continuing studies of heavy minerals, microfossils, and sedimentation. Gryc and Ralph L. Miller, who took over the Navy Oil Unit in 1948, also reported the results of its reorganization and the plans for the coming fieldwork by geologic and seismic parties. The committee approved plans for additional magnetometer and gravimeter surveys of and drilling a third test well on the Barrow structure and asked John Reed (Sr.) to determine if a special seismic survey by the USGS project at the Arctic Research Laboratory at Barrow could be used to fix the bottom of permafrost.

During the 1949 season, the USGS placed six geologic parties in the field in NPR–4. William P. Brosgé and Allan N. Kover studied the Titaluk anticline north of Maybe Creek; Charles Whittington and A. Samuel Keller examined Carbon Creek and the upper Meade River; Arthur L. Bowsher and J. Thomas Dutro, Jr., worked on the Mississippian-age rocks and structure along the north front of the Brooks Range; William Patton, Jr., and Irvin L. Tailleur looked at the Okpikruk and Kiruktagiak areas west of the Chandler River; Marvin D. Mangus, Robert Detterman, and Arthur H. Lachenbruch worked along the Etivluk, Kuna, and Nigu Rivers, along the Colville between the Kuna and the Ipnavik, and in the Killik's headwaters; and Robert Chapman and Edward Sable studied areas along the Kokolik and Kukpowruk Rivers. The South Barrow test well 2, drilled to 2,505 feet, produced more than 30 million cubic feet of gas in 1949 to serve the Barrow camp, but No. 3, completed to 2,900 feet, proved dry. The initial test well at Oumalik reached 9,200 feet by year's end, but additional core tests of the Simpson wells proved inconclusive. Greenman and the Operating Committee met again in

Washington on November 17 to plan operations for 1950 that would add Bell helicopters to the fixed-wing aircraft and ground vehicles used to transport personnel, equipment, and supplies for eight field parties during the 1950 season.

The number of geologic surveys and special assignments by the USGS for the ECA increased during fiscal year 1949–50. The Alaskan and Foreign Geology Branch's program of in-service training in geology and administration for foreign nationals grew to include 25 persons from 13 countries. As part of work in the Americas, Carl Fries, Frank Simons, and other members of William Johnston, Jr.'s Branch completed or continued their investigations of Mexico's copper, iron, lead, phosphate, silver, and zinc deposits and the eruption of Parícutin, where Ray Wilcox finished his tour as "permanent observer" on July 31, 1948. Fries relieved Wilcox, who returned to the Aleutians during the field seasons of 1949 and 1950 for additional volcanological studies of the Near Islands as part of the investigations by the USGS unit based on Adak. John Dorr 2d and Philip Guild remained in Brazil investigating and mapping iron and manganese deposits in Minas Gerais; they were joined there briefly by Charles Park, Jr., and also by John Collins, Joel B. Pomerene, and Arthur Rynerson, who began longer term assignments with the project. Branch geologists also studied copper, lead, and zinc in Peru and earthquake damage in Ecuador. For Venezuela, the USGS built a requested water-discharge integrator and furnished detailed plans to enable that country to manufacture enough instruments to serve its entire irrigation program.

The Foreign Geology Unit also began preparing for a considerably larger program abroad in cooperation with the ECA, especially after the Truman administration extended its cooperative economic program to the Eastern Hemisphere. During 1949, William Pierce, while examining lignites in Greece, located major new reserves in areas near Athens that might supply the city's power needs for at least 40 years. The USGS recruited 14 geologists, mining engineers, and topographers for cooperative work in Africa for the ECA-British Colonial Surveys program. Branch geologists also aided the ECA in determining the feasibility of airborne-inductive and aeromagnetic exploration in the French colonies in Africa. USGS geologists began a survey of all mineral commodities throughout Afghanistan, in cooperation with that country's Royal Department of Mines. Glen Brown, William Johnston, Jr., George C. Taylor, Jr., and four Thai specialists completed a 7-month reconnaissance, during September 1949–April 1950, of Thailand's geology, minerals, and groundwater supplies. Brown, after completing his doctorate at Northwestern in February 1949, spent 8 months with Victor Stringfield's Colorado Plateau Project at Grand Junction working on the groundwater origin of uranium ores. Brown returned from Bangkok and finished his Thailand report in September 1950. John Dorr 2d, relieved as head of the USGS Mission in Brazil, reported to New Delhi in March 1950 to conduct, under State Department auspices, studies of mineral resources in the State of Orissa in central-east India. While there, Dorr advised the Geological Survey of India about what geophysical surveys, additional geologic work, and diamond drilling would be required before developing known deposits. Earl Irving and his assistants emphasized studies of manganese resources in continuing cooperative work on the Philippines' mineral resources.[151] In South Korea, during May–June 1949, David Andrews expanded earlier work by David Gallagher's team by briefly examining for the ECA all of the anthracite-producing areas except Samchok. Late in August, Andrews returned to South Korea with Ewart M. Baldwin, Kenneth G. Brill, Jr., and John Reinemund. During November 1949–March 1950, they extended the reconnaissance and used 1:20,000 topographic bases, produced by the Army's 64th Engineer Battalion (Topographic) from the 1:40,000 air photos requested by the ECA and the USGS, to map the Hambaek, Hwasun, Macha-ri, and Tangyang coal fields. Andrews' team specifically recommended a diamond-drilling program to delineate reserves.

The coal shown here lay between brecciated shale blocks near the Macha-ri thrust fault, where Cambro-Ordovician beds were thrust over the coal-bearing Sa-dong Formation (Pennsylvanian–Permian) in the Macha-ri coal field, about 125 miles east-southeast of Seoul, in the Republic of Korea (South Korea). The USGS expanded its immediate postwar studies of South Korea's mineral resources by sending geologist David Andrews and his team, at the Economic Cooperation Administration's request, to the country during 1949–50. Andrews' team concentrated on assessing coal resources to help solve the country's fuel problems. During September 1949–May 1950, geologist John Reinemund evaluated the Macha-ri deposits, South Korea's second largest producing coal field. Most of the field's more than 3 million metric tons produced since 1935 went by a 7.5-mile aerial tramway to the Yongwol powerplant. Half of the remaining coal reserve of 28.3 million metric tons, Reinemund estimated, was recoverable. (From Reinemund, 1957, pl. 8.)

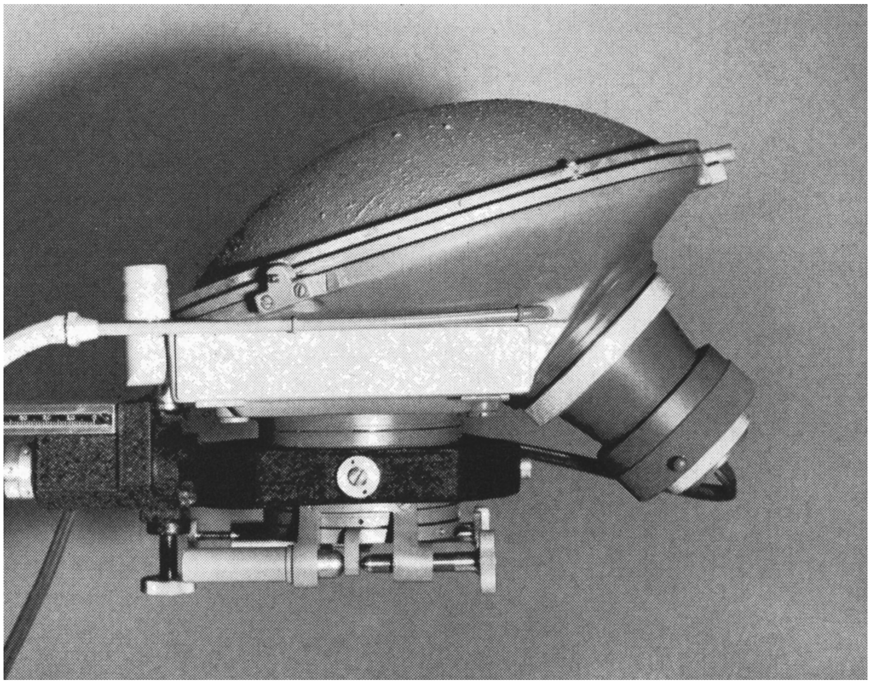
During fiscal year 1949–50, the USGS modified aspects of its topographic-mapping program to begin delivering on its third and most recent promise to map the Nation within 20 years, provided the agency received the required funds. As a standard reference geoid, the USGS continued to use the North American datum of 1927 that it adopted in that year, but the agency now moved to standardize contour intervals and scales. On October 14, 1949, Wrather directed that future maps of coastal and navigable-water areas would show underwater contours, certain obstructions, and other landmark features. On March 22, 1950, the Director revised the scales for national and more local coverage for the third time in the agency's history. Originally, mappers in the USGS national program that began in 1882 compiled topography at scales of 1:250,000, 1:125,000, or 1:62,500, "depending upon the degree of complexity of the topography and the geological phenomena, [and] upon the density of population and industrial importance of the region." From 1879, the USGS also topographically mapped areas of specific concern, especially mineral and mining districts, and engineering works, that required coverage at about 1:12,000 or larger scales. In view of the increasing need for more detailed coverage, in the 1890s the USGS discontinued its 1:250,000 series, reduced plans for continuing to map at 1:125,000, and increased the areas to be mapped at 1:62,500. Subsequent demands for even more detailed maps led the USGS to consider another doubling of scale, to 1:31,680, or a half mile to the inch. Engineering preference for a larger map sheet, and direct foot ratios, finally led to the adoption of 1:24,000 scale, or 2,000 feet per inch, as standard for the 7.5-minute series in most areas. The 1:31,680 sheets would be converted to 1:24,000 "at reprint stage as circumstances may permit." The USGS would provide its long-promised national coverage with an atlas of maps at 1:62,500 and cover critical areas with special maps at 1:24,000 to address the increased "needs of engineering investigations, geologic and mineral studies, construction works," and "other projects of restricted area having similar requirements." "When practical," the 1:24,000 maps would use contour intervals "from either the 50-25-foot series, or from the 40-, 20-, 10-, 5-foot series, depending on the type of terrain or other circumstances." "Whenever practical," the maps would "be of standard [Federal] accuracy," be "field tested," and so noted "by an appropriate field engineer."[152]

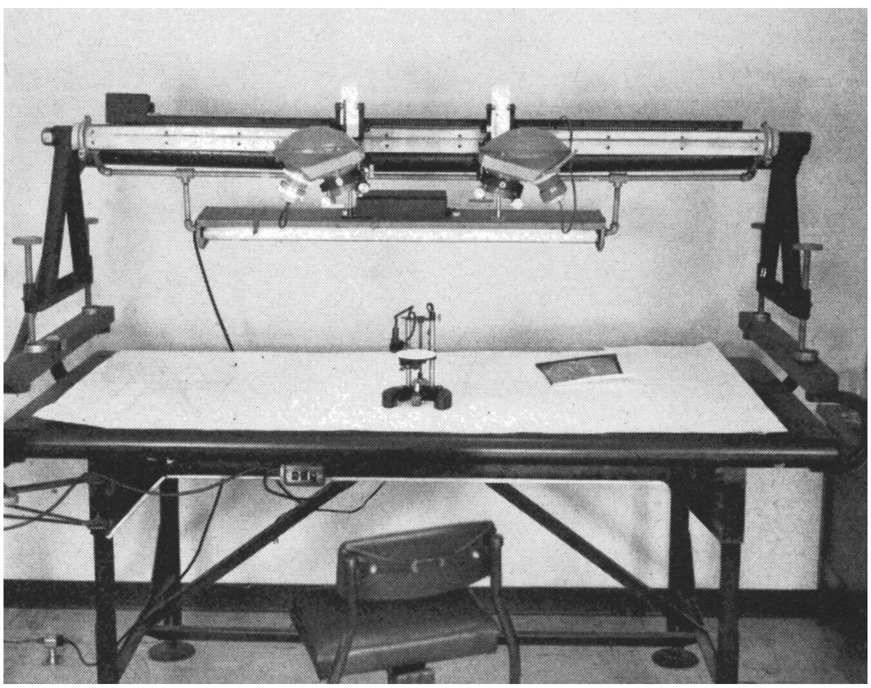
To support the USGS' growing work in Alaska, Wrather now extended to the Territory the basic specifications for the national topographic-map series of the continental United States, established by his Survey order of January 2, 1947.[153] Alaska, he stated, will "be covered as rapidly as feasible with a new series of 1:250,000-scale topographic maps"[154] to provide same-scale coverage as the 1:250,000 program for the States transferred in 1948 to the USGS from the Army Map Service.[155] The AMS adopted the 1:250,000 map series in 1942, when its prewar maps at 1:500,000, including national coverage on 87 sheets prepared in 1938–39, and new theater maps at the same scale proved inadequate for strategic purposes. The AMS correlated the layout of its 1:250,000 sheets with those of the 1:1,000,000 sheets forming the U.S. portion of the International Map of the World (a second edition prepared by the USGS and based on the equivalent AMS series but produced for civilian use) and added Arabic numerals to locate the former within the latter. The AMS had published its initial 1:250,000 map, the Washington, D.C., sheet (NJ 18–4) in 1947. Wrather's order now set the contour interval for the USGS' new 1:250,000 maps of Alaska at 200 feet with exceptions for 100 feet in flat terrain and 500 or 1,000 feet in areas that still lacked vertical control and suitable aerial photography. Wrather asked the Topographic Division to prepare the original and provisional sheets "in an expeditious manner, from * * * control, photographs, and other source materials" immediately available. He and FitzGerald intended to replace these preliminary maps with revised editions "whenever the availability of additional control and/or better source materials would result in substantial improvement." Wrather fixed the USGS mile-per-inch, or 15-minute, series at 1:63,360 in Alaska. Maps at this scale, with contour intervals of 200, 100, 50, or 25 feet, "depending on the type of terrain," would be prepared, "as rapidly as funds permit, for those areas * * * for which there is a specific and well-justified need." The 1:63,360 maps would "generally comply with the Federal standards of map accuracy" but they would not require "routine accuracy testing and field certifications."[156] To simplify the preparation of all of the Alaskan maps at 1:250,000 and larger scales, and to facilitate coordination "with sheets of the National Canadian topographic map series, Wrather required USGS topographers to "henceforth use the Universal Transverse Mercator (UTM) projection instead of the polyconic projection."[157]

FitzGerald's Topographic Division added some $4,531,000 in transfers to its $6,382,000 in direct appropriations for a total of about $10,933,000 for salaries and operations during fiscal year 1949–50, an increase of some $1,611,000 over the previous year. To this sum the States, counties, and municipalities supplied about $1,303,600. Other Federal agencies furnished roughly $3,227,000, including some $2,359,000 from the USBR, slightly more than $551,000 from the USAF, and more than $51,000 from the Commerce Department's Bureau of Public Roads, to support the compilation and printing of the 1:250,000 transportation maps for 28 States. Although the USAF increased its transfer sum by about $40,000, its Aeronautical Chart Service notified the USGS in May 1950 that the ACS planned to internalize all charting operations and to discontinue insofar as possible all contract work with other government agencies. The ACS and the USGS agreed to gradually curtail work assignments from the ACS to the USGS, and the USGS promised to try to finish all assigned work within the next 2 years. FitzGerald planned during the transition to shift all available production capacity in the Trimetrogon Section to the expanded but still understaffed domestic mapping program, the Division's primary postwar responsibility.

In fiscal year 1949–50, Division topographers mapped in all 48 States, the District of Columbia, Alaska, Hawaii, and Puerto Rico, in cooperation with 25 of the States and Puerto Rico but of them, the USGS considered only Massachusetts, Puerto Rico, and Rhode Island adequately mapped for current needs. "At the present rate," Wrather reported that

> **it will take until about the year 2000 before the entire United States is adequately mapped.[158]**





Photogrammetrist Russell Bean and his USGS team developed this ellipsoidal reflector-55 (ER–55) projector (above) for "stereoplotting by the direct double-projection method." The "55" in the ER–55 abbreviation represented the new projector's 55-millimeter principal distance, which facilitated diapositives twice the size of those in the Multiplex to improve image resolution. In 1945, Bean discussed with Charles Davey, Heinz Gruner, and Thomas Pendleton "the basic ideas" involved in crafting and using an ellipsoidal reflector to condense "the light for projecting the image." The Army Engineers aided "the successful fabrication of the [required] special mirror to precise specifications" by the Corning Glass Works, J.W. Fecker, Inc., and the General Electroforming Laboratories. Work on the pilot model began in 1949, and the USGS successfully demonstrated the ER–55 in 1952 at the International Congress of Photogrammetry in Washington, D.C. The patented ER–55 proved to be more economical, efficient, and versatile than the Multiplex's condensing-lens system. ER–55s initially were mounted in pairs on standard Multiplex supporting frames and oriented for vertical or convergent (below) low-oblique photography from Fairchild KC–1 cameras. The prototype Twinplex plotter, also developed by Bean's team, was shown at the American Society of Photogrammetry's meeting in 1950. The Twinplex originally used two Multiplex projectors, but their replacement by two ER–55s decreased "the costs of control and compilation." (Quotations from Bean, 1953, p. 71, 73, and 81; photographs from figs. 1 and 9. See also U.S. Geological Survey, Topographic Division, Research and Technical Control Branch, Section of Photogrammetry, 1952, and Bean, 1954.)

The Topographic Division also continued to concentrate some of its efforts on mapping the Missouri River Basin, of which, FitzGerald told the Senate subcommittee, only 8 percent had been adequately mapped. During the fiscal year, the USGS mapped there an additional 10,630 square miles, part of the domestic compilation of 51,460 square miles. By now, map reproduction by multicolor photolithography and other new methods had nearly replaced copper-plate engraving in the USGS; of the 771 topographic maps reviewed and forwarded for reproduction during fiscal 1949–50, only 19 were produced by the older method. About a third of the 661 maps cleared for reproduction were compiled originally by other agencies for special purposes. During the fiscal year, the Trimetrogon Section completed entirely new photocompilations for some 408,000 square miles worldwide, photorevised maps for nearly 114,000 square miles, and finished cartographic compilation for some 112,000 square miles. The Special Map Projects Section published two additional sheets—Lake Erie ([N]K–17) and Mount Shasta ([N]K–10)—of the International Map of the World, now being coordinated by the U.N. Cartographic Section. The Trimetrogon Section also continued work on another five of these 1:1,000,000 sheets and, for the Bureau of Public Roads, on the transportation map of the United States.

In 1949, the Topographic Division also began a comprehensive and large-scale project new to Federal domestic mapping. The cooperative program with Kentucky would provide the Bluegrass State, within 5 years, with complete map coverage of its 40,395-square-mile area on an estimated 763 maps, at a scale of 1:24,000 and contour intervals of 10 or 20 feet. Initial and smaller scale coverage by the USGS dated from 1882–1929.[159] The new topographic-mapping program was promoted by the Kentucky Chamber of Commerce, based on advice from State Geologist Daniel J. Jones, and supported by cooperative funds from Kentucky's government. The Division also started other cooperative but less comprehensive agreements with State or municipal governments in Ohio and Utah, and its topographers developed and tested new methods in utilizing trimetrogon aerial photography for mapping at 1:62,500 and used them to map one 15-minute quadrangle in the Beehive State. Additional military requirements and civilian requests increased the Division's mapping activities in Alaska, and field operations began on Molokai Island in Hawaii. The Division continued to use helicopters in Alaska and elsewhere during the 1949 field season to support its field operations, and the AMS and the U.S. Coast and Geodetic Survey (USCGS) also contracted for them for their activities in the Territory. The Division also appraised and classified all of its nearly 12,000 topographic maps and those prepared by other agencies and distributed by the USGS to evaluate their general usefulness and application to the needs of the Nation's expanding economy. On the basis of this work, the Map Information Office compiled two index maps showing the status of topographic mapping in the United States.

To aid current and future field-mapping projects, the Topographic Division revised its instructions for transit-traverse surveys and began preparing two new manuals. One provided fourth-order leveling with the Johnson Elevation Meter; the other replaced its *Topographic Instructions* (Bulletin 788), issued in 1928 as six separate chapters and as a whole volume. The Division planned to distribute its new topographic instructions as a loose-leaf notebook so that future revisions could be made by chapters to keep the guide current. Division engineers devised and evaluated new methods and instruments to increase the ease and efficiency of field and office operations, including shoran control for determining horizontal position and radar altimetry to fix vertical control for photogrammetric mapping in remote areas. Photogrammetric engineers completely redesigned the Kelsh plotter and exhibited the completed prototype of Russell Bean's Twinplex, the new double-projection plotter, at the 1950 meeting of the American Society of Photogrammetry. The Twinplex, "designed to utilize low-oblique, wide-angle photography obtained with two synchronized and rigidly coupled cameras,"[160] initially used Multiplex projectors, but ellipsoidal reflector-55 (ER–55) projectors replaced them in the improved version in 1952. The engineers continued an experimental-mapping project to determine the Twinplex's performance characteristics. They also ascertained the suitability of a German PK nine-lens camera, with a 2-inch focal length and a 130-degree coverage, for preparing small-scale planimetric maps. To lower the costs for and improve the preparation of reproduction copy for maps, staff members tested and evaluated for scribing new drafting papers, scribecoat, and other treated plastics as soon as they appeared on the market.

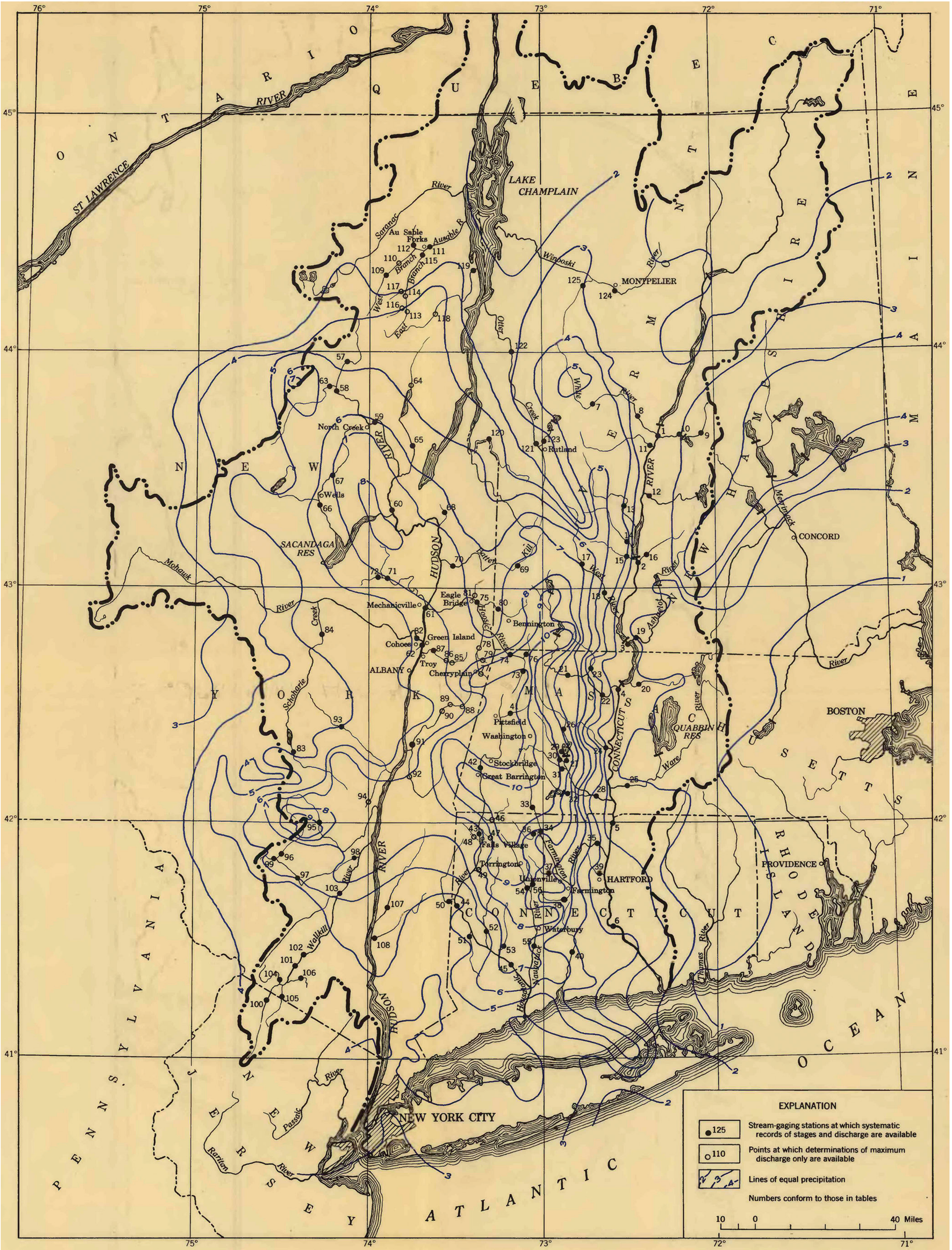
Paulsen's Water Resources Division received slightly more than $3,933,000 in direct appropriations for fiscal year 1949–50, of which $2,940,000 was available only for cooperation with States, counties, and municipalities, but the usual transfer funds brought the total available for salaries and operations during the year to just under $9,692,000, an increase of about $1 million over the previous year. To these adjunct funds, the States, counties, and municipalities contributed about $2,770,000. Other Federal agencies furnished roughly $2,844,000, including some $1,391,000 from the USBR, nearly $858,000 from the Army, $214,000 from the AEC, and more than $113,000 from the State Department. By July 1, 1949, the Division established Water Resources Councils in all States to serve a practical purpose for two or more district offices. Recent experiences taught the Division's leaders that in addition to determining the occurrence and availability of water, they must also fix the extent and methods of development, utilization, and conservation in areas where the limits of readily available supplies were being reached. Several projects underway appraised the water supplies of highly developed areas by correlating utilization and availability of water and estimating the future potentialities of the supplies. Inventories also were being made nationwide of requirements for water by industries and the total amount of water drawn by all types of users. These studies yielded an estimate of withdrawal of water from streams, lakes, reservoirs, and underground sources of about 200 billion gallons a day, of which about 25 billion gallons came from groundwater. Work also continued to provide accurate and extensive information about water resources in the Columbia and Missouri River Basins, to facilitate the continued economical design and operation of their water development and control projects, and to ensure supplies for livestock watered on all public lands. Division hydrologists completed determinations begun in 1948 of the amount of sediment deposited in Lake Mead behind Hoover Dam. This study, conducted in cooperation with the USBR and the Navy Department, indicated that at the present rate of sedimentation, Lake Mead probably would not be filled before the year 2380. Reservoir efficiency posed a related problem, especially in the West. Some reservoir sites proved unusable because the predicted high rate of evaporation from their surfaces would leave little water for beneficial use. To meet the need for more accurate information on the amount of evaporation from reservoirs, the USGS, again in cooperation with the USBR and the Navy, began in April 1950 a comprehensive investigation of evaporation at Lake Hefner, near Oklahoma City. A month later, Truman dedicated the Grand Coulee Dam on the Columbia, in operation since 1942 and a potential site for a similar study. Members of the Quality of Water Branch analyzed some 40,000 water samples for chemical quality and more than 100,000 samples for sediment content from 170 sites sampled daily and an equal number of sites sampled intermittently.

As a measure of the increasing interest in water supplies nationwide, Truman established within the Executive Office of the President, on January 3, 1950, a Water Resources Policy Commission to study and make recommendations "with respect to Federal responsibility for and participation in the development, utilization, and conservation of water resources." Truman directed the new Commission to concentrate on "(a) the extent and character of Federal Government participation in major water-resources programs, (b) an appraisal of the priority of water-resources programs from the standpoint of economic and social need, (c) criteria and standards for evaluating the feasibility of water-resources projects, and (d) desirable legislation or changes in existing legislation relating to the development, utilization, and conservation of water resources."[161] Truman asked the group to send its final report to him by December 1, 1950. The President appointed a seven-member Commission, composed of educators and engineers, and chaired by mechanical engineer Morris L. Cooke.[162] The Cooke Commission met later in January and organized a staff of about 50 persons, gathered largely from Federal agencies and universities, into a series of committees in major fields. Using data from the Water Resources Division's districts and State councils, Charles L. McGuinness and Arthur Piper prepared the USGS report, requested by the Committee in March and completed in April. Their "Water Facts in Relation to the National Water-Resources Policy" contained three principal parts concerning a national policy, 10 rivers in America's future, and water-resources law. McGuinness summarized two parts of the report in USGS Circulars 114 (U.S. water situation) and 117 (water law) in 1951.

By the end of fiscal year 1949–50, the Surface Water Branch operated some 6,300 streamgaging stations in the conterminous States, 50 in Alaska, and others in Hawaii, an increase of about 100 units beyond those extant in 1948–49. In addition to the usual flow statistics compiled during the year, Branch hydrologists investigated the characteristics of water flow and developed new equipment to improve the accuracy of or to expedite current-meter measurements. Comparative determinations of the relative merits of the mean-section and mid-section methods of computing current-meter discharge measurements led to adopting the latter technique for official use. Flood-frequency analyses continued in several districts, and hydrologists also studied low-flow characteristics of small ungaged streams by using simultaneous-discharge measurements to correlate them with adjacent gaged streams. Measurements of Arizona's Blue Spring, at the bottom of the Little Colorado River's canyon, recorded a flow of more than 100 cubic feet per second, making it the only first-magnitude spring in the State and 1 of about 65 in the Nation. Joseph Wells appointed a committee to explore the possibilities of improving the Branch's annual reports on streamflow to make them more helpful to users. A study for the Army Engineers determined the consumption rate of water by phreatophytes along Arizona's Salt and Gila Rivers as an aid to evaluating the feasibility of salvaging the water for human use by eliminating those plants. The study demonstrated that areas of differing kinds of vegetation could be mapped accurately and rapidly from a low-flying aircraft.

National interest in groundwater, both as an overdeveloped resource in some areas and as a potential source of additional water in others, reached a new high during fiscal year 1949–50. Geologists and hydrologists in the Ground Water Branch conducted investigations in more than 400 projects in the States, Alaska, Hawaii, Puerto Rico, and the Virgin Islands. They also prepared more than 250 formal reports and papers and responses to several thousand requests for information on local and regional groundwater conditions. Those papers included a study of the qualitative aspects of the relation of soil structure to infiltration and unsaturated flow above the water table as a precursor to the results of quantitative work underway. Research and development in the Branch produced a Lucite-tube device to sample earth materials from outcrops and test pits that could be transferred to a permeability measuring instrument without disturbing the materials. Branch members also perfected an advanced design of the permeameter and developed a technique for deaerating the water that passed through it, thereby eliminating past errors of up to 1,000 percent in determinations of permeability. Morris Muskat's "Physical Principles of Oil Production," published in 1949, rapidly became another important reference for USGS investigations of groundwater movement.

In the West, geophysical surveys located water supplies on the water-short Navajo and Papago Indian Reservations and also helped to find a site for a deep test hole on an Army Ordnance depot near Flagstaff, in an area where groundwater occurred at great depth and drilling proved expensive. The Branch's study for the AEC at Valle Grande in New Mexico showed the presence of large amounts of stored water in sediments deposited in the crater of a huge ancient volcano but only a relatively small perennial supply. Harold Thomas' hydrologic reconnaissance of the Green River in Utah and Colorado showed that careful studies of groundwater geology, streamflow, and water quality at carefully selected stations could contribute significantly to a better understanding of the characters of stream systems.


EXPLANATION
125 Stream-gaging stations at which systematic records of stages and discharge are available
110 Points at which determinations of maximum discharge only are available
Lines of equal precipitation
Numbers conform to those in tables
10 0 40 Miles
LAKE CHAMPLAIN
MONTPELIER
CONCORD
BOSTON
PROVIDENCE
HARTFORD
NEW YORK CITY
ALBANY
SACANDAGA RES
QUABBIN RES
HUDSON RIVER
CONNECTICUT RIVER
ST LAWRENCE RIVER
ONTARIO
QUEBEC
NEW YORK
VERMONT
NEW HAMPSHIRE
MAINE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW JERSEY
PENNSYLVANIA
ATLANTIC OCEAN

◀ This map (originally at 1 inch = 20 miles and on white stock) of flood-flow determinations in 1949 for a 4,500-square-mile area in six northeastern States shows isohyetal (equal-precipitation) lines in blue. Numbers (also shown in blue) denote total inches of precipitation received. Filled circles represent the streamgaging stations with systematic records of stage and discharge; open circles show locations where only maximum-discharge records were available. The area received 5–12 inches of precipitation in December 1949. Analyses of data from 125 streamgaging stations in the basins of the Hudson and Connecticut Rivers that measured water stages and (or) discharges yielded determinations of flood flow. In postwar years, USGS hydrologists continued their studies of the nature and effects of floods, partly to aid efforts at mitigation and also help the insurers and the insured. (From U.S. Geological Survey, Water Resources Division, 1952, pl. 1.)

Arthur Piper and Raymond Nace continued to study groundwater occurrences in Idaho's Arco area, evaluated the area's suitability for large-scale industrial operations, and projected groundwater motion in relation to radioactive-waste disposal from the National Reactor Testing Station, whose Experimental Breeder Reactor No. 1 began producing usable electricity on December 20, 1951.

In the East, a study of the hydrology of Indiana's Eagle Lake produced data for the investigation of the groundwater profile adjacent to the lake as a function of lake level, one intended to facilitate predicting the effect of changes in the lake stage on the water table. New York's Conservation Foundation sponsored a nationwide survey of America's groundwater as a contribution to appraising that situation in relation to other national problems. Research on the disposal of radioactive wastes on Long Island already had yielded useful data on the behavior of various tracers used in mapping groundwater movement.

In federally supported work abroad, Paul H. Jones evaluated, during March–April 1950, groundwater resources in Chile's Río Elqui Valley and the adjacent region, and its Huachipato-Talcahuano area for, respectively, irrigation and industrial uses. In the Azores in April and May 1950, George F. Worts, Jr., assessed for the USAF the geology and groundwater conditions in the volcanic terrain at the east end of Terceira Island and made recommendations for securing needed water supplies for the Military Air Transport Service's Lajes Field. Branch colleagues in the United States helped to train visiting hydrologists from Chile, India, and Venezuela.

The Conservation Division added a little more than $67,000 in transfers to its direct appropriations of nearly $1,066,000 for classifying lands and supervising mining and oil and gas leases during fiscal year 1949–50. Of the Division's total of about $1,133,000, an increase of nearly $40,000 over the previous year, the Navy supplied about $29,000 and the USBR provided some $22,000. In mid-August 1949, Krug's Secretarial order expanded the authority of the Division's regional supervisors of oil and gas and of mining by authorizing them to "act for the Secretary * * * in finally approving applications for suspension of operations and production for periods aggregating 12 consecutive months or less," to "grant temporary approval of applications for suspension for periods in excess of 12 consecutive months subject to final approval, modification or revocation by the Secretary on review," and to "terminate suspensions of operations and production previously granted by the Secretary."[163] Early in October, Krug delegated to Wrather the authority to "enter into agreements for the acquisition and accept conveyances of lands or interests in lands whenever" they "are to be acquired for administration through the Geological Survey pursuant to any act of Congress."[164]

Operations by the Conservation Division's units during fiscal year 1949–50 included actions by the Mineral Classification Branch on nearly 15,900 cases involving the outright disposal of Federal lands with no reservation of any mineral, the disposal of such lands with the reservation of one or more specified minerals, or the exercise under the Federal leasing laws of the Government's right to explore for and produce one or additional mineral substances from lands under its jurisdiction.[165] To aid this work, Robert E. Spratt began serving as Staff Assistant to John Northrop in Northrop's additional role as Chief of the Mineral Classification Branch. The number of completed mineral reports decreased by 9,075 cases, or about 36 percent, compared to those reviewed in fiscal 1948–49, a decline that reflected the public's diminished interest in acquiring oil and gas leases in view of a threat of overproduction of those energy resources. Members of the Water and Power Branch worked in Alaska, California, and the Columbia, Colorado, and Missouri River basins. They surveyed two reservoir sites and 90 miles of river channel and published maps of 300 miles of 8 rivers, 3 dam sites, and 3 reservoir sites. At the end of fiscal 1949–50, power-site reserves totaled more than 6.8 million acres in 23 States and Alaska. Reservoir-site reserves in nine States totaled more than 137,000 acres. In 1949–50, the Mining Branch supervised slightly more than 1,200 properties under lease, permit, license, and secretarial authorization, of which some three-fourths were on the public domain. Production of energy resources from these sources was valued at more than $85 million, and royalties accrued from them totaled $2.6 million, also a decrease compared to fiscal 1948–49. Coal production also fell following additional strikes by mine workers and increased competition from other fuels. Although potassium production also decreased due to prolonged strikes, its output still exceeded in value that of coal. The use of lower grade ores and lower prices accounted for the decline in lead and zinc concentrates produced from Indian lands in Oklahoma. On April 15, 1950, Truman, wishing to ensure continued competition to hold down prices, vetoed a bill intended to amend the Natural Gas Act of 1938 by removing the Federal Power Commission's authority to regulate sales of natural gas to interstate pipeline companies for resale by producers and gatherers not affiliated with the buyers. During fiscal 1949–50, the Oil and Gas Leasing Branch supervised operations on slightly more than 28,900 properties on public lands, a increase of some 26 percent from fiscal 1948–49, and slightly more than 6,550 leaseholds on Indian lands. Production from petroleum deposits on the public lands fell somewhat during fiscal 1949–50, and royalty returns totaled $21,637,000, a decline of nearly $3.4 million. Royalties from aggregate production from the now 254 active wells in NPR–2 fell to $945,500, a loss of nearly $37,000.

In the late 1940s, the United States significantly increased its security arrangements in both hemispheres. On May 2, 1948, the Charter of Bogotá, signed on April 30 by representatives of the United States and 20 Latin American nations meeting in the 9th Pan-American Conference, founded the Organization of American States (OAS). The new OAS was designed to supersede the Pan-American Union in promoting cooperation and peace in the Western Hemisphere. The OAS charter went into effect on December 13, 1948, when Colombia became the 14th nation to ratify the agreement. The OAS, with headquarters in Washington, comprised four principal parts—Council, Secretariat, Inter-American Conferences (once every 5 years), and Foreign Ministers Conferences. On June 11, 1948, the Senate approved Arthur Vandenberg's resolution favoring U.S. participation in regional security agreements within the U.N. framework. In Washington, on April 4, 1949, representatives of 12 nations—Belgium, Britain, Canada, Denmark, France, Iceland, Italy, Luxembourg, The Netherlands, Norway, Portugal, and the United States—signed a pact, the North Atlantic Treaty Organization[166] (NATO), to maintain, by force if necessary, the region's security. Sweden, Switzerland, and the new Republic of Ireland chose not to join NATO, which did not invite Franco's Spain or Greece, whose civil war continued until October 16. An attack on any NATO member would be considered an assault on all of the signatory nations. The NATO treaty established a council, to plan for joint action and mutual military and other aid, to which new members could be admitted by unanimous approval. Truman sent the treaty to the Senate on April 12, the Senators ratified the pact on July 21, the President signed it 4 days later,[167] and it went into effect on August 24.

As the Soviets ended their blockade of West Berlin on May 12, 1949, the Allied Powers agreed to join their occupation zones and organize them as a new German Federal Republic (West Germany) to give self-rule to the people of the 11 (later 9) western German states and West Berlin. Representatives of those German states prepared a constitution that led to proclaiming the Federal Republic at Bonn on May 23. Reflecting the results of elections in August for the Bundestag, Theodor Heuss, a Free Democrat, assumed the presidency of the new country, and Konrad Adenauer, a Christian Democrat, became its Chancellor on September 15. Six days later, the United States, Britain, and France restored civil status to West Germany. The Soviet Union responded by declaring, in East Berlin on October 7, a

German Democratic Republic (East Germany) to comprise the Soviet zone, except those areas east of the Oder-Neisse line annexed by Poland and Soviet Kaliningrad. The Soviets and their six satellite states in Eastern Europe—Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, and Romania—did not respond to NATO until 1955, when they organized the Warsaw Pact. From June 1949, Tito's Yugoslavia, unlike its neighbor Albania, now under Communist dictator Enver Hoxha, continued to pursue an independent socialist course that included increased contacts with the West. Hoxha, Albania's premier since 1944, continued to favor the Soviet Union until, in the middle 1950s, he shifted his loyalty to the People's Republic of China.

A week before the Soviet Union established East Germany, with its capital in East Berlin, Stalin added a nuclear weapon to his arsenal. America's postwar confidence that its science and technology were among the best in the world, if not preeminent, was rudely shaken when President Truman and British Prime Minister Attlee announced on September 23, 1949, that the Soviet Union had recently detonated an atomic bomb, at least 3 years ahead of the predictions of most American experts. As the Soviets worked toward ending the U.S. nuclear hegemony, Stalin gave the Ministry of Armed Forces to General Nikolai A. Bulganin early in March 1947. Marshal Aleksandr M. Vasilievsky replaced Bulganin on March 4, 1949, as Andrei Vyshinsky succeeded Vyacheslav Molotov as Foreign Minister, but Stalin had kept General Boris Vannikov and physicist Igor Kurchatov at their vital posts in Lavrenti Beria's atomic-bomb project.[168] Kurchatov's Soviet-German team had begun testing their prototype nuclear reactor in Moscow early in 1946, aided by advice from Niels Bohr and based on information he claimed the Americans had published. The Soviet physicists achieved a self-sustaining chain reaction in June 1948. A second reactor at Chelyabinsk, in the southeastern Urals and near the border with the Kazak Soviet Socialist Republic (now Kazakhstan), produced plutonium, while weapon designers continued their operations at Sarova (Sarov since 1995), 200 miles southeast of Moscow. The latter group included Andrei D. Sakharov, a young physicist, who joined Kurchatov's designers in 1948 to help develop a thermonuclear device.

For their initial nuclear explosion, the Soviets used not their own version but the purloined American "Fat Man" design to build a plutonium-implosion device they called "First Lightning," termed "Joe-1" by the United States, and mounted, like the Trinity "gadget," on a 100-foot tower. On August 29, 1949, a nervous Beria, the two Russians who witnessed the Bikini tests in 1946, and Kurchatov and his team observed the 20-kiloton explosion of the new device at a site some 60 miles west of Semipalatinsk (Semey since 1991) in northeastern Kazakhstan. American weather observers in WB–29s, flying between Japan and Alaska, began recording increased levels of radiation in the skies east of Kamchatka and in other areas on September 3. By September 19, an AEC special committee—Vannevar Bush, Robert Oppenheimer, Robert Bacher, and General Hoyt Vandenberg—confirmed all the radiation data. They advised David Lilienthal and President Truman to announce the Soviet achievement. On September 25, two days after Truman's and Attlee's announcements, TASS, the Soviet news agency, confirmed the successful test. The Soviets followed their success by fabricating and exploding improved atomic bombs of their own design; Joe-2 yielded 40 kilotons.

In any future conflict between the Soviet Union and the United States, the Red Air Force could only deliver its atomic bombs in one-way missions by using its new four-engine bomber, the Tupolev Tu-4, formed from reverse-engineered parts of damaged B–29s that landed in the Soviet Union during World War II. The Tu-4 flew first in May 1947, but without extensive numbers of Tu-4s modified as tankers for aerial refueling (as more than 50 of the nearly 500 U.S. Superfortresses had been modified into KB–29s), the Soviet bombers would be able to reach the United States but then could not return to their bases. The USAF's Strategic Air

Command (SAC) began receiving B–50s, an improved version of the B–29 and also styled Superfortress, in February 1948. To demonstrate the SAC's global reach, a B–50A, refueled four times from KB–29s, completed on March 2, 1949, a 94-hour nonstop trip of 23,452 miles around the world. By then, the SAC operated 70 B–36s and B–50s, almost enough aircraft to deliver all of America's existing atomic bombs. The USAF also continued to develop rocket-powered missiles and aircraft. In 1945, Secretary Stimson had approved establishing a range at White Sands in New Mexico, south of Alamogordo, to test captured German V–2s and newer strategic guided missiles under the guidance of Wernher von Braun and his team. Secretary Forrestal announced late in 1948 that the United States also was working on an Earth-satellite vehicle program. On May 11, 1949, President Truman signed a bill that authorized the Secretary of the Air Force "to establish a joint long-range proving ground for guided missiles and other weapons,"[169] begun later at Cape Canaveral on Florida's Atlantic Coast, and provided up to $75 million for the site's development. The Joint Chiefs of Staff gave responsibility for strategic guided missiles to the USAF on March 15, 1950.

Congress and the President responded both economically and militarily to the earlier actions by the Soviets and now acted to counter their latest developments. The National Security Act amendments[170] of August 10, 1949, reorganized the National Military Establishment as an Executive Department—the Department of Defense (DoD)—to improve its fiscal management in promoting efficiency and economy, to provide for a Deputy Secretary and three Assistant Secretaries, to create a President-appointed and nonvoting Chairman of the Joint Chiefs of Staff, and to change the name of the War Council to the Armed Forces Policy Council. On October 6, Truman signed two additional bills to provide more foreign aid. The Foreign Aid Appropriations Act for fiscal year 1949–50 authorized $1.074 billion for the expenses required to carry out the provisions of the Economic Cooperation Act, an additional $45 million to Greece and Turkey, up to $4 million to enable "selected citizens of [Nationalist] China to study in accredited colleges, universities, or other educational institutions in the United States," and $912,500,000 for U.S. Army civil-function expenses in governing or occupying "certain foreign areas."[171] Congress and the President approved the Mutual Defense Assistance Act "to promote the foreign policy and provide for the defense and general welfare of the United States by furnishing military assistance to foreign nations." The act favored "the creation by the free countries and free peoples of the Far East"[172] of a NATO-like organization consistent with the U.N. Charter; authorized up to $500 million, later doubled, for NATO; $211,370,000 more for Greece and Turkey; $27,640,000 for Iran, South Korea, and the Philippines; and an extra $75 million for Nationalist China. On October 17, Truman authorized the production of atomic bombs in greater numbers. In view of America's economic and military reach, Stalin launched a "peace" offensive on December 31, his 70th birthday.

On January 31, 1950, Truman, increasingly concerned about Soviet capabilities and intentions, and unconvinced that the Russians would really change their ways, took further actions. The President ordered David Lilienthal and his AEC "to continue its work on all forms of atomic weapons, including the so-called hydrogen or superbomb."[173] Lilienthal, Acheson, and Louis Johnson had served as a committee to evaluate the proposed development of the "super." On November 9, 1949, Lilienthal reluctantly cast the deciding vote in the AEC's 3–2 decision to recommend the hydrogen bomb to Truman, but Lilienthal then resigned, effective February 15, 1950, as did his assistant William Golden, who remained with the AEC until 1958 but only as a consultant. Karl Compton, David T. Griggs, Ernest Lawrence, and Edward Teller approved the project, but George Kennan and Robert Oppenheimer opposed it on both moral and technical grounds. Teller then took the lead in developing the new fusion or thermonuclear device; on March 18, 1950, Truman ordered a crash program to develop the hydrogen bomb. In January, Truman authorized a greater role for the CIA in foreign affairs, including the overthrow of governments. On June 5, the President approved a third aid bill, the Foreign Economic Assistance Act, to provide an additional $2.7 billion for economic cooperation, principally via the European Recovery and Point Four Programs, $40 million more for areas in China (including Taiwan) not under Communist control, and $27,450,000 for donations to the U.N. Relief and Works Agency for Palestine Refugees in the Near East. This latest statute authorized up to $35 million for a number of measures including bilateral technical cooperation programs designed to use international "interchange of technical knowledge and skills * * * to contribute to the balanced and integrated development of the economic resources and productive capacities of economically underdeveloped areas"[174] by means of "economic, engineering, medical, educational, agricultural, fishery, mineral, and fiscal surveys, demonstration, [and] training."[175] The law also provided up to $15 million for contributions to welfare work by the U.N. Children's Emergency Fund.

As Truman signed the Foreign Economic Assistance Act, conflicts continued in Indonesia and Vietnam. On January 28, 1949, the U.N. Security Council again tried to end the fighting in Indonesia by requesting a second cease-fire, the return of captured leaders, and independence for the Indonesians not later than July 1, 1950. After negotiations at The Hague, The Netherlands and the Republic of Indonesia finally agreed to shift their sovereignty to the United States of Indonesia on December 27, 1949, and its Government now led by Sukarno as president, with Hatta as prime minister, and operating from Jakarta (formerly Batavia) on Java. The United States of Indonesia comprised 16 states but not Dutch New Guinea, whose association remained to be determined. Amid Communist, Muslim, and other insurgencies, the Indonesian states outside the United States of Indonesia agreed to join it on August 17, 1950. The United States of Indonesia lapsed, and the U.N. admitted the now larger Republic of Indonesia on September 28.

On the Asian mainland, Mao's and Stalin's governments recognized Hõ Chí Minh's Communist-nationalist regime in Hanoi in January and February 1950. On February 7, the U.S. and British Governments recognized the independence of Bao Dai's Republic of Vietnam (including Cochin China), Cambodia, and Laos as Associated States within the French Union, as the French had agreed during March, July, and November 1949. By that understanding, Bao Dai remained head of state, with government centers in Saigon and Hue, and France retained its military bases in the country. Ngô Dình Diêm, Bao's deputy, refused to agree. French forces had withdrawn from Indochina's northern border early in November 1949. In February 1950, the Viet Minh, reinforced by Communist Chinese advisers and weapons, resumed regular attacks. When France requested U.S. aid, Truman decided that NATO needed France's continued active participation. On May 8, 1950, the President agreed to provide an initial $10 million in economic and military aid to French efforts in Indochina. On June 27, Truman, acting on Acheson's recommendation, ordered a strengthening of U.S. forces in and an acceleration of American military aid to the Philippines, increased military assistance to France and colonial French forces in Indochina, and sent a 35-man military team to aid and cooperate with them.

Truman, in his State of the Union Message to Congress on January 4, 1950, asserted that America's situation "continues to be good."[176] "During the past year we have made notable progress," he continued, "in strengthening the foundations of peace and freedom, abroad and at home."[177] The President asked for statehood for Hawaii as well as Alaska and, in view of the 80th Congress' large reduction of taxes, reported a coming deficit but promised to hold Federal expenditures "to the lowest levels consistent with our international requirements and the essential needs of economic growth and the well-being of our people."[178] In a news conference held the next day, Truman also promised that the United States would neither be involved in China's civil conflict nor provide military aid to Taiwan. The President, in his economic report on January 6, called for specific legislation on a dozen important items, including the establishment of a Columbia River Authority and authorization of a St. Lawrence seaway and power project. His budget message of January 9 predicted receipts of $37.3 billion, or $460 million less than in fiscal year 1949–50, and outlays of $42.4, or $860 million less, to reduce the deficit by $400 million to $5.1 billion. Truman requested adjustments in the tax laws and promised to hold spending for national defense to $13.5 billion, or $7.5 billion less than in the previous year; international programs would receive $4.5 billion.

In the following month, U.S. hysteria over the "Red Menace," both real and imagined, reached a new high. On February 9, 1950, just days after British physicist Klaus Fuchs confessed to spying for the Soviet Union at Los Alamos, Senator Joseph R. McCarthy (R–WI), speaking at Wheeling, West Virginia, held up an undisclosed and unverified list of 205 subversives in the State Department that he claimed were all known to Secretary Acheson but still employed by him. McCarthy based his speech on earlier anti-Communist remarks by both Democrats and Republicans. His complaint that the Truman administration had been slow to remove subversives from the State Department clashed with the results of the 1946 investigation of some 3,000 of its employees. The screening found evidence against 284 of them, 79 of whom were actual perpetrators and were fired.

Senator McCarthy's claim, and those by the Federal Bureau of Investigation (FBI), heightened the ongoing scare,[179] originally brought on by the revelations about Fuchs and the U.S. nuclear spies, the fellow travelers, and the members of the American Communist Party, 11 of whose leaders had been convicted on October 14, 1949, of violating 1940's Smith Act by advocating the use of force and violence to overthrow the U.S. Government. More recent charges of espionage by Harry D. White, Henry Morgenthau's adviser at the Treasury Department since 1934, and by Alger Hiss further fueled the hysteria. White resigned in March 1947 and died in 1948 before he could be indicted. In August 1948, Americans learned about Hiss' alleged prewar passing of secret cables from the State Department to agents of Soviet military intelligence. After Hiss lied to congressional investigators, a second jury found him guilty of two counts of perjury on January 21, 1950. In March 1951, Hiss, his appeals exhausted, began serving a 5-year prison sentence.

Charges by McCarthy and others led to an investigation by a special subcommittee, of the Senate's Committee on Foreign Relations, chaired by Millard E. Tydings (D–MD), who also led its Committee on Armed Services. Exactly how many other Americans sympathetic to communism, and in positions of power or influence, may have acted illegally remained to be discovered and proved.[180] On July 20, 1950, the Senate subcommittee's report declared McCarthy's charges false. This outcome did not stop McCarthy, Senator Taft, and their supporters in and out of Congress, who believed the growing anti-Red hysteria would serve themselves as well as the Republican Party in the coming midterm elections. They continued to search for and expose as subversives alleged Communists and their sympathizers. McCarthy supported Patrick McCarran, now also Chairman of the Senate Subcommittee on Internal Security, who added anti-Communism to his long-standing aversions to liberals and reform. In September, the 81st Congress passed over Truman's veto, the Internal Security Act,[181] sponsored by Senator McCarran and Representative John S. Wood (D–GA), Chairman of the House Committee on Un-American Activities. The McCarran Act established a Subversive Activities Control Board, authorized registering Communist-controlled organizations and interning potential subversives during national emergencies, prohibited the employment of Communists in national-defense work, and prevented from entering the United States any persons who had been members of totalitarian organizations. The U.S. Supreme Court upheld the McCarran Act in June 1951, as it had the convictions of the 11 leaders of the American Communist Party.

On May 10, 1950, as McCarthy continued his crusade against Communists and fellow travelers in the Federal Government, Truman signed legislation that gave him, as historian Merton England noted,[182] the kind of organization for national science that he had sought from Congress since September 1946. Senator Taft's and other legislators' comments on Truman's pocket veto of the Senate's bill in August 1947 ended any hope of enacting a science foundation during the remainder of the 80th Congress' first session. Vannevar Bush and many of the other engineers and scientists who supported the measure continued to hope for and work toward a new compromise acceptable to them, Congress, and the President. Bush and Truman, in discussing strategy in a meeting at the White House on September 27, agreed that Bush, James Webb, and James Forrestal would join in drafting a new bill for Truman's review before it passed to its congressional sponsors. To point out the existing agreements about the foundation, and urge settlement of the remaining differences relating to its organization and operations, Howard Meyerhoff printed in *Science* for November 7, most of Bethuel M. Webster's comments that listed general agreement. Webster, a New York lawyer who served with Bush, Conant, and Jewett on the National Advisory Committee for Aeronautics (NACA) since before the war, emphasized the acceptance by most of those concerned of "freedom of research and education," "civilian administration," "emphasis on fundamental research in universities and colleges," "emphasis on training personnel," "utilization of both laymen and scientists in the program," "appointment and responsibility of the director,"[183] and "status of the board."[184] On March 25, 1948, Harley Kilgore, Warren Magnuson, and Alexander Smith in the Senate, and Charles A. Wolverton (R–NJ) in the House, introduced parallel measures, but their bills died when the 80th Congress adjourned.

The national science foundation's proponents tried again after members of the 81st Congress took their seats on January 3, 1949. Truman, in his budget message, repeated his call for a foundation. Senator Elbert Thomas introduced a new bill that passed out unamended on March 18. In the House, majority whip J. Percy Priest (D–TX) held hearings during March and April and reported out the bill on May 24. Priest's bill encountered ever-growing concerns by Democratic and Republican members about burgeoning bureaucracy, Communist infiltration and subversion, foundation-employee and grant-recipient loyalty (to be verified by the FBI), Federal economy, and agency territoriality (principally impingement on the National Institutes of Health) that also continued to be played out on similar and wider stages within the United States. Both bills lapsed when the 81st Congress' first session ended on October 19.

Vannevar Bush and Frank Pace, Jr., Webb's successor as Budget Director, agreed to continue to emphasize the foundation's role in national economy and defense, and science in higher education, but to revise its budget estimates to provide for reductions after the $25 million requested for the initial 2 years. Early in the 81st Congress' second session, Truman again asked the legislators to pass a foundation bill that he could sign. In *Science* for January 27, 1950, Dael Wolfle, in assessing the foundation's prospects for the year, urged his readers to send their views to their Representatives in the hope of assuring them that Priest's bill "will make important contributions to the nation's welfare."[185] On March 1, the House voted 247 to 125 to send the additionally amended bill to the Senate. After a 10-member conference committee (including Priest, Smith, Taft, and Thomas) melded it with S. 247, the joint measure passed the House on April 27 and the Senate on the following day. On May 5, the day that *Science* reported the bill as "perhaps as good a compromise as could be obtained now,"[186] the Bureau of the Budget recommended approving the bill and its ceilings on the budgets of $500,000 for the first year and $15 million for subsequent years. Truman signed the legislation on May 10 to establish the National Science Foundation.

The National Science Foundation (NSF) Act of 1950 founded an independent agency in the executive branch to "promote the progress of science; to advance the national health, prosperity, and welfare; [and] to secure the national defense." The new law authorized the NSF "to develop and encourage * * * a national policy for the promotion of basic research and education in the sciences," "to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences" by contracts, grants, loans, scholarships, or graduate fellowships. The statute also gave the NSF the power "to appraise the impact of research upon industrial development and upon the general welfare," "to initiate and support" defense-related research "at the request of the Secretary of Defense," "to foster the interchange of scientific information among scientists in the United States and foreign countries," to evaluate Federal scientific programs and correlate its own programs "with those undertaken by public and private research groups," "to establish special commissions"[187] as required, and "to maintain a register of scientific and technical personnel,"[188] to be transferred from the U.S. Employment Service. The act required the NSF to send an annual report to the President for submission to Congress before January 15 of each year. The law established a National Science Board, of 24 voting members, each with 6-year terms and $25 per diem plus travel expenses, led by a chairman and vice chairman elected for 2-year terms by the Board. The law also authorized an executive committee, also chosen by the Board, which prepared the annual report; a director, as ex officio member, appointed by the President with the Senate's advice and consent; and a deputy director, selected by the director. The NSF's four program Divisions—Medical Research; Mathematical, Physical, and Engineering Sciences; Biological Sciences; and Scientific Personnel and Education—each received the authority to appoint committees. The statute's security provisions eliminated support for any research and development in nuclear energy without the AEC's approval. These sections also mandated requirements and safeguards, established by the Secretary of Defense, for NSF research related to national defense, investigations of these concerns by other Federal agencies as requested by the NSF, FBI clearances of the "character, associations, and loyalty"[189] of any NSF employee to be permitted access to restricted information or property, and loyalty declarations from fellowship recipients. The law also gave the NSF the authority to accept transfer funds from other Federal agencies. On September 27, Congress added $225,000 to supplement the $500,000 originally provided for fiscal year 1950–51.

The founders intended NSF's program division for Mathematical, Physical, and Engineering Sciences to provide greater financial support for research in the earth sciences at academic institutions, but the USGS could not legally apply for these funds. USGS scientists might be able to use the NSF to their advantage by joining, as nonprincipal participants, in NSF-sponsored investigations as they continued to do in those funded by the Smithsonian, the scientific schools, and the Carnegie Institute of Washington and other granting organizations. They also might be called upon to advise the NSF, as they had long similarly aided the NAS and the National Research Council (NRC).

Oscar Littleton Chapman (1896–1978), the 34th Secretary of the Interior (1949–53) is shown here (seated at right) with President Truman (seated at left) and Assistant Secretary of the Interior Girard Davidson (standing in center). Chapman, a lawyer and Navy veteran, became Assistant Secretary of the Interior in 1933 and Under Secretary in 1946. Chapman succeeded Julius Krug as Acting Secretary on December 1, 1949, and served as Secretary until January 20, 1953. In 1950, Chapman successfully recommended to Congress and the President that they remove the USGS's 62-year-old millstone of line-itemized budgets by returning the agency to block funding for surveys, investigations, and research. Chapman also approved Director Wrather's request not to establish USGS Regional Directors. (Photograph by Abbie Rowe, National Archives and Records Administration [NARA], Still Picture Branch, record 8451352, December 21, 1950, NARA ARC identifier 200262.)

On November 10, 1949, Krug resigned as Secretary of the Interior and his resignation became effective on December 1. As Krug's successor, Truman nominated Oscar Chapman on January 5, 1950, and the Senate confirmed the new Secretary on January 18. Wrather, recalling Krug's departure, appreciated his "calm, deliberate air," and his "rational, open-minded attitude toward the affairs of the department," yet Krug gave Wrather "the impression that he was not entirely happy with the job" and took his long inspection trips in the field partly "to get away temporarily from the continuing round of annoying problems * * * in Washington." Krug, Wrather believed, "was heartily glad to be rid of the job and [so] could once more return to his personal affairs."[190] Chapman, Wrather found through several years' experience, "was thoroughly familiar with the normal duties of the several bureaus. He was affable and approachable and was generally liked throughout the Department." Chapman "was tolerant of the views of his associates and expected them to speak out without fear of reprisals." Wrather "did not always agree with him on matters of policy," but the Director felt sure that he lost "none of his friendship or respect by stoutly contending for what I believed was right."[191]

As Secretary, Chapman increased Interior's efforts to regionalize its bureaus' management as well as their operations. Vernon D. Northrup, the former Director of Interior's Division of Budget and Administrative Management and now the Administrative Assistant Secretary, convinced Chapman to move employees out of Washington to regional centers that would consolidate local offices and secure "greater economy and improved administration."[192] For Wrather, "Regionalization had a sinister ring to those familiar with Survey history,"[193] beginning with the disparate views of Directors King and Powell. King favored facilities nearer field areas to require less seasonal travel and facilitate local contacts and cooperation; Powell sought unified control and increased off-season discussions in the Capital. Northrup now wished to extend to the Department the Bureau of Reclamation's scheme in which each region's chief officer handled all of the Bureau's responsibilities in that area, "subject only to supervision from the Washington office." Wrather "did not believe that such a pattern would fit the Survey," as a "regional representative might satisfactorily supervise the work of one division, but he would inevitably clash with the other divisions with whose work he was not equally familiar."[194] Wrather supported Chapman's first goal by continuing to distribute "the work of the Survey to major field centers"[195] and continuing the agency's field committees. Wrather and Nolan planned to extend the Topographic Division's current geographic organization to the other USGS program Divisions. They proposed to Interior five USGS major operational centers—Washington (Atlantic States), Rolla (Mississippi Valley), Denver (Rocky Mountains), Sacramento (Pacific States), and Fairbanks (Alaska)—that could be modified geographically "to accommodate the differing requirements" of the program Divisions. Wrather opposed Chapman's second goal by deciding that

> **There would be no one-man regional directors. Each division would select its own officer-in-charge and line authority would extend to him from his division chief in Washington. The regional officers of the several divisions would constitute a committee to handle all matters common to the center. This committee would choose its own chairman. In this way the integrity of the Divisions would be maintained, and all could enjoy the advantages of unified house-keeping arrangements.[196]**

Chapman agreed.

As the NSF bill made its way through Congress in 1950, the Interior Department under Secretary Chapman followed other recommendations by the Hoover Commission in simplifying its budget estimates for fiscal year 1950–51. On January 10, 1950, when Chapman appeared before the House subcommittee on Interior's appropriations, Chairman Michael Kirwan commended Truman "for having given this post to someone who thoroughly knows the department, its problems, and its workings."[197] Chapman asked for nearly $669.5 million for fiscal 1950–51, some $79.3 million more than the previous year. Following the Hoover Commission's recommendations, the number of Interior's items for congressional action fell from 167 to 42; each of them grouped activities by major purpose intended, in part, to provide the subcommittee "with more concise and useful data" about and "also facilitate [its] action" on the budget. Chapman recognized "that the authorization of funds under a smaller number of appropriation items places greater responsibility upon the Department to control the use of funds for the purpose for which they were authorized." He promised "to demonstrate each year in our project and activity schedules that we have executed our programs and expended the funds authorized in accordance with the intent of Congress in granting the authorization."[198]

For the USGS, Interior proposed only one item—

"surveys, investigations, and research"[199]

—and listed under it the several programs previously shown as separate items. If Congress and the President approved the new format, the USGS would return to block funding for the first time since 1888, when Representative Hilary A. Herbert (R–AL) and his congressional colleagues, irked by what he termed Director Powell's extravagance and his failures to do what Congress authorized, forced the line itemization of the agency's entire appropriation. If now enacted, the recommended change would allow the Director, rather than Congress, again to determine priorities among the various elements of the USGS program and to modify them to meet emergency conditions without recourse to the Federal legislators. The USGS estimated that it would require for its surveys, investigations, and research (SIR) during fiscal 1950–51 a total of $20 million in direct appropriations, an increase of some $3.5 million over the previous year's request. Of the additional funds, $1,975,000 would go to topographic surveys and $1,262,000 to water-resources investigations. The USGS expected to receive another $11.1 million from Federal and nonfederal sources. Congress remained in a mood to economize. The House Committee on Appropriations previously tried to keep appropriations below the estimate; the committee now urged the chairmen of its subcommittees to hold appropriations below those for fiscal 1949–50.

The House subcommittee still looked favorably on the USGS. When Wrather appeared before the subcommittee on January 16, he reminded its members that the Hoover Commission's report recommended that the study of problems of water conservation and mineral resources should go forward regardless of the drive toward national economy. Chairman Kirwan replied "That is national economy." Kirwan made his position clearer by emphasizing that "Billions of our resources have been wasted down during the past 50 years. Now we are starting in the second 50 years of this century and we had better do a better job of trying to protect America."[200] Wrather assuaged the subcommittee's past concerns about the agency's difficulties in "recruiting adequate technical personnel" by reporting that "we are much more able to get competent young fellows to feed in at the bottom of the organization." After recent consolidation, the USGS was "now equipped to absorb a substantial increase in the amount of work done and do it efficiently."[201] On February 8, Henry Jackson supported the shift to SIR by calling it "merely language to consolidate all previous items dealing with this appropriation for the Geological Survey"[202] and Otis Beasley agreed. The Committee on Appropriations allowed the USGS $19,129,000, representing a cut of $871,000 in the estimate but still some $3,085,000 above the appropriation for fiscal year 1949–50. During the floor debate, Ivor Fenton defended the estimate's reduction by emphasizing the USGS' continuing responsibility for discovering, studying, and evaluating the Nation's minerals and water resources. Fenton admitted that the agency had done a fine job with the money it received, but he regretted that even more had not been done. The House approved its Committee on Appropriation's recommendation.

Thomas Nolan, as Acting Director, represented Wrather and the USGS at the agency's budget hearings held on April 5, 1950, by the Senate's appropriations subcommittee. Nolan and Gerald FitzGerald defended the requested increase for topographic mapping. To complete mapping the Nation, Nolan reminded the subcommittee, would require "very close to 50 years * * * at the present [funding] rate."[203] Chairman Carl Hayden asked whether or not the USGS "reduced the cost of topographic mapping per [square] mile by modern devices?"[204] Using shoran-controlled photography for position and "determining ground elevations from the air,"[205] especially in Alaska, FitzGerald assured Hayden, cut costs for equivalent accuracy. These methods not only improved the maps for the same cost per square mile but they even cut the cost up to one-half for certain types. Maps were now cheaper than 2–3 years ago, even as wages and accuracy requirements increased. The USGS, FitzGerald added, now printed 550 quadrangles each year, and Nolan noted that the agency also "prepared photographic equivalent copies of our multiplex compilation sheets" and made them "available to people with a need for them."[206] Nolan supported the requests to continue mineral surveys and geologic mapping, including trace elements and "a very modest study of volcanoes," begun "as a basis for prediction of new eruptions," by noting other applications. "Within the past week," Nolan reported, "one of the members of the special weapons group in the Army was most anxious to discover what could be made available to him with regard to the unconsolidated materials in one of these volcanic areas." That "member" likely was Brigadier General Herbert Loper, now Deputy for Atomic Energy to the Army's Acting Chief of Staff (G–4), and also the Army's member of the AEC's Military Liaison Commission (replacing Major General Kenneth Nichols), and the Deputy Commander of the Joint Task Force. "We fortunately had a map which we could show him," Nolan continued, "which he could use and which probably is going to be extremely important in the construction of a very large [unnamed] activity in a very critical [but also unspecified] area. That, I think, is * * * typical of the byproducts * * * and of the greatly increasing scope of the demands * * * in all of these activities."[207] Senator Hayden agreed, suggesting that

> **[i]t is just like any other research. You never know just when the facts will develop that will prove to be of tremendous value. You cannot classify them as you go along.[208]**

Carl Paulsen defended the requested increase for funds for USGS water-resources investigations by noting that the Nation's per capita consumption of water "probably more than trebled"[209] in recent years, from less than 200 to 1,300 gallons per day for all uses, due to significantly greater demands by agriculture and industry. Nolan also emphasized Oscar Meinzer's contributions in developing the science and technology of groundwater hydrology. While using the increased funds, Nolan urged that "we must develop more scientists of his kind, if we are to continue to meet these water problems that we have."[210]

The Senate, while reducing still further most of Interior's items, went along with the House's figure for the USGS but added supplemental funds to meet requests by the subcommittee's Dennis Chavez (D–NM), also Chairman of the Committee on Public Works, and other Senators, for collecting water records for operating the new interstate compacts. Congress and the President approved on May 31, 1949, the compact for the Arkansas River that representatives of Colorado and Kansas signed on December, 14, 1948. On June 2, 1949, they agreed on a compact for the Yellowstone River that representatives from Montana, North Dakota, and Wyoming were asked to sign not later than June 1, 1952. The Senate agreed to include $253,000 of the $275,000 the USGS requested to operate the interstate compacts for a total of $19,382,000, slightly less than the estimate, but the House did not approve the additional appropriation.

Wrather hoped that Congress and the President would enact appropriations for the USGS during the new fiscal year before July 1, 1950, but by then yet another foreign-policy crisis, this time on the Korean Peninsula, intervened to modify views in the legislative and executive branches about the amount of and priorities for Federal funds and to make USGS operations dependent on continuing resolutions. On April 19, 1949, the Soviet Union vetoed a resolution admitting the

U.S.-supported Republic of Korea to the United Nations. The last American troops withdrew from South Korea on June 29, leaving only a 500-man Military Assistance Group to advise President Rhee's government. The U.N.'s second commission announced on September 2 its failure to settle the continuing low-level conflict between the two Koreas and its fear that those countries neared outright war. When visiting Rhee in 1948, General MacArthur promised to defend South Korea, but he omitted Taiwan and South Korea from the defense of the Western Pacific. So did NSC–48, a finding issued on December 30, 1949, in which State Department staffers recommended a conciliatory approach to mainland China, hoped for its break with the Soviet Union, and urged ending aid to Chiang's government. Secretary Johnson, Senators Taft and McCarthy, Henry Luce, William Hearst, and others promptly opposed NSC–48. Early in 1950, Truman also objected to protecting Taiwan. In remarks before the National Press Club on January 12, Acheson supported NSC–48 by agreeing that the United States would defend Japan, the Ryukyus, and the Philippines. By not mentioning Taiwan or South Korea, he appeared to leave both outside the U.S. perimeter or even its sphere of influence or strategic concern in the Far East. Acheson did recommend that Truman seek a threefold increase in defense funds for fiscal year 1949–50.

On January 31, 1950, the day Truman requested the AEC to continue its work on the hydrogen bomb, the President asked Secretaries Acheson and Johnson to revise NSC–20 by reexamining U.S. objectives in both peace and war and the effectiveness of American strategic plans, in view of the Soviet Union's forthcoming atomic bomb and its potential for developing a thermonuclear (fusion) weapon.[211] The new statement, like NSC–20, was prepared by the State Department's Policy Planning Staff, where Paul H. Nitze, coauthor of the postwar U.S. Strategic Bombing Survey and head of State's Office of International Trade Policy, replaced George Kennan as Director on January 1. Nitze and his staff completed a draft version of NSC–68 in late February. On March 22, Nitze briefed Acheson, Omar Bradley, and Johnson, but Johnson left the meeting early to protest the seeming challenge to his authority. Johnson reluctantly signed off on NSC–68 on April 6, and it went to Truman on April 14. The authors of NSC–68 recommended a quick and continuing increase of the free world's economic, military, and political strength[212] but included no estimate of the costs involved. Truman promptly returned the document to the National Security Council for reconsideration and a lucid exposition[213] of the necessary programs and their required funds. The NSC's ad hoc committee met on May 2 and expected to finish its revisions by August 1. Meanwhile, Bradley accepted cuts in the military budget for fiscal year 1950–51 to $12.3 billion, and he also approved the $12.1 billion projected for 1951–52. Later, when Eisenhower opposed these reductions, the House and the Senate acted to try to raise military funds for fiscal 1950–51 by as much as $2.5 billion.

As Congress deliberated and Nitze's team modified NSC–68 in response to Truman's request, events in Korea made their decisions even more important. Kim Il Sung went to Moscow in late December 1949 to try to convince Stalin to approve and support Kim's plan to incite a revolt within South Korea, invade and conquer the country, and establish therein a Communist government. On February 14, 1950, Stalin and Mao signed in Moscow a 30-year pact of friendship, alliance, and mutual assistance and then signed several economic agreements. Kim returned to Moscow during March and April and visited Beijing in May. Kim, Mao, and Stalin agreed that the United States would not respond militarily to an attack on South Korea but, if America did so, Kim's forces would conquer Rhee's country before any meaningful U.S. intervention could prevent it.[214] Stalin authorized additional shipments of weapons and supplies, but he did not promise open support. Although the South Koreans elected a more moderate national assembly on May 30, Kim refused to have any dealings with Rhee and his conservative adherents in the proposed larger body that also represented the north. Kim continued to plan for unification through direct military action. His North Korean People's Army (NKPA) comprised 135,000 men, 30,000 of them veterans of two wars, grouped in 10 divisions and an armored brigade equipped with 120 Soviet T–34 medium tanks. Ample reserves supported the NKPA regulars. South Korea's army mustered on paper about 100,000 men, including 65,000 in eight divisions. ROK divisions lacked tanks, medium and heavy artillery, rocket launchers, and recoilless rifles.

At 4 a.m. on Sunday, June 25, 1950 (local time), just 20 days after Truman signed the Foreign Economic Assistance Act that added $100 million to the $70 million given to South Korea earlier in the year, Kim's forces crossed the 38th parallel in six principal columns, and other units began successful amphibious assaults on the east coast south of that line at Kangnung and Samchok. The North Koreans completely surprised elements of four of the eight South Korean divisions. The main NKPA column on the west broke through the South Korean units, captured Kaesong, and moved rapidly southeast toward Seoul.

The U.S. Ambassador's news of the attack, sent from Seoul, reached Washington at 2:45 p.m. on Saturday, June 24 (local time). The alert also surprised the Truman administration, whose attention was focused on Europe, the Middle East, India and Pakistan, the Communist Hukbalahap ["Huk"] insurrection in the Philippines, the Communist insurgency in Malaya, and other parts of the world where Communist aggression seemed more likely. Truman immediately flew from Missouri to Washington and conferred with principal advisers Acheson, Bradley, Louis Johnson, Finletter, Matthews, Secretary of the Army Pace (formerly Budget Director), Sherman, Hoyt Vandenberg, Webb, and General Joseph L. Collins, the Army Chief of Staff. On the following day, June 25 (Washington time), the United Nations Security Council adopted a U.S. resolution demanding an immediate cease-fire and a pull-back by the North Koreans and called on member nations to assist in carrying them out. The Soviet Union failed to veto the measure because Yakov A. Malik, the Soviet Union's former ambassador to Japan, who replaced Andrei Vyshinsky at the U.N., boycotted all sessions from January 13 to protest the U.N.'s failure to unseat Nationalist China's delegation from Taiwan. On June 26, the U.S. Ambassador, who believed that Seoul would fall before help arrived, ordered all nonessential U.S. personnel and dependents evacuated to Japan. Beginning on the 27th, about 850 persons departed from Kimpo airfield west of Seoul.

Truman did not intend to add South Korea to the list of countries allegedly "lost" to the Communists on his and Roosevelt's watches. Truman saw the new conflict, which he called a bandit incursion, as an opportunity to rearm America, reassure NATO and Japan of his commitment to collective security and containment, and demonstrate that the U.N.'s mandate to keep or restore the peace required deeds as well as words. Unlike World War II, America would not have more than 2 years in which to prepare for combat. On June 27, 1950, Truman ordered General MacArthur to use U.S. air and naval forces in the Far East to defend South Korea. The President termed U.S. intervention a police action and thereby avoided any delay in securing a declaration of war from Congress. Thomas Dewey promptly provided bipartisan support by approving the President's decision to aid South Korea. The President announced that the U.S. 7th Fleet, based principally at Subic Bay in the Philippines, would prevent any further conflict between the two Chinas by patrolling the Taiwan (Formosa) Strait. Truman approved strengthening U.S. forces in and accelerating military aid to the Philippines. He also directed that consideration be given to assisting the forces of France and its Associated States in Indochina and sending a military mission to provide them with close working relations.

On June 27, U.S. air and naval forces began active operations against the North Koreans. As U.S. destroyers evacuated some 900 additional American civilians from Inchon, Seoul's port on the Yellow Sea, American fighter aircraft shot down seven North Korean planes over Kimpo and the front. Although the U.N. adopted a second resolution calling on member nations to assist the Republic of Korea in repelling the armed attack and restore international peace and security in the area, Seoul and Kimpo fell to the invaders on June 28. On the next day, as Truman approved air and naval actions against North Korea, MacArthur flew to Suwon and traveled north almost to the Han River, where he reported that he also would need U.S. ground units to repel the attack. The nearest American troops were in Japan, the four understrength divisions of the 8th Army, led by Lt. General Walton H. ("Johnnie") Walker, earlier one of Patton's corps commanders, but they lacked medium tanks and effective antitank weapons. MacArthur planned to have two of these divisions slow and then stop the North Korean forces while he led the third and other reinforcements in a seaborne assault on the enemy's western flank.

Vice Admiral C. Turner Joy, who commanded U.S. Naval Forces Far East, ordered the 7th Fleet to Okinawa. Task Force 96 continued its blockade, escort, evacuation, and patrol duties, as Task Force 77, including fleet carrier *Valley Forge*, sortied from Subic Bay and Hong Kong on June 27. The next day, British light carrier *Triumph* and her escorts left the latter port to join the U.N. naval effort. Ships of the Royal Australian Navy sailed for Korea on June 29, followed by vessels from the Royal New Zealand Navy on July 3. As the North Koreans pushed south of the Han River on June 30, additional civilian employees of Federal agencies, including four USGS geologists, began leaving Pusan for Japan. David Andrews had returned to Korea in May, with Raymond C. Robeck and David J. Varnes, to complete work at two coal fields and begin mapping at Samchok; James D. Vine joined Andrews' project early in June. Andrews arrived in Tokyo on June 30 and his teammates there on July 2–3 but without most of their notes, maps, and equipment. Also on June 30, Truman authorized the use of U.S. ground forces against the invaders and a naval blockade of and strikes by U.S. aircraft on targets in North Korea, and MacArthur requested an American regimental combat team from Japan. On July 1, as the civilian evacuees continued to leave Korea, one Army infantry battalion, reinforced but still with more postwar soldiers than combat veterans, arrived in Pusan by air from Kyushu, entrained and moved northwest toward Taejon and the front. Also on July 1, Congress and Truman extended the Selective Service Act for 1 year and agreed to call up individual members of the Reserves for 21 months of active duty. The Second World War, like the First, failed to end war. Only 5 years after the victory of the Allied Nations, many veterans of the 1939–45 war found, or would find, themselves called to participate in a new conflict.

Chapter 7.
Natural Resources and National Security, 1950–1953

Our natural resources programs are being modified in order to make the greatest immediate contribution to our national security.[1]

—Harry S. Truman

Beginning in July 1950, the United States slowly built up its forces in South Korea, as the major partner in the United Nations' effort to repel North Korea's invasion, while continuing to rearm at home and contain the Soviet Union abroad. The Truman administration proved woefully unprepared for a major war. The number of men and women in the Nation's armed forces, and their stores of equipment, had been reduced to dangerously low levels. At the end of 1948, 6 months after women were integrated into the military, the force totaled only 1.6 million and continued below authorized strength. Only the number of U.S. nuclear weapons rose significantly after World War II, to about 100, after Truman ordered increased production of bombs of the new design introduced in December 1948. The troops closest to Korea included 4 of the Army's 10 active, but understrength, divisions in Japan and 1 regimental combat team on Okinawa. The Navy kept the three *Midway*-class aircraft carriers in the Atlantic and the Mediterranean to counter any Soviet aggression but sent to the Pacific, as additions or replacements, other major warships as soon as they could be transferred from other areas or readied for sea. The Navy also ordered USS *Missouri* to Korean waters and began reactivating the three other *Iowa*-class battleships, a fleet carrier, and other reserve vessels. On July 3–4, 1950, aircraft from USS *Valley Forge* and HMS *Triumph* struck North Korean airfields at Pyongyang and Haeju. These and subsequent sorties, and those by the U.S. Far East Air Forces, destroyed most of North Korea's air force, but they did not interdict the North Korean People's Army (NKPA) columns moving south of the Han River.

Early on July 5, U.S. troops began combat operations against the North Korean ground forces.[2] The American infantry battalion, reinforced by additional crew-served weapons and a 105-millimeter (mm) howitzer battery, established a blocking position just north of Osan on the highway that connected Seoul and Suwon with Pusan. Although Task Force Smith lacked tanks, anti-tank mines, and air support, many of its members and military personnel elsewhere in South Korea and Japan expected an easy victory. The Americans valiantly tried but failed to stop two attacks by the main NKPA column, both led by Soviet-built T–34 tanks, as the U.S. 2.36-inch rocket launchers fared no better against the T–34s than they had against German Tiger tanks. The U.S. task force's remnants retreated beyond Osan, having delayed the NKPA column by just 7 hours at the cost of more than 150 men dead, wounded, or missing. U.S. overconfidence disappeared as well.

On July 7, as Lt. General Walton Walker arrived in Korea and President Truman asked the Selective Service System to resume the draft, the United Nations requested and approved General of the Army Douglas MacArthur, now the senior American officer on active duty, as overall commander of its forces in Korea. As additional Army battalions arrived piecemeal from Japan, they imposed additional delays before withdrawing to a position in front of Taejon (now Daejeon). NKPA units captured Taejon on July 20, as Truman asked Congress for $20 billion to rearm the United States and a mechanism to mobilize America's resources to support the United Nations (U.N.) effort in Korea. On the same day, the Senate committee's report called false the repeated charges by Senator Joseph McCarthy that the Federal Government was rife with Communists.

The 8th Army slowed but did not halt the North Koreans' thrust south to conquer the remainder of the peninsula and retreated toward Taegu (Daegu), where General Walker established his headquarters on July 13. Walker withdrew his units toward the Naktong (Nakdong) River, where, on July 29, he issued a stand-or-die order. Although up-gunned versions of U.S. medium tanks, 155-mm medium howitzers, and 3.5-inch rocket launchers arrived to bolster the defense, 10 North Korean divisions closed on the line held by 4 U.S. divisions and 5 divisions from South Korea (Republic of Korea, ROK). The Pusan Perimeter, completed by August 4, enclosed an area of some 250 square miles.

The siege of the Pusan Perimeter began on August 8. The NKPA's assaults were aided indirectly by Soviet efforts in the United Nations, where Yakov Malik returned to the Security Council on August 1 (New York time) and assumed the Council's presidency. Thereafter, Malik vetoed every resolution about the conflict in Korea that the Soviet Union did not approve. To bypass Soviet opposition, the General Assembly, with Indonesia as its newest and 60th member as of September 28, adopted on November 3 the U.S. uniting-for-peace resolution that enabled it to take any emergency action required but vetoed in the Security Council. The United States continued to commit more of its active forces to Korea, and Truman ordered the activation of additional Army and Marine units and individuals in the National Guard and the Reserves.

The President then dealt with two pressing domestic issues. On August 25, 1950, Truman used a war-emergency law enacted in 1916 as the basis for ordering the Army to seize America's railroads to prevent the general strike the workers intended to call on August 28. The railroad workers decided not to walk out, but Truman did not return the railroads to the owners until May 1952. On August 28, 1950, he signed the Social Security Act Amendments, intended to "extend and improve the Federal Old-Age and Survivors System" and to modify the law's "public assistance and child welfare provisions."[3] The statute increased the post-1950 wage base for taxes to $3,600 per year, with a new schedule for payroll taxes; extended the system to more than 9 million people, including more of the elderly and those self-employed and those in the agricultural and home industries and in State and local governments; and hiked benefits by 70 percent.

As the 8th Army and ROK forces struggled to defend the Pusan Perimeter, and Syngman Rhee's government now in Pusan, more U.S. support personnel went into combat formations, South Koreans filled out American units, and reinforcements from other U.N. countries began to arrive in Korea. On September 1, 1950, Truman described the situation in Korea in a radio and television address to the Nation. The President reported that 30 U.N. members promised specific aid in Korea. Air and naval units from Australia, Britain, Canada, France, The Netherlands, and New Zealand were already participating in the conflict. Australia, Canada, France, Greece, the Philippines, Thailand, and Turkey, Truman added, also pledged additional ground-combat forces, while other nations promised medical, transport, or other combat-support units. The President reaffirmed U.S. policy in Korea by saying that the Nation would uphold the U.N. charter and South Korea's right to be free. "We do not want the fighting in Korea," Truman declared, "to expand into a general war," and it would not if the Communist Chinese stayed out, as he hoped they would. The United States had no territorial ambitions in the Far East, the President added, and, although "[w]e do not believe in aggressive or preventive war," America would defend countries against external attacks. In Korea, Truman concluded, "[w]e want peace and we shall achieve it."[4]

As the U.N. Command's forces grew in Korea in 1950, the United States extended its efforts to contain Communism and defend the Pacific. The Governments of Australia, New Zealand, and the United States (ANZUS) began considering a security treaty for mutual defense and the peaceful settlement of any disputes between them. On September 1, 1950, the North Koreans launched another series of offensives around the Pusan Perimeter. The number of U.N. combat troops and supporting personnel within the perimeter rose by September 8 to numbers twice those of the overextended North Koreans. U.N. forces, now with a fivefold advantage in tanks, continued to control the air over and the sea around Korea.

As U.N. forces defended the Pusan Perimeter, the emergency in Korea and requirements for continued containment of the Soviet Union elsewhere began to affect profoundly the work of the civilian as well as the military components of the Truman administration. As Truman's actions in dealing with the Korean crisis won immediate support in the 81st Congress, national defense assumed priority over domestic issues. This change interrupted or delayed some activities by the Interior Department and other Departments and their bureaus but accelerated others. The renewed emphasis on and funding for national security forced a change in the orientation of programs by Interior and its agencies, as it did with the coming of American participation in World Wars I and II. The USGS, after a nearly 5-year effort to renew its research capital, again began shifting its regular mix of applied and basic studies to directing most of its operations to support the war in Korea, containment elsewhere, and military and civil-defense programs at home. The Geologic Division expanded and accelerated its investigations of strategic minerals, including those containing fissionable material; operations in military geology; activities in geology abroad; and studies of urban geology. The Topographic Division, at the request of the Army Engineers, reoriented and enlarged its program of topographic and related mapping. The Water Resources Division also changed many of its activities to meet defense needs. The Conservation Division's increased workload reflected the rising interest in the public lands and the heightened industrial tempo. Director Wrather and members of his staff remembered the lessons the agency learned during the two global conflicts earlier in the century. The USGS, Wrather promised, would devote its

> **best efforts to meeting the very real needs of national defense, yet the Survey, from its earliest days has been concerned with the wise utilization of our natural resources; instinctively, it will bear in mind the Nation's long-term needs during this present emergency as it has during other times of crisis.[5]**

As in World Wars I and II, the success of USGS contributions to ending the conflict in Korea would depend as much on the amount of funds that its planners and presenters could generate as it would on the operations by the agency's scientists, engineers, managers, and supporting personnel.

On September 5, a day before Truman signed the Interior Department's appropriations bill for fiscal year 1950–51, he advanced Federal records management by signing the Federal Records Act, which gave the Administrator "immediate custody and control of the National Archives Building and its contents" and "authority to design, construct, purchase, lease, maintain, operate, protect, and improve buildings" used to store "records of Federal agencies in the District of Columbia and elsewhere."[6] The new law established a National Historical Publications Commission, composed of the Archivist of the United States as chair, the Librarian of Congress, one member each of the House and Senate, one member of the Federal judiciary, one representative each of the Departments of State and Defense, two members of the American Historical Association, and two members "outstanding in the fields of the social or the physical sciences" appointed for 4-year terms by the President. The statute authorized the Commission to "make plans, estimates, and recommendations for such historical works and collections of sources * * * appropriate for printing or otherwise recording at the public expense."[7] The act provided for a Federal Records Council, also composed of representatives of the legislative and judicial branches and of agencies in the executive branch. The Council would advise the Administrator in establishing "economical and efficient management of records in Federal agencies," formulate "standards for the selective retention of records of continuing value" and "assist Federal agencies in applying" them, inspect "the records of any Federal agency" to assure compliance, and "establish, maintain, and operate records centers for the storage, processing, and servicing of records for Federal agencies prior to their deposit with the National Archives [founded in 1934]." The law required the head of each Federal agency to "establish and maintain an active, continuing program for the economical and efficient [and safe] management of the records of the agency."[8] The act prohibited the National Archives from charging more than 10 percent beyond the cost of providing internal microfilming and other reproductions of records. On February 12, 1951, Oscar Chapman's Secretarial order established a Records Management Program for Interior.[9]

Before approving Interior's appropriations bill for fiscal year 1950–51, the 81st Congress and President Truman also inserted a new level of administration between the Interior Secretary and the USGS by following one of the Hoover Commission's recommendations. As of May 24, Reorganization Plan No. 3 of 1950 aimed to set the Department's resource activities on a more purposeful course. That enacted plan provided for one additional (programmatic) Assistant Secretary of the Interior, to "be appointed by the President, by and with the advice of the Senate, to perform duties prescribed by the Secretary of the Interior," and also authorized an Administrative Assistant Secretary to "be appointed, with the approval of the President, by the Secretary of the Interior."[10] On July 17, Secretary Chapman gave the now four Assistant Secretaries new programmatic titles—Administration, Mineral Resources, Public Land Management, and Water and Power Development—reflecting shifts in their supervisory responsibilities that Chapman backdated to June 9.[11] He also reassigned some of his agencies to reflect this new table of organization and established in the Office of the Secretary a Program Staff, to join therein the Solicitor's Office and the Information Division, and, on November 24, a Division of International Activities and a Director who reported to the Assistant to the Secretary. The new Division would (1) consider "the possible foreign impact" of Interior's domestic policies and programs; (2) supervise and improve "participation by Interior's representatives on committees dealing with foreign affairs"; (3) establish Interior's "viewpoint on international matters of concern to it"; (4) make good on Interior's commitments on foreign matters; (5) prescribe "procedures for the conduct of international activities; (6) foster "required cooperation and working relationships on foreign programs" by Interior's bureaus and offices; (7) review "legislative proposals involving the Department to determine their impact on foreign affairs"; and (8) maintain "continuing liaison"[12] with the State Department, other Federal agencies, the United Nations, and other international organizations.

When three persons then part of Chapman's managerial team and a returning colleague filled the four posts of Assistant Secretary, Chapman fixed their responsibilities on December 1.[13] Vernon Northrup, still the Director of the Division of Budget and Administration, received the new title of Administrative Assistant Secretary and the supervision of five Divisions—Administrative Services, Budget and Finance, Management Research, Personnel Management, and Property

Management. Chapman appointed Girard Davidson as the Assistant Secretary for Mineral Resources and made him responsible for developing and managing Interior's mineral programs, including those of the USGS, the U.S. Bureau of Mines (USBM), the Minerals and Fuels Division, the Division of Oil and Gas,[14] and the Division of Geography. Dale E. Doty, a Special Assistant to Chapman while the latter served as Under Secretary, became Assistant Secretary for Public Land Management and supervised the Bureau of Land Management (BLM), the Bureau of Indian Affairs (BIA), the Fish and Wildlife Service (FWS), the National Park Service (NPS), the Office of Land Utilization, and the Office of Territories, formerly the Office of Territories and Island Possessions. A Director still led the Office of Territories, as Chapman had renamed and reorganized it on July 28.[15] The office included, in addition to its Territorial Officers (principally the Governors and their staffs), the Chairmen of four new Branches—three geographical (Alaska, Caribbean, and Pacific) and one administrative. William E. Warne, the Assistant Secretary for Water and Power Development, managed the U.S. Bureau of Reclamation (USBR), but to it Chapman added the Division of Power and the Bonneville, Southeastern (established on March 21) and Southwestern (reorganized on October 23) Power Administrations. Chapman placed the appointments of the programmatic Assistant Secretaries on a rotational basis. Robert R. Rose, Jr., completed his single 2-year term in Wyoming's House of Representatives in 1951 and replaced Davidson as Assistant Secretary for Mineral Resources. Wrather came to view Rose as a real gain for the USGS, especially after Davidson responded to the Agriculture Department's objection to conclusions in a USGS Bulletin by asking the USGS to add to all its future publications a disclaimer that the agency's views did not necessarily reflect Interior's policy. Wrather, who viewed Davidson's request as "absolute poison"[16] for public confidence in the USGS, likewise convinced Chapman.

Early in 1950, Secretary Chapman also revived the issue of greater decentralization of Interior and its bureaus. He arranged to establish an outside group to assess Interior's field services, an Appraisal and Evaluation Committee composed of four academicians—Thomas C. Donnelly, James W. Fesler, Charles McKinley, and C. Herman Pritchett. Under a research contract with Interior, Executive Director Joseph E. McLean and his staff at Princeton University guided the Committee's 5-month review. L. Wade Lathram, Director of the Division of Management Research in Administrative Assistant Secretary Northrup's office, served as Interior's liaison to the Committee. Its report, dated September 15, 1950, asked Interior to give "careful consideration" to its existing organization to achieve "individual bureau efficiency and over-all departmental effectiveness"[17] by accelerating past and in-progress changes. The Interior Committee and the Princeton staff offered nine principal recommendations to Chapman: (1) make continued efforts throughout Interior to regard and manage land, water, and mineral resources "as a unity";[18] (2) increase the Secretary's staff to facilitate "planning, programming and supervision of policy execution"; (3) designate "a Secretarial officer as full-time director of the Program Staff and as chairman of the Program Committee"; (4) obtain "similar degrees of decentralization within the bureaus" and "[r]oughly uniform (but fluid) regional boundaries and to the greatest extent possible common field headquarters";[19] (5) fully recognize and adequately finance the key position in each field committee to "promote long-range needs" and facilitate the intradepartmental and interdepartmental coordination of bureaus and similar coordination with their State, municipal, and private cooperators; (6) make every effort "to incorporate areal as well as functional considerations in the budget process";[20] (7) keep unchanged, "for the time being," the "present [river-basin-based] regions of the field committees," except possibly for the Eastern Region; (8) reinforce, via Interior's "top management," "present efforts to develop a department-wide career service";[21] and (9) take "[i]mmediate steps * * * to decentralize personnel authority over professional legal personnel."[22]

The Interior Committee-Princeton report then made specific recommendations for improving the internal organization and external relationships of the USGS and seven other Interior agencies. The report did not critique the quality of USGS work. Instead, it recognized the indispensability of the USGS "to the intelligent utilization of resources and the maintenance of America's technology"[23] and its rightful recognition "as an outstanding scientific group, with some of the world's most brilliant scientists among its personnel." The report did emphasize that

> **the organizational pattern through which the Survey operates deserves considerable criticism.[24]**

The Interior Committee-Princeton report constructively hammered the USGS, both internally and externally. Asserting that the USGS since its founding had "remained virtually indifferent to questions of organization"[25] and did not respond effectively to changes during and after World War II, the report claimed the agency's "professional scientists, losing themselves in the technical aspects of their protracted projects, ignore the advantages efficient administration can give to them." On June 30, 1950, the USGS employed 1,300 persons at its headquarters and another 7,257 at field locations. The headquarters staff represented 15 percent of the agency's total employees, the largest ratio of Interior's agencies. With the USGS organized into programmatic rather than geographic Divisions, the "integration of Geological Survey work in specific regions is thus not the responsibility of any official short of the Director's Office." "Indeed," the report continued, "the integration of its findings is not an important objective of the Survey," which left that task "to those who utilize Survey data."[26] The report reviewed perceived problems in integrating and controlling planning and programming, personnel, property management and accounting, and procurement and made six principal recommendations for improvements. After evaluating the arguments for and against regionalization, the report favored the USGS establishing "a common regional pattern"[27] in which field organization followed the boundaries of the field-committee regions, decentralizing agency operations, and delegating "authority for program formulation and execution"[28] to regional directors. To assist regionalization, the report recommended "that review of maps and publications in the regions be handled by these specialists," "committees of regional division heads be appointed in each region to assist * * * in coordinating programs," and "small technical libraries be set up in each region." More specifically, the report recommended that "the staff of specialized geologists attached to the Director's Office should be advisors only"[29] and that the Water Resources Division should "maintain a single district office in each state to provide contact with state cooperators."[30]

To improve USGS relations within and without Interior, the Interior Committee-Princeton report recommended three prime changes. The USGS must "continue to expand its formal and informal relationships with related agencies"[31] and aid an "intensive study * * * directed toward the clarification of a national minerals policy" to end the confusion created by the area of "uncertain responsibilities between"[32] the USBM and the USGS. Although the scientific classification of the public lands was one of the two founding missions of the USGS, the Interior Committee-Princeton report, recognizing that the Conservation Division's regulatory activities had "no place in a basic research and service agency,"[33] recommended abolishing the Division and transferring its functions, funds, and staff. The report suggested sending the Mining Branch and the Oil and Gas Leasing Branch to the BLM; the Mineral Classification Branch to the USGS Geologic Division; and the Water and Power Branch to the USGS Water Resources Division or to the USBR or to the Federal Power Commission.

Wrather had dissuaded Secretary Krug from requiring the USGS to increase its decentralization and appoint regional directors. Wrather gave Chapman his views on why and how the USGS had already decentralized its field operations as much as he thought good management and operations allowed. The regional coordinating committees established with representatives from all Divisions would continue to function, but Wrather wanted to keep intact the direct lines of management between the Division Chiefs and the Assistant Director and Director. Wrather, in his memorandum of December 21, 1950, written in response to the Interior Committee-Princeton report[34] and after his meeting with Chapman, asked his Division Chiefs to restudy consolidation to locate field headquarters at field centers to facilitate operations and avoid any inefficient and uneconomical dispersion wherever possible. The surplus ammunition plant west of Denver facilitated the choice of a site for the Rocky Mountain field center, but no equivalent location seemed available on the West Coast reasonably near existing USGS offices in California, principally those in Sacramento and San Francisco. To secure a western site, USGS managers began extended but ultimately unsuccessful discussions with Stanford administrators about constructing a USGS center on campus and sharing it with the Department (now School) of Earth Sciences. Adequate space at Berkeley also proved impossible to obtain. When Thomas Osborne, of the General Services Administration's (GSAd's) San Francisco office, found no suitable existing facilities for lease in the bay area, he requested bids to build and lease one in the Palo Alto area. The USGS, through Osborne, negotiated a $550,000 low-bid contract to construct 40,000 square feet of office space, with adjacent open land, at Menlo Park, near Palo Alto. The new facility was intended to house between 175 and 225 persons, including the USGS people at the Old Mint Building and other locations in San Francisco. Later, as additional buildings were constructed at the new site (overseen by David Gallagher from December 1952), plans called for some of the USGS staff in Sacramento to relocate to Menlo Park.

On September 6, 1950, when Truman signed the Interior Department's appropriations bill for fiscal year 1950–51, the President and Congress also agreed to send $62.5 million in Marshall Plan aid to Spain. The latter decision represented another step in the long process of restoring Spain to the West's good graces and adding her armed forces to those of the North Atlantic Treaty Organization (NATO). The appropriations act gave Interior about $623.3 million, some $46.2 million less than Chapman requested. The new law provided the USGS with $19,382,000, about $3.24 million more than the total of direct and deficiency appropriations the agency received for fiscal 1949–50. The statute also ended the line itemization of the USGS budget, a requirement in effect since 1888 and, since then, a constant reminder of one of the major results of Director Powell's failed policies and practices. The act replaced line itemization with the Interior-requested authorization for funds for

> **surveys, investigations, and research.[35]**

The new law returned the agency to its block-funded status of 1879–87 and allowed it to make decisions on how it would best use its own direct appropriations in the Nation's interest. The statute compressed the agency's brief into two parts. The first paragraph described the nature of USGS work:

> **For expenses necessary for the Geological Survey to perform surveys, investigations, and research covering topography, geology, and the mineral and water resources of the United States, its territories and possessions; classify lands as to mineral character and water and power resources; give engineering supervision to power permits and Federal Power Commission licenses; enforce departmental regulations applicable to oil, gas, and other mining leases, permits, licenses, and operating contracts; and publish and disseminate data relative to the foregoing activities.[36]**

This section also continued the limits on the use of USGS funds for surveys, investigations, and research (SIR) for cooperative work with nonfederal agencies. The agency's direct appropriation included $3.1 million "available only for cooperation with States or municipalities for water resources investigations," and the law also required that "the share of the Geological Survey in any topographic mapping or water resources investigations carried on in cooperation with any State or municipality shall not exceed 50 per centum of the cost thereof."[37]

The second paragraph covered USGS administrative provisions. This section made the entire "amount appropriated [as the agency requested] available for personal services in the District of Columbia"; allowed the purchase of no more than 129 "passenger motor vehicles," of which 85 could only be replacements; authorized "printing and binding"; required reimbursing the GSAd for security guard services, enabled "construction and maintenance of necessary buildings and appurtenant facilities," approved the "acquisition of lands for gaging stations," and authorized

> **contracting for the furnishing of topographic maps and for the making of geophysical or other specialized surveys when it is administratively determined that such procedures are in the public interest.[38]**

The funds received from other sources raised the total monies managed by the USGS in 1950–51 to about $36,373,000, an increase of nearly $5.8 million over the previous fiscal year. Of the new sum, 51 percent came from direct appropriations for SIR activities, later reported by the USGS as some $18,429,000. Other Federal agencies furnished more than $13,346,000, or 37 percent, and States, counties, and municipalities supplied nearly $4,519,000, or 12 percent. The USBR led the group of civilian agencies transferring more than $100,000 each by providing about $4,871,000. The U.S. Atomic Energy Commission (AEC) furnished nearly $3,189,000, Interior's new Defense Minerals Administration (DMA) gave almost $281,000, the Department of State (DoS) provided nearly $585,000, the Economic Cooperation Administration (ECA) supplied some $167,000, the BIA shifted about $118,000, and other Federal sources combined to produce another $642,000. The Army and its Engineers transferred more than $2,207,000, the U.S. Air Force (USAF) furnished about $659,000, and the U.S. Navy (USN) supplied $451,000. The USGS received nearly $746,000 for general administration, a raise of about $346,000 over the previous year's total. That new sum for general administration represented an increased direct appropriation of nearly $77,000 and the total of $269,000 transferred by the AEC, the USAF, the Army, the BIA, the USBR, the DMA, the ECA, the USN, and the DoS.

On September 8, 1950, 2 days after approving Interior's direct appropriations for fiscal year 1950–51, the 81st Congress and President Truman responded to the demands of wars hot and cold by approving a defense-production bill, introduced in the House on July 19, aimed in part at assuring an adequate and continuing supply of mineral raw materials. Truman also issued an Executive order delegating to the Secretary of State[39] the responsibility for carrying out the Point Four Program approved by Congress. The Defense Production Act provided for establishing "a system of priorities and allocations for materials and facilities" and authorized "the requisitioning thereof"; provided "financial assistance for expansion of productive capacity and supply," "price and wage stabilization," and "the settlement of labor disputes"; strengthened "controls over credit"; and "by these measures" facilitated "the production of goods and services necessary for the national security."[40] The new statute authorized purchases from or loans and grants-in-aid to private business enterprises to expand their productive capacities, develop technological processes, and produce essential materials, "including the exploration, development, and mining of strategic and critical minerals"[41] under Federal approval and supervision.

On September 9, Truman, in another radio and television address to the Nation, promised that the Defense Production Act would ensure the production of the materials and equipment required for national defense, raise workers' salaries, and prevent inflation. The President's Executive order issued earlier that day established an Economic Stabilization Agency and also authorized and directed the Secretary of the Interior "to encourage exploration, development, and mining of critical and strategic minerals and metals."[42] Truman took additional steps to secure and maintain the resources required for national defense. On September 11, the President and the Secretary of Commerce founded the National Production Authority (NPA) and appointed Manly Fleischmann of New York as its Administrator. Truman signed additional legislation on September 27 that gave the GSAd slightly more than $598,637,000 during fiscal year 1950–51 to fulfill the provisions of the Strategic and Critical Minerals Stock Piling Act of 1946. Not more than $14 million of that sum would "be available for transfer to the appropriation 'Operating Expenses,' for the reactivation of industrial plants [mothballed] under the provisions of the National Industrial Reserve Act of 1948."[43] On October 13, Wrather's Survey order designated Harold Bannerman as the Director's deputy "to maintain liaison with" Interior, the USBM, "and other agencies concerned with such functions"[44] as Secretary Chapman might redelegate to the USGS and to draft policies for and to administer USGS operations by its Geologic Division and its other Divisions as might be required under the Defense Production Act.

The security of a long-term supply of oil for the United States remained one of the most important issues involving these strategic and critical materials, as the Nation continued increasing its net imports and consumption of petroleum. The Senate, in the midst of its debate on the defense production bill on August 15, authorized its Committee on Interior and Insular Affairs to study available fuel reserves, except atomic energy, as well as present and probable future rates of consumption. The Senate intended this assessment to aid in formulating a national fuels policy to meet the needs of the United States in peace and war, including recommendations for methods to encourage development to assure the availability of fuels adequate to serve an expanding economy and security requirements. As in earlier postwar years, some persons argued for importing more oil in peacetime to preserve domestic resources for use in war and others urged the development of a synthetic-fuels industry.

The development of technology for drilling offshore now offered a third possibility, the resources of the Continental Shelves, but one that became a partisan issue. Wrather, in testifying before a Senate committee investigating during June 1945 possible new sources of petroleum, suggested as promising targets the world's Continental Shelves. The results of the hearings contributed to Truman's proclamation, on September 28, 1945, that asserted U.S. jurisdiction over the natural resources of the subsoil and seabed on the Nation's contiguous Continental Shelves. A year later, Everette DeGolyer reported that geophysical surveys had discovered in the shallow waters in the northern Gulf of Mexico, between the mouths of the Mississippi and Sabine Rivers, no fewer than 30 salt-dome structures similar to those already producing petroleum in adjacent onshore areas. By then, Louisiana, which claimed jurisdiction out to 27 miles from her coast, had leased some 375,000 acres to exploration companies that had drilled five wells from fixed platforms. Four other wells had been similarly drilled off Texas. When Kerr-McGee discovered oil on October 4, 1947, by drilling from a floating platform of three linked Navy surplus vessels anchored 12 miles off Louisiana's coast, both the Federal Government and the States promptly claimed ownership of the Continental Shelf. After the U.S. Supreme Court dismissed California's claim by ruling in June 1947 that the Federal Government had full dominion over the underwater resources,[45] Federal suits followed against Louisiana and Texas in 1948. On June 5, 1950, the Justices approved the Federal case in ruling against those two States. Chapman's subsequent Secretarial order of September 18 delegated to the USGS Federal Oil and Gas Supervisor in Los Angeles Interior's authority in the 1947 agreement between the Attorney Generals of the United States and California "respecting mineral operations in the submerged lands and tidelands lying along the California coast"[46] but reserving to the State 30 days' rights of appeal to the USGS Director and the Interior Secretary.

Chapman further addressed the issue of sufficient oil supplies by also establishing on October 3, 1950, the Petroleum Administration for Defense[47] (PAD) and gave himself, like Harold Ickes, another hat as its Administrator. Secretary of Defense Johnson had approved the transfer of the Army-Navy Petroleum Board from the Joint Chiefs of Staff to the Munitions Board, effective May 1, 1949. Chapman selected Bruce K. Brown to be the PAD's Deputy Administrator; Brown, formerly Harold Ickes' Assistant Deputy Administrator of the Petroleum Administration for War (PAW), was now Chairman of the Military Petroleum Advisory Board and a member of the National Petroleum Council. The PAD's Assistant Deputy Directors included Alfred P. Frame, later Associate Deputy Administrator; C.E. Davis, for domestic operations; Stribling Snodgrass, another veteran of the PAW and DeGolyer's Middle East Oil Mission in 1943–44, who now took over foreign operations; and Hugh A. Stewart, who also served as Director of Interior's Oil and Gas Division. James Brazil, the geologist and Navy officer who worked in Naval Petroleum Reserve No. 4 (NPR–4) in 1944, served 2 years as Administrator and Executive Officer in Commodore Greenman's Office of Naval Petroleum and Oil Shale Reserves (ONPR), and then returned to the petroleum industry, came back as Chief of the PAD's Exploration and Reserves Branch.

The PAD immediately asked the USGS to investigate the nature and occurrence of the Scurry Reef oil fields, stratigraphic reservoirs discovered jointly by Humble and Sun in July 1948 in Scurry County, northwest of Abilene, in the Midland Basin of western Texas. By the end of 1949, the 315 wells in the Scurry fields had produced nearly 4.3 million barrels of oil. Exploration and production, from January 1948 by Seaboard and other companies, in adjacent Borden and Howard Counties to the west began to define these limestone-reef complexes as part of a much larger structure, the 90-mile-wide Horseshoe Atoll of Pennsylvanian and Early Permian age. The results of the USGS studies, the PAD hoped, would advance more reasoned development in these fields that might yield at least 2.5 billion barrels overall. In December 1950, the USGS sent petroleum geologist Howard E. Rothrock to Midland to lead the agency's regional study of the Horseshoe Atoll and its reservoir problems, in cooperation of the Bureau of Economic Geology at the University of Texas.

Under 1950's Defense Production Act, as amended and extended[48] on July 31, 1951, the Interior Department received responsibilities for metals and minerals, solid fuels, electricity, and fishery commodities to add to its work in petroleum and natural gas. To carry out these new duties, Secretary Chapman established, on December 4, 1950, four new Defense Administrations.[49] The new organizations were Fisheries; Minerals, or Minerals Exploration, as of November 20, 1951; Power, or Electric Power, as of February 5, 1951; and Solid Fuels, similar to the one that operated during World War II. On December 5, 1950, Chapman appointed Albert M. Day as head of Fisheries, USBM Director and former Army Engineer Colonel James Boyd as head of Minerals, D. Loring Marlett as head of Power, and Dan H. Wheeler as head of Solid Fuels. USGS members helped Interior and Boyd to plan and organize the Defense Minerals Administration to increase the production and quantity of strategic and critical minerals. The DMA quickly assigned new duties for minerals to the USGS. Interior also involved the USGS with the Defense Solid Fuels Administration as well as the Petroleum Administration for Defense.

Congress, responding to the recent prolonged coal strike, generated a variety of resolutions and bills but passed none of them. The Korean crisis made the matter more urgent. At a Senate committee's request, Chapman set up a staff group to work with the committee's staff to develop background information to which the USGS contributed a comprehensive statement on fuel reserves.

On January 3, 1951, as the 82d Congress began its first session, Truman's Executive order drew on the authority he received under the Defense Production Act in founding the Defense Production Administration[50] (DPA), as part of the National Production Authority, and the President gave the new organization general charge of the NPA's defense program. Truman appointed Edwin T. Gibson, a director of General Foods Corporation who retired in 1951, as the DPA's Acting Administrator. On June 2, Congress and the President agreed to provide nearly $27,332,000 in additional funds as a supplement for defense-production expenses during fiscal year 1950–51, provided that the year's appropriations be made available for renting and (or) repairing buildings "in the District of Columbia and elsewhere," without regard for the restrictions of the law enacted in 1933 and provided that the funds were used to reimburse Presidential appropriations for defense allocated to agencies to carry out the provisions of the Defense Production Act. The supplemental-appropriations act extended the aggregate of outstanding funds borrowed by the Treasury Department from $800 million to $1.6 billion. This law also authorized transfers between agencies of defense appropriations or allocations for salaries and expenses but prohibited any such allocation if the agency could perform its defense activities "by its regular personnel by use of the foregoing authority to realign its regular programs."[51] To conserve building and related materials for use in mobilizing the country for defense, the NPA announced on January 15, a 30-day nationwide ban, effective February 15, on all construction by commercial firms.

As Congress and the President acted to improve national defense, Director Wrather made additional significant changes in USGS administration during fiscal year 1950–51 to try to manage more effectively operations by the agency's employees. On December 21, Wrather's memo to Secretary Chapman provided for field centers to accommodate the USGS' growing activities within the agency's established geographic regions. On the next day, Wrather reassigned the Office of the Chief Counsel to the Director's Office.[52] Less than a month later, Wrather established an Alaska Survey Committee, composed of representatives from each Division. The Director appointed William S. Twenhofel (William H.'s son) as interim Chairman, until the first annual leader was elected from among the members on January 1, 1952, to "act as the Survey representative in Alaska on matters affecting the Survey as a whole, or affecting more than one Division,"[53] as advised by the Committee. Wrather made the Management Services Officer the Committee's Executive Secretary and asked Twenhofel to convene the Committee once a month. In the Director's Office, James J. Ryan became Chief of the new Branch of Service and Supply. To make the results of USGS investigations more rapidly available to users in academia, government, and industry, Wrather and the Division Chiefs arranged to have more of them issued in preliminary form in the series of Circulars; revised versions of some of them later appeared again as Circulars or as Bulletins or Professional Papers.

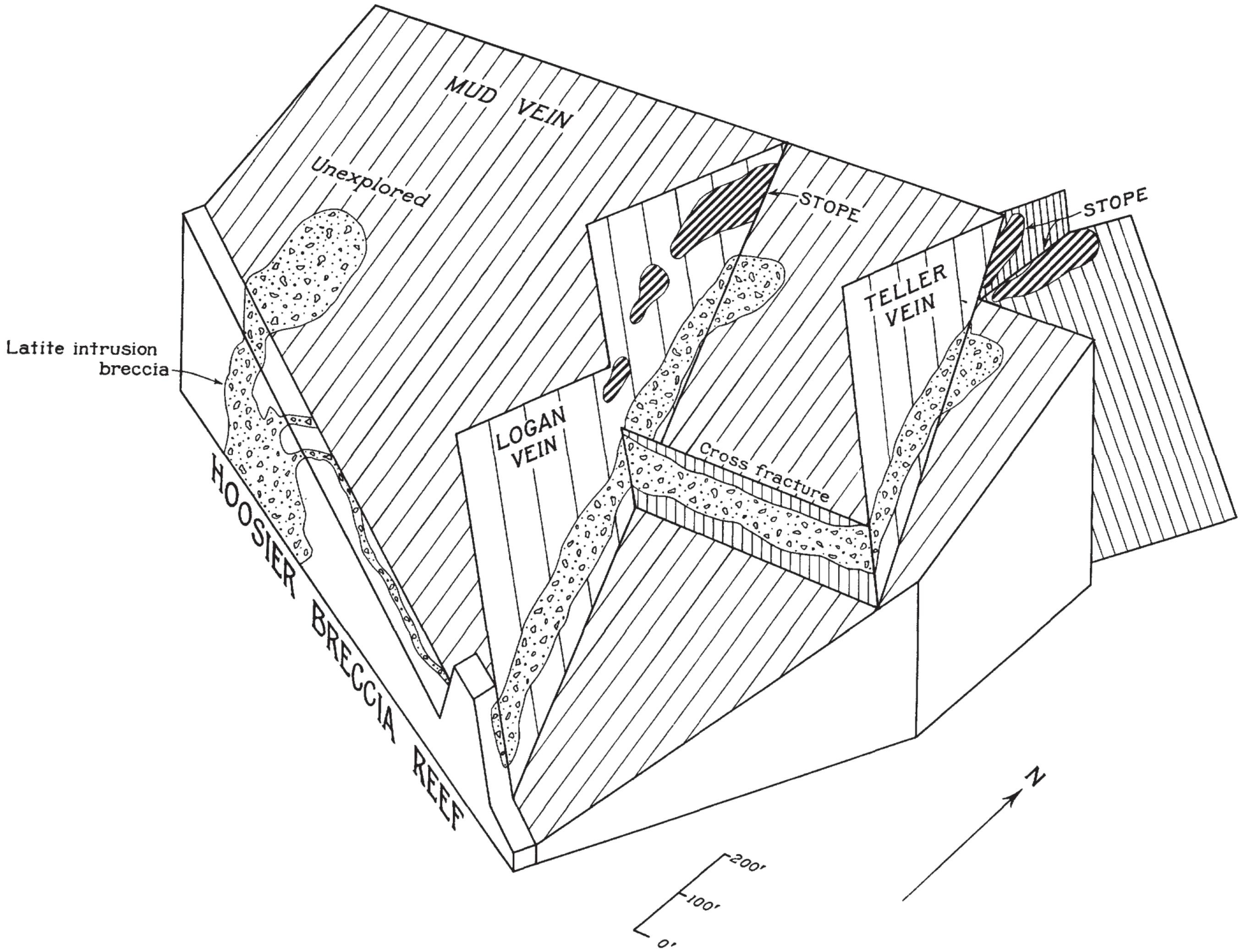
Wilmot ("Bill") Bradley's Geologic Division, like the Topographic Division, reoriented its programs during fiscal year 1950–51 to increase its support of national defense. During the year, the Geologic Division managed about $9,698,000, including nearly $4,074,000 in direct appropriations, or 42 percent, for geologic and mineral-resources surveys and mapping, an increase of almost $1.3 million from the previous year's total. Outside sources supplied another

$5,624,000, or about 58 percent of the Division's funds. Military transfers totaled nearly $994,000, mostly from the Army and the Navy. The AEC shifted to the Division more than $2,946,000, or almost $451,000 more than in fiscal 1949–50. Other civilian Federal agencies transferred a total of some $1,479,000, including nearly $477,000 from the State Department, about $455,000 from the USBR, $279,000 from the DMA, $161,000 from the ECA, and $54,500 from the PAD. For cooperative geologic work, seven States and several counties and municipalities gave about $205,000, a gain of $119,000 from the past year.

To improve the coordination of plans and operations by personnel in the Geologic Division's branches at Denver, Bradley assigned Raymond C. Becker as Staff Geologist at that city's Federal Center. Becker, as geologist in charge and chief administrator at Denver during 1951–62, also guided Building 25's conversion from its munitions-related internal layout to USGS offices and laboratories and coordinated USGS work for the Missouri River Basin interagency program.

Geologists in Olaf Rove's Mineral Deposits Branch during 1950–51 conducted 90 separate studies of more than 30 different mineral commodities in more than 30 States. About three-quarters of the Branch's programmatic work focused on strategic minerals; most of the other projects involved iron, phosphate, potash, and other commodities, which, although not classified as strategic, remained essential to the Nation's continued economic welfare. Vincent McKelvey, Richard P. Sheldon, Earle R. Cressman, Montis Klepper, Roger W. Swanson, and other Branch and AEC geologists explored, sampled, and made tonnage-grade studies, especially in the phosphate fields of Florida, Idaho, and Montana. They also published an analysis of the relation of pebble-phosphate deposits to the Pleistocene shorelines of Florida and Georgia and began investigating phosphate- and uranium-bearing sediments off Florida's west coast. Geologic mapping by Harold James, Carl E. Dutton, and their colleagues in the Iron River-Crystal Falls Range in Michigan's Upper Peninsula led to the discovery of important new iron-ore deposits and new ore-bearing areas. David Gallagher completed his tour as Chief of the Colorado Plateau Project in 1950 and then led a DMA field team in Joplin in Missouri. Richard Fischer and other members of the Colorado Plateau Project[54] and of projects on related work in the West, still funded by the AEC, expanded their reconnaissance surveys for and sampling of uranium and other radioactive materials in carnotite, coals and related carbonaceous rocks, oolites, phosphates, and other deposits in Arizona, Colorado, Idaho, Montana, New Mexico, South Dakota, and Wyoming, while continuing to advise the USBM about drilling operations. Lorin Stieff and Thomas W. Stern completed a report that described new techniques for preparing photographic emulsions used to determine the location and concentration of uranium and other radioactive elements in rock samples by recording their alpha-particle tracks.

Elsewhere in Rove's Branch, Thomas Lovering and Edwin Goddard continued studies of Colorado's Front Range begun in the 1870s by S. Franklin Emmons and carried on by a number of his coworkers and their successors in the USGS. Lovering and Goddard published a comprehensive report on the geology and ore deposits of the Front Range and its more than 30 mining districts. The USGS also issued an earlier study of the beryl- and mica-bearing pegmatites in Idaho and Montana by Walter C. Stoll. For the new DMA, Rove's commodity geologists recommended special programs designed to reduce deficiencies in the supply of 23 strategic and critical minerals. They also processed some 500 of the nearly 800 applications for Government assistance in locating and developing deposits of nearly 50 commodities and completed about 100 field examinations. For the National Security Resources Board, newly revitalized under Stuart Symington's leadership, Branch specialists finished confidential reports of the world's resources of 12 strategic metals and minerals and began similar studies of 34 other mineral commodities.

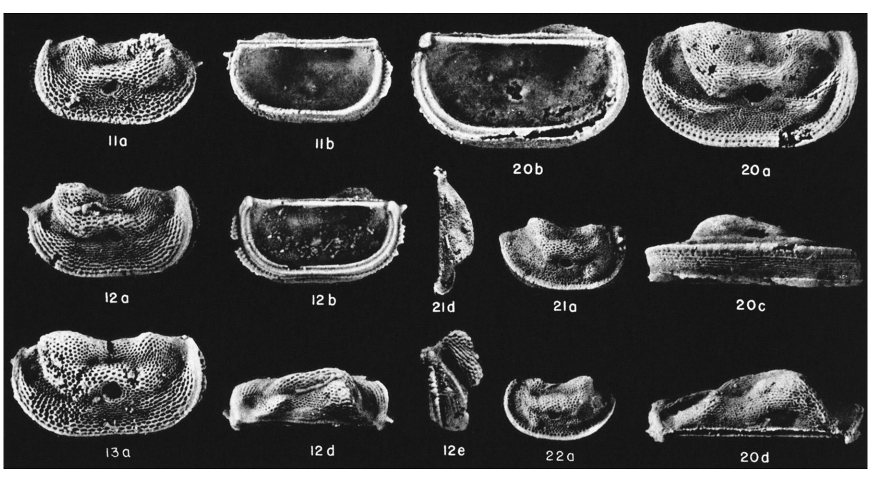


This block diagram shows the relation of potassium-rich and biotitic latite dikes and intrusion breccias to the gold-telluride ore shoots in Colorado's Logan Mine, 1 of 95 mines in the Gold Hill district west of Boulder. Thomas Lovering's and Edwin Goddard's study of the district formed part of their investigations from 1930 of the geology and mineral resources of the Front Range between the Colorado-Wyoming border and Cañon City. They and their USGS colleagues conducted their work "in cooperation with the Colorado Geological Survey Board and the Colorado Metal Mining Fund." The Logan Mine, like most other mines in the district, yielded medium- to high-grade ore taken mostly from gold-telluride fissure veins and lesser amounts of silver from silver-lead veins. The Logan Mine was "well known for its rich free-gold ore," but, unlike most of the district's other mines, the Logan also produced "[m]oderate amounts of tungsten ore" from a shoot north of its "Mud vein near [the] intersection with [its] Hoosier [breccia] reef." Lovering and Goddard assigned the mineralization in the Front Range, except in the Cripple Creek district, to the Laramide orogeny (Late Cretaceous-early Tertiary). (Quotations and diagram from Lovering and Goddard, 1950, p. 7, 238, and 254 and fig. 24; see also Lovering, 1941, and Morris, H.T., 1996.)

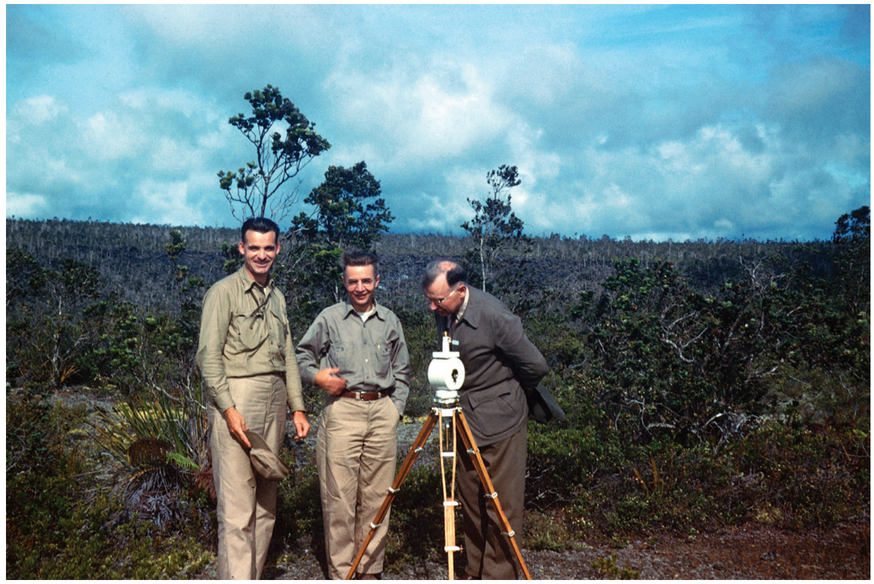
Wrather and Nolan personally reviewed the relations between the Geologic Division's Trace Elements Planning and Coordination Office (TEPCO) and the AEC's exploration group in the Western United States. Their studies included the area around Arizona's Monument Valley, a locale readily identified by the public through images from film director John Ford's westerns since his *Stagecoach* in 1939. Wrather and Nolan worked to resolve problems connected with duplication of assignments and to reach an agreement to divide the geology and exploration functions, return geology to the USGS, and leave development and production with the AEC. Other members of the Geologic Division began similar studies in California after Truman signed, on September 25, 1950, an act that authorized the USGS, the USBM, and the NPS to survey the "area within the revised boundaries of the Joshua Tree National Monument" and to determine and report to Congress by February 1, 1951, about whether the "area is more valuable for minerals than for the National Monument purposes for which it was created."[55]

Carle Dane's Fuels Branch began or continued nearly 60 regional oil and gas investigations, ranging from detailed bed-by-bed mapping of outcrops to using well samples to correlate subsurface sequences, in more than 20 States in fiscal year 1950–51. Branch geologists better determined the extent, depth, and reserves of the richer oil-shale zones of the Green River Formation in northwestern Colorado and in northeastern Utah. Donald C. Duncan and Carl Belser published a map of the distribution, thickness, depth, and estimated reserves of the oil shales in Colorado's eastern Piceance Creek Basin. To guide development of the Scurry and other reef-crest or reef-flank oil fields in the Midland Basin's Horseshoe Atoll, Howard Rothrock, Donald A. Myers, Robert T. Terriere, and other specialists worked, in cooperation with the PAD, the Texas Bureau of Economic Geology, and the USBM, to establish the regional correlation of the basin's Pennsylvanian and Permian rocks. Rothrock's team also began investigating the reefs' biotas, petrography, petrology, sedimentology, stratigraphy, and structure, as well as their petroleum occurrences. To support these efforts, Helen M. Duncan, Mackenzie Gordon, Jr., Donald Myers, Gregory Sohn, Keith A. Yenne, and Ellis L. Yochelson evaluated the reefs' brachiopods, bryozoans, corals, fusulinid foraminifers, gastropods, ostracodes, and other fossils. As part of the continuing and now more urgent task of reappraising the coal resources of the United States, Paul Averitt, Henry L. Berryhill, Jr., Andrew Brown, Donald M. Brown, George V. Cohee, Charles B. Read, Frank D. Spencer, James V.A. Trumbull, Gordon H. Wood, Jr., Alfred D. Zapp, and their colleagues published new detailed estimates of coals in Michigan, New Mexico, and Wyoming. They also continued general and detailed examinations of coal resources in Indiana, Kentucky, Montana, North Dakota, Oklahoma, South Dakota, and Virginia, including coking coals in Indiana, Kentucky, and Montana. Louise R. Berryhill (Henry's wife) and Paul Averitt prepared an overall view of the coking-coal deposits in the West. Core-drilling results and field studies by William J. Mapel, James Schopf, and James R. Gill in the area around Lake DeSmet, northwest of Buffalo in Johnson County, Wyoming, revealed a continuous bed of subbituminous coal about 100 feet thick, under less than 100 feet of overburden, and in an area of about 2.5 square miles.

Geologists in Edwin B. Eckel's Engineering Geology Branch conducted 25 field projects in 14 States during fiscal year 1950–51, paying special attention to the occurrence and causes of landslides. They continued their contributions to Interior's program for developing the Missouri River Basin, still the Branch's principal effort, and to mapping with construction agencies in Arizona, Colorado, Massachusetts, Rhode Island, Washington, and Puerto Rico to provide data on bedrock depth, sources of construction materials, foundation conditions, industrial-plant sites, irrigation suitability, landslide-area stability, and reservoir capacity. To advance national defense, they expanded the Branch's program of mapping larger U.S. cities by continuing work in Portland in Oregon and Knoxville in Tennessee and by investigating locales for underground shelters in San Francisco[56] and alternate sites for bridges across San Francisco Bay. Studies also included research to determine the effect of water-level fluctuation on landslides in the Upper Columbia River Valley, an assessment of sand and gravel resources of NPR–3 around Teapot Dome in Wyoming, and an evaluation of the Rocky Flats plant site near Denver.



These benthic marine ostracodes, representing three species of the new genus *Aurikirkbya*, were collected from an outcrop in the upper part of the Leonard Formation (Permian) in the Glass Mountains in Texas. USGS paleontologist Gregory Sohn's measurements of the frequency distribution of hinge length demonstrated growth series for both valves in 252 specimens of *A. wordensis* (Hamilton). Paleontologists studied these and other fossil ostracodes—tiny freshwater and marine crustaceans recovered from surface samples and well cores—to determine their relative geologic ages, to correlate their enclosing rocks or sediments, and to interpret the environments in which they lived. (From Sohn, 1950, pl. 7, figs. 11a,b; 12a,b,d,e; 13a; 20a,b,c,d; 21a,d; and 22a; all figures originally shown at about × 18.)



Ray Wilcox photographed (from left to right) geologist Gordon Andrew Macdonald (1911–78), geophysicist Henry Rochambeau Joesting (1903–65), and geologist Ruy Herbert Finch (1890–1957) in 1951, as they looked at a USGS magnetometer used in ground surveys of Kilauea Volcano in Hawaii Volcanoes National Park. Macdonald, who joined the USGS in 1939, served as Director of the USGS Hawaiian Volcano Observatory (HVO) in 1951–55, before moving to the Hawaii Institute of Geophysics (see Lockwood, 1980). Joesting worked on Jan Mayen Island northeast of Iceland, and in New Mexico, Venezuela, and Alaska until 1944, before supervising the U.S. Bureau of Mines' geophysical explorations for war minerals and then serving as Chief of the USGS Geophysics Branch (1946–53; see Henderson, R.G., 1965). Finch joined the HVO in 1919 and worked at Lassen Peak during 1926–35. He succeeded the HVO's founder Thomas A. Jaggar when Jaggar retired as Director in 1940. Finch led the HVO until 1951. The USGS magnetometer surveys formed part of a growing number of geophysical, geological, and related scientific investigations aimed at increasing knowledge of the nature and behavior of Kilauea and other Hawaiian volcanoes to enable more accurate predictions of eruptions. (Photograph from the USGS Denver Library Photographic Collection as Wilcox, R.E., wire0529, https://www.sciencebase.gov/catalog/item/51ddd113e4b0f72b44721c71; see also Macdonald, 1958.)

In Charles Hunt's General Geology Branch, 1950–51 brought a major change in the Hawaiian Volcano Observatory's management. As approved by Wrather, Bradley, and Hunt, Gordon Macdonald succeeded retired Ruy Finch, and Chester Wentworth left the Hawaii Sugar Planters Association to join the HVO. Howard Powers, Ray Wilcox, and their younger colleagues at the USGS facility on Adak in the Aleutians continued to map and investigate the Near Islands and Kiska, Little Sitkin, and others in the Rat Islands.[57] In California's Mojave Desert, Foster Hewett, Jerry Olson, Lloyd C. Pray, Daniel R. Shawe, and William N. Sharp completed detailed studies of the Mountain Pass area that outlined potentially mineralized areas of rare-earth deposits. They also discovered the Sulphide Queen carbonate body—with abundant rare-earth elements, principally cesium but also including some thorium, and barium—the largest such deposit yet discovered anywhere. Nelson Darton's 1:500,000 geologic map of South Dakota appeared in 1951, 3 years after his death. Branch geologists also completed some special mapping in Puerto Rico.

Wrather, Bradley, and Henry Joesting reorganized the Geophysics Branch in 1950. They kept James Balsley's Airborne Surveys and also Ground Surveys, where Gordon D. Bath replaced Joel Swartz in January. Aeromagnetic and aeroradioactivity surveys traversed some 43,000 miles in 12 States. Branch scientists used survey results to enlarge the known extent of iron-rich deposits in Minnesota's Vermilion Range, to trace additional buried structures in Michigan's iron areas, and, in conjunction with ground surveys, to extend Maine's known deposits of magnetite and associated manganese and to explore adjacent unmapped areas. The Ground Surveys Section also measured thermal gradients in ice and permafrost in Alaskan drill holes, determined the depths of aquifers, located highway materials, studied buried valley systems, and found areas favorable for lead-zinc and carnotite ores. On August 2, 1950, Wrather's Survey order[58] approved Bradley's shift of Frank Stead's Technical Planning and Development Unit (TPDU) from the Mineral Deposits Branch, where it had been since June 24, 1949, to the Geophysics Branch, as recommended by Joesting, Rove, and Stead. The TPDU, still wholly funded by the AEC but now with long-range functions more suited to the Geophysics Branch, provided Geologic Division field parties with gamma-ray logging units, portable field-survey units, airborne instruments, and other radiometric equipment and aided their use. The TPDU, renamed the Radiation Section, also developed geologic applications of radiometry and bases for interpreting radioactivity data, including some applications beyond those required by the AEC program. The new Radiation Section, still led by Frank Stead, included geologists Kenneth G. Bell and Allen S. Rogers, Henry Faul (a paleontologist turned geophysicist), and physicists Kenneth A. Keisel and Arthur Y. Sakakura. The Branch's mathematical investigations included continuing work on the extension of resistivity tables for the flow of current in multiple-layered ground, methods of interpreting aeromagnetic surveys, and a report (in cooperation with the Naval Ordnance Laboratory) that showed that broad magnetic anomalies might extend to altitudes of 20 miles.

To support efforts on behalf of the DMA during 1950–51, the Alaskan Unit of the Alaskan and Foreign Geology Branch established a small working unit in Juneau. In a partial return to contributions made during World War II, USGS geologists in Alaska investigated strategic and other mineral deposits in the Glacier Bay area, the Haines-Skagway area, the Juneau gold belt, the lower Kuskokwim region, the Prince William Sound copper district, the Seward Peninsula tin area, and the Willow Creek district. They also looked at construction materials near the Alaska Railroad and Alaska Highway, along Cook Inlet, and on Kodiak Island. Farrell F. Barnes and Donald M. Ford studied cores recovered from USBM drilling in the lower Matanuska coal field and evaluated prospects for further development. Branch geologists also extended studies of the Aleutian Range's petroleum potential northward from the area around Iniskin and Chinitna Bays northeast to Tuxedni Bay. Don Miller and his colleagues continued fieldwork in the Yakataga and Katalla areas, and the USGS released a preliminary geologic assessment of the Yakataga oil field.[59]

Planning for the 1950 field season in NPR–4 continued on February 20, when Commodore Greenman, Colonel Kotick, Lewis MacNaughton, Walter English, Director Wrather, and USGS geologists George Gryc, Ralph Miller, and John Reed (Sr.) met as a part of a larger subcommittee and made specific recommendations for work by seven parties and three drilling operations. The Operating Committee, during its 12th regular meeting of April 19–21, approved test wells at South Barrow 4, Topagoruk 1, Meade 1, North Simpson 1, and Umiat (Ruby) 4 to 7 and under Lake Minga (Sinclair Lake) to investigate permafrost there. The Committee decided to defer drilling the East Simpson test well (the former Simpson 2) and suspend work on Oumalik 1, now down to 11,872 feet but with only shows of gas. South Barrow 4 pierced the gas-bearing zones as expected, Meade showed favorable indications of gas, and pumping tests on the Umiat wells showed that oil could be produced successfully from within the permafrost zone by cable-tool rather than rotary drilling; Umiat 4's potential was more than 75 barrels a day. By April, the USGS completed 52 1:96,000 photogeologic maps of quadrangles north of the Brooks Range and a series of 1:250,000 compilations for planning and regional studies, but Gryc and his colleagues agreed to suspend photogeologic work until William A. Fischer completed field studies as aids to interpreting more effectively the air photos. Fischer worked for the USGS in 1942–44, interpreted air photos in the Pacific as a Navy Lieutenant during 1944–46, and then mapped areas in NPR–4 with the Navy Oil Unit and uranium deposits in Western States. In 1950, he began directing the application of photogrammetric instruments and techniques to geologic mapping and related studies, initially of 1:24,000 quadrangles on the Colorado Plateau, by his photogeologists in George Gates' Alaskan Geology Unit. Gryc also reported a shift of the planimetric-map compilations from Denver to the Trimetrogon Unit in Washington, D.C. Greenman, who could not support work outside NPR–4 that did not contribute to that program, said that it would be shut down by the end of 1952 unless significant evidence indicated that a major discovery would be forthcoming or that such a discovery was made before then. In the summer, the Committee established at Fairbanks a joint staff, composed of the local leaders of each agency and organization, to review the program and its activities and advise the Operating Committee.

During the 1950 field season, the USGS Navy Oil Unit sent out seven geologic parties, the largest number yet, only one of which the USGS funded. Edward Sable's Party 1 mapped the Driftwood anticline. William Patton, Jr.'s Party 2 studied stratigraphy and structures in the Siksikpuk-Nanushuk area. William Brosgé's Party 3, supported by Navy helicopters, examined Lisburne Group exposures in the northern Brooks Range. Charles Whittington's Party 4, with "weasel"-tracked vehicles, mapped parts of the Carbon Creek and Ketik anticlines. G. Donald Eberlein's Party 5, also with weasels, looked at foothills in the area of the Killik and Etivluk Rivers and mapped the Aupuk anticline along the Colville. Irvin L. Tailleur's Party 6, also weasel-borne, investigated the structurally complex area between the Etivluk and Kiligwa Rivers. Thomas Dutro, Jr.'s Party 7 boated down the Nimiuktuk and Kugururok Rivers to the Noatak and its mouth. The six geophysical parties, five seismic and one gravimetric, concentrated detailed efforts in areas around Driftwood Creek and the Topagoruk and Meade Rivers and made reconnaissance surveys in the eastern and western parts of NPR–4.

The Operating Committee for NPR–4 met twice more during 1950 but thereafter convened under a new manager. When the Committee held an interim meeting in Fairbanks during September 12–14, Greenman introduced Captain Robert H. Meade, who led Seabee brigades in the Aleutians and the Philippines during World War II, as his new Deputy and prospective replacement as Director of Naval Petroleum and Oil Shale Reserves (DNPR). Greenman approved only minimum drilling to determine the productive limits of the Simpson and Umiat fields, limited geologic and geophysical work to fixing areas for completing drilling before the end of 1952, and forbade shallow drilling outside NPR–4, except possibly on the Gubik anticline. The Committee's 13th regular meeting, the last one chaired by Greenman, was held in Washington during November 27–December 1, 1950. Attendees agreed to drill 10 test wells on anticlinal structures, including one at Gubik to 5,000 feet. They recommended 60- to 90-day production tests at Umiat and four geologic and three geophysical parties for the 1951 season. Greenman's policy statement about NPR–4 on December 22 reported the Navy's approval of the exploration program for calendar 1951 but again cautioned that the work would be terminated in 1952 "unless very favorable results are obtained prior to 1 July 1951."[60] Gryc and William Fischer discussed specific structural features "revealed by the photogeologic work."[61]

Captain Meade, DNPR since December 1950, convened the Operating Committee's 14th regular meeting in Fairbanks on June 18, 1951; Reed again represented Wrather, and the USGS participants also included Gryc, Ralph Miller, and geologist Thomas G. Roberts, head of the city's USGS Arctic Coastal Area Subsurface Investigations' laboratory. Reed announced that Gryc would replace Ralph Miller as head of the USGS Navy Oil Unit when Miller succeeded Carle Dane as Chief of the USGS Fuels Branch in August. Attendees accepted estimates of about 70 million barrels of recoverable oil in the Umiat field, but they projected that a commercially viable pipeline would require 60,000 barrels per day from Umiat, and they knew that such a production rate could only be proved by tests in that field. The number of similar fields required to "justify the operation of NPR 4 as a whole"[62] remained open for discussion. The participants agreed to complete the test wells at Gubik (to 6,000 feet or into the objective sands), Kaolak, and Topagoruk. They recommended continued or new additional drilling near South Barrow and at Knifeblade Ridge, Titaluk, and Umiat. On June 22, Committee members reviewed the direct and byproduct results of the NPR–4 program for visiting Assistant Secretary of the Navy John T. Koehler, who especially noted the value of people learning "to work in the Arctic the year-round."[63] At the 15th regular meeting during November 5–8, the Committee wrote off Cape Simpson as a commercial prospect, reestimated oil reserves at Umiat at 30–100 million barrels, and suggested natural gas reserves at Gubik of about 900 billion cubic feet; the prospects at Umiat and

Gubik were partly tested by drilling in 1951. Committee members reviewed proofs of USGS Oil and Gas Investigations Map OM–126, "Geology of the Arctic Slope of Alaska," on three sheets at 1:1,000,000, by Thomas Payne and his colleagues. For 1952, attendees recommended drilling test wells at Grandstand, Weasel Creek, Wolf Creek, and two other sites; conducting geologic and geophysical fieldwork by three parties each; completing exploration to determine the full oil potential of NPR–4 and adjacent public lands; and continuing the program into 1953 at an additional cost of $8.5 million.[64]

During the 1951 season, the USGS Navy Oil Unit sent four field parties into NPR–4. Party 1's Samuel Keller and Robert Detterman examined the Shaviovik-Sagavanirktok Rivers area. Patton's Party 2, with William Brosgé and Marvin Mangus, studied the Okokmilaga and John Rivers part of the Brooks Range. Irvin Tailleur's Party 3, with Bion H. Kent and Hillard N. Reiser, worked south from the Colville River to the south side of the De Long Mountains. Sable's Party 4, with Thomas Dutro and Robert H. Morris, examined Driftwood Creek, the Colville's headwaters, and the Nuka River. The single geophysical party completed closure on the Gubik anticline. The USGS, by year's end and with William Fischer's direction, produced nearly full photogeologic coverage of NPR–4 at 1:96,000 and completed half of similar compilations at 1:250,000. By then, the USGS also finished 1:48,000 base maps for all of NPR–4.

Members of the Foreign Geology Unit continued studies in both hemispheres during fiscal year 1950–51. As part of USGS work in Latin America, John Dorr 2d, Philip Guild, Joel Pomerene, and Arthur Rynearson carried on their studies of iron, manganese, and other mineral resources of Minas Gerais in Brazil. Support for their efforts came from the State Department's Technical Cooperation Administration[65] (TCA) and the geologists of Brazil's Departamento Nacional da Produção Mineral. Dorr and his colleagues also helped to train additional Brazilian geologists and improve that country's facilities for exploration and research. USGS and Peruvian geologists examined the copper-lead-zinc deposits of Hualgayoc; they also observed the results of the May 1950 earthquake at Cusco. Harold Bannerman and William Johnston published USGS policy for training foreign geologists, and members of the unit advanced the in-service skills and experience of 19 young technicians from Brazil, the Dominican Republic, India, Mexico, and Pakistan.

In the Eastern Hemisphere, USGS scientists completed, continued, began, or planned investigations in Afghanistan, India, the Philippines, South Korea, and Thailand. On March 24, 1951, William Johnston returned from India, where he represented the Truman administration, Wrather and the USGS, and the Geological Society of America at the centenary of the Geological Survey of India (GSI) in New Delhi. While there, Johnston conferred with representatives of India's government and industry about Point Four geological projects in Orissa (Odisha) and elsewhere in the country, including the future detail of a geophysicist and an engineering geologist from the USGS. Johnston participated in the Indian Science Congress in Bangalore, in meetings at Lahore in Pakistan of the U.N. Economic Committee for Asia and the Far East, and in other conferences elsewhere in India and Pakistan. He also looked at the mining in India of coal at Bermo, iron at Naomundi, manganese at Nagpur, and mica at Koderma. In January 1951, George C. Taylor, Jr., also began investigating Orissa's groundwater resources. Geologist John A. Straczek, who led USGS field parties in Cuba and Peru during 1943–45 and 1947, now worked in India and continued earlier efforts by Dorr and other USGS geologists on the cooperative Point Four manganese project in Orissa. Unit members also completed, in cooperation with the Royal Department of Mines, a reconnaissance of Afghanistan's mineral deposits. David Andrews, Raymond Robeck, and David Vine returned to South Korea in September 1950 to complete field studies for their coal and mineral investigations sponsored by the Economic Cooperation Administration, finished their final reports, and then shifted in January 1951 to work on the military geology of Korea. In July 1950, Ronald K. Sorem began aiding Earl Irving's ongoing investigations, in cooperation with the Philippine Bureau of Mines, of manganese deposits on the islands of Busuanga and Siquijor and other mineral resources in the Philippines. On November 7, Ceylon (Sri Lanka) signed an agreement to accept geologic and other aid under the Point Four Program. India and Pakistan signed a mutual full-trade pact on February 24, 1951. Andrews left Korea to study, during March–June 1951, Thailand's lignite deposits and to advise the Thai Government about their development and utilization.

When Glen Brown returned to work in Saudi Arabia in 1950, he encountered the changed relationships between Middle Eastern governments and Western oil companies later described by Daniel Yergin. Kuwait, with estimated reserves of 4 billion barrels, joined Saudi Arabia, with its 3 billion barrels of reserves, in 1946 in exporting oil. In 1947, Ashland, Phillips, and Sinclair formed the Independent American Oil Company to gain a concession in Kuwait's part of the Neutral Zone it shared with Saudi Arabia. J. Paul Getty's geologist[66] and Sheik Abdullah Suleiman al-Hamdan, still Ibn Saud's Finance Minister, signed a concession, at a higher price per barrel, in 1948 for the Saudi portion of the Neutral Zone. By 1950, oil from Middle East sources provided 17 percent of the world's total supply, including the amounts used by Europe, which increasingly consumed Middle East oil rather than its own coal, as promoted by the Marshall Plan. The Trans-Arabian Pipeline, completed by International Bechtel in September 1950, began delivering oil at Lebanon's port of Sidon (Saïda) in November. On December 31, Sheik al-Hamdan secured from Aramco a 50:50 split in oil revenues, the same agreement Venezuela gained from Standard of New Jersey and Royal Dutch/Shell in 1943.

In 1949, as Saudi oil exports continued to grow, Ibn Saud had asked the U.S. Minister in Jiddah for renewed American help in evaluating the mineral resources and water supplies of parts of the Kingdom outside the Aramco concessions. The King specifically requested that Glen Brown be assigned to lead the reconnaissance geologic mapping and related work, promising that his government would pay all costs and that Sheik al-Hamdan would sponsor and direct the effort. Brown had just completed for the Military Geology Branch a chromolithographic geologic map of Saudi Arabia, at 1:4,500,000, as the initial product of the MGB's "Basic Map Compilations" that included data gathered from the best available sources for use in planning for terrain studies. USGS geologist George R. Rozanski finished a hydrologic map of Egypt, at 1:2,000,000, as the initial one in the series. When the State and Interior Departments concurred in Brown's new assignment for 1950, arrangements were made with International Bechtel for housing, an office and storage space, vehicle maintenance, and other support. Brown immediately asked the Geologic Division to add Roy O. Jackson, a geologist and photogrammetrist, to the new project. Captain Jackson initially encountered Brown at Kharj in April 1945, while Jackson established a geodetic net to control the trimetrogon air photo strip his U.S. Army Air Forces (USAAF) squadron flew across the Arabian Peninsula. Jackson, working from the U.S. Mission at Ta'if in the Hijaz, also had met Bramkamp, Steineke, and other Aramco geologists, U.S. consul Parker Hart, and several Saudi officials.

American and British military maps proved inadequate for geologic compilation, so Brown and Jackson planned traverses and compiled data on test prints of the new air photos taken by the crew of Aero Service Corporation's modified B–17 as part of high-altitude, 1:60,000 photography of most of Asir Province and the coastal plain between Asir Province and the Red Sea. Brown planned to begin systematic mapping in Asir, north of the Kingdom's border with Yemen, fix geodetic positions there by astronomical observations, and measure elevations with barometers and Wild T–2 theodolites. After Aero Service finished the initial work in Asir, it gained photographic coverage aimed at producing controlled mosaics, at 1:100,000, for compiling geographic and geologic data. Brown and Jackson used the summer of 1950 to organize and conduct a preliminary reconnaissance of the Jiddah area. They began more detailed fieldwork late that year in Asir and then gained the help of Sharif Kasem and Hisham Farouk, two young Saudi geologists in training, as field assistants for mapping in Asir. In 1951, the TCA and the U.S. Ambassador agreed to the establishment of a Point Four Mission in Saudi Arabia. Brown chaired the new Mission's Natural Resources Division, and Jackson served as his geologist. They planned to spend most of the next 2 years mapping the igneous and metamorphic rocks of the Arabian Shield and the sedimentary sequences of the Red Sea coast and planning for and drilling water wells. Brown, now also an informal adviser to the Saudi Minister of Agriculture and Water, helped to plan water-resources development in the major cities and groundwater irrigation in additional oases. In 1951, Brown's and Jackson's studies east of Riyadh led to test wells that discovered water in a Pleistocene channel under Wadi Hanifah, between Riyadh and Kharj. Similar investigations and drilling in Wadi Khulays, northeast of Jiddah, disclosed water in a sedimentary basin that produced sufficient supplies into the 1970s, when desalinization plants replaced these sources. Minister al-Hamdan then asked the USGS for a surface-water hydrologist to evaluate stream runoff in Asir and in the Red Sea littoral, assess groundwater recharge in the Riyadh area, and conduct related studies.

Frank Whitmore's Military Geology Branch, with continued financial and other support from the Army Engineers, and its Intelligence Division's Colonel Julian D. Abel, expanded its staff and operations to meet the needs of U.S. armed forces in Korea and elsewhere. Fritiof Fryxell took another leave of absence from Augustana College to return to the MGB for a year's service as its Assistant Chief. For the Natural Resources Section in Tokyo, MGB personnel continued in 1950–51 to supply special reports on terrain analysis and mineral and other natural resources. These reports included Charles Park's views on the potential of Japanese iron and manganese ores and assessments by others of the country's platinum-group metals, coal fields, fire clays, gold and silver deposits and mines, ore beneficiation, bentonite and bleaching clays, and the control and utilization of its rivers. Maurice L. Brashears, Jr., in evaluating Japan's groundwater, recommended institution-based investigations to remedy the harmful effects of overuse (particularly in the Nagoya, Osaka, and Tokyo areas), secure aquifer recharge, end surface-water wastage, and improve technology, operations, and management. Other specialists assessed coal fields in northern Honshu, Hokkaido's coals and terrain, and rock-phosphate resources in the Ryukyus; compiled routes and methods of evacuation in Korea; assessed the rehabilitation of Korean highway and railroad tunnels; looked at the sources of iron ore in Asia; and examined soils and cross-country movement in the Trans-Urals. Harold Burke completed evaluating Tinian's groundwater, while the rest of the Pacific Geologic Mapping Program's team prepared to extend their work to Guam, whose administration passed from the Navy to the Interior Department on August 1, 1950.

Members of the MGB also completed additional special reports abroad and at home. Branch specialists completed a 38-sheet, 1:250,000 terrain analysis of Korea and prepared studies, at 1:50,000 and 1:250,000, of the Chungju, Inchon, Seoul, and Taejon areas. Helen L. Foster assessed subsurface conditions at Pusan, Taegu, and Kimpo Airfield. Her colleagues also finished large-scale topographic maps of more of Korea's coal fields, prepared engineer-intelligence studies of Taiwan and its mineral resources, and evaluated the mineral resources of central Sumatra. Frank Reeves assessed Borneo's oil resources for the Interior Department, Maxim Elias identified for the Army Engineers sites in Turkey suitable for seismic arrays, and newly hired Cornelia C. Cameron mapped for the Navy Hydrographic Office the geology and terrain of the area around the port of Vólos in northern Greece. In Europe, MGB members analyzed England's Norfolk County for cross-country movement and suitable airfield sites. In the United States, they finished studies of trafficability at the Army center at Big Delta, Alaska. William Davies and Selma Moses (who in 1951 married USGS geologist Lawrence D. Bonham) assessed military terrain near Pittsburgh, Philadelphia, Baltimore, and Norfolk. Their colleagues also classified Upper Kuskokwim lands in Alaska for the Conservation Division, investigated the geology of Alaska's Chena area for the Soil Conservation Service, and assessed ferrous and nonferrous resources in the 6th Army area in the West Coast States. Whitmore reemphasized the importance of using geological information in constructing military highways.

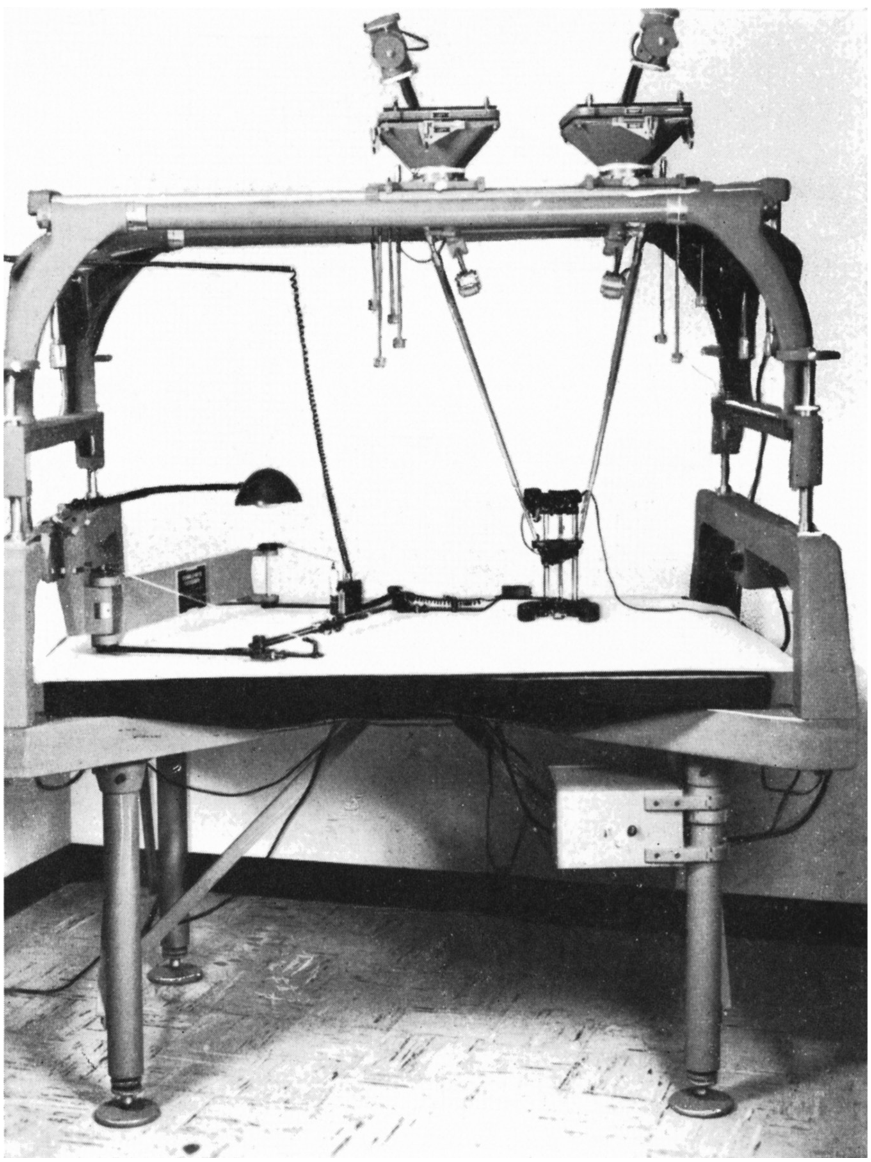
Gerald FitzGerald's Topographic Division drew on about $13,186,000 to support its surveys and mapping during fiscal year 1950–51, an increase of some $2.25 million over the previous year. Direct appropriations provided $7,521,000, or about 57 percent of all the funds received by the Division. The USBR continued as the chief contributor among the cooperating Federal agencies by increasing its funding by $453,000 to a total of $2.8 million, and the Army returned to making significant transfers by supplying $618,000, only $6,000 less than the sum provided by the Air Force. To these amounts, the Bureau of Public Roads and other Federal agencies added nearly $307,000, and States, counties, and municipalities transferred slightly more than $1,248,000, a decrease of some $55,000. Division managers decided to direct mapping operations during the next 6 years largely toward fulfilling the urgent requirements of the defense program, but, after reaching the maximum effort in the third year, they expected to give more attention to requirements for nonmilitary maps. In another long-range assessment, the Division appraised and classified almost 12,000 topographic maps prepared by other agencies and sold or distributed by the USGS through the end of calendar 1950. This review demonstrated that only about 25 percent of the country was adequately mapped to supply the current general needs of the expanding economy.

During 1950–51, USGS topographers mapped in some 3,700 quadrangles in all 48 States, and in cooperation with 26 of them, the District of Columbia, and Alaska, Hawaii, and Puerto Rico. When the fiscal year began, the Topographic Division continued to emphasize large-scale mapping of both militarily and economically important areas, but the Army Engineers in November 1950 provided funds for reorienting and expanding the Division's program to complete by 1957 the coverage of about 60,000 square miles of strategic areas in the conterminous United States and in the Alaska Territory. The Division began field revising its map coverage of the Hawaii Territory and accelerated all of its mapping in Alaska, where helicopters supported four field parties on the Alaska Railroad and the Richardson Highway. The Division adjusted work at its compilation and map-finishing facilities in the West to complete large-scale maps covering 30,000 square miles in Alaska and advance the 1:250,000-scale series more than 1 year ahead of schedule, while continuing the 1:63,360 mapping in the Territory's strategic heartland and high-priority coverage of parts of central and southwestern Alaska considered essential for the Alaska's economic development. Division topographers also completed about 61,000 square miles of new and revised mapping in the 48 States, nearly 2,000 of which were in the Kentucky 1:24,000 project, but coverage at 1:62,500 still formed the major part of the work. Mapping continued on 75,000 square miles of the Missouri River Basin. Work under contract, now authorized by statute, provided complete air-photo coverage of Puerto Rico as a basis for topographic and geologic maps of that island.

Photolithographic reproduction now formed nearly 94 percent of the published maps as the Topographic Division phased out copperplate engraving in favor of color-separation drafting on metal-mounted paper or other scale-stable media in preparing maps for reproduction that led to a tenfold increase in map products compared to the output in the years before World War II. The Division's Trimetrogon Section completed some 925,000 square miles of charting for the Air Force.

In other programs, the Division finished relief shading on 25 maps, including those of Chattanooga, Tennessee, the Great Smoky Mountains, and the Gunnison River-Black Canyon National Monument (now Black Canyon of the Gunnison National Park) in Colorado, as part of providing shaded-relief maps of areas of special physiographic interest. For the 1:1,000,000 International Map of the World, the Division published three additional sheets—Austin ([N]H–14), Cascade Range ([N]L–10), and Mississippi Delta ([N]H–15)—and continued work on Los Angeles ([N]I–11) and Savannah ([N]I–17) but suspended the preparation of additional sheets. The Division also issued 38 new sheets of the 1:250,000-scale transportation map of the United States—8 in Alabama, 9 in Louisiana, 15 in Nevada, and 6 in Ohio—while continuing to prepare sheets in 6 other States. On December 22, 1950, Wrather's Survey order[67] abolished the Map Reproduction Branch's Photographic Library and transferred its function, funds, collection, facilities, and staff from the Topographic Division to the Library in the Geologic Division, which had contributed 90 percent of the collection and wholly funded it since 1948.

Research and development by Topographic Division engineers in 1950–51, when James Buckmaster began serving as Acting Chief of the new Instrument



Photogrammetrists Harry Kelsh and Russell Bean and Bean's USGS research team combined to redesign Kelsh's 1943 stereoplotter after Kelsh transferred from the Department of Agriculture's Soil Conservation Service (now the Natural Resources Conservation Service) to the USGS in 1948. Their new modifications incorporated the use of wide-angle photography and eliminated the lamp houses that illuminated the full-sized diapositive area but also produced high heat. They devised compact and movable light sources to illuminate successive parts of the diapositive and a cam to adjust principal distance to correct camera-lens distortion. In 1951, the Trimetrogon Section modified a Kelsh plotter for use with trimetrogon photographs. Bean's team continued to improve the patented Kelsh plotter and it was widely used by the USGS and by industry during the 1950s and 1960s. (From Ray, 1956, fig. 12.)

Design Section, involved new methods using trimetrogon aerial photography to determine their accuracy and cost in compiling the 1:250,000 series and other standard maps. Another experiment prepared and tested photomosaics as plane-table compilation sheets in topographic field surveys. Division engineers also redesigned the Wilson alidade for additional use with glass plates, tested the rigidity of tripods for survey instruments, and studied the effect of the sun's radiation on precise levels. In Alaska, members of the Division experimented with extending vertical control inward from shorelines, and a contract airborne survey of about 78,000 square miles in the central part of the Territory tested the feasibility of obtaining ground elevations for topographic mapping by using the electronic Airborne Profile Recorder. Topographers in California, aided by portable radio-telephones used to synchronize observations, employed a direct-measurement electronic method similar to shoran while measuring horizontal angles to determine elevation points for supplemental control. Russell Bean and his research team refined the Twinplex system and its ellipsoidal reflector-55 (ER–55) projectors. The Twinplex, a compact, efficient, and versatile instrument also known as Bausch and Lomb's "Balplex," replaced the Multiplex units. In October 1950, the Division's Photogrammetry Section at Arlington began developing the Orthophotoscope,[68] in conjunction with Kelsh and ER–55 double-projection plotters, to convert conventional-perspective photographs to the equivalent of orthographic photos. The conversion eliminated image displacement due to camera tilt or ground relief and enabled accurate measurements of horizontal distances on the uniform-scale orthophotos.

Interest in the conservation and development of natural resources by the Truman administration and the 81st Congress produced legislation by November 1950. Congressional hearings in 1949 led to bills introduced to provide an accelerated mapping program and a comprehensive program for basic data about water. Both bills were reported out favorably by House committees in July 1950, but they died on the House floor, overwhelmed by the rush of defense-oriented legislation. In November, the House issued "A Program to Strengthen the Scientific Foundation in Natural Resources"[69] to supplement the records of the hearings. The report criticized the slow completion rate of national mapping and proposed a new program to finish the topographic mapping in 20 years and geologic coverage in 30 years. The proposed topographic mapping program would cost about $25 million annually, rising gradually from $18 million in fiscal year 1950–51 to $25 million in each of the fiscal years between 1953–54 and 1969–70. The geologic mapping effort would need $7 million in fiscal 1950–51 and would increase to $24 million in each of the years between 1956 and 1980. If Congress and the President continued appropriations only at the 1949 level, it would take 53 years to complete the topographic mapping and 158 years to finish the geologic coverage. The report included supporting programs for cadastral and control surveys, charting offshore areas, and mapping soils. It also proposed for the USGS a 20-year program, costing $50 million, to map federally owned parts of the Continental Shelf.

The House's report also labeled as inadequate and fragmentary the nature of Federal investigations of the Nation's water resources and noted six principal problems. First, no satisfactory determination had yet been made of the overall quantities of precipitation in each catchment area or drainage basin. Second, available precipitation records had not yet been used to determine volumes of water that could serve as a starting point for systematic accounting of water resources. Third, measurements of stream runoff were restricted principally to the larger rivers and streams. Fourth, measurements, or even identification, of the location and character of subsurface water movements remained almost completely lacking. Fifth, evapotranspiration continued to be the area of greatest deficiency in accumulated data and research. Sixth, the executive branch had failed to coordinate the efforts of its agencies engaged in measuring and investigating the various features of the hydrologic cycle and had not delegated responsibility for appraising and interpreting the measurements and other hydrologic facts collected. At present, the report noted, the USGS program of groundwater studies was almost completely tied to projects for which funds from States, counties, and municipalities were available on a matching basis. This arrangement left few, if any, monies for groundwater research before the planning stages of the extensive water-resource projects financed by the Federal Government. The work of the basic-data-gathering agencies, the report continued, was so completely absorbed in recording the measurements and publishing the raw data that they could pay comparatively little attention to appraisals and interpretations by the experts who knew most of the limitations and possibilities of the data they collected. Especially important, the report urged, was keeping those basic-data agencies free from bias or influence. It was also vital that they have the responsibility to provide dependable interpretations of the quantity, quality, and availability of the Nation's water resources.

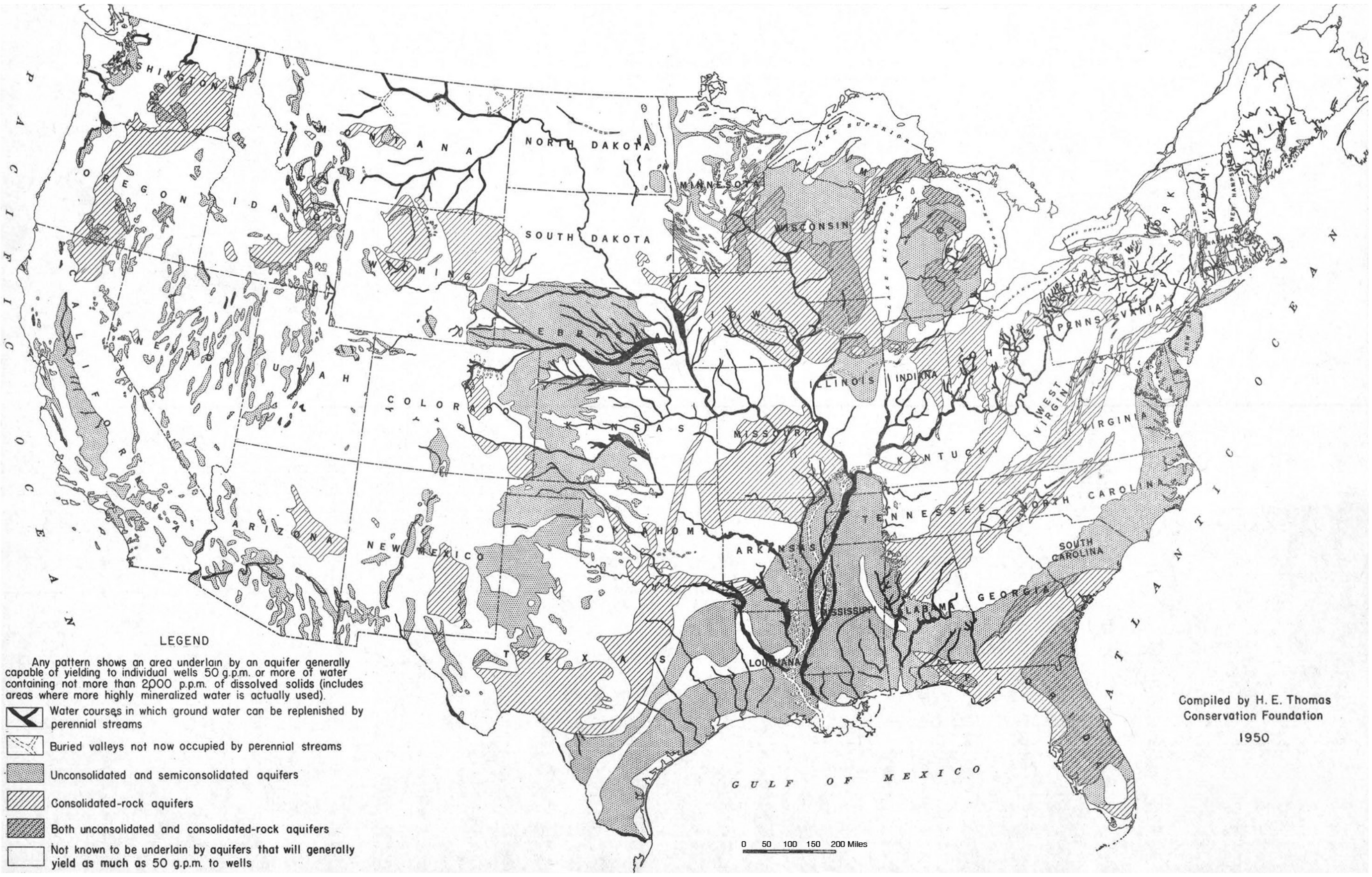
On December 11, 1950, the President's Water Resources Policy Commission issued Volume 1 of its report on "A Water Policy for the American People." Echoing John Powell and his like-minded successors, Morris Cooke and the other Commissioners concluded that the river basin should be the fundamental unit for comprehensive planning in water and related land-use issues. Their recommendations included those for program planning, evaluating proposed water-resources developments, gathering basic data, financing, designing reimbursement procedures for recovering a portion of the benefits resulting from public expenditures, managing water resources, reclaiming lands, ensuring water supplies, tracing sources of pollution, facilitating transportation on waterways, securing and expanding hydroelectric power, preserving and enhancing fish and wildlife resources, and recognizing and expanding recreational potentialities. Water-resources investment should aim at achieving "the maximum sustained use of lakes, rivers, and their associated land and ground water resources to support a continuing high level of prosperity throughout the country." Congress should establish national objectives including "the safeguarding of our resources against deterioration from soil erosion, wasteful forest practices, and floods; the improvement and higher utilization of these resources to support an expanding economy and national security; assistance to regional development; expansion of all types of recreational opportunity to meet increasing needs; protection of public health; and opportunity for greater use of transportation and electric power."[70] If the reorganization of the field of natural resources were not carried out according to the Hoover Commission's recommendations, the Cooke Commission suggested that Congress set up separate river-basin commissions for each of the major basins not yet so covered, with independent chairmen appointed by the President, to coordinate the surveys, construction, and operations therein of the Federal agencies. Volume 3 of the Cooke Commission's report, transmitted on February 5, 1951, treated water-resources law.[71] Volume 2, following on February 19, examined the possible effects of the proposed policies on California's Central Valley and on nine other river basins—the Alabama-Coosa, the Colorado, the Columbia, the Connecticut, the Missouri, the Ohio, the Potomac, the Rio Grande, and the Tennessee.[72]

The Water Resources Policy Commissioners remained clear about the need for basic data in water-resources studies. Congress should provide ample funds, they recommended, for compiling and analyzing the necessary basic information, including climatic, economic, geologic, hydrologic, land, and soil data, to assure sound and comprehensive, multiple-purpose basin planning. All basin recommendations should carry a precise statement as to the adequacy of the data upon which they were based, and managers should be prepared to withhold approval of recommendations in areas with inadequate data. "A survey program designed to supply the country with full geological and hydrological knowledge of its surface and groundwater resources,"[73] the Commissioners urged, should be initiated immediately, with ample funding for the early compilation of essential information and continued thereafter to meet all the requirements of basin programs. A comprehensive annual program of all water used and requirements in relation to available sources of supply should be prepared and reported for regions and localities on a basis permitting 10- and 20-year running forecasts of requirements and supply. A survey also should be undertaken to evaluate the possibilities of and provide a program for developing the water now being consumed in the West by cottonwoods and other allegedly unneeded and water-loving plants whose roots tapped the water table or the capillary fringe above it. The Commissioners also recommended setting a 10-year interval within which "a reasonable program for cleaning up the Nation's polluted waters"[74] could be accomplished, appropriating sufficient funds for administrative and regulatory activities of the Public Health Service's Division of Water Pollution Control, and making available ample funds for Federal loans to municipalities.

The Commissioners predicted dire times ahead for the Nation's water resources unless Congress and the President acted promptly to solve current and projected problems. They asked the Federal Government to "recognize that, with growth of population, urban concentration, industrialization, and the need for an expanding agricultural base, availability of fresh water may soon become a limiting factor in the expansion not only of the Nation's arid and semiarid regions but also of our entire civilization." The Government, they urged, "should, therefore, accept the responsibility for large investment in broad research programs designed to expand the available supplies of water."[75] The Commissioners recommended that the policies they offered be incorporated in a single statute. Truman endorsed their report on March 14, 1951, and asked the Budget Bureau to review and suggest legislation; no general bill followed but many of their proposals were adopted in other ways.

The Water Resources Division during fiscal year 1950–51 shifted the emphases of many parts of its program to meet defense needs more effectively. Carl Paulsen's Division amassed nearly $11,503,000 to support salaries and operations during fiscal 1950–51, an increase of $1.8 million, or almost 19 percent more than the total available in 1949–50. Of this sum, direct appropriations provided $5,156,000, a $1.2 million increase. About $6,347,000, or 55 percent, came from outside sources. States, counties, and municipalities supplied more than $3,065,000, nearly $296,000 more than the previous year. The USBR, as before, led the Federal agencies in transferring funds of about $1,469,000, an increase of $78,000. The Army shifted $885,000, the Navy raised its total from $1,200 to nearly $48,000, and the Air Force resumed its contribution with about $13,000. The BIA transferred more than $106,000, an increase of $61,000 from the previous year. The AEC, the State Department, and the Tennessee Valley Authority (TVA) all reduced their funding, but only by a total of $37,000. Increased or new transfers of $108,000 from the Bonneville Power Administration, the ECA, and other Federal agencies more than made up those losses. The direct appropriation for soil and moisture conservation rose by more than $5,000 to $40,500.

Demands on the Water Resources Division for basic streamflow data continued to increase, and other domestic issues also continued to command the Division's attention. The floods of January 11–25, 1951, covered 1 million acres of the Missouri River Basin and caused $1 billion in damage; lands in Illinois, Kansas, Missouri, and Oklahoma were especially hard hit. The Surface Water Branch added about 100 gaging stations during the year to raise its total in operation to more than 6,300 sites, 52 of them in Alaska, observed by workers based at some 150 field offices and in cooperation with more than 170 Federal, State, and local agencies. The Branch introduced a new current meter for use under ice and the B–50 reel that automatically computed the meter setting. The Branch began compiling, from annual reports in USGS Water-Supply Papers, all U.S. monthly and annual records



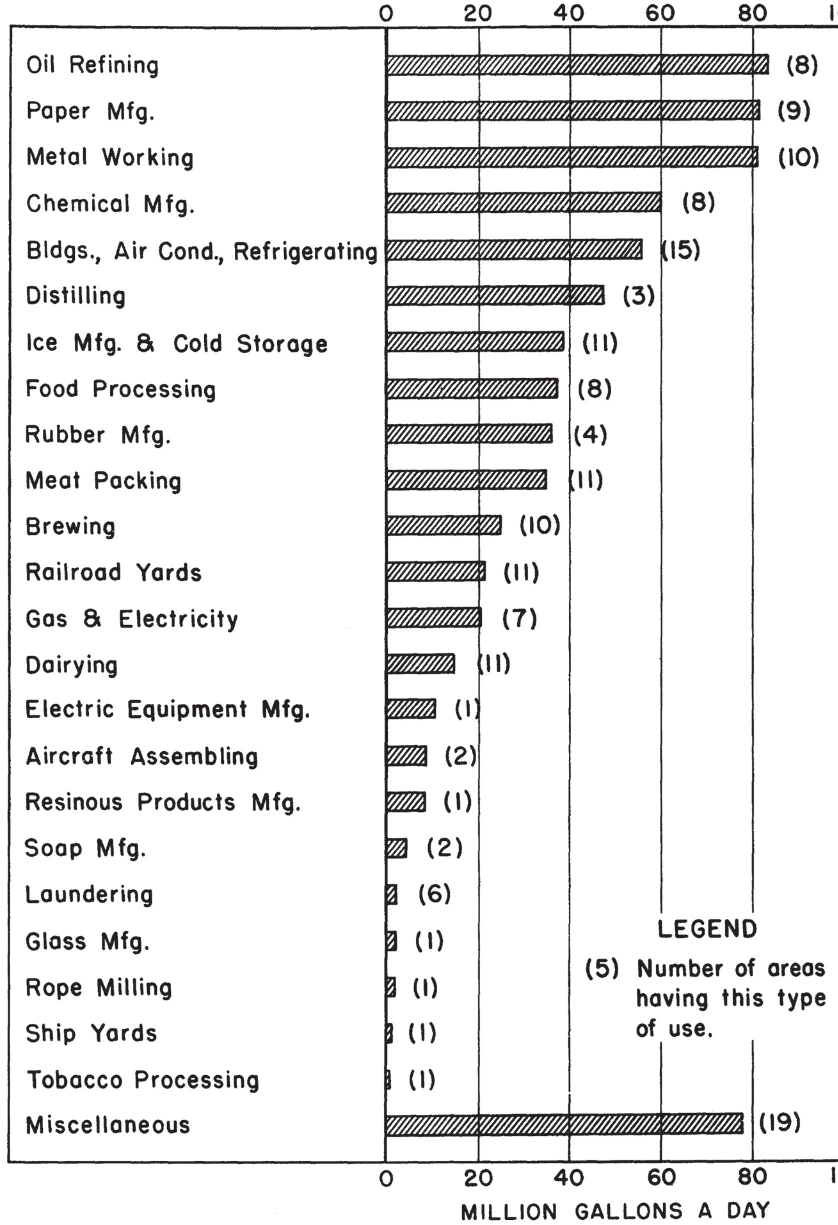
This map (originally at 1 inch = 300 miles) shows U.S. areas underlain by aquifers "generally capable of yielding to individual wells 50 g.p.m. [gallons per minute] or more of water containing not more than 2,000 p.p.m. [parts per million] of dissolved solids." Harold Thomas compiled this map in 1950 from data supplied by the USGS, other Federal agencies, and State agencies. Thomas' map shows several types of aquifers and more detail than Oscar Meinzer's 1939 map of four principal groundwater regions and their subordinate provinces (see Rabbitt, M.C., 1986, p. 401). In postwar years, the USGS continued its comprehensive studies of U.S. aquifers and the perennial streams that replenished them to supply the growing needs of industrial, municipal, and rural users. (Quotation and Thomas' map from McGuinness, 1951, fig. 17; see also Thomas, 1951.)

of streamflow during 1888–1950. Walter Langbein and Ethel M. Wilson (later Coffay) determined that up to September 30, 1946, the USGS collected some 95,000 stream-year records and 63 percent of the gaging stations established by the agency still were operating. Information about streamflow characteristics remained one of the important criteria in selecting several sites for new atomic-energy plants.

The Division's report on the estimated use of water in the United States during 1950 showed that withdrawals from streams, lakes, and underground occurrences totaled about 170 billion gallons each day, exclusive of the 89 million acre-feet of water used in developing power, or about 145 gallons per person per day. Industrial use averaged 77 billion gallons each day from private sources, including some brackish water. Rural domestic and stock supply consumed on average another 3.6 billion gallons per day. The Federal Government used the Division's water data in determining what supplies to provide from the public domain for watering stock. New supplies of water from wells, springs, or ponds, developed from exploration by the Division, at the request of the BLM or other agencies in charge, brought tens of thousands of acres into use for grazing. In many other areas, these data helped to improve old and uncertain supplies. The more evenly distributed use of water on public lands increased its value by diffusing concentrations of grazing and thereby reducing erosion. Division studies led to a better understanding of the effects of rainfall, vegetation, soil properties, and land use on rates of erosion and sedimentation to prevent further destruction of productive valleys devastated or being destroyed by systems of large gullies that impaired the land for grazing and irrigation, and also drained shallow groundwater and carried sediments into rivers that emptied into reservoirs.

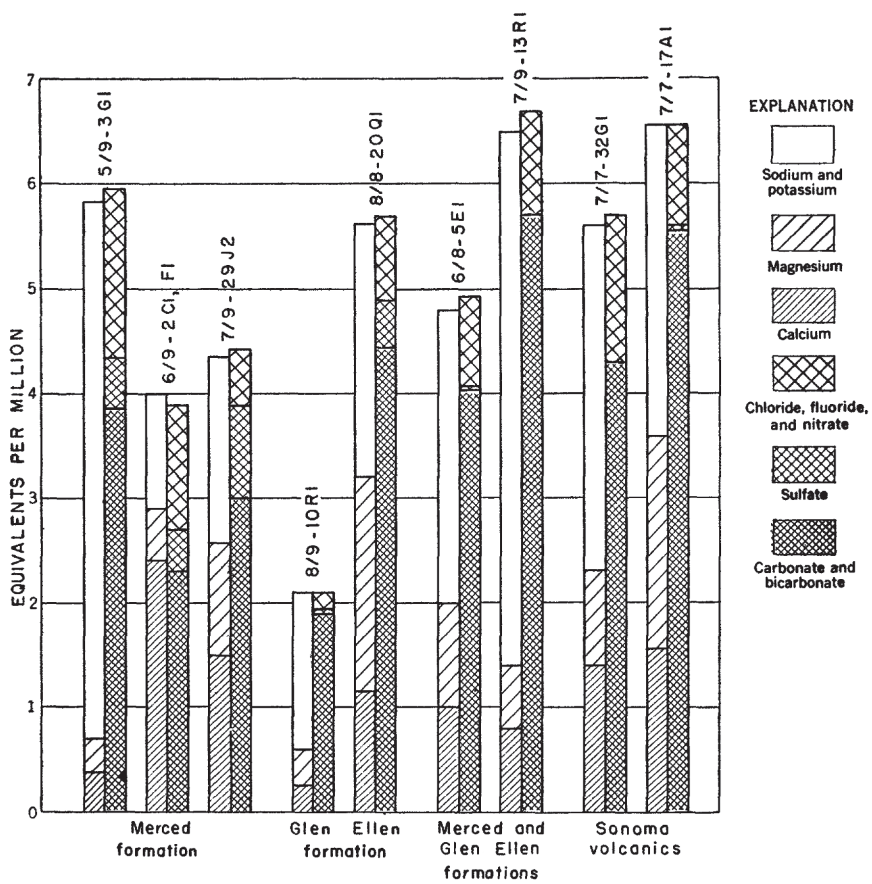
The development of U.S. groundwater resources accelerated during 1950–51. As in World War II, the proportion of groundwater studies related to

This chart shows the use of groundwater in millions of gallons a day (mgd) by industries in 20 selected metropolitan areas in the United States during 1945, not including water from municipal suppliers. The numbers in parentheses represent the areas that include oil refining (8) and the other industrial users. Accompanying maps showed the amounts of groundwater used each day for irrigation and consumed by industries and municipalities during 1945. California used more than 2,000 mgd for irrigation and slightly less than 500 mgd for municipalities. Industries in New Jersey used 500 mgd; those in Indiana and Ohio, only slightly lesser amounts. Texas, at about 100 mgd, led rural use in ways other than for irrigation. California led the Nation in the total use of groundwater, followed by Arizona and then Texas. (From McGuinness, 1951, fig. 16.)



national-defense activities increased at the expense of the other investigations underway. Most of the new defense-related studies, as before, also provided data expected to be useful in future projects, and many of them involved expanded research that yielded improved techniques applicable to groundwater problems of all types. Among them, hydraulic engineers adapted sonic methods of measuring depths to determine the thickness of earth materials and rock sequences. Groundwater personnel improved their equipment by developing for truck-mounting a set of compact and light-weight electrical well-logging instruments, adapting a sensitive electrical temperature-measuring instrument to show the direction and velocity of water movement in drilled wells, and developing an electrical tape gage that replaced batteries with an electrical current completed between dissimilar metals when the electrode contacted the water.

Studies by the Ground Water Branch involved cooperation with nearly 100 Federal, State, and local agencies. Harold Thomas' book "The Conservation of Ground Water," published in 1951, described occurrences and effects of use and a detailed national map of productive aquifers and potential yields to wells. Branch specialists extended their studies of mine-drainage problems, begun several years earlier in Michigan, to new investigations in Arkansas, Minnesota, and Tennessee. They hoped that their fundamental research, supported by a newly activated Research Section, on the movement of water in and adjacent to ore-bearing formations would provide cheaper and more effective methods of dewatering mines and enable the development of ores that then could not be worked economically. They also extended their research on the use of underground reservoirs in disposing of radioactive materials, spent brines, and other waste products. Fieldwork and geochemical experiments by Margaret D. Foster and her colleagues demonstrated that high bicarbonate concentrations in groundwater in the Atlantic Coastal Plain were due to ion exchange between the water and clay minerals. A study of microfossils from wells near the Brookhaven National Laboratory on Long Island yielded information about the character and continuity of the containing clay stratum, data important for evaluating the recharge and dependability of the water supply in the sand and gravel under the clay and for determining how radioactive wastes might be disposed of safely. Specialists also began an investigation in New Jersey of the relation of groundwater recharge and streamflow to soil and vegetation. They reported on the use of cyclic fluctuations of water levels in observation wells, such as those caused by ocean tides, in computing the hydraulic properties of water-bearing formations previously based largely on analyses of data gathered in controlled pumping tests of wells. They developed, using similar methods, a technique for computing hydraulic properties from the results of bailing tests made in wells where the depth of water or the cost involved precluded conventional pumping tests. For the AEC, the Branch specialists also studied groundwater resources in New Mexico's Valle Grande; they located much stored water in the volcanic sediments but only a small perennial supply in the area.



This graph shows the variations in chemical composition of the calcium-magnesium-bicarbonate water sampled from the principal wells in the Santa Rosa Valley of northern California. Well numbers are given above the columns. In postwar years, USGS hydrologists increasingly studied the chemical quality of groundwater throughout the rapidly developing American West. George T. Cardwell, cooperating with colleagues in California's Division of Water Resources during 1949–51, examined the geology, groundwater resources, and recharge capabilities of the 450 square miles of the Santa Rosa and Petaluma Valleys in Sonoma County, north of San Francisco Bay. Groundwater occurred in the Merced, Glen Ellen, and Sonoma Formations, a Neogene sequence of, respectively, marine sedimentary, continental sedimentary, and volcanic rocks. (From Cardwell, 1958, fig. 12.)

As part of the Ground Water Branch's international activities, George C. Taylor, Jr., after completing work in Thailand, spent 6 weeks during June–July 1950 planning a long-term cooperative program in hydrology with the Geological Survey of India. Taylor visited locales in Madras (now Tamil Nadu), a port on the Gulf of Kutch, and areas in Uttar Pradesh. Taylor returned to India in January 1951 to begin the technical-assistance program to further train GSI personnel; he and his trainees explored, mapped, and sampled groundwater resources in 22 areas on the Ganges Plains. Some of his Water Resources Division colleagues in the United States helped to train hydrologists from Canada, Haiti, India, Japan, and the Union of South Africa.

Scientists in the Quality of Water Branch's 13 laboratories, including one newly established at the University of California at Davis (UCD), determined the chemical content of nearly 50,000 samples and the nature of sediments in more than 125,000 samples during fiscal year 1950–51. Branch members began collecting daily and intermittent samples of surface water at a number of additional sites at streams in the West to follow mineral-content trends to ensure continued success in operating existing irrigation projects. The Branch founded a section during the latter part of fiscal 1949–50 to investigate the quantity and quality of water required to produce various manufactured products and assist the planning for and preparation of reports on the water resources of specific areas. Its members collected information on the quantity of water needed to yield a given unit of production, the chemical content of water permissible for certain industries, and the variation in the way water was applied within manufacturing or mining activities. The unit began its now more urgent work with the steel industry. Information obtained from industrial plants revealed that the basic industries producing the initial materials for later fabrication, such as gasoline, paper, plastics, rubber, and steel, required the largest volume of water, both for the individual plant and for a given tonnage or unit of production, and required water having specific chemical qualities and temperatures. Fabrication processes needed much less water, in some plants little more than the volume used for workers' sanitation.

For fiscal year 1950–51, Harold Duncan's Conservation Division received a total of $1.2 million for classifying lands and supervising mining and oil and gas leases, an overall increase of $67,000, or nearly 6 percent more than in 1949–50. Increases in direct appropriations of $1,950 for land classification and $94,000 for mineral supervision, and $2,800 transferred from the PAD, more than replaced the reduction of $30,000 for these functions in the total funds formerly transferred by the USBR, the Navy, and other Federal agencies, and the end of funding by the BIA and the States, counties, and municipalities.

Field and office work by all four of the Division's Branches again grew during 1950–51. The Mineral Classification Branch's case load increased by 700 items to 16,600 because the public became increasingly interested in acquiring Federal land for settlement or for prospecting for oil and gas resources, activities that more than offset a decline in applications for coal, phosphate, potassium, and sodium. During the year, the Mining Branch supervised 1,250 mining properties in 29 States and Alaska. Minerals produced from the monitored lands rose by nearly 5.5 million tons to over 19.1 million tons and generated royalties of about $3.8 million, some $956,000 more than in the previous year. The production of coal from the public lands, including the former Chickasaw-Choctaw lands in Oklahoma purchased by the Federal Government on May 1, 1949, rose by nearly 1.5 million tons, an increase achieved despite greater competition from other fuels that reflected the increased industrial tempo. Potassium production also rose after the prolonged strike in 1949. Indian lands in Arizona, New Mexico, and Utah produced substantial tonnages of uranium-vanadium ores. The Oil and Gas Leasing Branch supervised more than 38,900 properties on about 29.8 million acres of public lands, increases, respectively, of 34 and 26 percent from the totals in 1949–50. Fuels produced from public, acquired, and Indian lands yielded total royalties of nearly $34.8 million, a gain of nearly $5.9 million. In California's NPR–2, similar production from 258 wells, 4 more than in 1949–50, provided royalties of about $913,000, a $32,000 loss, and those from the Army's Rio Vista gas field added another $380,000. The Water and Power Branch supervised the construction and operation of nearly 840 power projects under licenses from the Federal Power Commission or permits and grants from the Interior Department, or in cooperation with the BIA, representing an increase of almost 190 projects compared to 1949–50. Branch classifications increased the power-site reserves in 23 States and Alaska by 4,500 acres to a total of more than 6.8 million acres. The Branch completed nearly 5,160 hydraulic and mineral classifications, 1,205 more than in 1949–50. In addition, the Branch finished topographic surveys of 15 sites for dams and reservoirs and more than 120 miles of river channels.

On September 9, 1950, as the USGS program divisions increased their efforts for national defense, President Truman announced he intended to substantially increase U.S. ground forces in Europe by adding units to the two divisions already there. The North Atlantic Council, meeting in New York City during September 12–19, agreed to view any attack on the German Federal Republic as an assault on Council-member countries. The representatives decided to resist Soviet aggression as far east as possible, to increase their forces in and revise their occupation laws for West Germany, to relax their controls on its economy, including ending limits on steel production, and to allow the West Germans to begin formal diplomatic relations with other nations. The North Atlantic Treaty Organization's augmented forces also would someday include a Bundeswehr. The Soviet Union responded to these decisions by sending Vyacheslav Molotov to Prague to meet, during October 20–21, the foreign ministers of Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania. Molotov denounced NATO's new policies toward West Germany and again called for a peace treaty and the unification of the two Germanys. On October 24, French Premier René Pleven proposed a European force of 100,000 men, within NATO, to defend the continent, including West German components up to battalion level. In November, NATO's military representatives began a policy of restraining the Soviet Union by combining the nuclear weapons carried by U.S. strategic bombers, Euro-American ground forces supported by European tactical airpower, and U.S.-European naval forces. In December, France agreed to America's request for the participation of West German troops above battalion level in any European defense force established under Pleven's plan.

On September 21, 1950, two days after the Council's meeting ended, George Marshall reluctantly succeeded Louis Johnson as Secretary of Defense, who left on September 19, a day after Truman asked for Johnson's resignation. Marshall, although concerned that the time he spent in China and some of his other past service might give Republicans additional ammunition to use against Truman, assumed responsibility for rebuilding U.S. armed forces and, with the Joint Chiefs of Staff (JCS), for planning how best to expel the North Koreans from South Korea and implement the detailed recommendations in U.S. National Security Council Directive 68/2 (NSC–68/2) of September 30.

While the North Atlantic Council deliberated, U.N. forces in South Korea exchanged defense for attack by invading tide-swept Inchon, Seoul's port, while other units broke out of the Pusan Perimeter. The North Koreans' final assaults there began on September 13 but sputtered out against the Perimeter's defenses. The Army and Marine divisions of the U.S. Army's newly reactivated X Corps assaulted Inchon in Operation Chromite on September 15, with General MacArthur observing from *Mount McKinley*, as the 8th Army counterattacked in the south. General Bradley, who received his fifth star on September 20, and the JCS doubted the wisdom of MacArthur's plan, but General Eisenhower supported the Inchon landing and it succeeded brilliantly, in part because Kim Il Sung ignored Chinese warnings and failed to order the harbor and its approaches mined. MacArthur's troops recaptured Kimpo Airfield and then took Seoul on September 26. On that day, they also linked up north of Osan with 8th Army units coming up from the southeast. The 8th Army and X Corps completed the destruction or scattering of the North Korean divisions and drove some of their remnants north across the 38th parallel and completed the U.N.'s original mandate to liberate South Korea. MacArthur and Syngman Rhee recommended immediate pursuit across the border to complete the North Koreans' defeat, occupy their country, unite the peninsula under Rhee's rule, and demonstrate that Communist domination was not inevitable. On September 27, Truman, as recommended in NSC–81/1, and supported by Acheson, Bradley, Eisenhower, and Marshall, authorized operations north of the 38th parallel.

On September 30, 1950, Premier Zhou Enlai, encouraged by Stalin, who supplied knowledge from his spies that Truman likely would not authorize using atomic bombs against the People's Republic of China, suggested to India's Ambassador that the People's Liberation Army might have to intervene on behalf of the North Koreans. Mao decided to do so on October 2, the day after ROK units crossed the 38th parallel. The President and the JCS continued to hope to avoid a confrontation with mainland China, but MacArthur and Acheson assured them that the Chinese were bluffing and, if they were not, they would be soundly beaten. U.S. forces crossed the parallel on October 9 and moved north toward Pyongyang. MacArthur withdrew X Corps and sent it by sea around the peninsula to land at Wonsan and move north and northeast. Communist Chinese "volunteers" began to enter North Korea as Zhou denounced the transgression and declared that China would act. Truman and MacArthur, meeting briefly at Wake Island on October 15, talked alone and then together with Bradley, Pace, Harriman, Radford, and others, as U.N. forces closed on Pyongyang and Chinese forces led by General (later Marshal) Lin Piao (Lin Biao) began crossing the Yalu River into North Korea. MacArthur, backed by the Central Intelligence Agency's (CIA's) assessment, again assured Truman that the Chinese Communists would not enter the war unless U.N. forces attacked across the Yalu River into Manchuria. MacArthur wished to "unleash" Chiang's forces on Taiwan against both North Korea and mainland China. Truman's and MacArthur's joint communiqué from Wake only papered over their real differences in strategy.

On November 1, 1950, two weeks after Truman's meeting with MacArthur on Wake Island, violence of another kind came to the President's doorstep when two Puerto Rican separatists tried but failed to enter Blair House to assassinate him. Truman had signed a statute on July 3, to provide "for the organization of a constitutional government by the people of Puerto Rico"[76] to enlarge the island's self-governing authority. When that status did not appear promptly, the separatist gunmen attacked. In June 1951, Puerto Ricans voted for self-government by a popularly elected governor and a bicameral legislature. Congress and the President approved the Commonwealth Act in July and, a year later, the Commonwealth's constitution adopted by its people for a free polity in association with the United States.

United Nations' forces, now including units from Australia, Britain, The Netherlands, the Philippines, Thailand, and Turkey, occupied Pyongyang on October 20, 1950. Four days later, when the Joint Chiefs did not object, MacArthur ordered a general advance to the Yalu River. Units of the X Corps reached the Yalu on November 21, and MacArthur ordered an end-the-war offensive on the 24th. Communist Chinese forces continued to flow across the Yalu; they began fighting alongside North Korean units on October 26 and MacArthur publicized their presence on November 5, but he grossly misrepresented their numbers. Communist Chinese forces, now more than 300,000 men, began attacking the divided and overextended U.N. troops on November 25. The Chinese "volunteers" lacked the U.N.'s armor, artillery, and air-to-ground support, but they were mostly disciplined and veteran light infantry, victors over the Japanese and the Nationalist Chinese. During October, other Chinese Communist units invaded and occupied Tibet. On November 30, as the Chinese Communists continued their offensive in North Korea, Soviet Ambassador Malik vetoed a resolution in the U.N. Security Council that called on the Chinese to withdraw from North Korea and promised to safeguard their common border. The Chinese forces' attacks shattered MacArthur's confidence, forced the evacuation of X Corps from Hungnam and Wonsan, drove the 8th Army south from the Yalu, retook Pyongyang, and recaptured Seoul in January 1951.

The Truman administration also increased its aid to the French counter-insurgency war in Indochina. A U.S. Military Assistance and Advisory Group[77] arrived in Saigon on September 8, 1950, to help support Bao Dai's Republic of Vietnam. In mid-October, France announced America's promise to provide more military and related funds and equipment. On December 23, an agreement among the United States, Cambodia, France, Laos, and South Vietnam recognized their common interest in supporting freedom and its principles in the region. The agreement led to providing France with financial aid to help its forces reassert control over all of the former French Indochina. As the multinational French Expeditionary Corps fought the Viet Minh in Tonkin, protests grew in France, and Bao Dai's political and military support eroded in Saigon and in Vietnam's countryside. The Viet Minh broke the French cordon defenses in Tonkin's northern and northeastern border areas in October 1950, facilitating increased support from China. During January–February 1951, when Giáp's premature offensive failed to penetrate the French perimeter around Hanoi and the Red River (Sông Hông) delta, his troops reverted to guerrilla tactics. The United States sent $500 million in aid to France in 1951.

Truman, continuing his administration's response to the disaster in Korea and concerns for containment elsewhere, consulted with allies and advisers and then acted during November 1950–March 1951 to strengthen America's defense and economy. On December 1, the President asked Congress to provide in fiscal year 1950–51 an additional $16.8 billion for the Defense Department and another $1 billion for the AEC. A week later, Truman and British Prime Minister Attlee met in Washington to discuss military and political policies in Korea and in Europe, as Britain neared the end of its Marshall Plan aid on January 1. Early in the next year, Attlee announced a 3-year program for rearming Britain that would cost £4.7 billion. On December 16, Truman declared a state of national emergency, established within the Executive Office of the President an Office of Defense Mobilization (ODM), and appointed Charles Edward ("Electric Charlie") Wilson to lead it. The DMA and other new agencies followed the ODM early in 1951. General Order No. 2 by Eric A. Johnston, the Economic Stabilization Administrator, created on January 24 the Office of Price Stabilization (OPS), whose Director's position Truman authorized on November 30, 1950, pursuant to the Defense Production Act; he appointed Michael V. DiSalle to the post.

Another Executive order established the Defense Materials Procurement Agency[78] (DMPA) on August 28, 1951, to increase the production and procurement of raw materials vital for national defense, and Truman made Jess Larson its Administrator. Larson's DMPA quickly delegated its exploration functions to Interior Secretary Chapman, who passed them on to the Defense Minerals Administration and, on September 11, added "Exploration" after "Minerals" to the DMA's name. On November 27, the DMEA's operating committee held its initial meeting to begin reviewing applications from industry for contracts, grants, and loans to discover and mine strategic and critical minerals. More than a month earlier, on October 10, Truman signed the Mutual Security Act to "maintain the security and promote the foreign policy and provide for the general welfare of the United States by furnishing assistance to friendly nations in the interest of international peace and security." The new statute authorized more than $7 billion in "military, economic, and technical assistance"[79] for NATO countries or other crucial European nations like Greece. Funds also went to Iran, Israel, Palestine, Turkey, countries elsewhere in the Near East and in Africa, the Philippines, South Korea, Taiwan, and the American Republics. The act enabled detailing U.S. personnel to foreign governments and international organizations. The law also provided $55 million "to promote increased production, in areas covered by this Act, of [strategic] materials in which the United States is deficient,"[80] under authority of 1948's Economic Cooperation Act. The new statute abolished the ECA and transferred its functions and personnel to a new Mutual Security Agency (MSA), in the Executive Office of the President. Truman nominated and the Senate promptly confirmed Averell Harriman who also served on the NSC, as the MSA's Director. The MSA began operations on December 31.

During these months, Truman also acted to strengthen science's role in supporting the Nation. Truman announced on November 2, 1950, his selections for the National Science Board. The 24 persons chosen for the NSB, as Merton England recorded, were drawn nationwide from 20 universities and colleges, 2 institutions that provided monetary grants, and 2 industrial firms. The NSB also included two women (one of whom was a Nobelist) and two African-Americans. Detlev Bronk, James Conant, Lee DuBridge, Donald McLaughlin, and the other members of the National Science Board, except "Electric Charlie" Wilson, met with Truman and John Steelman at the White House on December 12. There, they chose Conant as Chairman, and a nine-member executive committee chaired by Bronk, and discussed what they wanted in a director. On December 18, William Golden, a former banker and now Special Assistant to the Bureau of the Budget's Director, reported to Truman recommendations on how best to mobilize science in support of the conflict in Korea. In 1949, Vannevar Bush recommended establishing a new office of scientific research and development to deal with the next war, one that would report directly to the President and advise him on scientific matters. Golden asked Truman to choose an eminent scientific leader, appoint that person as the President's science adviser, and select a Science Advisory Committee. When Truman later formed the Committee, over Lucius Clay's objections, the President established it within Wilson's ODM. By April 20, 1951, Oliver Buckley, the former president of Bell Telephone Labs, served as the Committee's Chairman and also as Truman's Science Advisor. The 10-member Committee included Bronk, Conant, DuBridge, James R. Killian, Jr. (who succeeded Karl Compton as president of the Massachusetts Institute of Technology [MIT] in 1948), Robert Oppenheimer, and Alan Waterman (chief scientist of the Office of Naval Research [ONR]). DuBridge succeeded Buckley as the Committee's Chairman on May 23, 1952.

The new National Science Board, convening again on January 3, 1951, drew up a ranked list of 10 candidates for the post of Director of the National Science Foundation (NSF) that included Detlev Bronk (listed 1st), Lloyd Berkner (3d), Alan Waterman (7th), and Everette DeGolyer (10th).[81] Biophysicist Bronk, who had served with the National Defense Research Committee (NDRC), the OSRD, and the ONR, was now president of Johns Hopkins and also president of the National Academy of Sciences (NAS), but he allegedly favored including the military in the NSF's purview. Conant took the list of candidates to the White House, but Golden did not favor any NSF involvement in "the military stuff,"[82] unlike Bronk, who said he would accept only if it did. Bronk withdrew his name from consideration at the NSB's meeting in February. When Berkner took another post, Conant joined Golden in passing down the list to recommend Waterman. On March 9, the NSB approved Truman's intention to nominate Waterman, who also was the personal choice of DuBridge, Karl Compton (Waterman's former boss), Vannevar Bush (whom Truman had not appointed to the NSB), and other colleagues. The Senate confirmed Waterman later in the month; he took his oath of office on April 6 for a 6-year term, at $15,000 per year. The NSF began formal operations from its headquarters in the District of Columbia in a building at 16th and I Streets, N.W.,[83] and it was funded by an appropriation of $225,000 for fiscal year 1950–51. Physicist Paul E. Klopsteg left the Argonne National Laboratory to serve as Assistant Director of the Division of Mathematical, Physical, and Engineering Sciences, one of the NSF's four program divisions.

The debate about how to fight and end the conflict in Korea continued at home and abroad. Hoover, Taft, and other isolationists within and outside Congress responded to Truman's recent actions by beginning a public debate on the administration's policy in Europe and around the world. The Republicans, after decrying the stalemate in Korea and attacking the Truman administration as "soft" on Communism, gained seats in the mid-term elections on November 7 for the 82d Congress, but the Democrats retained margins of 35 in the House and 2 in the Senate.[84] Former President Herbert Hoover's radio address, on December 20, recommended against any further involvement in campaigns in Europe and also proposed ending aid to Europe until its countries provided for their own defense. Hoover, returning to the isolationism popular in the years between the world wars, called for building up American air and naval forces and the Nation's bases in the Pacific, while rearming Japan. On January 5, 1951, Taft began a major debate in a Senate speech that supported Hoover's views. Taft complained that Truman planned and conducted foreign policy without consulting the people or their elected representatives, thereby questioning the relative authority of the President and Congress in fulfilling U.S. obligations. On the same day, the Soviet Union agreed to resume joint deliberations with the United States to settle the former's debt of $11 billion for Lend-Lease aid received during World War II; talks begin on January 15, but they ended without agreement 16 days later. On January 6, Americans learned that the Truman administration continued to supply arms and ammunition to the Republic of China on Taiwan, despite the President's earlier claim that the United States would no longer do so; Acheson confirmed the shipments on April 25.

Kenneth Wherry, still the Senate's minority leader, continued the foreign-policy argument by introducing a resolution on January 8 prohibiting the dispatch to Europe of additional U.S. ground forces without Congress' approval. General Eisenhower, NATO's Supreme Allied Commander Europe (SACEUR) since December 1950, appeared before an informal joint session of Congress on February 1, 1951, and supported sending additional American personnel, equipment, and supplies to aid Europe's defense. Later that month, Secretary Marshall, while testifying during hearings of the Senate's Armed Services and Foreign Relations Committees, related his and the Joint Chiefs of Staff's existing plan to add four divisions to the American forces in Europe during 1951. Marshall and the service chiefs also thought unwise any attempt by Congress to limit the number of U.S. troops assigned to NATO. Thomas Dewey and fellow Republican Harold E. Stassen then supported the Truman administration's plans for European defense as an Eisenhower program. The Republican-led debate on foreign policy fizzled out on April 4, 2 days after Eisenhower took command at Paris, when the Senate approved the plan to add four U.S. divisions in Europe. The Senators asked the President to seek their approval for any further augmentation there and for sending other troops elsewhere in the world. Truman applauded the Senate's approval of his plans for collective security, but he ignored the Senators' request for prior consultation.

As the debate continued, the U.N. forces slowed and then halted the Communists' second invasion of South Korea, and Truman continued to act to bolster national defense. The President, in a news conference on January 4, 1951, confirmed that he would not authorize using atomic bombs on the People's Republic of China unless Congress declared war. By January 15, U.N. forces retreated to a line about 50 miles south of Seoul in South Korea's narrow waist. There, the 8th Army, augmented by Canadian forces that had been arriving since December 19, regrouped under a new leader. On December 26, Lt. General Matthew B. Ridgway had replaced Lt. General Walker, who died when his jeep collided with a ROK truck on an icy road. Ridgway, who led the 82d Airborne Division and then the XVIII Airborne Corps in combat in Europe during World War II and served as one of the Army's Deputy Chiefs of Staff in the postwar years, took hold and raised the 8th Army's morale. The 8th Army attacked forces of the People's Republic of China[85] and North Korean People's Army (PRC–NKPA) 2 days later, pitting its advantages in armor, artillery, airpower, and logistics against the Communists' much larger edge in manpower. On March 14–15, 1951, U.N. forces retook Seoul and some areas north of the 38th parallel.

On December 28, 1950, as the 8th Army began its offensive, Truman signed a bill extending vocation rehabilitation and other benefits "to certain persons who served in the military, naval, or air service on or after June 27, 1950."[86] The new act, made more permanent in 1952, provided for veterans of Korea and elsewhere, with at least 90 days of service, benefits and educational opportunities similar to those granted to World War II veterans. On March 9, 1951, Secretary Marshall reported that U.S. armed forces now totaled 2.9 million men and women, a twofold increase since the Korean war began. The defense buildup, based on NSC–68/2, Marshall predicted, would be completed by mid-1952, well ahead of the original projection of fiscal year 1953–54. Truman signed a bill on June 19 that further amended the Selective Service Act of 1948 to "provide for the common defense and security of the United States and to permit the more effective utilization of [its] manpower resources * * * by authorizing universal military training."[87] The new law authorized the registration, classification, and examination of potential draftees to July 1, 1955; lowered the age of inductees to 18.5 years; increased their length of service from 1.5 to 2 years of active duty and added reserve participation that raised their total obligation to 8 years; and authorized increased personnel levels for the three services.

By now, the Korean war not only aroused concern about how the United States would meet its immediate defense needs there and worldwide but also imparted urgency to considerations of the long-term supply of mineral commodities and other strategic and critical raw materials. Truman, in his economic report to Congress on January 12, 1951, warned the Nation that while "the rapid expansion of the defense program must be the first objective in all that we do," the Korean conflict was not a global war. He called for "a continuing balance between the build-up of military strength and the build-up of economic strength," so that America would not be "weak at some future time if total military strength should then be required." Truman urged his fellow citizens to prevent the deteriorations of our agricultural, range, and forest lands and the misuse of "critically needed minerals and supplies of water," although "the use of some of these resources" must be expanded "to reach the full potential of our industrial strength."[88] "If Western Europe were to fall to Soviet Russia," he cautioned in the State of the Union Message 4 days earlier, "it would double the Soviet supply of coal and triple the Soviet supply of steel. If the free countries of Asia and Africa should fall to Soviet Russia, we would lose the sources of many of our most vital raw materials, including uranium, which is the basis of our atomic power."[89]

Truman, in his economic report, also estimated that more than $140 billion would be required in fiscal years 1950–51 and 1951–52 for national security programs, including U.S. forces, economic and military aid abroad, atomic energy, and stockpiling. Production would be expanded under the DPA, but the President also asked that supplies of critical materials and products remaining after defense needs were met be divided equitably among other users. Truman also recommended wisely developing all resources, promoting conservation of scarce materials, and developing substitutes. The Truman administration's price ceilings, established to fight inflation, led to reducing American demands for materials imports and ended the wholesale importing of these resources that occurred during July–December 1950. Truman specifically urged increasing industry's steel capacity and its supplies of iron ore by drawing on lower grade domestic sources and those in Labrador, through the proposed St. Lawrence Seaway and Power Project, and Venezuela to offset losses from the declining Lake Superior deposits. Interior Secretary Chapman also noted the need to continually expand the domestic economy but highlighted the dangers of concentrating "solely on short-term goals"[90] and making unlimited demands on America's limited natural resources without making "proper provision for the use of resources from beyond our own shores."[91] America, Chapman continued, now imported "75 percent or more"[92] of the amounts consumed of nine strategic-mineral commodities—asbestos, chromite, cobalt, industrial diamonds, manganese, mica, nickel, platinum, and tin; it also imported more than 45 percent of the lead and zinc used and from 25 to 75 percent of bauxite, fluorspar, and tungsten. Chapman, as his recent predecessors did in times of crisis, called for more information about domestic and foreign sources of minerals, as well as the Nation's fuel, land, and water resources. Members of the new 82d Congress reintroduced bills to provide an accelerated program of topographic and geologic mapping and a comprehensive effort to acquire basic data in water resources.

On January 15, Truman announced a Federal budget for fiscal year 1951–52 that called for $71.6 billion in expenditures, 78 percent more than those for 1950–51, but anticipated only $55.1 billion in revenues, leaving a large expected deficit of $16.5 billion, which would be triple that of fiscal 1950–51. The President recommended increasing natural-resources appropriations to $2.5 billion, half of which would be devoted to atomic-energy programs because the "economic and military strength of this country is dependent upon the availability and wise use of our basic natural resources." "These resources," Truman noted, "while extensive, are not unlimited. Our land, forest, water, mineral, power, atomic, and other resources made a vital contribution toward winning World War II and are now called upon to support the present military expansion. The Federal Government," he added, "has a large responsibility for ensuring the use of these resources to maximum advantage."[93] "Our natural resources programs," the President continued, "are being modified in order to make the greatest immediate contribution to our national security. In some cases, it is necessary to postpone desirable long-range development in order to accomplish urgent immediate objectives."[94] Truman noted that "the resources programs of the various agencies emphasize the development of Alaska for economic security and national defense." He pointed out how USGS and USBM efforts during and since World War II "concentrated upon research on the adequacy of mineral resources, the discovery of new resources, and means for improved development, conservation, and use of existing reserves. All of these activities," he emphasized, "have a clear defense significance and budget increases are recommended to accelerate them."[95]

While Truman waited for congressional action on these and related measures, he established the President's Materials Policy Commission (PMPC) on January 19, as urged by Stuart Symington's National Security Resources Board (NSRB). Truman asked the new PMPC "to make an objective inquiry into all major aspects of the problem of assuring an adequate supply of production materials for our long-range needs and to make recommendations which will assist me in formulating a comprehensive policy on such materials." The President expected the PMPC to study the long-range outlook for requirements and supply and balance them. The "prospect and estimated extent of shortages," the "consistency and adequacy of existing Government policies, plans, and programs," and those "of private industry practices" required considering "the needs and resources of the nations" cooperating closely with the United States "on military security and economic matters."[96] Truman appointed William S. Paley, president of the Columbia Broadcasting System, as the PMPC's Chairman. Paley's commissioners included George R. Brown, a construction engineer and executive at Brown and Root in Houston, Texas; Arthur H. Bunker, president of the Climax Molybdenum Company; Eric Hodgins, an editor and writer for *Fortune*; and Edward S. Mason, dean of Harvard's School of Public Administration and president of the American Economic Association. To assist the PMPC's deliberations, Philip H. Coombs directed its executive staff and oversaw its advisory staff of groups on domestic and foreign energy resources, technology, security and market policy, and commodity studies. USGS geologist Thomas Lovering served full time as the agency's liaison and one of the PMPC's four staff consultants. USGS geologists completed evaluations for the PMPC about marginal ore reserves of 15 mineral commodities and began studies of practices in exploration and discovery for several important minerals. Other contributors to the studies and reports included Alan Bateman; Everette DeGolyer; Samuel Lasky, on loan full time from his post as Staff Assistant for Minerals in the Interior Secretary's Office; the still-active Charles Leith; petroleum geologist A. Irving Levorsen, dean of Stanford's School of Mineral Sciences during 1946–50; Hugh McKinstry; and Eger Murphree.

On February 23, 1951, Michael Kirwan's House appropriations subcommittee began hearings on the USGS budget request of $22.9 million for fiscal year 1951–52, an increase of about $3.5 million from 1950–51. Director Wrather reemphasized his agency's continuing major responsibility for gathering "basic data about our natural resources" but stated that the increasing requirements for defense made necessary the "conversion of a full peacetime program into a twofold program for peace and defense * * * coordinated by the end of the current fiscal year." The USGS intended its long-range, topographic-mapping program "to obtain complete coverage of the continental United States with either [larger-scale] engineering or general-purpose maps,"[97] the latter about 70 percent less expensive to produce. The Army Engineers, Wrather continued, asked the USGS, on November 28, 1950, "to reorient and expand its mapping program so as to complete the mapping of about 600,000 square miles in the United States and Alaska by 1957." General-purpose maps would have to cover only 60 percent of Alaska; the provisional series of maps at 1:250,000 now being compiled from aeronautical charts would suffice for all of the Territory until a more accurate and same-scale series could be prepared from reconnaissance surveys. An additional 25,000 square miles also must be mapped, he cautioned, to meet additional "known civil requirements directly related to national defense"[98] to support the war economy. The USGS planned to enlarge its mapping force as rapidly as possible and prudent by asking for an increase of $1.65 million in SIR funds for topographic surveys and mapping. Wrather also expected to receive for USGS topographic work $1.8 million in cooperative funds from States, counties, and municipalities and $2.9 million in transfers from other Federal agencies; of the latter sum, $2.3 million would come from the USBR, and the Department of Defense (DoD) would contribute only $300,000 in USAF monies. He reminded the subcommittee how difficult it was for the USGS to maintain a technical staff to meet requests from other agencies when the funds required for doing so were not in the agency's own appropriations.

Wrather also stressed how USGS geologic and mineral-resource surveys and mapping, and its water-resource investigations, also would serve national defense and the mobilization economy, but he did not add that the service would be at the expense, as in both world wars, of drawing on the agency's basic-research capital built up before and after those conflicts. "Much of the current [geologic] program based on the urgent peacetime need and search for essential minerals needed only minor modification in emphasis or timing," he noted, as the effort already emphasized mineral and fuel commodities "now critically short of defense needs," including those required for jet engines. The peacetime economy placed demands upon the Nation's water supplies "well above the peak consumption of World War II"[99] and now increased even further by industrial mobilization and military use. Requests for information about the availability and adequacy of water supplies were increasing as they had in the past conflicts.

The USGS asked for SIR-funds increases for fiscal year 1951–52 of $1.7 million for its geologic work and $700,000 for water-related investigations, including some 40 new streamgaging stations at military establishments. Wrather expected cooperative and transfer funds to add $3.3 million and $5.6 million, respectively, to these sums, of which the DoD would supply $1,590,000. The USGS also requested $86,000 more for its land-classification and mineral-lease supervision and regulation activities, which Wrather assured the subcommittee continued to "contribute directly to the requirements of the Nation's mineral program"[100] by aiding increased reserves and production. As the Public Buildings Administration insisted that $1.8 million was needed to complete the multiyear relocation of USGS facilities to the Denver Federal Center, Wrather asked for half that sum to continue the work. Benton Jensen, ever frugal but very interested in this work in his State, now placed on record the $150,000 program of soil and moisture conservation proposed by the USGS but disallowed, unwisely said Jensen, by the Budget Bureau. William Norrell asked to record another statement extolling Wrather's abilities, "so the general public may know the caliber of the official that we have at the head of the Geological Survey."[101] Jensen thought it "fair to say that you have the most able and efficient agency in Government today."[102] Representative Kirwan, not to be outdone in what was becoming a bipartisan lovefest, added he believed the hearing seemed "like attending the best university in the country to sit here and listen to you."[103] Without dissent, the subcommittee approved the full amount of the estimate for the USGS.

By the time Interior's appropriations bill came up for review by the full House in late April 1951, the Korean war entered a new phase. After a stalemate of several months near the 38th parallel, General MacArthur, convinced that Chinese troops and airfields on the Manchurian border must be attacked in order to win the war, threatened the People's Republic of China with bombing and naval bombardment, even though the administration continued to try to avoid a wider war. MacArthur denounced Truman's intent to begin peace talks in a letter to Joseph Martin, Jr. (R–MA), now the House minority leader. Five days later, on March 24, MacArthur summoned the Chinese in Korea to surrender or face attacks against their homeland. Martin released MacArthur's letter for publication, although both men knew the U.S. Constitution barred America's military from making national policy or opposing the Commander in Chief, including his order in December that all military missives to the press be preapproved by the administration. After Truman consulted General Bradley and the Joint Chiefs of Staff, he fired MacArthur for insubordination. On April 11, Truman relieved MacArthur of his four commands—U.N. forces, Allied Powers in the Far East, U.S. Forces in the Far East, and U.S. Army Forces in the Far East—and replaced him with Lt. General Ridgway. General James A. Van Fleet took over the 8th Army. From many citizens in the United States, including prominent Members of Congress, came roars of outrage and calls for impeaching the President and the Secretary of Defense. The firestorm far exceeded the one generated when Eisenhower fired Patton for insubordination in 1945. MacArthur, while addressing an informal joint session of Congress on April 19, defended his policy preferences but accepted Truman's decision. MacArthur, recalling an old barrack-room ballad, said at the end of his military career that, like all old soldiers, he would just vanish in the mists of time.[104] MacArthur did not go quietly; he testified before Senate committee hearings during May 3–June 25 and continued to harbor Presidential aspirations. Truman ignored political and public pressure to reinstate MacArthur. Ridgway, gaining a fourth star, continued to use the U.N. forces' superior firepower and planned to save lives by avoiding costly attacks intended to gain showy tactical victories but only nonstrategic territory.

When the USGS appropriation request reached the House floor, only a few days after MacArthur addressed Congress, Representative James C. Davis (D–GA) insisted on cutting the appropriations of all the civilian Federal agencies. The USGS budget, Davis emphasized, not only remained uncut but was also some 24 percent greater than the previous year. Davis offered an amendment to slash USGS appropriations by $1 million, half from topography and the remainder divided equally between geology and water resources. Both Kirwan and Jensen opposed this change. Although Jensen reminded his colleagues that he had supported all budget reductions so far proposed, he insisted that he could not vote to cut USGS funds. The agency remained vital to the Nation's defense, Jensen continued, and he also felt that Wrather, whom he praised again, would not ask for any more money than he needed. Jensen rallied some of his colleagues to try to prevent the adoption of Davis' amendment, but it passed by a majority of just two votes.

By the time the Senate appropriations subcommittee took up Interior's funding bill on May 8, the tension had been somewhat relieved. Congress evaluated MacArthur's dismissal and the American public, losing interest in the process and its results, admitted that perhaps there was something to Truman's side of the story. Secretary Chapman, appearing before Carl Hayden's subcommittee, deplored the House's reduction of $39 million in his Department's request. He specifically asked to restore the USGS cuts because "the money is being spent for the gathering of scientific data which is essential to our economic development and our security."[105] When Wrather testified 3 days later, he also emphasized that all USGS programs continued to trail "far behind national needs."

> **Each time the Nation faces an emergency this lag becomes apparent, and determined efforts are made to fill the need quickly. In this emergency period, I feel that I should stress the effects of this cut on the defense effort.[106]**

Wrather then responded to several specific and difficult questions. Although the Nation faced critical shortages of about 50 mineral commodities, Wrather told the Senators, the DMA did not plan to transfer funds to the USGS after the third quarter of fiscal year 1950–51. Senator Joseph C. O'Mahoney (D–WY), who also chaired the Committee on Interior and Insular Affairs, repeated his earlier view that "mapping is essential from every point of view in the development of our minerals in the country."[107] "Every other civilized country in world is adequately mapped,"[108] Hayden obligingly noted and asked yet again how long it would take the USGS to map the United States. FitzGerald estimated "Nearly 50 years at the present rate."[109] Wrather clarified the magnitude of the problem by adding that if the USGS put off civilian mapping requirements during the current emergency, the agency could not meet military needs, even though its work remained well coordinated with the U.S. Coast and Geodetic Survey (USCGS) and other mapping agencies. The USGS did expect to receive from the Army Map Service (AMS) $200,000, only one-fifth of the required sum, to begin aerial photography before trees leafed out in critical areas in 1952, provided the item remained in the fourth military supplement bill. Wrather and Carl Paulsen convinced Senator Guy Cordon (R–OR), who lauded USGS topographic-mapping achievements, that all aspects of the agency's water-resources investigations aided national defense. Wrather, in pointing out the paucity of adequate records that were at least 50 years old and therefore vitally required for present planning and utilization of water, emphasized the need for "a continuous record over longer periods of time and * * * a more thorough network of stream gauging" for determinations of adequacy, "especially within the smaller areas."[110] Hayden's subcommittee, still mostly sympathetic to USGS needs but under instructions from the full Senate to cut all estimates for personal services by at least 10 percent, trimmed another $600,000 from the USGS budget. Senator Paul H. Douglas (D–IL) proposed a further reduction of $2 million, but the Senate voted for the funding level recommended by its subcommittee. The House accepted the Senate's figure.

When Truman signed Interior's appropriations bill on August 31, 1951, the new law, plus supplemental funding of $150,000, enacted on November 1, and nearly $714,000 more on June 5, 1952, gave the USGS almost $22,164,000 for fiscal year 1951–52. The directly appropriated funds of about $21,864,000 later reported by the USGS rose by $3.4 million, or nearly 19 percent, above the past year's sum. Those monies represented 46 percent of the total of slightly more than $48 million received by the agency. The act of August 31, 1951, limited USGS personal services to $13,455,000 and made $3.3 million "available only for cooperation with States or municipalities for water resources investigations."[111] Federal transfer funds reached $20.8 million, or 43 percent of the total monies, including $8.3 million from the DoD, $6.2 million from the AEC, and $3.9 million from the USBR. States, counties, and municipalities provided nearly $5.3 million, an increase of about $773,000 over 1950–51. These outside funds of almost $26.1 million represented nearly 55 percent of the USGS total and an increase of more than 46 percent from the previous year's sum. To meet the growing needs during the national emergency, the USGS continued to increase its staff, and the agency received nearly $948,000 for general administration during 1951–52. On June 30, 1951, the USGS employed 6,917 persons, of whom 5,477 were classified as full time, 297 as part time (or when actually employed [WAE]), and 1,143 as field assistants and laborers. Of this total, 414 people worked in the Director's Office, including the 122 in Fred Graff's Branch of Map Reproduction. The staffs of the four program divisions rose by 10 to 33 percent in the 8 months during November 1950–June 1951.

The transfers of money from other agencies, as always, were two sided and drew internal comment. On May 2, 1952, the Pick and Hammer Club's players, in their annual show, "Future Indefinite or Down to Our Last Centennial,"[112] looked back in "1978" from offices in Washington and "Various field stations in the wilds of Fairfax"[113] in Virginia. Some of the songsters recalled, to the tune of the "Surrey with the Fringe on Top" from "Oklahoma!," that nothing had changed since they decided the USGS was "Unhinged on Top":

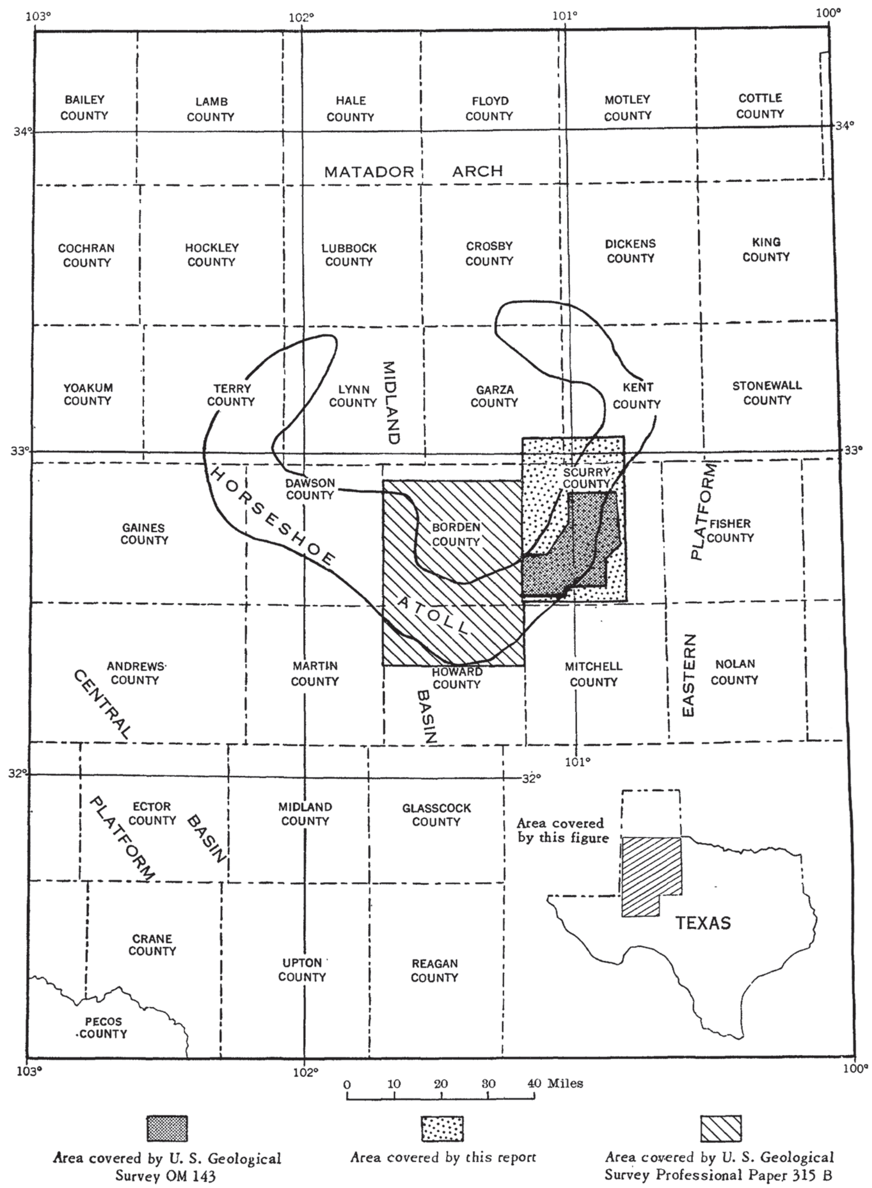
If you like your life topsy-turvy,
Why not come and work for the Survey?
Come and try to work for the Survey
With the brass on top.
No research and no time for science;
All our days belong to our clients;
Question[n]aires must have full compliance,
And they never stop.
The Director's purple and the C.G.'s pale,
The Branch Chiefs are all in a lather;
While field men chained to their desks, go stale
Answering memos from Wrather.
D.M.A. demands our attention,
Nothing else is worthy of mention,
Other work is held in suspension,
Or is just let drop.
Oh, it's scurvy in the Survey with the brass on the top.[114]

The Geologic Division received $14,801,000 during fiscal year 1951–52, including $5,763,000 in direct appropriations, or 39 percent of its total funds, for its salaries and operations by its 1,593 employees as of June 30, 1951. The staff of 1,306 full-time and 183 part-time employees and 104 field assistants and laborers represented a significant increase since November 3, 1950. About $8,825,000 of the total funds came from other Federal agencies. These monies included $5,799,000 transferred by the AEC, which almost doubled its 1950–51 transfer; $1,478,000 from the DoD; $994,000 from the Army and its Engineers; $698,000, from Interior; $376,000 from the USBR; and $241,000 from the Mutual Security Agency. States, counties, and municipalities added another $212,000, an increase of about $7,000.

In fiscal year 1951–52, Geologic Division scientists evaluated applications for grants and loans received by the DMEA and also evaluated measures for the preparation and enforcement of contracts, both forwarded to the Division by the DMEA. Howard Rothrock and his team completed their 1:48,000 map (OM–143) and preliminary evaluation of the geology of the Scurry Reef and other parts of the Horseshoe Atoll in the Midland Basin for the PAD. After Rothrock resigned in March 1952, to return to work in the oil industry, Richard E. Bergenback, Donald Myers, Philip T. Stafford, and Robert Terriere extended the detailed reef studies, focusing on the size, shape, porosity, and arrangement of the reef's stratigraphic reservoirs to assist planning for continued development, and completed assessing the regional geology of adjacent parts of northwest Texas. Members of the Division also prepared confidential reports on the world's resources of chromium and tungsten for the NSRB, now under Jack C. Gorrie, after Truman asked Stuart Symington to lead the Reconstruction Finance Corporation; enlarged the already extensive program of geologic mapping and drilling for the AEC; expanded military geology and associated studies for the Army Engineers and other parts of the DoD; and increased geological work abroad for the DoS. Expanding the Geologic Division's facilities and personnel to meet "the acute demands of national defense," as twice before during the century, Wrather noted, drew heavily on the organization's existing resources and slowed its regular work. The Director asked for the means to enable the USGS "to continue its traditional and carefully planned research and geologic mapping from which have come byproducts that have proved valuable in times of crisis."[115]

During 1951–52, a USGS geologist joined the scientists who formally advised the National Science Foundation, which received $3.5 million for its salaries and operations during the fiscal year. William Rubey was the only geologist on the 11-member committee advising Paul Klopsteg's Division of Mathematical, Physical, and Engineering Sciences. Three of that Division's initial grants that year went to earth scientists. Truman's letter of January 15, 1952, printed in the NSF's initial Annual Report, noted that the Foundation "will support these areas of basic research and science training where the needs are most acute and will ultimately assume the major responsibility for the Federal Government's support of basic research through grant or contract."[116] James Conant, writing in the same volume, suggested this investment should distinguish carefully between applied research, which he likened to "drilling for oil when you know where the oil is," and fundamental research, which he termed "prospecting for oil in a hitherto unexplored area." To clarify the distinction, Conant recommended substituting "programmatic" for applied and "uncommitted"[117] for fundamental research.

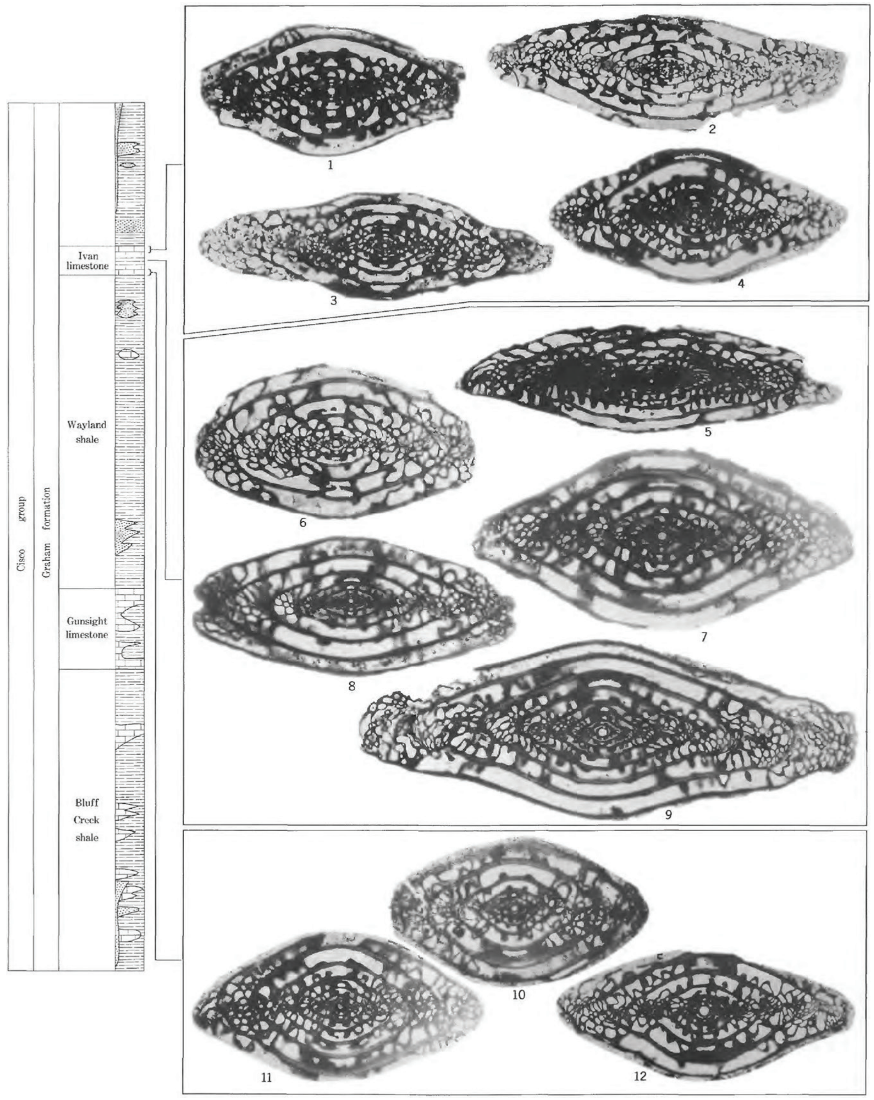
While Rubey advised the NSF's Division[118] during fiscal year 1951–52, members of the Mineral Deposits Branch began or continued field investigations in 66 projects in 28 States and Puerto Rico, including exploratory drilling in Iowa, Utah, and Wisconsin. Branch geochemists developed field tests for antimony, barium, manganese, and selenium to add to their array of determination techniques. Branch geologists conducted regional studies of mineral resources in New England and



This map (originally at 1 inch = 30 miles) outlines the area enclosed by the upper Paleozoic Horseshoe Atoll, an arcuate structure some 70–90 miles across in the northern Midland Basin of west Texas. Wells in the area began producing oil in 1948. Recovery from the Scurry Reef and the atoll's other fields reached 140 million barrels by the end of 1952. Howard Rothrock led a USGS team's investigation during most of 1950–53 into the atoll's biotas, rocks, structure, and petroleum occurrences; the team was aided by colleagues from the Petroleum Administration for Defense, the U.S. Bureau of Mines, and the Texas Bureau of Economic Geology. Most of the oil occurred in Pennsylvanian-age limestone reservoirs, capped by Permian shales, along the structure's crest. (From Stafford, 1959, fig. 1.)

adjacent parts of New York and in the Arkansas, Red, and White River Basins. Structural delineation of favorable areas for lead-zinc deposits in Wisconsin helped to disclose a new ore body, expected to yield 100 million tons with an estimated value of $135 million. USGS geologists and paleontologists aided the Tennessee Division of Geology's discovery of a major zinc ore body. Analyses of bauxite samples from Arkansas indicated that they contained about one pound of columbium (niobium), a vital component of jet engines and steel, per ton of ore. The amount of columbium handled during the State's current production of bauxite nearly equaled the present global production of the metal. Branch geologists and geochemists examined the possibility of using waste materials from bauxite and titanium metal plants as new sources of columbium. During the year, the mineral industry also made several important discoveries using USGS recommendations based on its mineral investigations aided by the new geochemical and geophysical tools and methods. In the West, Branch geologists discovered two potentially valuable phosphate deposits in Idaho and Montana. Geochemical prospecting by Branch members led to new extensions by the mining industry of the main cobalt-copper veins in Idaho's Blackbird district. A producer of mercury in California

These transverse sections show specimens of species of the fusulinids *Dunbarinella* (fig. 5) and *Triticites* (figs. 1–4, 6–12) from the Ivan Limestone Member of the Graham Formation (Pennsylvanian); the specimens are from Brown and Coleman Counties of central Texas southeast of the upper Paleozoic Horseshoe Atoll. These microfossils were collected from outcrops and well cores during 1949–55 and identified, dated, and correlated by Donald Myers and other USGS geologists and paleontologists. Fusulinids (extinct protozoan foraminifers) had calcareous multichambered endoskeletons known as "tests." Fusulinids occurred in marine sedimentary strata deposited during Ordovician through Triassic time. (From Myers, 1960, pl. 21; all figures originally shown at × 10.)



revealed the existence of four large ore bodies, whose discovery depended in part on USGS-developed ideas of structural control of the district's deposits.

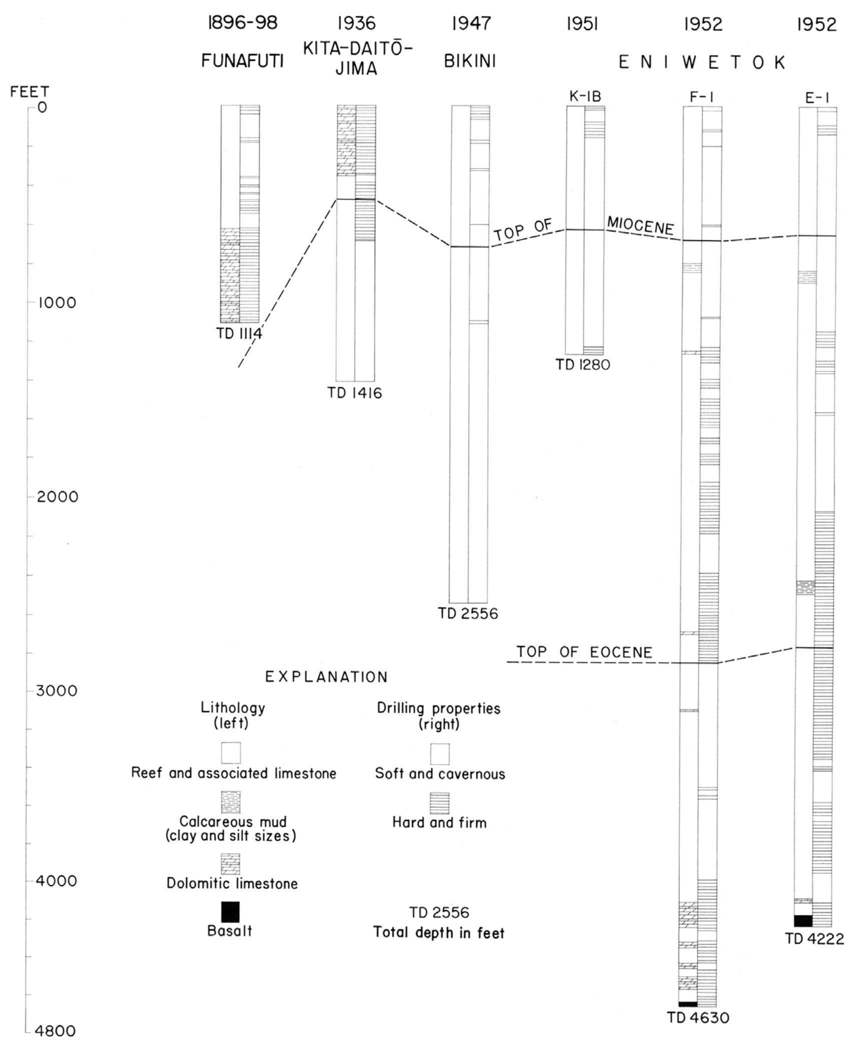
Vincent McKelvey succeeded Hubert Keiser as Chief of the Trace Elements Planning and Coordination Office. Lorin Stieff and Thomas Stern expanded their laboratory studies of the isotopic geochemistry of uranium and thorium and their decay products. In an attempt to bring order to and guide the renewed uranium boom in the West,[119] the AEC and the USGS revised their popular booklet "Prospecting for Uranium," including sections on the uranium-bearing minerals, with color photographs of samples of autunite, carnotite, pitchblende, tobernite, and uranophane ores; where to look and how to test for them; tests for fluorescence and radioactivity; prospecting with Geiger counters; laboratory assays and selling procedures; and applicable laws and regulations.[120] The Colorado Plateau Project continued to expand its staff and geographic coverage by mapping deposit-bearing formations outside the Uravan Mineral Belt in key areas in Arizona, New Mexico, and Utah to understand regional trends and controls on mineral distribution. The results, as before, aided exploration for economically important occurrences and their testing by diamond drilling and subsequent resource appraisal. To aid uranium prospectors in Alaska, TEPCO reopened its testing laboratory at College in facilities provided by the University of Alaska.

During fiscal year 1951–52, the Fuels Branch continued its twin emphases on petroleum and coal. Branch projects included 27 regional studies, in 18 actual or potential petroleum-bearing States, all of which were carefully integrated with operations by the oil and gas industry, the State geological surveys, and other agencies. Fuels geologists published a total of 20 Oil and Gas Investigations Maps and Charts, Circulars, and Professional Papers on regional topics in seven States in the West, issued a revised map of U.S. oil and gas fields, and also widened their investigations of the oil-shale deposits in the Green River Formation in Colorado and Utah. Division biostratigraphers began studies of the zonation and correlation of oil-producing strata in the Williston Basin of North Dakota and Montana. As part of the continuing systematic reappraisal of the Nation's coal resources, Paul Averitt's group finished new assessments of the overall coal resources of Colorado, Indiana, North Dakota, South Dakota, and Virginia. Other specialists continued detailed geologic mapping of coal fields in 11 States—Colorado, Indiana, Kentucky, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Washington, and Wyoming—and published reports on the coals of South Dakota and Virginia. James Schopf's studies of coal samples at the Coal Geology Laboratory in Ohio yielded new information about the paleobotany, petrography, and radioactivity of coals that helped to solve problems in dating and correlating coal beds, increasing the understanding of their genesis, and advising how to use them as effective sources of synthetic liquid fuels and chemicals.

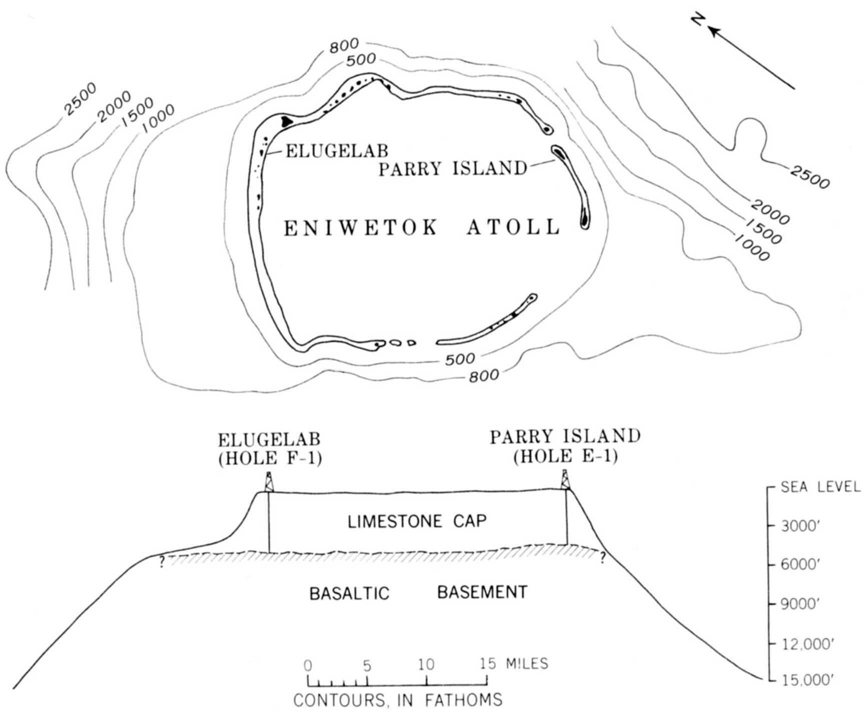
In the General Geology Branch, scientists continued or began work on 19 projects in 15 States, Puerto Rico, Hawaii, and the Aleutians during fiscal year 1951–52. In September 1951, Clifford Kaye completed his geologic mapping of the San Juan metropolitan area, published in 1959 at 1:30,000, and Isla Mona in the Windward Passage and his studies of Puerto Rico's Quaternary shorelines begun in March 1949. All eruptive activity ceased at Parícutin on March 4, 1952, but Carl Fries, Jr., Celedonio Gutiérrez, and their colleagues, with the continued support of the USGS, the U.S. State Department, the Instituto Nacional para la Investigación de Recursos Minerales, and other government organizations in Mexico continued to study the volcano through June 1953. In the Aleutians, during the 1951 and 1952 field seasons, George D. Fraser, Willis H. Nelson, Howard Powers, and Ray Wilcox led several field teams of 12 other USGS geologists working from facilities on, and supported by, the USGS schooner *Eider*, in mapping and studying additional islands. The teams completed work on Kiska and Amchitka. They also examined three of the smaller islands in the Rat group, four of the nine Delarofs, and southern Adak, Kagalaska, Kanaga, and Tanaga in the western Andreanof Islands and published coverage at 1:25,000 for the smaller islands and from 1:63,360 to 1:250,000 for the larger islands or groups of islands.

The Engineering Geology Branch conducted 17 field projects in 10 States during fiscal year 1951–52. About a third of the Branch's program remained centered on the Missouri River Basin, to support Interior's development effort there, and included studies of landslides at South Dakota's Fort Randall Reservoir. Branch geologists mapped detailed areas along the upper Green River in Utah to furnish data for a new regional project of land development and waterpower. The Branch added four new cities—Denver, Los Angeles, Omaha, and Seattle—to its urban-mapping project[121] while continuing work in Great Falls in Montana, Knoxville in Tennessee, Portland in Oregon, and San Francisco in California; it also continued cooperative geologic mapping with Massachusetts and Rhode Island. Late in the fiscal year, Ray Wilcox, now the Branch's resident expert on volcanoes, traveled to Nicaragua to study, with Frank Simon, the results of the eruption in Santiago Crater. Wilcox advised Nicaragua's Government about ways and means to protect more effectively its people, agriculture, and livestock from future eruptions. The ONR and the Army Engineers supported geothermal investigations in arctic and subarctic locales by Branch scientists, some in cooperation with John Cederstrom, David Hopkins, and other members of the Alaskan Geology, General Geology, Geophysics, and Military Geology Branches of the Geologic Division and the Ground Water Branch of the Water Resources Division. The investigators provided scientific and engineering information on the thickness and temperatures of permafrost, the effects of heated buildings on the cold reserve beneath them, and the time required for drill holes to reach thermal equilibrium.

Preparations for nuclear-weapons testing by the United States continued to involve USGS geologists in deep drilling and related studies in 1951–52. On January 25, 1951, aboveground tests of nuclear weapons began at the Nevada Proving Grounds (now the Nevada Test Site), an area chosen by the AEC in December 1950 that included Frenchman and Yucca Flats. The Mid-Pacific Expedition, a multiship effort during 1950–52 sponsored by the University of California and the Navy Electronics Laboratory (NEL) and led by Roger Revelle (Scripps Institution of Oceanography [SIO]) and Robert S. Dietz (NEL), included dredging on seamounts and related work at Bikini Atoll. Russell W. Raitt, Jr., extended the magnetic and seismic studies of 1946–47 with seismic-refraction surveys across and outward from Bikini and also over adjacent Sylvania Guyot to add to new data from coeval photography and bottom sampling of Cretaceous fossils. Raitt's results indicated a volcanic-rock basement below the lagoon at depths of about 2,000 to 6,900 feet. As part of preparations for additional nuclear-weapons tests, Harry Ladd directed drilling operations at Enewetak Atoll and initially used the same rotary core rig that



This diagram correlates the core-based stratigraphic records of deep wells drilled to depths of 1,114–4,630 feet on six island sites in the open (west-central) Pacific Ocean during 1896–1952. In addition to holes drilled on Funafuti, Kitadaito-jima (formerly North Borodino Island), and Bikini, they included the three deep holes drilled by Harry Ladd's USGS-industry team on separate islands in the Marshall Islands' Eniwetok (now Enewetak) Atoll during 1951–52, as part of scientific preparations for tests of the new U.S. thermonuclear weapon. In 1951, the team used the rotary core rig, the same one used on Bikini, but now truck mounted, to drill hole K–1B on Engebi Island, near the atoll's southeast end. K–1B descended to a depth of 1,280 feet (earlier reported as 1,285 feet), where it ended in Miocene sediments. In 1952, the team used a larger and taller trailer-mounted rig to drill hole E–1 on Parry (Medren) Island to a depth of 4,222 feet; coring recovered olivine basalt from the hole's lowest 14 feet. Hole F–1, to the northwest on Elugelab Island, reached a depth of 4,630 feet and basalt before the hole collapsed. (From Ladd and Schlanger, 1960, fig. 287; see also Ladd and others, 1953.)



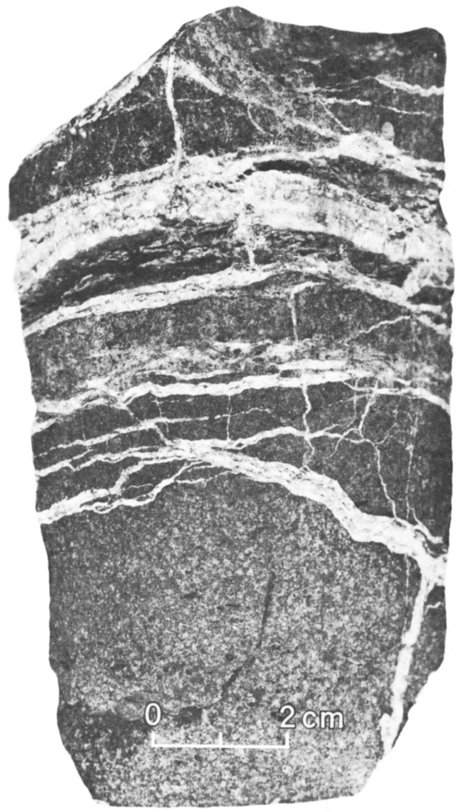
This generalized chart of Enewetak Atoll (above, originally at about 1 inch = 21 miles) and geologic section through Elugelab and Parry Islands (below), based on data from drill holes E–1 and F–1, "firmly established the fact that the foundation of that atoll is a basaltic volcano that rises 2 miles above the floor of the ocean." That conclusion confirmed the Darwin-Dana model, as coral-reef growth had kept pace with the rate at which the oceanic volcanic mountain sank. The study left undetermined the mechanism responsible for the sinking and the geologic age of the basement rocks. Contours on the chart show water depths in fathoms; 1 fathom = 6 feet. (Quotation, chart, and geologic section from Ladd and Schlanger, 1960, p. 899 and fig. 285.)

he had used on Bikini in 1947. The Armed Forces Special Weapons Project, the ONR, and the Navy provided planning and logistical support for the drilling for the AEC and the Los Alamos Scientific Laboratory. Ladd's team drilled four shallow holes on the seaward reef off Engebi before the tests in May 1950. Deeper wells at Enewetak followed in 1951–52, as part of the geological, geochemical, geophysical, and botanical workup. In 1951, Ladd's team drilled well K–1B on Engebi Island to a depth of 1,285 feet (later revised to 1,280 feet) before it tailed out in Miocene sediments. Two new wells, supervised and studied by Ladd, Earl Ingerson, and their USGS, ONR, and Los Alamos colleagues in 1952, passed through deepwater foraminiferal limestones of Eocene age, later also dated by radiometric methods. Members of the drilling team added "Basalt or Bust" to the wall of the geologists' office, and these wells finally reached basement rock. Well F–1 on Elugelab reached a depth of 4,630 feet before the hole collapsed. Joel Swartz took downhole thermal measurements as E–1 on Parry descended to 4,222 feet, where coring recovered 14 feet of fractured olivine basalt.[122] Ladd, who earlier favored Alexander Agassiz's reef theory, promptly put up on the rig a sign saying "Darwin Was Right!" In 1954, Kenneth Emery, Joshua Tracey, and Ladd acknowledged that the

> **[a]ccumulation of the shallow-water organisms seems to have been essentially continuous throughout most of the atoll's history, indicating a continuing or periodic submergence[123]**

in post-Cretaceous time. The cause and rate of basement-rock subsidence in these atolls remained to be determined.

Richard Rhodes, in his book "Dark Sun," recounted how work by Edward Teller, Ernest Lawrence, and other physicists led to the successful hydrogen bomb.[124] On November 1, 1952, 3 days before the Presidential election, the United States exploded at Enewetak the 10.4-megaton "Ivy Mike" thermonuclear device powered by the fusion of the hydrogen isotopes deuterium and tritium, the latter an artificially generated isotope whose half-life of 12.5 years also made it valuable



This specimen of olivine basalt from hole E–1 drilled in 1952 on Parry Island in Enewetak Atoll was part of the initial core, at 4,208–4,211 feet, of three cores recovered from the basement rock. Laboratory analyses showed that this basalt contained labradorite feldspar (60 percent), augite clinopyroxene (20 percent), olivine (15 percent), and opaque minerals (5 percent). Some of the lighter colored calcite veinlets that cross the basalt specimen contained greenish alteration products. Reaching basement rock on Parry confirmed the Darwin-Dana subsidence model of coral-reef formation; the corals grew upward at a rate that kept pace with the subsidence of the basement-rock foundation. Scale in centimeters (cm). (From Ladd and Schlanger, 1960, fig. 282; originally published in Ladd and others, 1953, pl. 1, fig. 1.)

as a tracer. The blast, whose explosive power exceeded by some thousand times that of the Hiroshima bomb, obliterated Elugelab and Engebi Islands. Eight months earlier, on February 26, Churchill announced that Britain had joined the atomic club after the British detonated a 25-kiloton device in the Montebello Islands, 50 miles off the northwest coast of Australia.

Federal support for development and science in Alaska led to the completion in 1951 of airports at Dillingham, Fort Yukon, Kotzebue, Ninilchik, and Seldovia and the transfer that September of the annual Alaska Science Conference (begun in Washington in November 1950) to the headquarters of Mount McKinley (now Denali) National Park. Wrather enacted Bradley's recommendation to consolidate Geologic Division activities in Alaska under unified management. Wrather's Survey order of March 10, 1952, established an Alaskan Geology Branch,[125] with George Gates as Chief, who operated from his office in San Francisco, and Ernest H. Lathram as Staff Geologist in Washington. The Alaskan Geology Branch assumed the functions and responsibilities of Gates' Alaskan Unit of the Alaskan and Foreign Geology Branch and the General Geology Branch's Aleutian Volcano Investigations Unit. The Geologic Division transferred personnel, records, and equipment of the former Alaskan Unit to San Francisco. Wrather asked Gates' Alaskan Geology Branch, in collaboration with the Division's other Branches and John Reed (Sr.), still the Director's Staff Coordinator for Foreign and Territorial Functions, to plan "a comprehensive program of geologic investigations for Alaska combining short-term economic and military objectives and long-range systematic geologic mapping and research designed to meet the broadest foreseeable national and Territorial needs."[126] Among the new Branch's geologists working in Alaska, Arthur Grantz, who joined the USGS in 1949, studied magnetite deposits near Tuxedni Bay and newly hired C. Ladell ("Pete") Sainsbury investigated antimony occurrences at the south tip of the Cleveland Peninsula and tungsten deposits in the Hyder district, both north of Ketchikan. Coal investigations continued in the Bering River, Kenai, Matanuska, and Nenana fields. Late in the fiscal year, the USGS issued a preliminary report on the Katalla oil field. USGS scientists also observed river-ice conditions near highway and railroad bridges, operated portable core drills, and studied tracked-vehicle trafficability in the Territory.

Specific planning for fieldwork in Alaska's NPR–4 during the 1952 season began with a meeting at Fairbanks, during March 11–13, of the members of the renamed Executive Operating Committee. The attendees agreed to continue or begin test wells at Grandstand, Gubik, Square Lake, Umiat, Weasel Creek, and Wolf Creek. They proposed six similar drilling operations, including new wells at East Titaluk, West Big Bend, and West Meade, for 1953, and four or more wells, including a pre-Cretaceous test down to 9,000 to 12,000 feet in 1954. A subcommittee summarized work to date in the five principal areas of NPR–4, the coastal plain west and east of the Colville River, the northern foothills west and east of the Anaktuvuk River, and the southern foothills. As the program's goals were essentially met only on the coastal plain west of the Colville, achieving its objectives in the other four areas would require "a full-scale exploration program with emphasis on drilling * * * at least through 1957."[127] The new Advisory Committee, chaired by Captain Meade, met during April 14–15 in Denver, where Wrather, John Reed (Sr.), George Gryc, and William Fischer represented the USGS. In June, a Navy survey board, composed of Navy officers and petroleum-industry civilians, evaluated the NPR concept and operations. The board, noting the difficulty and vulnerability of transport in NPR–4, suggested that it, as the least desirable of the existing reservations,

> **be transferred to another Government agency for administration at such time as feasible after the completion of the present exploratory program**

but that the NPR–4 program should be continued "at its present level in order not to lose current extensive investment," even though the work should "be considered only as an exploration of natural resources and not as a reserve."[128]

George Gryc's Navy Oil Unit operated three field groups in NPR–4 during June–August 1952. Samuel Keller's Party 1 examined the Canning-Shaviovik and Kemik Creek areas, including the Kemik anticline, and demonstrated minimum closures of 500 to 900 feet. Robert Detterman's Party 2 looked at the northern foothills area between the Chandler and Anaktuvuk Rivers, one that included the Big Bend, Grandstand, and Hawk anticlines and discovered closures of 200 to 1,000 feet. Later efforts in Washington proved that the area's photogeologic maps were accurate only where the geology was uncomplicated and good vertical control existed. William Brosgé's USGS-funded Party 3, including Dutro, Mangus, and Reiser, mapped some 5,000 square miles in the northeastern Brooks Range between the Sagavanirktok and Kongakut Rivers, almost as far east as the Canadian boundary. Only four wells were drilled during 1952 "to conserve fuel for the drilling of 2 deep tests planned for 1953."[129]

Members of the Military Geology Branch continued studies in both hemispheres in 1951–52 but emphasized locales and topics in the Pacific and East Asia. A series of Executive orders between September 7, 1949, and June 29, 1951, transferred the administration of Guam, American Samoa, and the Trust Territory of the Pacific Islands (TTPI) from the Secretary of the Navy to the Secretary of the Interior,[130] as the initial step toward self-government. In Secretarial orders, Chapman assumed responsibility for American Samoa and the TTPI, each governed by a High Commissioner; former Senator Elbert Thomas continued to serve as the TTPI's civilian High Commissioner. In the MGB's Pacific Geologic Mapping Program, Joshua Tracey's team, including newly hired Seymour O. Schlanger, gained additional support from the USAF and began in August a 3-year survey of the botany, climate, geology, hydrology, marine geology, and soils of Guam, a U.S. unincorporated territory since 1950. Special reports completed by the MGB's Tokyo office for the Army's Chief Engineer in Japan included an inventory of aggregates on Okinawa. Among reports finished for the Office of the Chief of Engineers (OCE) in Washington were summaries of the state of ground, trafficability, airfield construction, and airborne operations in the combat zone between the 37th and 39th parallels in Korea (by Esther J. Aberdeen and Franklin Newhall) and water supplies and installations in Japan and South Korea (by Frederick Blach). In work about Europe, Nicholas Shreders completed for the OCE geologic maps of Spain and Portugal at 1:250,000 on 82 sheets and 1:1,000,000 on 35 sheets. Spain's Francisco Franco and Portugal's António Salazar agreed on April 15, 1952, to increase their mutual military collaboration and its relation to NATO's plans for defending Europe. The MGB's Edward C.T. Chao, Jack Rachlin, and four other geologists combined their efforts to produce annotated bibliographies and summaries of the adequacy of construction materials and water supplies in Belgium, France, Italy, Northern Ireland, Portugal, and Spain.

Wrather's Survey order of March 10, 1952, also renamed the Alaskan and Foreign Geology Branch as the Foreign Geology Branch but kept William Johnston as its Chief.[131] Geologic activities abroad increased in scope and tempo under the impetus of 1951's Mutual Security Act.[132] Branch members continued the long-range programs of metallic-minerals investigations in Brazil, Mexico, and Peru; resumed studies of nickel deposits in Cuba; and began reconnaissances in Chile and Paraguay as preparation for providing advice to their governments about mineral exploration programs. Cleaves Rogers and three Mexican colleagues finished a 3-year investigation of the Concepción de Oro in Zacateca. Benjamin N. Webber spent 1951–52 assessing mineral resources in British Guiana (Guyana). Philip Guild completed his 4-year study of the geology and mineral resources in Brazil's Congonhas district. Herbert Hawkes, Jr., supported by the MSA and the (British

Colonial) Geological Survey of Nigeria, examined the Nyeba lead-zinc district. Data from USGS studies in India led to determining 6 million tons of proved reserves of manganese. Fuels investigations in Thailand aided the discovery of 10 million tons of coal in deposits previously thought insignificant. In the Philippines, work by Earl Irving and Ronald Sorem led to a report on the archipelago's sedimentary basins that generated renewed interest in domestic exploration for oil[133] and to mapping potential manganese deposits in the central islands. Branch geologists also helped to train 27 foreign geologists in field areas in the United States and to give others 3-month orientations in administration, science, and technology in and outside Washington.

The Geophysics Branch's airborne geophysical surveys, in 12 Northeastern and Western States, returned data for 40,000 miles of traverses during 1951–52, aided by recent hires. Geophysicist Randolph W. ("Bill") Bromery, a pilot who served with the Tuskegee Airmen, joined the Branch's airborne-surveys unit in 1948. Bromery continued to encounter racial prejudice in many of his contacts with the world outside the agency, as did his colleague Roland G. Henderson, a geodetic engineer and geophysicist. As Bromery later recalled, Balsley and William J. Dempsey (Sr.) oversaw the design and construction of the Curvilinear Graph Rectifier "to draw the magnetic profiles to fit the actual horizontal map scales and the changes in the vertical scale of the magnetic gamma readings." In 1951, Henderson gained a third job classification as a mathematician, as did his colleague Isidore Zietz; together they developed "the mathematical techniques for the geological interpretations of the airborne magnetic data."[134] One of the airborne survey's flights over California's Sacramento Valley mapped the largest intensity aeromagnetic anomaly, 1,200 gammas at 10,000 feet, yet recorded in the United States. Other flights over the Duluth gabbro and its copper-nickel ores in Minnesota and Wisconsin also recorded high-intensity anomalies. Total-intensity aeromagnetic maps of counties and quadrangles principally in Indiana, but also in Maine, Michigan, Minnesota, Missouri, and New Mexico, continued being prepared and published, at 1:63,360, with contour intervals of 10 to 100 gammas, by Dempsey and his colleagues. The Branch issued a primer about aeromagnetic maps to aid user interpretation. The now-routine airborne surveys for radioactivity proved increasingly useful in uranium investigations and were extended to new areas in Arizona, Florida, Minnesota, and Utah. Dempsey organized a compilation unit to digitize, plot, and analyze the strip-chart records from the airborne scintillometers. Ground surveys, in 11 States, Alaska, and two areas outside North America, continued to return data useful for determining bedrock depths, finding and studying aquifers and buried-valley systems, and aiding mineral-deposits investigations.

Chief Topographic Engineer (CTE) Gerald FitzGerald continued to fine-tune the Topographic Division during fiscal year 1951–52. On November 5, 1951, FitzGerald appointed photogrammetrist George S. Druhot, editor of the *Topographic Division Bulletin*, to replace Alfred Stiefel as Chief of the Coordination and Liaison Section, in Robert Lyddan's Plans and Coordination Branch. Wrather and FitzGerald also changed the boundaries of the Division's four geographic regions to distribute its workload more evenly and to expedite the mapping of high-priority areas for the Defense Department. As realigned by a Survey order[135] on December 27, the Atlantic Region now contained Puerto Rico and all of the States east of the Mississippi River, except for Alabama, Florida, Michigan, and Mississippi. That quartet passed to the Central Region, which extended west from the Mississippi to the western boundaries of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. The Rocky Mountain Region included Alaska Territory, Colorado, Montana, New Mexico, Texas, and Wyoming. The Pacific Region comprised the remaining seven Western States and Hawaii Territory.

On June 30, 1951, the Topographic Division employed 2,566 persons, 859 more than on November 3, 1950; 1,997 were full time, 18 were part time, and 551 were field assistants and laborers. The Division received $18,485,000 to support surveys and mapping by its staff during fiscal year 1951–52, about $5.3 million more than the previous year's total. Direct appropriations provided $8,386,000, or about 45 percent of all the funds received by the Division. The Army and its Engineers, spurred by the national emergency,[136] transferred to the Division $4,772,000, more than $4 million above the amount in 1950–51 and double the largest sum given by the War Department during any year in World War II. The Air Force transferred $811,000 to the Division, an increase of $187,000. These gains returned the Division's staff and programs to heavy dependence on sustained funding by the military. The USBR, by providing $2.2 million, continued to lead the cooperating Federal agencies, but that figure represented a loss of $591,000 from 1950–51's contribution and required a one-third reduction of the Division's operations in the Missouri River Basin. Other Federal agencies shifted an additional $480,000. Twenty-nine States (four more than in 1950–51) plus counties and municipalities transferred some $1,783,000, a gain of more than $534,000.

The Topographic Division directed its program during fiscal year 1951–52 largely toward meeting the immediate needs of the Defense Department, an effort only in its second of six projected years ending by the beginning of fiscal 1957–58. When the DoD set earlier completion dates for mapping certain areas, the Division diverted persons from projects begun in other areas, hired additional personnel, and awarded contracts to cover separate mapping operations. The three regional offices at Arlington, Rolla, and Sacramento were quartered in new air-conditioned buildings designed to meet the requirements of mapping operations, and additional air-conditioned space was provided at Denver. To raise production capacity, the Division increased double-shift operations in all its photomapping units and overtime work in nearly all its offices. Contract mapping, of areas comprising 16,000 square miles at a cost of $1.5 million, and representing a continued departure from usual practice, forced the Division experts to write detailed specifications for the work to be performed and establish procedures for inspecting and testing the work so that it would comply with well-established internal standards. The Trimetrogon Section prepared 400 special charts, depicting 376,000 square miles, 60 percent of which were newly compiled, for the USAF under its increased funding. The Section also did some special mapping for other Federal agencies, including a test of a new slotted-template method on maps at 1:24,000 of 55 quadrangles in Louisiana. The Division limited its mapping for Federal agencies not directly involved with national defense; the Budget Bureau's procedures set the priorities for these efforts, even though the work could not begin until the Division increased its capacity. In 1951–52, Division employees completed 69,500 square miles of topographic mapping in the conterminous United States and began mapping Puerto Rico at 1:30,000. USGS base and contour editions in Spanish of 1:200,000 and 1:240,000 topographic maps of Puerto Rico and adjacent islands appeared, respectively, in 1951 and 1952. In Alaska,[137] field parties, supported by seven helicopters, mapped areas totaling about 16,400 square miles at 1:63,360 and nearly 37,000 square miles at 1:250,000. The Division continued to publish and distribute its civilian edition of the AMS's 1:250,000 national series but, on July 23, 1951, responsibility for the Transportation Maps of the United States being compiled for the Bureau of Public Roads passed from the Division to the USCGS. The Division, supported by the State Department's Technical Cooperation Administration and the Mutual Security Agency, also continued to train topographic engineers and photogrammetrists from free-world nations and provided advice on, specifications for, and supervision, inspection, and testing of air-photo and map compilation.

Topographic Division experts also continued to try to improve mapping equipment and methods during fiscal year 1951–52. Research to adapt electronic methods[138] to establish more efficient geodetic control received considerable attention. Tests of mapping for which elevations were based upon vertical measurements by an aircraft equipped with radar, shoran, and a sensitive barometric altimeter proved encouraging. The polastrodial continued to make possible the daylight observations of azimuth under conditions previously considered unfavorable. Division members assessed optical-reading telescopic alidades and a new, pendulum-type, self-leveling, and optical-reading alidade, expecting both the optical-reading and auto-leveling features to speed field mapping. In photogrammetry, the Division and the USAF worked to develop an improved Twinplex stereoplotting instrument. The Division let contracts for additional Multiplex equipment, and Kelsh and universal plotters, whose acquisition was expected to increase capacity by nearly 40 percent, and signed other contracts to produce 10 of the new and improved T–11 aerial cameras with Planigon lenses nearly free of distortion.

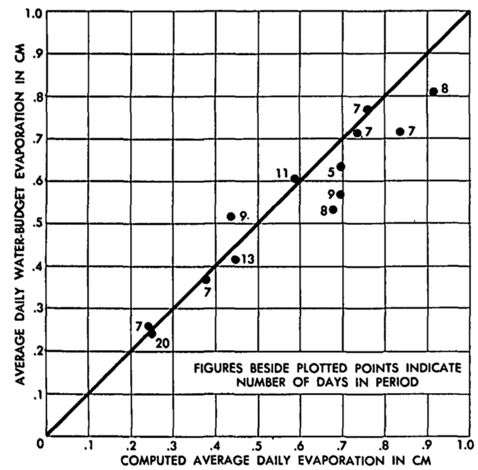
The Water Resources Division managed about $12,441,000 for salaries and operations during fiscal year 1951–52 by its staff of 2,111 persons, a gain of 604 since November 3, 1950; 1,550 employees were full time, 92 were part time, and 469 were field assistants and laborers. Of the total funds, nearly $5,847,000, or about 47 percent, came from direct appropriations, of which $3,300,000 was limited to cooperation with the States, counties, and municipalities. These governments supplied slightly more than $3,285,000, representing a gain of $219,000. The USBR's transfer fell to $1,269,000, a loss of $200,000, although the Division still operated in the Missouri River Basin 290 streamgaging stations and assessed groundwater quantity and quality at more than 100 locations. The DoD transferred $979,000, and the DoS shifted about $131,000. The AEC raised its support to more than $192,000, and other Federal agencies supplied about $649,000.

The Division, among its organizational changes during the year, activated in November 1951 a Program Control Branch, with George Ferguson as its Chief, to develop and operate a coordinated system of defining, planning, budgeting, allocating, and accounting for all of the Division's programs. Ferguson's new Branch contained Carl W. Morgan's Fiscal Management Section, Kenneth B. Young's Program Development Section, and George D'A. De Buchanne's Program Coordination Section, with John C. Kammerer as the Branch's staff scientist. In 1952, the Technical Coordination Branch added a third Section, Water Utilization (the Branch's former title to 1948), led by Jack B. Graham, to its existing Sections of Research and Technical Reports. The new Section's projects included Rivers and Land Morphology, Soil and Moisture, Water Losses, and Water Utilization. The Division's activities abroad expanded significantly in 1952, and some of its members trained hydrologists from Brazil, Canada, India, Mexico, and other countries. Other Division personnel began or continued observations of surface water and groundwater in Guam, Samoa, and the U.S. Virgin Islands.

The Surface Water Branch during fiscal year 1951–52 continued to observe streamflow at about 6,400 stations and, as before, publish the results in the annual series of Water-Supply Papers. The Branch established in 1952 two new units—Tate Dalrymple's Technical Standards Section and Carl E. Kindsvater's Research Section. Branch members experimented with using electronic machines to compute stream-discharge records, installed continuous water-temperature recorders at some gaging stations to provide data for ready consultation by industry, and prepared a preliminary report on the return flow of irrigation water in the Columbia River Basin. Studies of sediment movement in streams furnished data for Federal and State agencies involved in planning and operating storage reservoirs, diversion works, and canal systems.

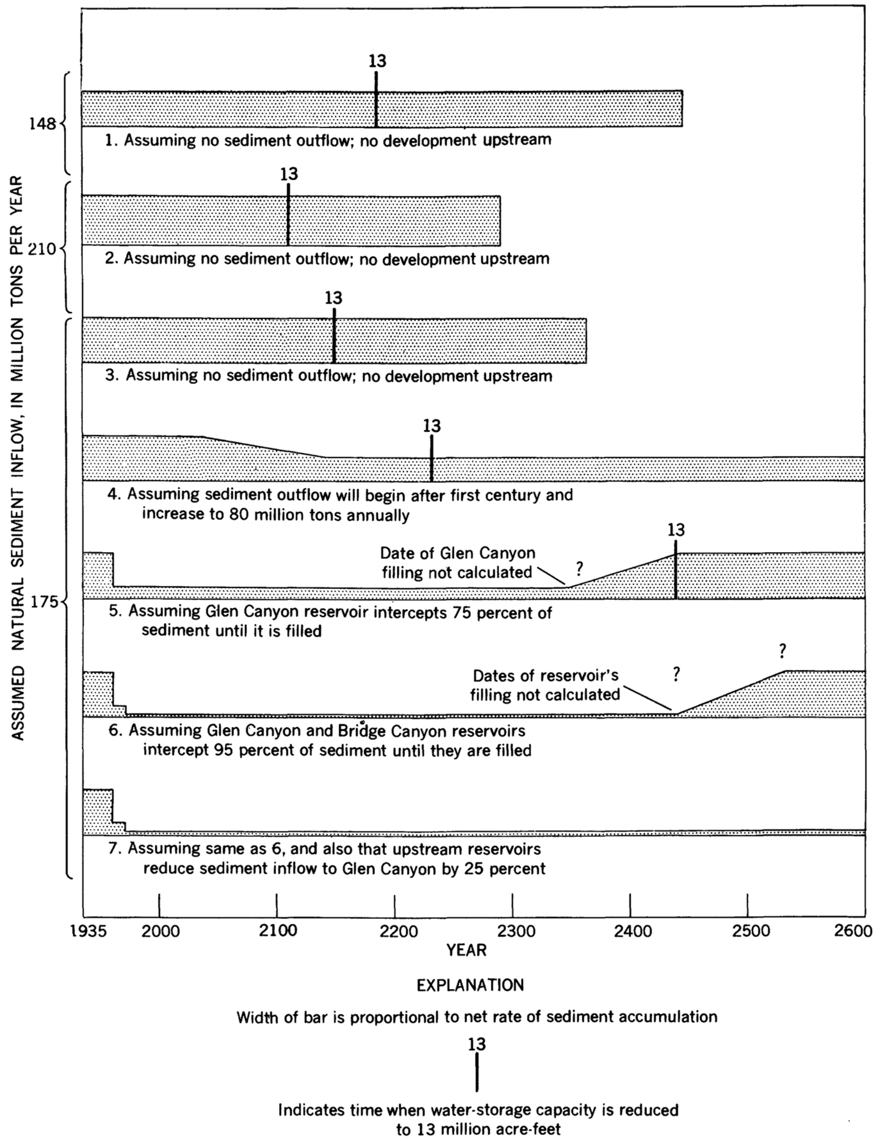
As part of Interior's program to protect the public lands in the West under the Department's care and maintain their high productivity, Branch members continued their studies of soil and moisture conservation, aided by the USGS appropriation now increased to $43,700. As new sources of water were discovered, and additional arid and semiarid land was put to better use, the Surface Water Branch, in collaboration with other Interior agencies, examined and reported on critical soil-erosion problems and evaluated conservation methods. For many reservoirs, Branch personnel determined the rate of sediment fill and amount of upstream erosion and continued studies of sediment origin, stream-channel entry, transport, and deposition, including problems of scour and fill. In cooperation with and funded by the USBR, the Branch expanded its investigation of the amount of sediment carried as bedload, rather than suspended load, at several sites in the Missouri River Basin, but the reduction in transfer funds curtailed basinwide investigations. Branch members also essentially completed the study at Lake Hefner to develop basic methods for more accurately measuring evaporation from reservoirs. Cooperative work with the USBR, the NEL, and the Weather Bureau determined the amounts and rates of losses by evaporation from reservoirs and applied them to evaluating Lake Mead to help manage the waters of the lower Colorado River. Branch experts also investigated using reflected sound waves to determine the thickness and character of bottom sediments at several locations and the nature of the foundation at the site of a potential major engineering structure in Maine.

In 1952, the Ground Water Branch also began two new Sections—Ground Water Hydraulics, led by William F. Guyton and then Russell H. Brown when the Division shifted Guyton to studies of national water use, and Manpower and Training, directed by Garald G. ("Jerry") Parker (Sr.). Branch members, experimenting with new equipment and methods, began a study of numerical methods and electronic computers to measure areal groundwater recharge, flow, and discharge. This investigation grew from work at Indiana's Eagle Lake on the effects of proposed drainage ditches on lake and water-table levels and groundwater recharge. Efforts by Branch personnel at El Paso, Texas, showed that wells there might be used to artificially charge aquifers. Deep drilling in Utah revealed aquifers that might be discharging into Utah Lake water that could be recovered without affecting the overlying aquifers now being used. Branch members continued using electric logs to determine not only the mineral content of groundwater but the approximate concentrations of different ions in the waters of various aquifers. A new technique introduced measured amounts of water into wells to gain quantitative data on their value as indicators of water level and aquifer productivity. Branch specialists developed an electrically operated water-stage recorder for wells too small or deep for standard floats that made the continuous collection of water-level data less costly. They also converted 8-day recording gages to 30-day operations by using an inexpensive battery-operated clock escapement. Investigations at and near the Army arsenal at Huntsville in Alabama indicated that the structure of limestone strata controlled groundwater occurrences in a manner not previously observed, suggesting that similar supplies might be found and evaluated in limestones of other areas. The Branch planned studies of the effect of groundwater movement on the accumulation of oil and gas that an industry geologist suggested might lead to new discoveries of petroleum in presently unproductive areas. Routine investigations also aided the choice of a site near Portsmouth, Ohio, for a new atomic-energy plant. In 1952, the Division began gathering preliminary data on a few representative samples of the natural, or "background," radioactivity of water resources, with the principal hopes of finding new sources of fissionable materials, gathering information vital to public health in the event that radioactive materials accidentally or deliberately entered water bodies, and advancing hydrological understanding. Mining hydrology studies in eastern Tennessee solved the problem of water inflow that prevented extraction of zinc from an important deposit and led to investigations of similar problems in Arkansas, Michigan, and Minnesota and proposals for work on others in Alabama and Wisconsin.



This figure compares computed and observed daily evaporation in centimeters as determined by the Cummings Radiation Integrator at Lake Hefner, near Oklahoma City, during 1950–52. Interagency atmospheric and water sensors were deployed on or below barges anchored in and floating evaporation pans in shoreline frames at Lake Hefner and later at southern Nevada's Lake Mead (1952–53). USGS personnel and collaborating specialists from the Navy Bureau of Ships, the Navy Electronics Laboratory (NEL), the U.S. Bureau of Reclamation (USBR), and the Weather Bureau gathered data to test the energy-budget and mass-transfer methods of estimating thermal-energy budgets at Lakes Hefner and Mead. They determined that Lake Mead lost by evaporation during 1952–53 about 875,000 acre-feet, an amount equivalent to 7 feet of water lakewide. (From Harbeck, 1952, fig. 92; see also Harbeck and others, 1958.)

These actuarial projections for sediment fill in the reservoir behind Hoover Dam during the years 2000 to 2600 are based on the results of atmospheric, geodetic, hydrographic, hydrologic, and sedimentation surveys of southern Nevada's Lake Mead in 1947–49. To improve estimates of water-reservoir capacity and loss, and to propose remedial treatments, specialists from the U.S. Bureau of Reclamation (USBR), the U.S. Coast and Geodetic Survey (USCGS), the Navy, the USGS, and the Weather Bureau joined in studying evaporation and sedimentation rates in Lake Mead and also in Lake Hefner in central Oklahoma. (From Smith, W.O., and others, 1960, fig. 64; modified from Thomas, 1954, fig. 9.)



As part of the Ground Water Branch's work abroad, Thomas E. Eakin conducted a field reconnaissance during November 1951–January 1952 of Iran's water resources and recommended long-term technical assistance in investigating that country's ground and surface waters. Eakin then served as the Water Resources Division's representative on the USGS Foreign Activities Committee. The Branch sent Joseph W. Lang to Tehran to advise the Shah's government about developing its groundwater resources; during April–October 1952, Lang investigated 25 areas throughout Iran, including several locales along the Caspian Sea's southern shore. Other members of the Branch began studies of 2,000 irrigation wells in India's Ganges Plain, started new investigations in Libya, and built a discharge integrator for Chile.

In response to continued concern about nationwide problems of water pollution and its abatement, the Quality of Water Branch exchanged data during fiscal year 1951–52 on streamflow and the chemical and physical properties of surface water and groundwater with public agencies that collected information primarily on bacteriological pollution; the cooperatively published interpretations of the combined information included a pollution survey of Ohio's part of Lake Erie.

Branch members contributed physical and chemical data from irrigation projects to those who tried to control the increasing concentrations of mineral contaminants formed by reusing water. Branch researchers also determined the minimum flows necessary to flush harmful pollution from industrial plants and sewage so that managers could make usable the waters of certain reaches of dam-controlled streams. These data also supported groundwater studies that included the contamination of certain aquifers by leaks from poorly cased wells, the effects of mixing groundwaters of varied chemical qualities, pollutant dispersal from surface disposal of wastes, and the encroachment of oil-field brines and oceanic waters into freshwater aquifers. Investigations of disposals of septic-tank effluent near Paducah, Kentucky, demonstrated that effluent might be drained safely into permeable but unsaturated rock units if the nature of the rocks had been confirmed by hydraulic research. The Branch began collecting data on the minimum requirements of many industrial users and, in places, the necessity of conserving the supply by wise reuse, by obtaining preliminary information on the water needs of the aluminum, carbon black, copper, paper and pulp, petroleum, and rayon industries.

In the Conservation Division during fiscal year 1951–52, Harold Duncan appointed to his staff two Assistants—Robert Spratt (shifted from his similar post in John Northrop's Mineral Classification Branch) and Johnson B. Mitchell. The Division received almost $1,332,000, or $132,000 more than the amount in the previous year, for classifying lands and supervising mining and oil and gas leases. Of that total, about $1,284,000 came from direct appropriations to continue the Division's limited dependence on outside funding. The Navy transferred to the Division nearly $31,000, and States, counties, and municipalities resumed their contributions with some $12,000, but the USBR and other Federal agencies shifted only $4,600. As of June 30, 1951, the Division employed 233 persons, or 24 more than on November 3, 1950; 210 were full time, 4 were part time, and 19 were field assistants and laborers.

Increased demands led the Conservation Division's Mineral Classification Branch to markedly accelerate its services during fiscal year 1951–52. Division members handled more than 28,000 cases, a 65-percent increase over those processed in 1950–51, due to the clearance of applications for radioactive and other mineral rights under the leasing laws applicable to the public lands. The Mining Branch supervised nearly 1,200 properties that yielded royalties of slightly less than $3.8 million. The production of coal fell by more than 800,000 tons, owing to greater competition from other fuels and the prolonged strike in the steelworks that produced a general slowdown in other industries. The production of sodium rose, as did that of lead and zinc, although that pair's lower grade ore somewhat offset the increased tonnage. Potassium production remained about the same as in 1950–51, but one of the new producers in New Mexico began operations in December 1951 and another expected to begin work in October 1952. The Oil and Gas Leasing Branch supervised more than 63,160 oil and gas properties on the public lands, an increase of 62 percent from those managed in 1950–51; some 1,360 properties were on acquired lands, and nearly 7,740 leaseholds were on Indian lands. Royalties from fuels produced from public, acquired, and Indian lands rose to more than $44.2 million (an increase of $9.4 million), production from NPR–2's 262 active wells yielded royalties of nearly $817,000, and the Army's Rio Vista gas field supplied an additional $416,000. The Water and Power Branch supervised construction and operations on 940 power projects—nearly 135 under license from the Federal Power Commission, more than 600 under the Interior's permit or grant, and 200 in cooperation with the BIA. Members of the Branch performing classification work increased power-site reserves in 23 States and Alaska to nearly 7 million acres. They also investigated the geology of 6 dam sites, completed topographic surveys of sites for 8 dams and 1 reservoir, plus 41 miles of river channels, and published maps of 7 dam sites and 89 miles of river channels.

In the fall of 1951, while truce talks in Korea that began during the summer remained stalemated, the United States extended its mutual-defense arrangements, and World War II officially ended. When Winston Churchill returned as Britain's Prime Minister, Frederick Lindemann (Lord Cherwell) again replaced Henry Tizard as the Government's chief scientific adviser. Although Zhou Enlai rejected in January a U.N. offer for a cease-fire in Korea, Yakov Malik made a similar proposal in the Security Council on June 23. Negotiations started at Kaesong on July 10 and continued on October 25 at Panmunjom, where Vice Admiral Turner Joy led the U.N. Command's delegation. The participants principally discussed establishing cease-fire and demarcation lines, prisoner exchanges, and airfield reconstruction, proposing as supervisors of any agreement representatives from Czechoslovakia, Poland, Sweden, and Switzerland. Meanwhile, the United States and the Republic of the Philippines strengthened their ties by implementing on August 30 a mutual free-trade pact that extended to 1954 and promised gradual reductions in tariffs for an interval of 20 years thereafter as a supplement to the rehabilitation and military assistance acts of 1946. On September 1, 1951, the United States completed the ANZUS mutual-security and assistance treaties with Australia and New Zealand and also with the Philippines. Three days later, representatives of the United States and 48 other nations[139] met at San Francisco to sign a treaty of peace with Japan. The agreement, signed on September 8, gave Japan full sovereignty and independence, provided for withdrawing occupying forces within 90 days after ratification, eschewed reparations, and allowed the formation of a self-defense force. Japan recognized Korea's independence, surrendered all claims to Formosa (Taiwan), the Pescadores, the Kuril Islands,[140] Sakhalin, and the Pacific islands mandated to the Japanese by the League of Nations after World War I, and accepted U.N. trusteeship over the Ryukyu and Bonin Islands under the sole administration of the United States. In a separate treaty signed that day, Japan agreed to continue hosting U.S. armed forces and supply nonmilitary aid to the U.N.'s effort in Korea. On October 25, the Conservatives won Britain's national election and gained a 16-seat majority in the House of Commons. Two days later, Winston Churchill began a second term as Prime Minister and Minister of Defense. Anthony Eden rejoined Churchill for a second tour as his Foreign Secretary and presented the Colombo Plan to provide an initial £8 billion to aid economic development in Borneo, Ceylon, India, Pakistan, and Sarawak. In Noumeá on November 7, the ANZUS nations agreed to extend their pact's coverage to include Guam and the Trust Territory of the Pacific Islands. The U.S. Senate ratified the peace treaty with Japan and the mutual-defense pacts with Australia, Japan, New Zealand, and the Philippines on March 20, 1952. World War II in the Pacific officially ended on April 28, as the American-Japanese pact for mutual security went into effect; the Japanese began diplomatic relations with Taiwan on August 5, and the United States loaned some 70 frigates and landing craft to Japan on November 12.

Early in January 1952 and again early in April, Churchill, Eden, and Lindemann came to Washington to review with Truman, the Secretaries of Defense, State, and the Treasury, and Harriman their joint concerns in foreign policy, especially the recent activities designed to secure Europe's defense. As part of their mutual agreements, the two countries announced on January 18 a short-term minerals exchange by purchase that provided Britain with 1 million long tons of U.S. steel, scrap, and pig iron in return for 20 long tons of tin and 55 million pounds of aluminum; the United States promised to replace the aluminum by its own exports by mid-1953. The Truman administration agreed on May 5 to station U.S. troops, by Iceland's request on April 7, 1951, at Icelandic facilities as part of NATO and completed on April 27 a similar agreement with Denmark for the defense of

Greenland during the next 20 years. Nine days earlier, France, West Germany, Italy, and the three Benelux nations signed a treaty to integrate their coal and steel markets, and the West Germans later joined the pact. On September 6, Portugal and the United States agreed to have the Azores included in NATO's defense plan. NATO's Council, while meeting in Ottawa during September 15–20, decided to invite Greece and Turkey to join the pact, which they did in February 1952; ground forces from both countries continued to serve with the U.N. Command in Korea. On September 20, representatives of Britain, France, and the United States met in Washington to try to end the legal occupation of West Germany and to add the Federal Republic's armed forces to a European army but on a fair-share basis. George Marshall resigned as Secretary of Defense on the following day. To succeed Marshall as Secretary, Truman nominated Robert Lovett, formerly Stimson's Assistant Secretary of War for Air during 1941–45 and Marshall's Under Secretary of State in 1947–49.

As another step in postwar rehabilitation and defense of Europe, Truman declared that the state of war between the United States and Germany ended officially on October 24, 1951. The United States and Yugoslavia signed an agreement on November 14 by which the former, beginning in July 1952, promised to supply Marshal Tito's country with artillery, jet aircraft, tanks, and other military equipment, materials, and services. That decision reflected Tito's opposition to the People's Republic of China's participation in the Korean conflict and his government's improved relations with Italy and West Germany. In January 1952, the United States and the Soviet Union offered differing plans in the United Nations to control atomic energy by continuing inspections and prohibitions, but neither country accepted the other's plan. During the second Truman-Churchill meeting, the United States announced on April 6 that it was developing a hydrogen bomb. On April 9, the two leaders issued an agreement in which the United States promised not to store nuclear weapons at its air bases in Britain without British approval. Eisenhower, who had said in January that he would respond to a Presidential draft, announced his resignation as SACEUR on April 12; a month later, Ridgway replaced Eisenhower in Europe, and Mark Clark succeeded Ridgway in the Far East. On May 27 in Paris, representatives of the Federal Republic of Germany joined those from the Benelux countries, France, and Italy in establishing a European Defense Community (EDC), a single-command organization, linked to Britain and headquartered in Paris, that reported directly to NATO. France did not ratify the agreement. Separate understandings promised West Germany full sovereignty, an end to Allied occupation but retention of military rights there, and acceptance of money and armed forces from the Federal Republic for NATO's defense of Europe. Britain and the United States agreed to maintain indefinitely their garrisons in Europe. Although Truman signed in August a protocol to the North Atlantic Treaty that extended its defense guarantees to include the EDC, the French National Assembly rejected the EDC. On August 1, France agreed to "Europeanize" the Saar and include it in the joint coal-steel agreement. The initial session of the European Coal and Steel Community's council voted on September 10 to try to extend the economic group to the political realm; that effort ended when the Bundestag declared the Saar election illegal and refused to recognize its pro-French results.

Truman's budget message to Congress on January 21, 1952, estimated for fiscal year 1952–53 Federal expenses of $85.4 billion, receipts of $71 billion, and a deficit of $14.4 billion, all sums except the last one greater than those in 1951–52. The $27 billion he proposed for natural-resources expenditures, $543 million less than in 1951–52, included $29 million, a $1 million increase, for the USGS. The USGS, with the USBM, continued to "appraise known sources and make surveys for new sources of critically needed materials—such as uranium, nickel, cobalt, tungsten, copper, and lead—and conduct research aimed at improving mining practice and methods of extracting materials, recovery of secondary metals, and increased efficiency in the use of substitutes."[141] Truman also emphasized his administration's plan to continue research and operate pilot and demonstration plants for producing liquid fuels from oil shale and coal. On February 11, Truman urged Congress to extend and strengthen the Defense Production Act[142] and help expedite the production of bauxite from Jamaica, copper from Chile, and nickel from Cuba. After Truman appointed Manly Fleischmann to succeed Edwin Gibson at the Defense Production Administration, the President nominated Henry H. Fowler as Fleischmann's replacement at the National Production Authority; in September, Truman asked Fowler to follow John Steelman as head of the Office of Defense Mobilization. In other changes in 1952, James Webb resigned as Under Secretary of State and joined Kerr-McGee. When James Boyd left the DMEA and the USBM to become vice president for exploration at Kennecott Copper Company, John J. Forbes replaced Boyd at the USBM. Truman added, on March 6, that the United States required $7.9 billion to finance its foreign aid during fiscal 1952–53. He also repeated, on April 19, his January request for action by the legislators on the St. Lawrence Seaway and Power Project. To ensure continued Federal control of U.S. offshore fuel resources, Truman vetoed on May 29 a Senate Joint Resolution that would have established free titles to the States for the lands and natural resources beneath navigable waters within their boundaries.

Secretary Chapman requested $621.5 million for Interior during fiscal year 1952–53, or about $100 million more than in 1951–52. The new total included $12 million more for the USBM and the USGS, whose exploration programs for strategic and critical materials, Chapman asserted, "should be 10 times as great as they are today."[143] The Bureau of the Budget (BoB) approved for the USGS a SIR total of $29,055,000, a $7.6-million increase over the previous year's sum, to cover the larger salaries required by 1951's Pay Act, the AEC's needs, and the $4.9 million in domestic-mapping funds previously provided by the Army Engineers to expand a strategic effort that was now the USGS' basic responsibility. Managers of the USGS topographic program proposed to map about 4 percent of the 2.5 million square miles not yet covered. Chapman also emphasized the Nation's need for continued discovery of oil reserves in light of American industry's continuing expansion. Eighteen years earlier, Interior and the American Petroleum Institute had reported U.S. known reserves of 21 billion barrels. At the present rate of use, Chapman noted, those reserves would have lasted no more than 15 years. Now, with known reserves of 25 billion barrels, the production rate was 6 million barrels per day or 1 million less than the rate of consumption.

Wrather appeared before the House's Interior subcommittee, chaired by Representative Kirwan, on January 21, 1952, 4 days before Chapman's testimony. Wrather expected the USGS to receive total receipts of $50.9 million from Federal and nonfederal sources, $1 million more than in 1951–52. In supporting the request for the full SIR amount, Wrather and his managers emphasized the significant new discoveries of iron, zinc, columbium (in bauxite), and cobalt, the last two used in manufacturing jet engines. They also reported the increased monies expected from the Army Engineers; the greater air-photo coverage and helicopter-supported triangulation control that enabled up to five-times faster work than originally planned in mapping Alaska's topography; and the increasing requests from the AEC, the USAF, and the NSRB for water-supply data and investigations of sites for industry, bases, and depots. Representative Norrell asked Bill Bradley if the funds provided for studies of Arkansas bauxite, other U.S. mineral resources, and other vital problems, if approved, could be used flexibly. After Bradley said yes, Wrather responded for the rest of the USGS program by emphasizing the need for adequate funds not specifically earmarked "for some specific purpose or project."[144] "That is particularly true," Wrather continued, "in water because the demands for financing water programs are distributed all over the country." The USGS, he concluded, could make one of its greatest contributions to national welfare

> **if we just had in our budget money which we could hold inviolate, subject to administrative direction on what these pressing problems are, allowing us the opportunity to study the situation and reach sound conclusions.[145]**

The House Committee on Appropriations approved the full amount recommended by the subcommittee, but, on the House floor, Representative William M. Colmer (D–MS) proposed an amendment to set the appropriation at the previous year's figure. In opposing the change, Kirwan urged his colleagues to remember the needs for running the Nation and its defense and vote down the amendment. Instead, the House passed the modification and selected $25,362,685 to represent the last year's appropriation. The legislators, in doing so, may have misread the data in the justification that gave the total available for fiscal year 1951–52, excluding the pending estimate for pay raises. Carl Hayden's Senate subcommittee on Interior's appropriations heard Chapman on April 16. The Secretary asked the subcommittee to restore to the USGS in full the nearly $3.7 million cut, an amount 5 percent below the current appropriation, on the House floor, but Senator Cordon urged his colleagues to keep the 1951–52 level. Wrather and his administrators appeared on April 25 and asked for a full restoration by activity; otherwise many operations including the work on high-temperature metals and the strategic mapping would be delayed. The USGS, Wrather testified, could not absorb the costs. In response to Hayden's query about the topographic work, FitzGerald said that even with full funding and the technological advances "It will take us about 30 years"[146] to map the conterminous United States but that the coverage of Alaska would be completed in 6 to 8 years. When Hayden asked about the value of transferred versus direct funding, Wrather pointed out the former's unreliability, using as a recent example the Army Engineers' reduction in their transfer funds that caused the USGS to "drop 75 gaging stations operated for flood control." He emphasized that

> **our problem is keeping a competent and efficient organization capable of dealing adequately with a fluctuating workload which results from depending too extensively on transferred funds.[147]**

The full Senate proposed a further reduction in USGS funds to $25,301,000 but, in the end, it accepted the House's figure. The conference committee recommended distributing the USGS appropriation among its activities as set out in the Senate's report, except to reduce the amount for topographic surveys by $138,415 and increase that for water-resources investigations by $200,000. The legislators agreed to fix the final figures for direct appropriations for fiscal year 1952–53 at $25,362,685. That total included $11,306,585 for topographic surveys, $5,810,000 for geologic and mineral-resources surveys and mapping, $6,187,000 for water-resources investigations, $43,700 for soil and moisture conservation, $360,000 for land classification, $1,080,000 for supervising mineral leases, and $575,400 for general administration.

As Interior's budget for fiscal year 1952–53 neared approval, the President's Materials Policy Commission, chaired by William Paley, transmitted to Truman on June 2, 1952, its report, the five-volume "Resources for Freedom," and the President sent it on to Congress. The Paley Commission's "major premise" held that

> **[t]he over-all objective of a national materials policy for the United States should be to insure an adequate and dependable flow of materials at the lowest cost convenient with national security and with the welfare of friendly nations.[148]**

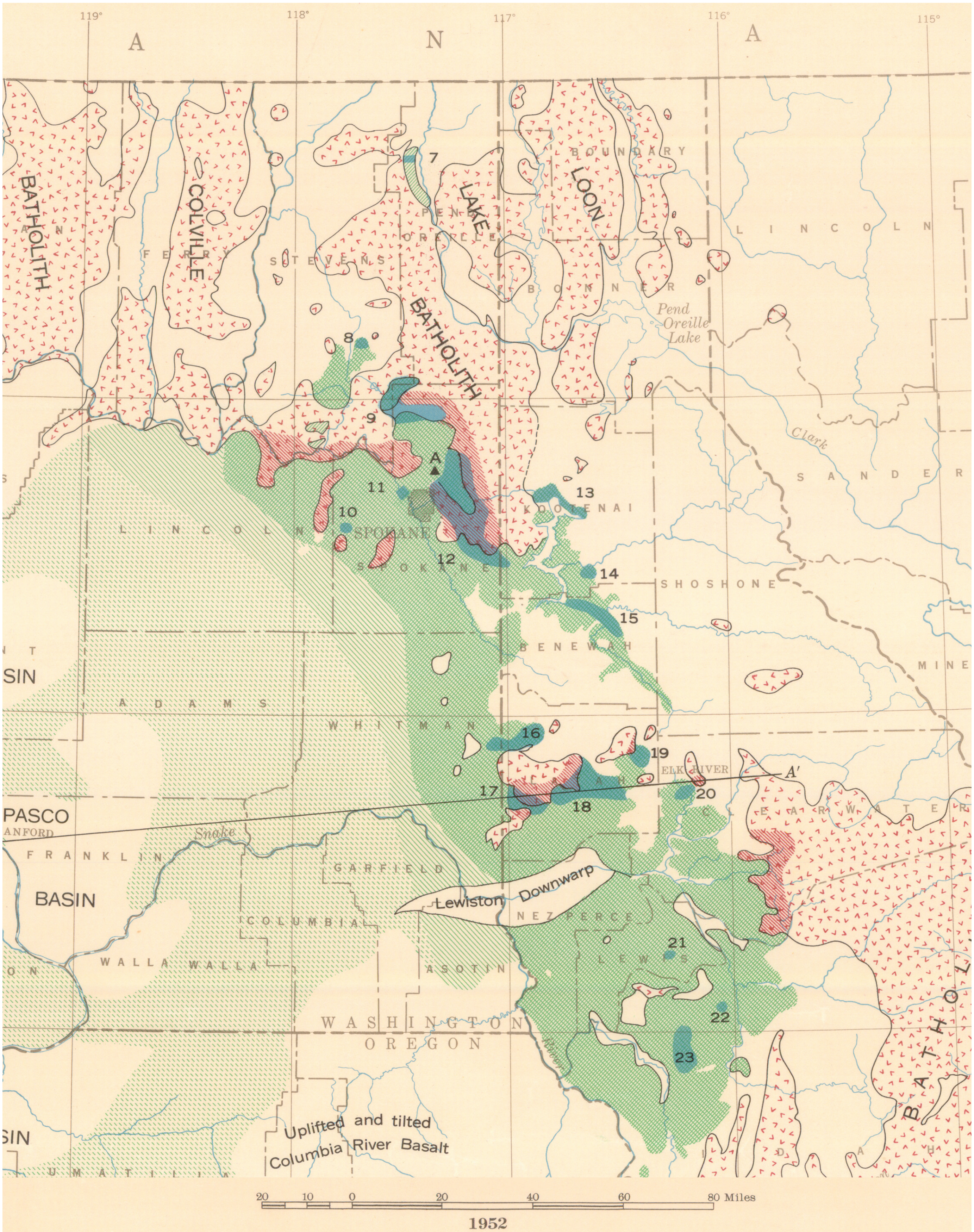
The Commission emphasized, as its "most important conclusion," that

> **the job must be carried on cooperatively by Government and private citizens, not periodically at widely spaced intervals, but day by day and year by year.[149]**

The Paley Commission estimated that materials consumption would increase by 153 percent in the next 50 years, minerals use would rise twice as fast as the total of all other materials, materials demand by the United States compared to that of the rest of the free world would increase unevenly, and, although new and substitute materials would be produced, that the Nation would become a net importer of other key resources besides copper, lumber, petroleum, and zinc. The Commissioners hoped that new discoveries, sufficient energy resources, and new technology would counter expected continuing rises in prices. The Commission's report, in discussing mineral, timber, agricultural, and water resources, represented the most comprehensive treatment ever given to the material-resources problem.

The Commission, in asking for "more facts and better analysis," recommended strengthening the program-analysis staffs and fact-gathering and analytical abilities of Interior's Office of the Assistant Secretary for Mineral Resources, the USBM, and the USGS "to develop and maintain a comprehensive appraisal of the minerals and energy position and prospects of the United States and the free world."[150] The Commissioners emphasized "an impelling need to accelerate the topographic and geologic mapping of the United States and Alaska." They called the current rate of progress on adequate-scale mapping to support mineral discoveries of one-half of 1 percent of the total land mapped in a year "pitifully inadequate to the Nation's needs."[151] They suggested that personnel shifts and new recruitment "might be possible to increase the rate of geologic map making by 50 percent in 5 years, and to double it in perhaps 5 years more." "Similar increases," they added "could be made in topographic mapping."[152] The Commissioners recommended that direct exploration for minerals by the USGS and the USBM should "be limited to those situations in which the national interest requires enlargement of reserves or knowledge about reserves but in which the risks are so great or the promise of reward in a reasonable period so small that private industry cannot be expected to undertake the work." In that mode, the two agencies would "anticipate and seek to avert emergencies rather than responding to them after they have developed."[153] That view and the recommendation that "stockpiling of strategic and critical materials [from all available sources and to the fullest possible levels] be made a permanent instrument of the national materials policy of the United States," including "the provision of adequate funds at all times for orderly purchases commensurate with possible emergency needs"[154] and the prohibition of withdrawals other than in times of national-security emergencies, demonstrated that the Commissioners also had learned the minerals lessons of World Wars I and II and the Korean conflict.

The Paley Commission focused much of its effort on metallic and nonmetallic minerals. In August 1951, the Truman administration lifted controls on asbestos, beryllium, columbium, fluorspar, graphite, kyanite, manganese, mercury, and tantalite (tantalum ore); it also centralized purchases of rubber and tin to reduce their inflated prices and build their stockpiles, but the efforts met with mixed success. The Paley Commission's second volume, edited by Lasky, contained the results of a long-range survey of prospects in the United States and the rest of the free world for 30 key commodities, of which most were minerals. They included aluminum, antimony, beryllium, bismuth, chromium, cobalt, columbium, copper, fluorspar, lead, magnesium, mercury, mica, molybdenum, nickel, quartz crystals, sulfur, tin, titanium, tungsten, vanadium, zinc, and zirconium. The fourth volume contained evaluations of the promise of improved exploration that combined geochemical,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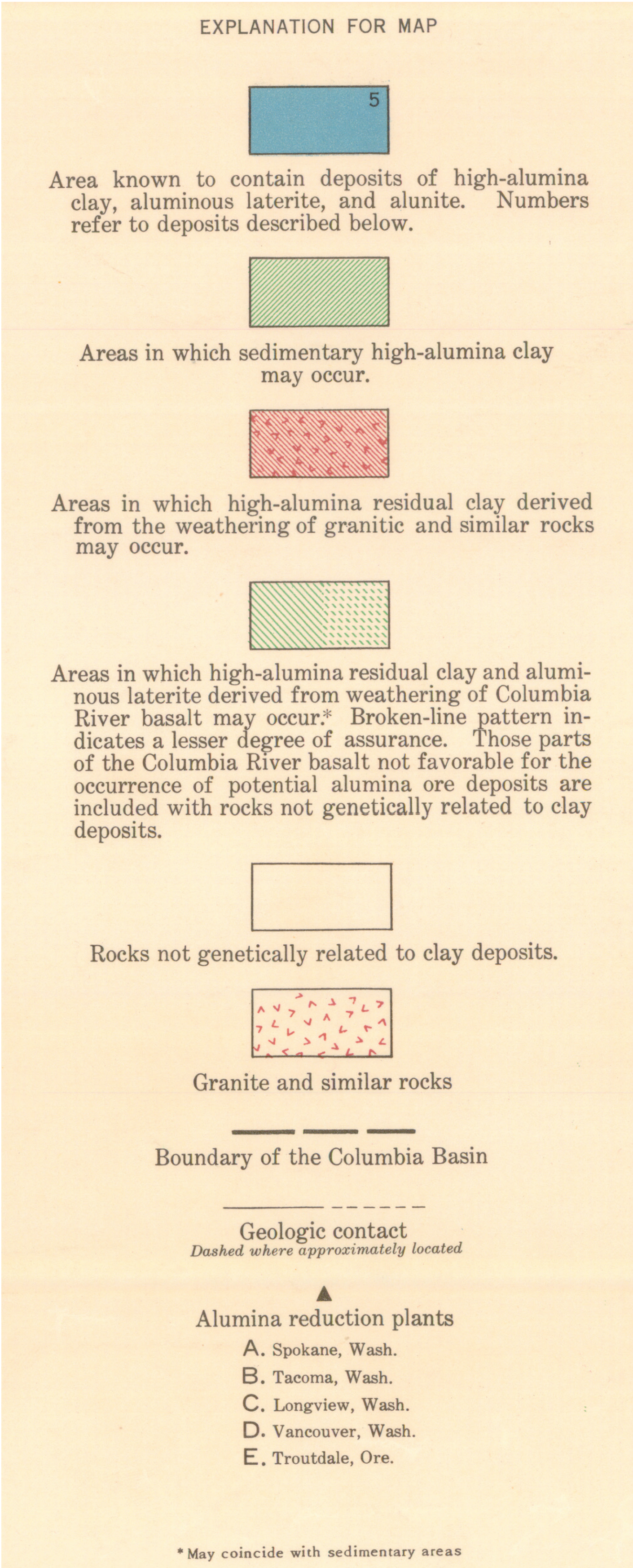


This part of Mineral Investigations Resource (MR) Map 1 (originally at 1:1,500,000) shows the geologic environment of alumina resources near Spokane in the Columbia River Basin, which encloses major portions of Idaho, Oregon, and Washington and minor parts of Montana, Nevada, and Wyoming. The map shows the areas having known potential resources and the areas in which other deposits might occur. The numbers (8–23) on this part of the larger map denote the locations of known and described deposits of high-alumina clay, aluminous laterite, and alunite, which also contained lesser but recoverable amounts of gallium, iron, and titanium. The increased use of aluminum during and after World War II led to a greater interest in U.S. sources of aluminum other than bauxite. The alumina-reduction plant at Spokane (A) was one of five facilities then producing aluminum in the Columbia Basin. The Mineral Investigations Resource Map series began in 1952, and MR 2 appeared in 1955. (From Sohn, 1952.)

geophysical, and photogeologic methods; mining-law revisions; new materials and technology; recycling; and substitution for increasing the supplies of these and other materials. Minerals "scarce in relation to their use"[155] included antimony, beryllium, bismuth, cadmium, cerium, chromium, cobalt, columbium, copper, fluorspar, germanium, gold and other noble metals, lead, manganese, mercury, molybdenum, nickel, platinum, radioactive metals, selenium, tantalum, tin, tungsten, vanadium, and zinc. Others, "both scarce and undeveloped,"[156] included cesium, gallium, hafnium, indium, lithium, rhenium, strontium, tellurium, thallium, and the rare earths. The report of a National Research Council (NRC) panel, requested by the Commission and enfolded into the fourth volume, emphasized that "abundant reserves of undiscovered minerals" lay "within economically accessible depths below the surface" and that "adequate research and development" could produce "exploration techniques capable of locating a large part" of these ores. The NRC panel suggested three main "lines of attack on the exploration problem."[157] Its members recommended determining the temperature and pressure of depositional solutions, the chemistry of mineral formation, and the significance of the nature of wall-rock alteration and alteration suites. They also listed testing color photography in regional geobotanical and geological studies (using colored or dichroic stereoscope filters in laboratory experiments to highlight diagnostic color indicators), expanding the principles of photogeology, and increasing coverage by detailed aerial photography. The panel also urged adapting known methods and devising new techniques of geophysical prospecting, including designing and developing new equipment for generating and measuring electromagnetic signals, conducting airborne electromagnetic surveys, and investigating natural potential differences.

In assessing the Nation's energy problem, the Paley Commission's first and third volumes, the latter also edited by Lasky, evaluated limited supplies and rising demands in looking at coal, natural gas, nuclear fuels, oil, oil shale, solar energy, and waterpower. The American Petroleum Institute (API) reported on March 12, 1952, a domestic production of 2.2 billion barrels of crude in 1951, compared to the yearly average of almost 1.9 billion barrels in 1946–50; proved reserves of 27.5 billion barrels, not including natural-gas liquids, compared to 23.1 billion barrels in 1946–50; and new discoveries and developments that yielded 4.4 billion barrels, compared to 2.9 billion barrels during 1946–50. The American Association of Petroleum Geologists (AAPG) noted that since 1944, the ratio of dry holes to successful wells in wildcat fields had remained constant at 8 to 1. *World Oil* reported increases in 1951 of 37 million feet drilled and 1.9 barrels of proved reserves per foot drilled. The United States continued to produce, as a percentage of its known reserves, nearly three times that of all the other countries in the free world. The Commissioners projected, on the basis of information from the API's Committee on Petroleum Reserves, the USBM, and other sources, that the Nation's demand for petroleum would increasingly outpace domestic production through 1975, whereas the latter would likely peak in 1963 or 1967 and then decline slowly or more rapidly, although the third scenario showed a continued rise. America's present use of 6.5 million barrels of oil each day, they suggested, would increase to 13.7 million, or about 110 percent, by 1975, as the total demand of the free world rose from 10 million to 26.8 million barrels, or nearly 170 percent. The Commissioners knew that new domestic discoveries of significant structural and major stratigraphic oil fields continued to be made. Perhaps additional supplies would come from secondary recovery methods in existing fields; commercial quantities of synthetic oil, within 10 years from oil shale and then from coal; and rising imports from greater reserves proved by increased drilling in the Middle East and elsewhere to make up the shortfall of 2.5 million barrels per day in net imports in 1975, up from 545,000 each day in 1950.

The Commissioners, in urging a national policy for energy and other material resources, argued that petroleum reserves for times of war would be helped most by an "'underground stockpile' of semiproved oil deposits which could be drilled up as required with maximum speed and at minimum expenditure of materials and manpower on 'dry holes.'" As the Continental Shelf, "particularly that section off the Gulf Coast," provided such an area, they recommended that "the Federal Government encourage immediate exploration for oil on publically owned off-shore lands."[158] On January 16, 1953, Truman responded by issuing an Executive order setting aside the oil-rich submerged lands of the Continental Shelf as a naval petroleum reserve,[159] stating, as he did so, his belief that all its oil and gas belonged to citizens of the United States and not just those of California, Texas, and Louisiana. The Commissioners concluded "that the most important step for Government to take at this time toward developing a comprehensive energy policy is to achieve, through a single agency, a comprehensive and continuing review of the long-term energy outlook and an appraisal of the adequacy of public and private policies and programs for coping with the problems."[160] They recommended funding the NSRB as the central agency for collecting and evaluating "the facts, analyses, and program plans of other agencies on materials and energy problems and related technological and special security problems," recommending "appropriate action for the guidance of the President, the Congress, and the Executive agencies,"[161] and reporting annually to the President the long-term outlook for, changes in, new problems about, and necessary modifications of materials policy and publicizing it to the degree consistent with national security.

The most significant problem in water resources, the Paley Commission asserted, remained the large differences in the availability to and the use by the States of surface water and groundwater. The 17 westernmost States occupied about 60 percent of the Nation's land area, but they held only about one-fourth of its water supply. The Western States averaged less than 4 inches of runoff per year, compared to 16 inches for the 31 Eastern States. Water use, the Commissioners noted, also remained a regional rather than national problem, as industrial consumption remained heaviest in the Northeastern States compared to municipal, rural, and agricultural uses. The Commissioners estimated that industrial demands for water would rise from 80 billion gallons per day in 1950 to 200 billion gallons in 1975, and the total of domestic, industrial, and irrigation requirements would increase during the same interval from 185 billion to 350 billion gallons each day. New resources, they suggested, might come from reclaiming used water, additional regulation of streams, developing new groundwater reservoirs and artificially recharging existing ones, reducing losses from evaporation and transpiration, importing and desalinizing water, chemically seeding clouds to induce rainfall, and using substitutes for freshwater as industrial coolants. In formulating a general national policy for water resources and conducting programs for their use, the Commissioners recommended following five principles: (1) basing planning and development on all aspects of "collection, conservation, and use"; (2) employing "integrated action in each major drainage basin"; (3) applying the "highest economic use" to "scarce supplies"; (4) ensuring that benefits exceeded costs; and (5) requiring "known beneficiaries" to "help pay for improvements." The Federal Government, they suggested, could contribute best "to improving and increasing water supplies in three main areas:" through "basic studies and technological research," integrating all of its "multiple-purpose"[162] basin programs, and cooperating in all efforts to control and reduce pollution, which they believed to be the true nationwide problem. The Paley Commission, like the President's Water Resources Policy Commission, supported the Hoover Commission's recommendation for a Federal review board to "appraise the costs and benefits of proposed Federal development projects from a comprehensive national viewpoint."[163] The Paley Commission's report on water and other material resources also helped to establish Resources for the Future, a watchdog organization founded in 1952 and quartered in Washington but later moved to Baltimore.

Truman signed Interior's appropriations bill into law on July 9, 1952. On July 15, he also approved a supplementary $3.1 million for carrying out functions under the Defense Production Act. The USGS managed a total of a little more than $48 million for fiscal year 1952–53, a static figure only $5,400 beyond the sum supplied for 1951–52. The monies for 1952–53 included the direct appropriations of nearly $25,363,000,[164] or about 52 percent of the total available; $24,761,000 actually was received. Other Federal agencies transferred about $17,467,000, States and their political subdivisions supplied about $5,583,000, the sale of personal property provided nearly $129,000, the Federal Power Commission's (FPC's) permittees and licensees shifted about $70,000, and the sale to the public of aerial photographs and photographic copies of records generated nearly $47,000. The AEC topped the list of Federal transferees by providing $7,750,000, the largest sum yet sent by the AEC and $2.5 million more than it shifted in 1951–52, which increased its influence on the direction of USGS programs. The DoD transferred just under $3,873,000. That total, representing a net loss of $4.4 million, included nearly $2,207,000 from the Army and its Engineers but, as expected, nothing for topographic surveys; about $1,043,000 from the USAF; and a little more than $623,000 from the Navy. The USBR shifted nearly $3,505,000 (or about $400,000 less than in the previous year); the Mutual Security Agency generated $604,000, the DMEA provided some $472,000, and the TVA supplied nearly $100,000. The State Department, the BIA, and the DMPA transferred a combined $268,000 and other Federal agencies furnished $880,000.

As the new fiscal year began on July 1, 1952, the USGS employed 7,717 people; 6,368 of them were classified as full time, 259 were part time, and 1,090 were field assistants and laborers. The USGS had gained 800 persons, all of them full-time employees, since June 30, 1951. Of this number, 461 persons served in the Director's Office. The $3 million increase in direct appropriations for fiscal year 1952–53 enabled the USGS to expand its staff and some of its facilities to meet the demands of national defense, but this work already strained the agency's existing resources and now further impeded its regular program. The USGS continued to incorporate areal as well as functional considerations in its budget process. Ground was broken on March 27, 1953, for the new Pacific Coast Center scheduled to be completed by October 1. By then, Wrather and Nolan, who approved regional offices but not regional administration, centralized several support activities. Survey orders on February 17 established two new and major units, an Administrative Division and a Publications Office,[165] to which were reassigned many members of the Director's Office. The Administrative Division, led by its Chief Glendon Mowitt, the former Executive Officer, included the Accounts Branch, the Budget Office, the Organization and Management Office, the Rocky Mountain Service and Supply Branch, and the Service and Supply Branch for the other geographical regions. Wrather's memorandum of June 23 to the Division Chiefs stated a principal objective for each of the five Divisions and similar objectives for the principal operational Branches and Regions.

For fiscal year 1952–53, Bill Bradley changed the titles of his two Assistant Chief Geologists; Harold Bannerman became the ACG for Program, and Esper Larsen 3d became the ACG for Operations. The Geologic Division, on June 30, 1952, employed 1,761 people; 1,506 of them served full time, 152 others were part time, and an additional 103 were field assistants and laborers. The new total represented a net gain during the past year of 168, reflecting an increase of 200 full-time employees and a loss of 32 part-timers. Funds received by the Geologic Division from all sources for geologic and mineral resources surveys and mapping during fiscal 1952–53 provided almost $15,973,000, a net increase of some $1,172,000 over the previous year, due principally to the AEC's addition of slightly more than $1,368,000 to the funds it transferred in 1951–52. Direct appropriations provided about $5,556,000, a loss of nearly $207,000 from 1951–52 and a sum representing only 35 percent of the Division's total funds, continuing the decline in the ratio between SIR monies and transferred dollars. The AEC's funds alone, now at their largest level yet of nearly $7,168,000, represented 45 percent of the Division's total receipts and 70 percent of all its Federal transfer funds. The Army and its Engineers, the Navy, the BIA, the DMEA, the MSA, and other Federal agencies increased their transfers by a total of nearly $580,000, while the USAF, the USBR, and the DMPA reduced theirs by only $52,500. For the first time since fiscal 1941–42, the Geologic Division did not include in the USGS annual report for fiscal 1952–53 a specific amount of transfer funds from the USBM.

A Survey order on March 19, 1953, confirmed the Chief Geologist's responsibility for appointments to and operations by the Geologic Names Committee.[166] The reorganized Committee would include a Chairman, George Cohee, later known as "Judge," and not more than seven geologists, plus the Chief of the Paleontology and Stratigraphy Branch as an ex officio member, one geologist each from the Conservation and Water Resources Divisions, and temporary advisers and specialists on stratigraphic problems. The order also specified nine rules for the USGS administration of the classification and nomenclature of rock units, especially as they related to their use in manuscripts and appeals of the Committee's decisions to the Chief Geologist and the Director.

The Mineral Deposits Branch in fiscal year 1952–53 carried out 86 projects in 36 States, guided in part by Bannerman's white paper on Federal responsibilities for mineral exploration that highlighted a crisis in strategic and critical minerals he believed approached that of World War II.[167] Branch teams continued their exploratory geology and drilling in the lead-zinc district of Wisconsin and Iowa, in the Mojave Desert, and on the Colorado Plateau. Regional studies of mineral resources continued under the sponsorship of the two interagency committees—one for New England and New York and the other for the Arkansas, White, and Red Rivers. Branch geologists, financed by the DMEA and the DMPA, and working with USBM engineers, extended their evaluations of applications for mineral-development loans to private owners and provided the technical advice needed to enforce the contracts. Increased funding by the AEC facilitated enlarged physical exploration and geologic studies on the Colorado Plateau that identified new deposits of radioactive minerals of significant size and increased known reserves, as the Branch's work expanded to meet the AEC-mandated goal of 1 million feet of drilling each year. Related investigations in Colorado's Central City district by Paul K. Sims, newly joined Avery A. Drake, Jr., and their colleagues yielded two discoveries of potentially important uranium deposits.

Additional field investigations by Branch members during the year, especially those in the West, led to other discoveries. Long-term geologic mapping in the Black Hills by Jack A. Redden and other geologists helped to locate a beryl deposit that produced 250 tons of the beryllium-bearing mineral during 1952–53, a volume nearly 40 percent of the year's domestic output. Additional detailed geologic mapping by Earle Cressman, Richard Sheldon, Roger Swanson, and their colleagues in the Idaho-Wyoming phosphate region found a significant bed of phosphate rock; although low in grade, the bed proved widespread and as much as 12.5 feet thick. Arthur R. Kinkel, Jr., assisted by Wayne E. Hall and John P. Albers, continued mapping begun in 1946 in the Shasta copper belt near Redding. Their work and subsequent diamond drilling, both in cooperation with the California Division of Mines, disclosed mineralized ground that contained important amounts of copper and zinc sulfides. Studies in Minnesota's Cuyuna Range, coupled with laboratory development of a new technique for field use, led to devising a method to distinguish between similar-appearing slates in hanging walls and footwalls on the basis of a rapid chemical test for the alumina-titania ratio. This method, if found reliable, would reduce by up to 30 percent the number of drill holes required in exploring for new iron-ore deposits. Branch specialists also prepared a report on the iron-ore reserves for presentation among the other USGS-authored papers at the 19th International Geological Congress (IGC) in Algiers during September 1952. William Johnston represented Director Wrather at the 18th IGC in London in 1948,[168] but Wrather led the U.S. delegation to the 19th IGC in 1952.[169] Wrather participated in a pre-IGC coastal and inland excursion, but the "steel-frame corset [worn] for the ailment that later incapacitated"[170] him prevented his joining a postmeeting trip to mountains more than 800 miles south in the Sahara.

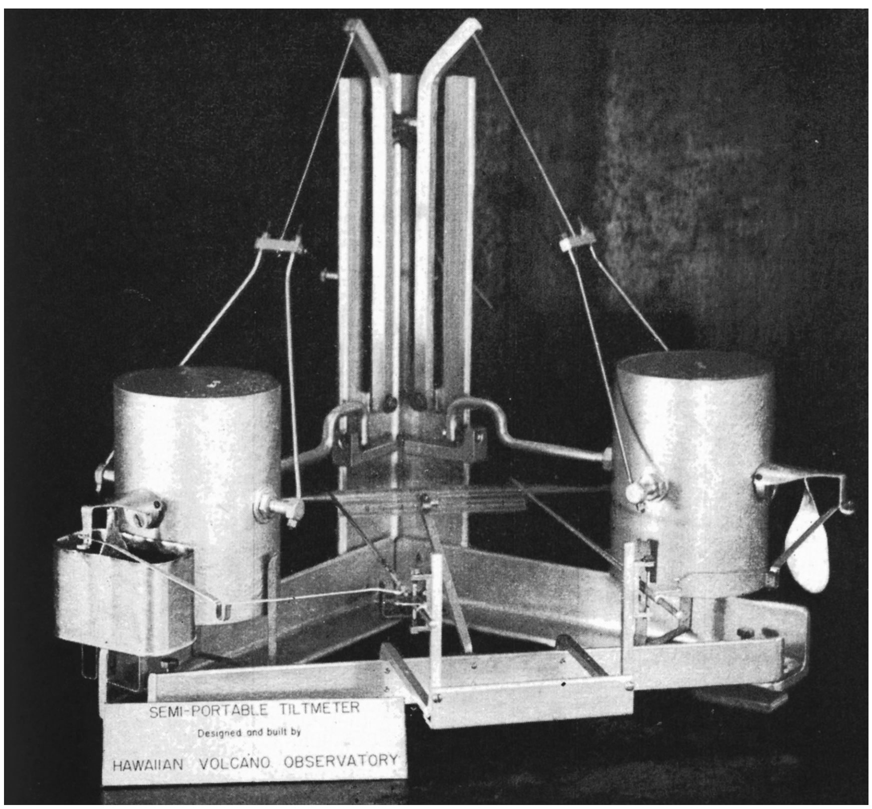
Fuels Branch members, after consulting with the oil and gas industry, State geological surveys, and other agencies, continued or began during fiscal year 1952–53 more than 20 regional studies in 16 States having known or potential petroleum resources. James Vine and the Conservation Division's Charles E. Erdmann published an oil and gas map of Montana on two sheets at 1:500,000. Investigations of oil-shale deposits in Colorado and Utah led to estimates that the shale in the mapped areas might yield as much as 79 billion barrels of oil. Branch geologists studied coal deposits in 17 States, and Andrew Brown and his colleagues published summary reappraisals of reserves in Colorado, North Dakota, South Dakota, and Virginia. For the AEC, Branch geologists made reconnaissance searches and several detailed studies, some accompanied by core drilling, in 17 States to obtain information on the distribution of coals containing radioactive materials. Branch members continued to investigate high-grade deposits of oil shale in Colorado and Utah, completed reports on areas totaling 635 square miles that held estimated reserves of up to nearly 80 billion barrels of oil, and filed an AEC-sponsored report on radioactive oil shale in the Southeastern States.

During fiscal year 1952–53, Division geologists mapped in 17 States and the Territories of Alaska and Hawaii as part of more than 20 ongoing or new projects. Two volcanic eruptions in these Territories drew public attention and helped to maintain support for the General Geology Branch's volcano-studies program. In Hawaii, Kilauea Volcano erupted in June 1952, and eruptions continued into November. Activity at Kilauea in 1952 was observed in detail by Gordon Macdonald and other geologists at the HVO, which had been relocated in 1948 from the northeast rim of Kilauea caldera to the northwest rim. On February 15, 1953, an eruption of Mount Trident, a triple-peaked volcanic complex 5 miles southwest of Mount Katmai on the Alaska Peninsula and about 275 miles southwest of Anchorage, sent an ash cloud to an altitude of 30,000 feet and later to 35,000 feet. Ray Wilcox sent geologist George L. Snyder, a former Navy pilot, to Kodiak to add his observations from USN aircraft to those made by USAF, U.S. Coast Guard (USCG), and commercial-airline crews. During February 25–March 13, and on June 17, Snyder, aided by Geophysics Branch seismologist Richard R. McDonald, studied the eruption, including the lava issuing from the southwest-side vent. Activity ended on June 30 without posing dangers to civilian or military installations.[171] Snyder then transferred to George Fraser's Eastern Aleutians Project. In May, the scientists at the USGS facility on Adak reported a mild eruption of Great Sitkin Volcano northeast across Kuluk Bay from Adak.

In fiscal year 1952–53, members of the Alaskan Geology Branch mapped areas in the lower Kuskokwim region, extended studies of copper mineralization near Prince William Sound, looked in detail at tin deposits and tungsten mineralization on the western Seward Peninsula, investigated perlite and diatomite occurrences in the area of Mt. McKinley (Denali) National Park, mapped power sites on the Kenai Peninsula, and searched for fissionable materials throughout the Territory, supported by a seasonal radiometric laboratory at College, Alaska. Engineering geologist George Plafker, who served with the Army Engineers and the Military Geology Branch before transferring to the Alaskan Geology Branch to work with Don Miller in the Gulf of Alaska Tertiary province, examined for the Conservation Division waterpower sites on the Kenai Peninsula during August–September 1952.

Farrell Barnes, Clyde A. Wahrhaftig, and other geologists continued the Branch's investigations of coal deposits in the Matanuska, Nenana, Susitna, and other fields. Results of Branch investigations led to the increases in the estimates of the Territory's inferred coal reserves; those in the Alaska Railroad belt rose by several million tons, including those recoverable by strip mining. Branch geologists also appraised the petroleum possibilities of areas near Nelchina, on the eastern slope of the Talkeetna Mountains, northeast of Anchorage, near the northeast end of the Cook Inlet-Susitna Mesozoic province, and in northern Alaska, including NPR–4.

Planning for the 1953 season in NPR–4, likely to be funded at only $4 million, began in Fairbanks during October 1–3, 1952, at a meeting attended by John Reed (Sr.), and continued at the regular meeting of the Advisory Committee, November 18–19, in Denver. George Gryc reported results of stratigraphic zonation and correlation of the North Slope's Cretaceous sequence and the work required for completing the interpretation. Drilling proposed for 1953 included two principal wells to test anticlines—a 10,000-foot penetration into pre-Cretaceous rocks at Shaviovik and a 7,000-foot well at Brady—supported by the work of one seismic crew and one of the three geologic parties. The other two geologic parties would examine the Kuparuk and Katakturuk areas, but all authorized and proposed photogeologic mapping would end, except for work on the Brady, Kuparuk, and Rex anticlines and the Cape Lisburne area. Results of coming discussions with congressional committees, Captain Meade noted on December 31, "might require the presentation of closeout alternatives."[172] When Robert B. Anderson, the new Secretary of the Navy, told the House Committee on Armed Services on March 6, 1953, that he intended to close out the exploration program in NPR–4, its members approved that decision. The Executive Operating Committee, meeting in Washington on March 10, determined which equipment would remain in NPR–4 and authorized the seismic party at Shaviovik to complete work needed to interpret the anticline; it was finished by early April. The Committee also decided to close the USGS



USGS scientists and technicians at the Hawaiian Volcano Observatory (HVO) designed and built this semiportable tiltmeter for use by HVO researchers in Hawaii and by members of the Aleutian Volcano Investigations Unit on Adak (1949–54). The instrument weighed about 90 pounds, and its upright post (at rear) was 16 inches tall. The tiltmeter originally was not equipped with a chronograph. It was housed "in a 20-inch cubical weatherproof box" that was installed on a concrete base. The tiltmeter had "a lever magnification of 15." When it was "operated with a period of 20 seconds a 1-millimeter shifting of the lever pointer" indicated "a tilt of 0.08 seconds of arc." (Quotations and photograph from Finch and Macdonald, 1951, p. 108–109 and fig. 34.)

Navy Oil Unit's Fairbanks laboratory in July but to fund a geological party to check specific structures to aid in completing the final report and support it by providing $575,000 in Navy funds through calendar year 1955. The Navy and Interior Departments agreed to turn over to the USGS the Navy's housing, offices, and warehouse at Fairbanks, where the cores and cuttings would be classified and stored as a reference collection. Members of the Pick and Hammer Club's annual show on May 2, 1953, marked the Navy Oil Unit's passing by borrowing Irving Berlin's title tune from his 1942 revue "This is the Army" for their "Home Groan Blues":

> **This is the Survey, Mr. Gryc,**
> **This is the place you won't get rich.**
> **You showed the Navy what rocks are for,**
> **But you can't drill for oil anymore.[173]**

Wrather accompanied Meade's inspection party when it visited Barrow and NPR–4, during July 3–4, to review closeout plans. At Barrow, they encountered the ONR's own inspection group, including Reed, which successfully recommended continuing the town's Arctic Research Laboratory[174] after work ended at NPR–4. Meade completed his tour as DNPR on December 16.

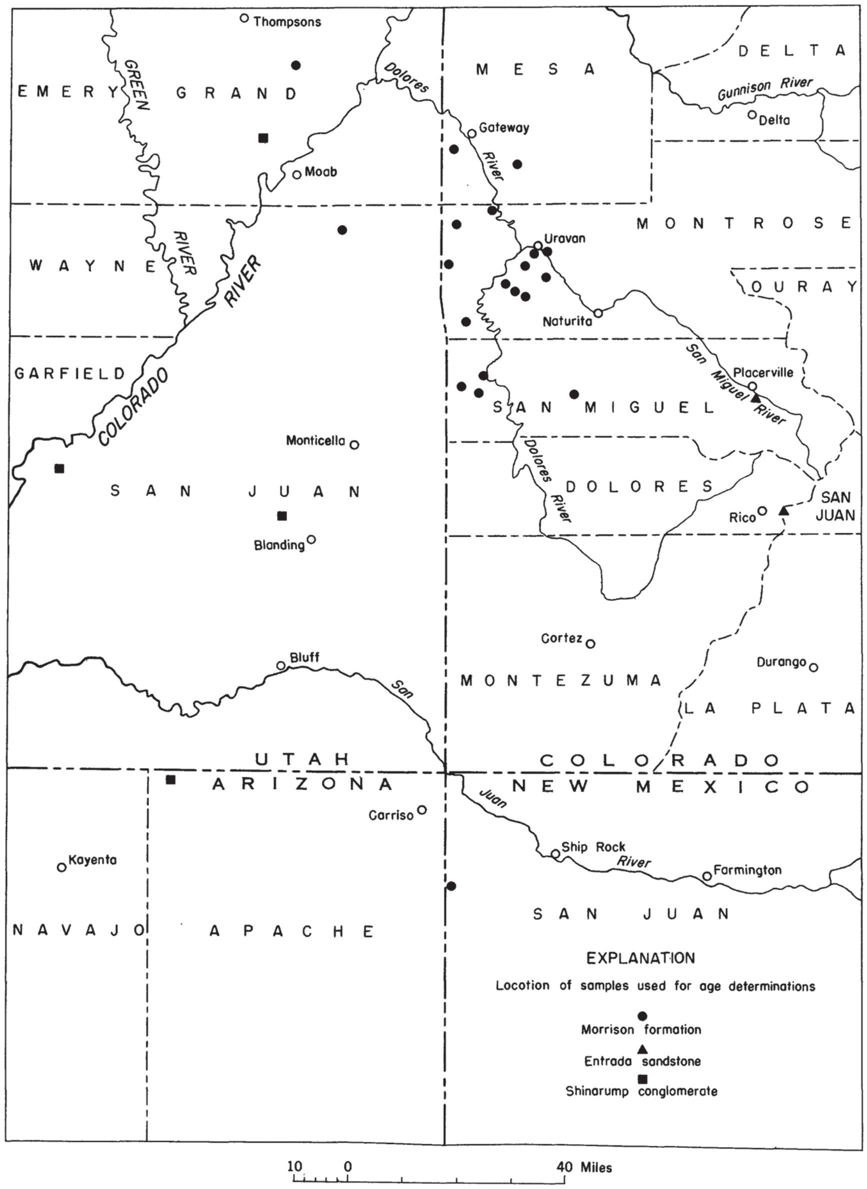
The U.S. Government expended a total of $47.6 million in its decade-long appraisal of the petroleum possibilities of NPR–4 and adjacent areas. Unfortunately, NPR–4 contained no giant oil fields, the industry's "elephants," like Spindletop, or even substantial ones. If important petroleum deposits were present in the Tertiary, Cretaceous, or older reservoir rocks of the Arctic Coastal Plain or the northern foothills of the Brooks Range, they would occur east and (or) south of NPR–4's eastern boundary in North Slope-Coastal Plain areas not yet tested by wells. The NPR–4 exploration program determined the initial "general geologic framework for all of northern Alaska," George Gryc recalled in 1985, "and established the feasibility and practicality of carrying out large-scale modern oil-exploration operations in the Arctic."[175] Drilling in NPR–4 disclosed nine fields, but only one of them contained a significant amount of estimated recoverable oil, the 70 million barrels at Umiat. Two others held useful estimated reserves of natural gas—5 billion to 7 billion cubic feet at Barrow and 22 billion cubic feet at Gubik.

Information from a total of 189,000 square miles of airborne-magnetometer, geologic, gravimeter, and seismic surveys, combined with the 37,000 square miles of trimetrogon photogrammetry of the entire NPR–4, generated an improved understanding of the geology of the Brooks Range and the North Slope. The new interpretations appeared in part on Thomas Dutro's and Thomas Payne's geologic map of Alaska, at 1:2,500,000, published by the USGS in 1954. The Navy also recovered uninstalled equipment and supplies from NPR–4 worth $11.9 million. The installed equipment at Barrow, worth $1 million, went to the ONR's Arctic Research Laboratory, and the equipment at Fairbanks, valued at $99,000, passed to the USGS Alaska center. Operations in NPR–4 also demonstrated conclusively that at times as many as 500 persons could live, travel, and work effectively and efficiently throughout the year in the fragile, harsh, and increasingly strategic Arctic on projects for America's defense and welfare. The USGS added to its support for that effort by issuing a topographic map, at 1:1,000,000, of NPR–4 and the rest of northern Alaska and a flow chart of Arctic work-feasibility conditions influenced by ice, light, and temperature, both as part of Reed's 1958 report on the history of the exploration.[176] During 1955–61, Harlan R. Bergquist, Robert Chapman, Florence R. Collins, Detterman, Dutro, Samuel Keller, Morris, Patton, Payne, Florence M. Robinson, Sable, and their colleagues reported on aspects of NPR–4's Paleozoic rocks; geology of phosphate deposits; geology of the Utukok-Corwin and Shaviovik-Sagavanirktok areas; geology and micropaleontology of cores from test wells in the Barrow, Gubik, Umiat, and 11 other areas; Mesozoic and Cenozoic tectonic elements; and vegetation.

The Geophysics Branch relocated its personnel from Baltimore, during September 1952, to office quarters in Washington and shop facilities in nearby Silver Spring, Maryland. The Branch modified a C–47 aircraft (transferred from the DoD, as N19950) for radioactivity and other airborne-geophysical exploration. In aerial surveys, now directed by William Dempsey (Sr.), over parts of 15 States, Branch geophysicists discovered above-normal radioactivity in Arizona, Florida, and Wyoming and completed a magnetic transect from Indiana across the southern Appalachians to the Atlantic Coast. James Balsley, Bill Bromery, Herbert Hawkes, Jr., John R. Henderson, Jr., Mary Hill, Matt Walton, and other geophysicists continued to conduct surveys and publish aeromagnetic-geologic maps of quadrangles and counties. Data on subsurface stratigraphy and structure obtained during ground surveys in 10 States, Alaska, and 3 areas abroad aided studies of mineral deposits and water supplies. Ground surveys made to delineate recorded aeromagnetic anomalies located new manganese deposits near Aroostook, Maine; others determined the thermal conductivity of permafrost in Arctic regions and aided the interpretation of electrical-resistivity anomalies in the Badger-Peacock mining district in Kansas. Continuing work funded by the AEC included exploration surveys, studies of radon in helium from natural-gas fields, and investigations of the physical and chemical properties of ore and country rock where the interstitial water was unaffected by drilling to aid interpretations of existing geologic and geophysical data and suggest new or modified exploration techniques. The Branch's quarterly journal *Geophysical Abstracts*, now directed by geophysicist Mary C. Rabbitt, began its 25th year of publication.

The Engineering Geology Branch's nearly 20 projects in 11 States continued during fiscal year 1952–53 to emphasize mapping large urban and rural areas in the United States principally to provide information for the planning of construction projects. Branch geologists again worked in the Missouri and Columbia River Basins and began studies on the upper part of the Green River drainage. Geologic mapping and detailed cooperative investigations also continued with Massachusetts and Rhode Island and with the cities and surrounding areas of Denver, Knoxville, Los Angeles, Omaha, San Francisco, and Seattle. The results of general and specific research on problems associated with landslides contributed to a report of landslides and engineering practices by the Highway Research Board's Committee on Landslide Investigations. Engineering geologists investigated for the NPS landslides and sites for relocating roads and tunnels near Mesa Verde in southwestern Colorado. They also cooperated with Ground Water Branch members in studying for the State of California the groundwater conditions on Angel Island in San Francisco Bay.

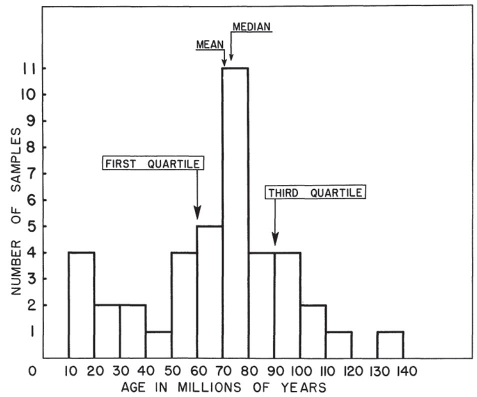
During fiscal year 1952–53, members of the Military Geology Branch continued their work in the conterminous United States, Alaska, the Pacific, Asia, Europe, and Greenland. Branch members completed for the Army Engineers "Geology and Its Military Applications," which appeared in August 1952 as Army Technical Manual 5–545 but remained a classified document until fiscal 1953–54. In Alaska, MGB geologists completed surveys of surficial geology in the Kobuk River area (east of Kotzebue), the Delta River region (southeast of Fairbanks), and the Tok-Mentasta Pass area (along the Glenn Highway south of the Tanana River).[177] Their colleagues continued to map in the southwestern part of the Copper River Basin and began new reconnaissance surveys near Bristol Bay, in the central part of the Kenai Peninsula, and along the route planned for a new road to connect Mt. McKinley (Denali) National Park with the village of Paxson on the Richardson Highway. The staff of the Pacific Geologic Mapping Program finished their work in the northern Marshalls in August 1952, including a reconnaissance of Bikar Atoll, northeast of Kwajalein, and its phosphate deposits. In the Marianas, Joshua Tracey's team continued mapping on Guam and made a reconnaissance of Rota to evaluate and plan for mapping that island in detail. Rota remained under Interior's control after



This map shows the 26 locations on the Colorado Plateau from which 41 samples containing more than 0.1 percent uranium were taken for analysis. Beginning in 1950, USGS geologists used the lead-uranium method to determine (for the U.S. Atomic Energy Commission) the geologic ages of these ores as clues to their origin and aids to further exploration. The ores included uraninite and carnotite from the Shinarump Conglomerate (Triassic), roscoelite (vanandiferous hydromica) from the Entrada Sandstone (Jurassic), and carnotite from the Morrison Formation (Jurassic). Other sampled deposits—from Colorado's Rifle district and Utah's Temple Mountain district—were not plotted on the map. (From Stieff, Stern, and Milkey, 1953, fig. 1; see also the map herein on p. 73.)

an Executive order in November transferred Saipan and Tinian back to the Navy, effective January 1, 1953.[178] MGB members also assessed a volcanic eruption on Kamchatka in November 1952, and completed a study of cross-country movement for tracked vehicles in Pakistan and in India's Punjab State. At the request of the Army Engineers and the Transportation Corps, several members of the MGB went to Greenland during the spring of 1953 to plan for engineering and other special studies on the island.

Continued support from the State Department's Technical Cooperation Administration, the Mutual Security Agency, the Point Four Program, and the governments of other countries enabled members of the Foreign Geology Branch during 1952–53 to continue and expand their studies worldwide, many in collaboration with colleagues in participating countries, and help to train specialists visiting the United States. Branch members extended their long-range investigations of mineral deposits and mineral potential in Brazil, Colombia, Ecuador, Mexico, Paraguay, and Peru. George E. Ericksen completed a 4-year study of lead-zinc deposits in the Hualgagoc and other districts of northern Peru. The Branch added



This histogram of the corrected lead-uranium ages for the 41 samples of ore deposits that contained more than 0.1 percent uranium from deposits on the Colorado Plateau "shows a pronounced maximum in the 70- to 80-million year interval." The analytical and chemical errors in the calculation of each of the geologic ages for the carnotite, roscoelite, and uraninite samples yielded an uncertainty factor of plus or minus 3 million years. The ores' calculated ages, thought to be close to their true ages, indicated that the uranium ores were formed not during the deposition of the Triassic and Jurassic formations, but rather at a later time in the latest Cretaceous and earliest Tertiary (now Late Cretaceous). That model suggested that additional ore would be found at greater depths. (Quotation and histogram from Stieff, Stern, and Milkey, 1953, p. 9 and fig. 7.)

economic geologists Richard G. Bogue, who worked with Herbert Hawkes, Jr., in Nigeria, and Gus H. Goudarzi, who had worked in the Gold Coast (Ghana), to Glen Brown's Point Four Program team in Saudi Arabia to aid in traverse-mapping more of the northern and northeastern parts of the Arabian Shield. Bogue and Goudarzi began detailed studies of minerals and mining along the proposed railroad route from Riyadh to Jiddah. Encouraged by Sheik Ahmad Fakhry's Directorate of Mines, established within Sheik al Hamdan's Ministry in 1946, Brown's team also looked for new or different occurrences at ancient mining sites. Those included Mahd adh Dhahab (Cradle of Gold), rediscovered by Karl Twitchell and other geologists in the 1930s. The Branch also contracted with Aero Service for an additional 68,000 square miles of coverage. Brown also planned during the next 2 years to map most of the remaining areas of the Arabian Shield and the Red Sea Coastal Plain and to drill additional water wells. Branch geologists finished a reconnaissance of metallic-mineral deposits of Burma (Myanmar), Iran, and Iraq and continued to provide technical advice to the members of the Geological Survey of India investigating manganese and other minerals. Branch members also helped to train in field and managerial techniques 40 young leaders, specialists, and technicians from Brazil, Burma, Colombia, Egypt, Greece, India, Mexico, Peru, the Philippines, and Thailand.

The Geochemistry and Petrology Branch during fiscal year 1952–53 completed a mobile spectrochemical laboratory to extend geochemical field investigations to detect minute amounts of significant trace elements as indicators of new areas of potential ore bodies. Branch members also used the lab in studies of disposing of radioactive waste. They advanced their expertise in determining geologic dates by radiometric methods. The Branch founded a facility for dating materials by the radioactive carbon-isotope method developed by 1947 by Chicago chemist Willard F. Libby. This technique, widely publicized in 1952, used the existing ratios of C^{14} to C^{12} in organic materials in a technique found reliable to about 50,000 years before the present. USGS and other geochemists used other known and new isotopic-decay sequences for dating geological materials, techniques usually accurate for intervals equivalent up to about 10 half-lives of the isotopes used. In 1952, Esper Larsen, Jr., promoted the lead-alpha method as an accumulation clock for determining the age of zircons in igneous rocks, while Lorin Stieff and Thomas Stern used lead-uranium ratios from mass-spectrometer analyses to determine the ages of some of the uranium ores from the Colorado Plateau and published preliminary results in 1953. Berkeley physicist John H. Reynolds continued to develop a radiometric method, based on the decay of potassium-40 to argon-40, intended to close the gap between intervals dated by the carbon- and uranium-based methods.

To some earth scientists, the radiometric-dating methods, sometimes inaccurately called "absolute," posed formidable competition to paleontological and other more conventional relative-dating techniques in fossiliferous rocks. Members of the USGS Paleontology and Stratigraphy Branch, who examined during 1952–53 some 60,000 fossil specimens for 550 reports[179] on their biologic affinities, geologic ages, and paleoenvironments, responded as players in the Pick and Hammer Club's show in 1953. To the show-stopping tune "Diamonds Are a Girl's Best Friend," from Leo Robin and Julie Styne's "Gentlemen Prefer Blondes" in 1949, they maintained, in "They Still Don't Make Good Dates," that using fossils, not the new radiometric methods, was the best way to determine the ages of sedimentary sequences. The songsters began with a prelude:

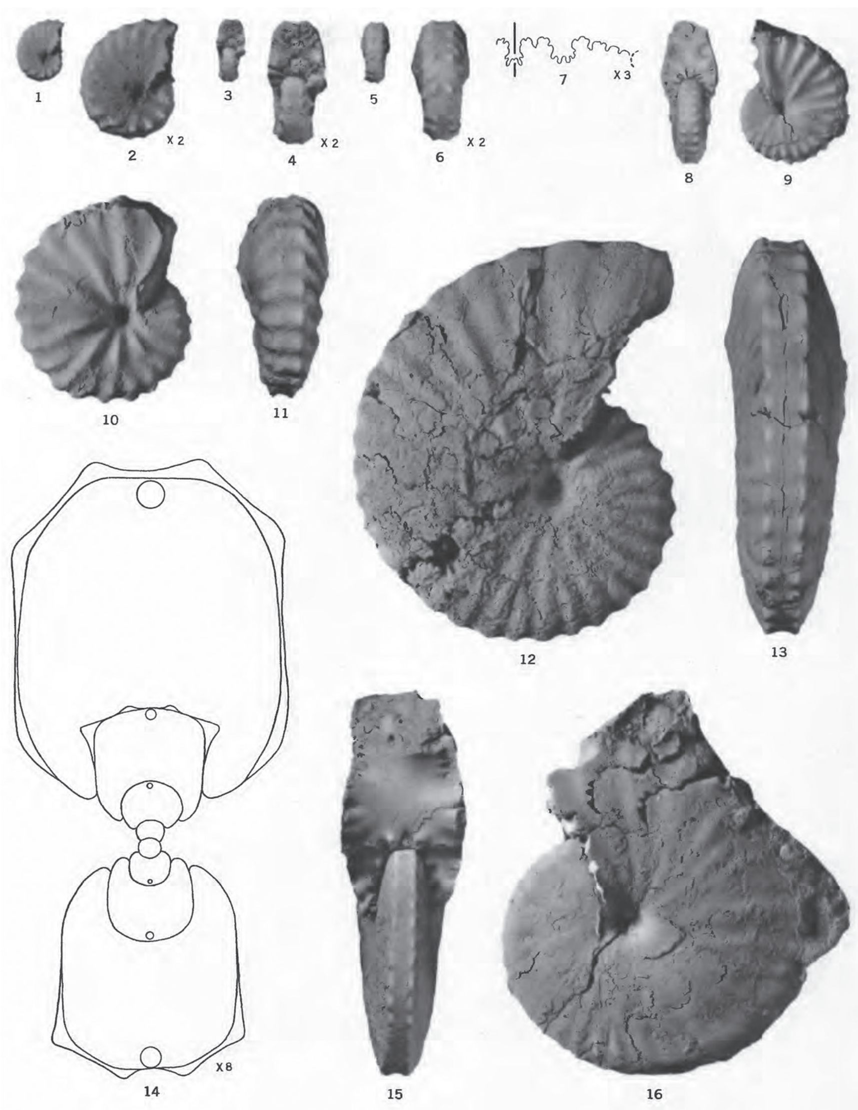
The many ways to date events
Have militant apostles,
But I prefer the evidence
Of diagnostic fossils![180]

Their verses lauded fossils as the “simple key / To orderly stratigraphy,” noted that the “Hard rock guys / May theorize, / But they all come to us in the end,” eschewed “pebble counts” and other statistical methods, and lastly cautioned:

Though the gang gets a bang out of nuclear fission,
Fossils are a churl’s best friend.
You can tell where the hell is the late Ordovician
If a trilobite is right in sight to steer you right.
Rocks with lead,
It’s often said,
Are a yardstick on which to depend;
But to set up a section by simple inspection,
Fossils are a churl’s best friend.[181]

Igneous, metamorphic, and sedimentary rocks without fossils went unsung.

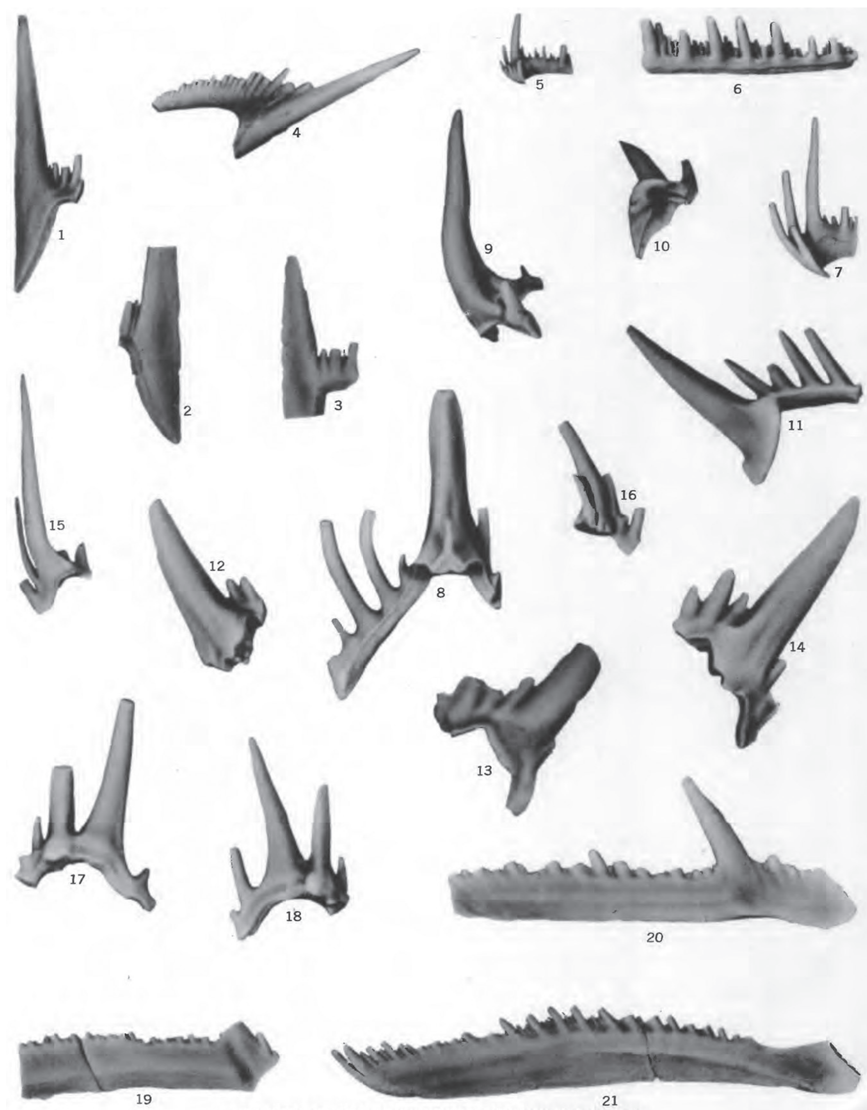
The Topographic Division’s $16,323,000 for its topographic surveys and mapping during fiscal year 1952–53 represented an unusual net loss of almost $2,162,000 compared to the funds available in 1951–52. The Division’s staff, as of June 30, 1952, numbered 3,159 employees; 2,555 of them served full time,



These specimens represent two new species of the ammonite genus *Metoicoceras* from the Mosby Sandstone (Cretaceous) in central Montana. The wavy-line sutures (figs. 7 and 12) of these cephalopods mark the partitions separating the chambers of their shells. The ammonites occupied the last or body chamber of their shells, as does the living *Nautilus*; figure 14 is a cross-section view of the internal whorls. Comparisons with ammonite faunas in the stage-ages of the global geologic time scale showed that these specimens of *Metoicoceras* lived during the late Cenomanian, an early interval in the Late Cretaceous. (From Cobban, 1953, pl. 6; figs. 1, 3, 5, 8–13, 15, and 16 originally shown at × 1; figs. 2, 4, and 6, at × 2; fig. 7, at × 3; and fig. 14, at × 8.)

16 served part time, and 588 were field assistants and laborers, for a net gain of 593. The $2,703,000 increase in the Division's direct appropriations to $11,090,000, or about 68 percent of total funds, returned more of the program to internal control. That gain, and an additional $113,000 in transfers from the AEC, the MSA, and other Federal agencies, $94,000 more from the USAF, and $22,500 from the USN did not compensate for the Division's expected loss of nearly $4.8 million in Army funds and $352,000 less from the USBR and $36,000 less from States, counties, and municipalities.

Wrather, continuing to decentralize operations, abolished the Special Map Projects Section[182] on October 14, 1952, and transferred to the four regional offices the Section's responsibility for preparing the 1:1,000,000 International series, the 1:500,000 State base maps, the 1:250,000 U.S. series on 468 sheets, and other small-scale maps. To accommodate this work, the Survey order also established a small-scale compilation unit in the Cartography Section of each region. On December 5, Wrather abolished the Trimetrogon Section, which prepared small-scale aeronautical charts and maps for the USAF, and established in the former Section's place a Special Maps Branch to reflect its expanded duties. The additional functions included compiling "large-scale planimetric and topographic maps of standard accuracy" by using "vertical and oblique Kelsh, Multiplex, and other



These specimens of species of *Prioniodus* and species of four other conodont genera were collected from outcrops of the Barnett Formation (Mississippian) in the Mason and San Saba areas in the Llano region of central Texas. These microfossils are phosphatic and shaped like bars, cones, and platforms. They also vary in color, in a sequence determined by USGS geologists Anita G. Epstein (later Harris,) Jack B. Epstein, and Leonard D. Harris to reflect the degree of postdepositional thermal alteration that made them useful in exploration for oil and gas. Conodonts were widespread during the Paleozoic and Triassic. Although the biological function and phylogenetic affinity of the enigmatic conodonts remained undetermined by the 1950s, conodonts were thought to be the bilaterally paired and serially arranged internal parts of early chordates or other small marine animals. Paleontologists subsequently found conodonts in association with soft-body fossils now assigned to early chordates related to modern hagfishes and lampreys. (From Hass, 1953, pl. 16, figs. 1–21; all figures originally shown at × 30; see also Epstein, A.G., Epstein, J.B., and Harris, L.D., 1977; and Knell, 2013.)

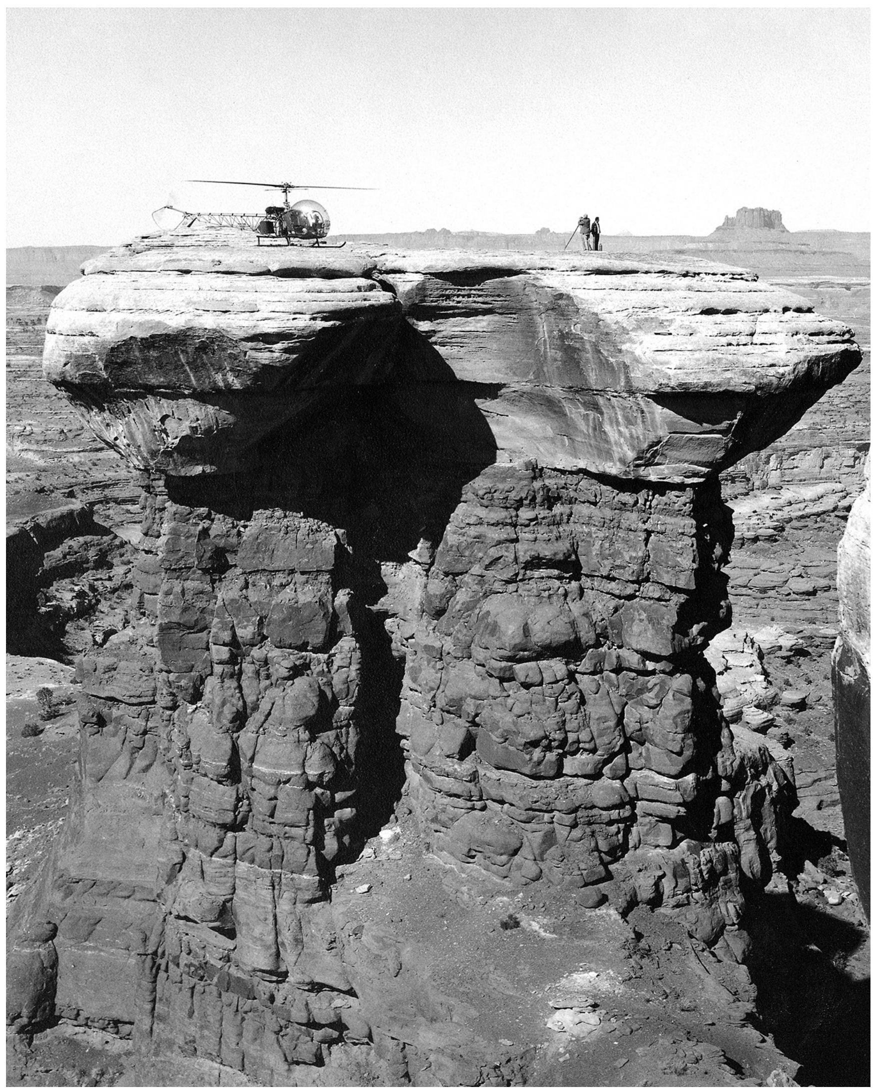
stereo-photogrammetric equipment," processing "photographic reproductions up to the press-plate stage for other USGS Divisions and the Aeronautical Chart and Information Service," compiling "maps from radar scope photography" and "radar prediction charts," producing shaded-relief plates, extending horizontal and vertical control by photoalidade to areas of little or no control, and performing "operational research to determine methods and procedures"[183] for mapping areas with unusual conditions.

Topographic coverage of the conterminous United States now stood at 67 percent, but only 30 percent represented maps of sufficiently good quality for current use. Wrather estimated that work during fiscal year 1952–53 would add 3 percent but thought that at "this rate, it will take about 25 years to complete mapping of the 48 States."[184] The Division continued to try to speed production and reduce costs while maintaining or improving accuracy. Russell Bean's team redesigned and refitted the Twinplex by replacing the Multiplex projectors with ER–55 projectors. As the new arrangement provided sharper images and greater accuracy for aerial triangulation and map compilation with twin low-oblique photography, CTE FitzGerald expected the improvements to revolutionize mapping techniques. The Division awarded contracts for the ER–55-equipped Twinplex plotters, one for each of the four regional centers, and arranged to deliver four Wild A8 plotters to the same centers. The Division abandoned the Twinplex before it became fully operational when "the successful development of super-wide-angle photography * * * eliminated the advantage of convergent photography."[185] The Division's experiments with equipment provided by the Army Engineers' Research and Development Laboratories showed that low-flying helicopters, constantly observed by the operators of ground-based theodolites, could take supplemental-control photography to considerably reduce required field operations.

Topographic Division managers and engineers thought the great increase in office computing generated by this method could be handled successfully by the AMS's Universal Automatic Computer (UNIVAC) introduced in Philadelphia on June 14, 1951, by engineer-entrepreneurs J. Presper Eckert and John W. Mauchly, who had developed ENIAC in 1946. UNIVAC, a general-purpose and high-speed digital computer, used vacuum tubes in storing and accessing data. The USAF purchased and installed a UNIVAC on February 1, 1952. The USN, for whom the National Cash Register Company constructed a number of the huge automated rapid calculators, or "bombes," to aid the original and later British machines in decrypting the German "Enigma" codes during World War II, used ENIAC and UNIVAC computers to improve gunnery control and in other applications. The Census Bureau, long an innovator in adopting business machines to its use, also acquired and began operating a UNIVAC, continuing a practice the Bureau started when it used for its 1890 and 1900 decennial censuses the electromechanical and punch-card devices designed and built by Herman Hollerith, whose company was one of IBM's predecessors. Topographic Division managers also began thinking about acquiring electronic computers[186] to perform routine calculations.

As the Division's topographic-mapping program in fiscal year 1952–53 remained largely oriented toward meeting the immediate needs of the DoD, mapping in areas outside those of deemed militarily important was limited. Even so, the Division continued double-shift and overtime operations in an effort to meet demands. The Division increased its compilation of maps in the conterminous United States by 18 percent to depict 83,100 square miles and estimated that by the end of 1952–53, about 30 percent of the Nation, excluding Alaska and Hawaii, would be adequately mapped. Division topographers mapped in Hawaii, for publication at 1:24,000, areas of Maui, Molokai, and Oahu and planned, after a priority request from the military, to extend the work to the main island. The Rocky Mountain Region established a permanent office in Fairbanks and named a Resident Engineer, as a complement to the Geologic Division's Resident Geologist, to coordinate all topographic mapping in Alaska. Mapping in the Territory covered about 12,000 square miles at a scale of 1:63,360, and the Topographic Division published 51 of the provisional series of 1:250,000 maps and compiled the remaining 8 to provide a uniform series for the entire Territory. Topographers in Puerto Rico added 1,500 square miles to the 900 square miles already mapped at 1:30,000 on the island. In cooperation with Interior's Office of Territories, the Division contracted for aerial photography, to be delivered during the winter of 1953–54, as the basis for mapping the U.S. Virgin Islands. In all, the Topographic Division completed more than 1,320 quadrangle maps, a record number, for printing and distribution during 1952–53; of this total, nearly 900 represented new mapping, about 100 were revisions, another 100 were produced by other agencies, and the remaining 220 formed civilian editions of maps previously compiled and published for military use by the DoD. Division members also participated in the 17th International Geographical Congress held in Washington in 1952.

The Topographic Division also expanded its efforts abroad. The Division's mapping program in Brazil supplied bases for USGS geologists to map and study areas having strategic-mineral deposits and prepared specifications and trained Brazilian engineers in topographic mapping by the plane-table method. The USGS, the USCGS, and the Inter-American Geodetic Survey, under their tripartite agreement, each continued to train technicians from other parts of South America and from



In 1953, USGS topographer Chester R. Lloyd and the helicopter pilot established this triangulation station atop the "Toadstools," a tiny mesa more than 1,000 feet above the junction of the Colorado and Green Rivers in the Orange Cliffs area southwest of Moab, Utah. In 1948, the USGS began using helicopters, flown under contract with the aviation industry, to increase the mobility of the agency's topographers and geologists and their access to areas of high elevation and rugged terrain. (From FitzGerald, 1979, fig. 7; also published in Evans, R.T., and Frye, 2009, fig. 22. See also the pre-landing photograph in Rabbitt, M.C., 1954, p. 355.)

Central America. Division members negotiated the contract for aerial photography, map compilation, and mosaics in Saudi Arabia as a project of the Point Four Program[187] for Glen Brown's team; completed the cooperative work, for the ECA, with the British Colonial Surveys in Kenya, Tanganyika (Tanzania), and Uganda; and provided the Mutual Security Agency with specifications for and advice about mapping areas in Angola and Mozambique; they also supplied advice about a large-scale, commercial topographic-mapping project in the Philippines later supervised by the Army Engineers. With MSA support, Division photogrammetric and topographic specialists provided advice and worked on map compilation in Burma and Jordan. Some of their colleagues also advised U.N. agencies.

The Water Resources Division's total funds for investigations during fiscal year 1952–53 increased by about $733,000 to nearly $13,175,000, of which nearly $6,115,000, or about 46 percent, came from direct appropriations for salaries and operations. The Division's staff, as of June 30, 1952, consisted of 2,103 persons, of whom 1,632 worked full time, 88 worked part time, and 383 others served as field assistants and laborers, for a net loss of 8 employees, reflecting separations, transfers, and activations or drafts for military service. Transfers of $41,000 from the USAF and $237,000 from the Army, offsetting the Navy's reduction of nearly $28,000, increased the Defense Department's contributions to a total of about $1,229,000. This gain plus $115,000 from the MSA and other Federal agencies exceeded losses of some $144,000 from the USBR and two other Interior agencies, $97,000 from the AEC, and $47,500 from the DoS. Cooperative monies received from States, counties, and municipalities continued their slow rise, this time by some $319,000 to nearly $3,604,000, or more than the $3.5 million of the Division's direct appropriation available only for that work.

During the year, members of the Division continued to study public water-supply needs and those of industry. They published nine preliminary reports on the water supplies of more than 1,200 of America's larger cities to update the information contained in the 1932 report about their industrial utility. Ongoing or new studies of industry's requirements included those for the producers of acetate, aluminum, nylon fiber, and rayon. Division personnel completed a report on the pulp and paper industry for use by defense agencies and began work on a similar summary for public release. For the NSRB, they started a series of integrated reports summarizing and evaluating water resources of specific areas to provide defense agencies with adequate appraisals. During the year, Division members completed 5 of the 13 studies underway of large industrial centers. At the request of the House Committee on Interior and Insular Affairs, they aided the preparation of a series of documents, "The Physical and Economic Foundation of Natural Resources," compiled to provide facts to guide the realization of a sound natural-resources policy for the Nation's economy. In cooperation with other Federal agencies, the Division undertook a program of coordinating and disseminating drainage-area data to try to achieve consistency in their use. Division members, supported principally by the MSA, continued surface-water- and groundwater-resources investigations in Afghanistan, India, Iran, Libya, and Saudi Arabia, while some of their colleagues field-trained visiting hydrologists from India, Israel, Pakistan, the Philippines, Thailand, and Turkey.

On July 3, 1952, President Truman signed the Saline Water Act "to provide for research into and development of practical uses for the economical production from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses."[188] To support this work, the statute provided $400,000 for each of the next 5 years, gained through efforts by Chairmen Clair Engle, of the House Subcommittee on Reclamation, Joseph O'Mahoney, of the Senate Committee on Interior and Insular Affairs, and many of their congressional colleagues in the 81st and 82d Congresses. In view of "the acute shortage of water in the arid areas of the Nation and elsewhere," and "the excessive use of underground waters throughout" America, Congress hoped to develop "a practicable low-cost means" of production "on a scale sufficient to determine the feasibility of the development of such production and distribution on a large-scale basis."[189] The new law gave the Interior Secretary authority to act, through the Department's agencies, to conduct research and technical development, make engineering studies, determine best designs and operations for plants, acquire information and lands, and cooperate with other organizations in adding economically to the Nation's supply of freshwater. The statute provided up to $2 million for 5 years, provided that the cost of correlating and coordinating information did not exceed $500,000. The USGS Water Resources Division participated in Interior's saline-water program by having a member of its staff serve on the Advisory Committee on Saline-Water Conservation.

During 1952–53, the Surface Water Branch continued to collect records of stream discharge at about 6,400 gaging stations nationwide, including nearly 300 in the Missouri River Basin and 488 in Alaska and Hawaii Territories. Members of the Branch advanced the compilation and condensation into one volume of all streamflow records prior to 1950 for each area covered by an annual report on surface-water supply. They gave increasing attention to the nationwide collection of data on water temperatures, making regular readings at more than 300 sites (plus 50 self-recording stations), to satisfy the growing demand for information by the users of streams for cooling and other industrial purposes. The Branch completed the preliminary design of and issued invitations for contracts for constructing a development model of an electronic computer to compile daily streamflow records. Branch personnel, on completing an investigation of the water flow through single constricted openings, expected the results to aid the design of future bridges. The Branch also operated 114 sediment stations on streams in the Western United States and continued its studies of the origin of sediments and how they enter stream channels, are transported, and finally deposited, including ongoing work on the amount of sediment carried as bedload at six locations in the Missouri and Rio Grande Basins. Branch members also completed more than 60,000 measurements of sediment content at 89 stations in the Missouri Basin. To improve sediment sampling, the Branch, in collaboration with other Federal agencies, developed a visual-accumulation tube for rapid and accurate determinations of the distribution of particle size in sands. During the year, the Branch published six reports on floods, three others on flood frequency, and four evaluations of river basins in the Pacific Northwest to show the influence of manmade structures on discharge records.

Investigations by the Ground Water Branch during 1952–53 included studies of groundwater occurrences and movement and saltwater encroachment. Branch personnel completed for the Army Engineers a three-part report on "Ground-Water Development in the Arctic," covering the geological, geophysical, and aerial-photographic interpretation of permafrost terrain. Work in a part of South Dakota's James River Basin delineated an aquifer that could yield water sufficient to support irrigation in that area. Branch members began studying the effect of groundwater movement on the accumulation of oil and gas in Wyoming's Bighorn Basin. Saltwater encroachment claimed more attention during the year. The Branch released a report that described conditions in southwestern Louisiana where the movement of saltwater from the Gulf of Mexico and tidal streams into the freshwater aquifers had created serious problems. Continuing investigations in other areas of saltwater encroachment included those in the Trinity River of Texas, in South Carolina's Combahee River, and in the lower Delaware River. Branch personnel further studied the possibility of establishing a freshwater barrier to prevent saline encroachment in California's Manhattan Beach area. Encroachment problems in Florida led to additional work to determine the origin and extent of saltwater migration into freshwater aquifers, and the Branch began to investigate the effects of reducing the migration of saline water into aquifers by recharging them with freshwater. Robert R. Bennett and Rex R. Meyer finished their report on the hydrogeology of the Baltimore area, which included an early use of flow-net analysis. The Branch also began issuing, as a training technique, its series of "Ground Water Notes." From March 1952 to March 1953, hydrologist Donald F. Dougherty joined the USGS team in Saudi Arabia, where he assessed runoff characteristics of ephemeral streams and surface-storage and groundwater-recharge potential near Riyadh. At the MSA's request, the Branch sent Leonard J. Snell to Afghanistan to begin, in June 1952, long-term aid in collecting and evaluating the streamflow data required to manage and operate the new and American-built engineering works in the Daryē Helmand Basin.

The Quality of Water Branch broadened its studies of chemical quality during fiscal year 1952–53 to evaluations of mineral pollutants in natural waters by including analyses for trace metals and other minute dissolved constituents whose occurrences influenced the use of water supplies for specific purposes. To support this work administratively, the Branch established a Physical Quality Section, led by Raymond B. Vice. Branch members also looked more carefully at the duration and frequency of low flow in streams, because the allocation of water often depended on the volume of water available for dilution. For the USAF and the Army, they continued studies of the potability of water at continental and offshore installations. For the Missouri River Basin project, they analyzed chemically more than 10,000 water samples from 28 stations. The Branch also began a program, supported by the AEC and served by the nearly completed laboratory facilities at Denver, to determine and interpret "background" or natural radioactivity and trace elements in water samples.

The Conservation Division received from all sources nearly $1,440,000 for its operations in classifying lands and supervising mining and oil and gas leases during fiscal year 1952–53. The $108,000 increase included nearly $95,500 more in direct appropriations for the latter function. As of June 30, 1952, the Division staff still numbered 233 persons, but it now comprised 215 full-time employees, 3 part-timers, and 15 field assistants and laborers. Direct appropriations, transfers by the Navy and Federal civilian agencies, and nonfederal cooperative funds for land classification in 1952–53 rose by just under $2,700, but the same sources supplied nearly $105,000 more for supervising mining and oil and gas leases.

The Division's four Branches extended their operations during the year. Members of the Mineral Classification Branch acted on some 19,260 cases, a decrease of 8,800 (about 31 percent) from the number handled in 1951–52. They also completed for internal and external use specific reports, requested by geologists in field offices, on coal, oil and gas, oil shales, and fluorspar deposits in areas in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming. The Mining Branch supervised about 1,260 properties, an increase of 60 from the previous year. Domestic production of coal again decreased nationwide, although it increased in Alaska. The five operating mines on public lands in New Mexico's potash field produced a total of more than 7.6 million tons of crude potassium salts, up from 5.4 million tons in fiscal 1951–52, and new mines were expected to be opened to develop reserves disclosed by geologic studies and core drilling. The Oil and Gas Leasing Branch supervised nearly 78,790 oil and gas properties on the public lands, about 2,010 leases on acquired lands, and some 8,270 leaseholds on Indian lands. The year's royalties from increased oil and gas produced from the public and acquired lands in 1952–53 reached nearly $32 million, revenue from the Indian lands amounted to about $16.5 million, and the NPR–2's yield reached $905,000, an increase of nearly $88,500 from 1951–52. Approval of new and termination of existing unit plans left 267 such plans in effect at the end of fiscal

1952–53. The Branch also contracted for the exploration and development of nearly 1 million acres of land in the Katalla-Yakataga area of southeastern Alaska. The Water and Power Branch continued to survey dam and reservoir sites and river channels; its members also supervised the construction and operations of 1,005 projects—134 licensed by the FPC, 671 Interior Department efforts, and 200 others in cooperation with the BIA—an overall increase of 65 from 1951–52.

On July 7, 1952, less than a week after the beginning of the new fiscal year, the Republicans met in Chicago to select their national ticket for the election in November. Taft and Eisenhower competed for the Presidential nomination. Both parties sought Eisenhower before and after he ended his tour as SACEUR in June. Truman offered to run as a candidate for Vice President in 1948, if Eisenhower would accept the top slot, but Truman failed to convince Eisenhower, who expected Dewey would win, to campaign as a Democrat. Eisenhower, who increasingly deplored many of Truman's policies, decided in 1951 to seek what he termed a greater duty. Herbert Brownell, Jr., who managed both of Dewey's campaigns and briefly led the Republican National Committee, went to Paris early in 1952 and told Eisenhower that Taft's projected lead required Eisenhower to fight for the nomination. Eisenhower authorized Brownell, Clay, Dewey, Lodge, and others to form an exploratory committee and enter him in the Republican primaries in New Hampshire, where he defeated Taft, and in other States. Brownell's "Fair Play" resolution resolved the dispute about seating delegates from several Southern States. MacArthur also was a candidate, disproving his assurance to Truman on Wake Island that Eisenhower would be the only five-star general to seek the Presidency. MacArthur gave the keynote address, but on the first ballot, the delegates chose Eisenhower. To balance the ticket and win back conservatives, the delegates selected California's Senator Richard M. Nixon for the second slot. Nixon moved from the House to the Senate in 1947 after campaigns in which he successfully played the soft-on-Communism card against both incumbents. After the convention, MacArthur ran in seven States as a candidate of the Christian Nationalist and Constitution Parties.

Eisenhower resigned his Army commission; having published "Crusade in Europe" in 1948, he now pledged to lead another crusade against the Democrats. The Republican platform promised to end the protection of subversives in the Federal Government; preserve the Taft-Hartley Act; reduce Federal power by returning some of it to local and State governments, including managing the coastal tidelands and their energy and other natural resources; secure statehood for Alaska and Hawaii; rebalance the national budget and restore equilibrium between Federal activity and private enterprise; and weigh more equally national resources and international commitments. The Republicans, again decrying Roosevelt's agreements at Yalta and Truman's containment of the Soviet Union, also pledged, in a plank written by John Foster Dulles, to liberate Eastern Europe. On August 14, Truman invited Eisenhower to the White House. Eisenhower refused, saying that he would only attend in the event of a major emergency, but he did accept, with Truman's approval, situation reports from the CIA.

On July 21, Democrats also met in Chicago to choose their new national slate. C. Estes Kefauver of Tennessee, the liberal Senator who defeated Truman in the New Hampshire primary and subsequent primaries, led on the first two Presidential polls. Truman, although not limited by the Constitution's Article XXII of 1951 that restricted future Presidents to two elected terms, or one if they had already filled more than 2 years of a unelected term, declared on March 29 that he would not seek reelection or accept renomination. Truman then threw his support to Adlai E. Stevenson 2d, the conservative grandson of Grover Cleveland's Vice President and Illinois' Governor since 1948. Delegates nominated Stevenson on the fourth ballot. Stevenson chose as his running mate not Kefauver but the more moderate Senator John J. Sparkman of Alabama, a Dixiecrat in 1948. Stevenson and Sparkman campaigned to continue Truman's domestic and foreign policies, including supporting NATO, repealing Taft-Hartley, and enacting Federal legislation to improve civil rights for all American citizens. Truman, before campaigning for the Democratic ticket, previewed the Federal budget for fiscal year 1953–54, through which the deficit would be reduced to $10.3 billion and which included $3.6 billion for natural-resources work, a reduction of $706 million.

As the national political campaigns played out during the summer and fall of 1952, both the war and the armistice talks in Korea remained deadlocked. United Nations and Communist forces, the latter increasingly stronger in artillery, alternated limited offensives on rugged land that required a grueling combat between the opposing infantry forces. U.S. casualties rose to more than 110,000, with another 13,000 listed as missing. In the air, bombs from Air Force, Marine, and Navy aircraft destroyed North Korea's last major industrial target, its electrical grid. Jet-to-jet aerial combat now involved wing-size engagements over northern North Korea. When Soviet swept-wing Mikoyan-Gurevich (MiG)-15s, flown by Russians and Chinese from airfields across the Yalu, struck U.S. bombers, fighter-bombers, and their escorts of swept-wing, North American F–86 Sabres, kill ratios rose steadily in favor of the U.S. pilots. At Panmunjom, after the Communists rejected the U.N.'s final offer on prisoner exchange, Lt. General William K. Harrison, Jr., who had replaced Vice Admiral Joy, led the U.N. representatives in walking out.

As the war continued, American industry began developing, continued testing, or introduced new technology—aircraft carriers, bombers, cannon, missiles, and submarines—between April and December 1952. Boeing started flying its new B–52 eight-jet Stratofortress bomber. Army Secretary Frank Pace, Jr., announced the development of a 280-mm artillery piece that would fire atomic shells. Truman, Navy Secretary Dan A. Kimball, and AEC Commissioner Gordon E. Dean attended the keel-laying of the nuclear-powered submarine *Nautilus*. When completed, under the direction of Captain Hyman G. Rickover (the Navy's General Groves), *Nautilus* would realize Philip Abelson's 1946 proposal to the Naval Research Laboratory (NRL), in response to a recommendation to give priority to ship propulsion as the major initial postwar use of atomic energy.[190] The keel was laid for the supercarrier *Forrestal*, a ship intended to replace the stillborn *United States* and use British-style angled flight decks, mirror-landing system, and steam catapults. The Navy completed its test submarine *Albacore*, with a teardrop-shaped hull that produced submerged speeds of more than 30 knots. Tests continued of the Navy's Regulus cruise missile, an improved Loon developed from the German V–1 and intended to be launched from surface ships or from surfaced submarines. Grumman started flying its propeller-driven JF–2 Tracker, an early warning aircraft, and the USAF began testing its new Sidewinder air-to-air missile.

In the year before the U.S. national election in 1952, other significant events in the Middle East, Africa, and the Far East combined to increase the Truman administration's burdens and uncertainties in foreign affairs. Recent developments in Iran, which provided 40 percent of the Middle East's petroleum as Daniel Yergin later recorded, seemed to threaten the world's oil supply. Anglo-Iranian, then the third-largest producer globally, controlled production, prices, and profits; the Shah's government received 36 percent of Iran's oil revenues. The Iranians wanted a 50:50 split[191] like the existing arrangement in Venezuela and the new agreement between Aramco and Saudi Arabia announced on December 30, 1950. George C. McGhee, a wealthy geophysicist, DeGolyer's son-in-law, and the U.S. Assistant Secretary of State for Near Eastern and African Affairs, brokered the deal with the Saudis and now tried to reach a similar understanding in Iran. After the Shah's premier refused Anglo-Iranian's offer of greater royalties and other payments, the Saudi announcement forced Anglo-Iranian to propose a 50:50 sharing. Mohammed Mossadegh

(Mussaddiq), a former professor of political science and now head of the Iranian parliament's oil committee, wanted nationalization. When the premier opposed that option, he was assassinated. On April 28, 1951, the parliament chose Mossadegh, who also led the National Front, as the new premier. The Shah signed an authorization to nationalize Anglo-Iranian effective May 1.

Bruce Brown's Petroleum Administration for Defense predicted that the resulting loss of oil would raise global demand above supply before year's end. The PAD helped the Truman administration to form a volunteer group of 19 petroleum companies to cooperate in blending facilities, operations, and supplies; these efforts, depending heavily on increased production by the United States, Iraq, Kuwait, and Saudi Arabia, raised world output by 2 million barrels per day in 1952 despite a 97-percent loss in supplies from Iran. On May 26, as Yergin described, Britain referred the dispute to the International Court of Justice at The Hague. Truman and Acheson sent Harriman to Tehran in mid-July to aid a British delegation negotiating with Mossadegh. When the mission failed, Britain increased its economic warfare against Iran and considered military action. Mossadegh rejected the British response to his ultimatum of September 12, and Iranian armed forces occupied the oil terminal, refinery, and port facilities at Abadan. The British petitioned the U.N. Security Council without favorable result and evacuated Abadan on October 4, although Churchill warned that securing Middle East oil was more important than holding South Korea. Iran submitted its case to the International Court on December 10, but that body, on July 22, 1952, decided it lacked jurisdiction. After the British refused Mossadegh's proposed settlement, Iran ended diplomatic relations with Britain on October 22. The British and U.S. Governments then planned a countercoup against Mossadegh to defend Anglo-Iranian and counter growing Soviet influence.

By then, the Governments of Egypt and Libya had changed as well, as had the situations in Iraq, Kenya, Malaya, and Indochina. In October 1951, Mustafa al-Nahhas, Egypt's Prime Minister, abrogated the Anglo-Egyptian Treaty of 1936, and Egyptian guerrillas increased their attacks on the Suez Canal during November 1951–January 1952. The U.N. General Assembly's resolution of November 21, 1949, approved an independent Libya by January 1, 1952, but Libya became independent on December 21, 1951, under its new constitution prepared by the National Assembly, which formally recognized Mohammed Idris el-Senussi as King Idris I. Libya joined the Arab League in February 1952. On July 23, 1952, an Egyptian officers' coup, led by Army General Mohammed Naguib and Colonel Gamal Abdel Nasser, overthrew King Farouk, who abdicated and left the country. Nasser, who supported the Germans in World War II, and was imprisoned with the younger Anwar Sadat, repeated some of the land and other reforms begun by Colonel Ahmed Arabi and other nationalist officers who rebelled in 1881–82. Egyptian reforms now produced longer lasting results. Also in 1952, the Baa'th Party was founded in Iraq, the Mau Mau rebellion and its terrorism began in British Kenya, and the British counterinsurgency war continued in Malaya. In Indochina, the French forces' success in defending the air-land advanced base at Na San in the northwest highlands during November–December 1952 suggested that using these tactics in other areas far beyond the fortified line around the Red River delta could win the war.

At home, issues involving inflation, labor, and materials also influenced America's political campaigns in 1952. Truman, to avert a planned strike for higher salaries by 600,000 American steelworkers, ordered on April 8 a Federal seizure of the mills. On June 2, the U.S. Supreme Court upheld an earlier decision rejecting the President's action because it lacked authority under the Constitution or from Congress. When Truman returned the steel mills to their owners, the workers promptly walked out. The President invited representatives of the owners and the unions to the White House, where they reached a compromise on July 24 that ended the 54-day strike but led to increased prices as well as wages. On June 27, Congress extended rent and wage controls and priorities for allocating materials, and passed, over Truman's veto, the Immigration and Nationality (McCarran-Walter) Act,[192] which codified and revised U.S. immigration and naturalization laws and established a Joint Committee on Immigration and Nationality Policy. The new statute maintained the 1924 Immigration Act's provisions for a quota system based on numerical limitations derived from a count of national origin, one-sixth of 1 percent of the people in the continental United States in 1920. The law continued the existing annual quota of 100 for Chinese immigrants, but it eliminated prohibitions on accepting people with at least one-half local ancestry from areas within the so-called Asia-Pacific triangle. The act established methods to screen persons considered undesirable or subversive, including restrictions on qualifications for admission, the registration and control of travel by aliens and citizens who were Communists in times of war or national emergencies, and the management of visas, reentry permits, and exclusions. The law authorized measures for controlling U.S. citizens abroad and also defined nationality at birth and measures for collective naturalization (including service in the U.S. armed forces) and the retention or loss of nationality status. As an aid to the American agricultural and other industries, the law also increased access for the "bracero" program for Mexican day workers and immigration from Puerto Rico.

Stevenson enjoyed an early lead in the polls, but Eisenhower and Nixon campaigned effectively against Truman's policies toward China and in Korea, and the alleged and demonstrated corruption in his administration at home, including improper gifts, kickbacks, and other alleged malfeasance by some of its members. "I like Ike," an increasingly effective Republican slogan, trumped "We need Adlai badly," while Truman, his approval rating with the voters still below 30 percent, remained the least popular President in recent times. The campaign's tone, however, rapidly worsened. Truman campaigned widely and sometimes savagely against Eisenhower, who said he hated partisan politics and took personally the President's attacks. Republicans labeled Stevenson an "egghead," an intellectual too removed from reality to remember to repair the sole of his worn shoe. On September 23, Nixon's televised "Checkers" speech, named for the dog received as a gift, highlighted the virtues of his wife's cloth coat and other examples of his alleged lack of wealth. Nixon's performance, maudlin but effective theater, successfully defused charges that he had maintained an illegal slush fund to advance his political agenda. The next day, Eisenhower announced that Nixon would remain on the ticket. In Denver, Eisenhower refuted McCarthy's bogus charge that Ike's mentor Marshall was "soft" on Communism. Before appearing with McCarthy in Milwaukee on October 3, Eisenhower blasted McCarthy in private but, influenced by Senator Knowland and Wisconsin's Governor Walter J. Kohler, Jr., deleted his defense of Marshall from his more widely reported public speech. When the Communists still refused to consider the voluntary repatriation of Chinese and North Korean prisoners held by the U.N., on October 8, negotiators recessed indefinitely the talks at Panmunjom. Eisenhower pledged in Detroit on October 24, during the last speech of his own whistle-stop campaign, to concentrate on ending the Korean war and to go there if elected. When Truman immediately offered Eisenhower passage on a Federal aircraft to Korea, the Republican candidate declined.

On November 4, Eisenhower swamped Stevenson in the national election, receiving 55 percent of the popular votes and 442 of the 531 electoral votes. The five candidates of the six minority parties received a total of less than 261,000 popular votes, and MacArthur emerged next-to-last among them. The Republicans also won the House and the Senate. In the 83d Congress, they would have a 1-seat majority in the Senate, not including Oregon's Wayne L. Morse as an Independent, and a 10-seat edge in the House, also with 1 Independent.[193] On November

5, Truman asked all Americans to "close ranks and work together for our mutual welfare as citizens of this great Republic."[194] On November 29, Eisenhower left in secret by air for Korea. During December 2–5, he met with Generals Clark and Van Fleet but spent most of those days visiting front-line areas. As Eisenhower did before the Normandy invasion, he tried to gain firsthand a better appreciation of the morale of the troops and now also something of the terrain on which they fought. Eisenhower returned from Korea in a Navy cruiser, using the long voyage to plan his administration in conversations with Herbert Brownell, Jr., Foster Dulles, George M. Humphrey, and other advisers.

While Eisenhower returned from Korea by sea, Truman, Churchill, and French Premier Joseph Laniel met in Bermuda during December 4–7 to review Big Three policies toward and relations with the Soviet Union, West Germany, and Austria and the current efforts in defense of the free world. Truman and Churchill met again in Washington during January 5–9, 1953, to discuss common policies for dealing with their domestic and international problems, including exchanging additional raw materials, increasing support for NATO, and ending the war in Korea. Churchill, who opposed extending the war to mainland China, held similar but briefer talks with Eisenhower in New York on January 5.

The Truman administration during its last weeks in office received and issued several documents, with recommendations for improving Federal management, science, and engineering. On December 31, 1952, Budget Bureau Circular A–47 contained reports about and budget estimates for Federal programs and projects for the conservation, development, or use of water and related land resources, including water supply.[195] The Missouri River Basin Survey Commission,[196] founded by Executive order on January 3, 1952, presented its final report, "Missouri: Land and Water," on January 12, 1953. Chairman James E. Lawrence, editor of the *Lincoln Star;* vice chairman and Senator Thomas C. Hennings, Jr. (D–MO); Senators James E. Murray (D–MT) and Milton Young; Representatives Clifford R. Hope (R–KS) and James W. Trimble (D–AR); and several engineers and farmers, some of whom also managed farm organizations or served in State legislatures, recommended specific actions to better protect, develop, and use the Nation's water resources. The next day, NSRB Chairman Gorrie sent his summary report to the President for publication later in 1953. On January 16, BoB Circular A–16 specified procedures for "Programming and Coordination of [Federal] Topographic Mapping."[197] Circular A–16 made the Interior Department responsible for the National Topographic Map Series and outlying areas of U.S. sovereignty and jurisdiction for the National Atlas. The Commerce Department received responsibility for the National Networks of Geodetic Control. The Circular asked agencies requiring maps in the National Topographic Series to prepare annually a priority statement of such needs in three levels—within 3 years, within 4 years, and after 4 years. Circular A–16 also required the map-making agencies to prepare program maps showing the areas where mapping 1:24,000 and 1:62,500 quadrangles would begin during the next fiscal year and specifically asked the USGS to prepare and publish semiannually maps showing the progress of mapping. The Circular made the USGS responsible for the collection, publication, and distribution of Federal topographical data and information. Truman also transmitted to Congress the varied evaluations by executive branch agencies of the report by the President's Water Resources Policy Commission, including the congressionally authorized basic surveys of three regions—New England-New York; the Arkansas-White-Red River Basins; and the Missouri River Basin—for their sensible development. The Commission recommended decentralized but unified or coordinated administration for these resource programs. Not all the agencies agreed.

On January 9, 1953, Truman's budget message presented his revised view of what expenditures and receipts might have been expected in fiscal year 1953–54 under a Democratic administration—$78.6 billion in expenditures, $68.7 billion in receipts, and a deficit further reduced to $9.9 billion. The $4.1 billion now proposed for activities in natural resources included $1.1 billion for developing land and water resources, with $500 million specifically for the river-basin development projects directed by the AEC and the USBR, but full or partial implementation depended on decisions by the new President.

Truman's second administration did not achieve the foreign-policy goals that he set forth in his inaugural address in 1949 or most of his domestic initiatives proposed in the Fair Deal. His stormy relations with organized labor in 1951–52 over mobilization, wage, and related policies contributed to Democratic defeat at the polls. Truman could say accurately that the United States successfully met the challenge of two of the Nation's largest postwar concerns—the growing struggle against Communist expansion abroad and the continuing conservation of resources at home. On Truman's watch, the strong movement to conserve natural resources, begun in the 1930s, usually prevailed over the proponents of monopoly, exploitation, and waste. Truman, in his State of the Union Message on January 7, 1953, predicted "a long hard test of strength and stamina, between the free world and the communist domain."[198] Eight days later, in his farewell address to the Nation, the President also forecast that "when history says that my term of office saw the beginning of the cold war, it will also say that in those 8 years we have set the course that can win it."[199] Truman believed that as the free world grew "stronger, more united, and more attractive to men on both sides of the Iron Curtain," and "the Soviet hopes for easy expansion are blocked," in time a major transformation would occur in the Soviet sphere, although no one could know exactly when or how it would happen. The change, Truman suggested, could come

> **by revolution, or trouble in the satellite states, or by a change inside the Kremlin. Whether the Communist rulers shift their policies of their own free will—or whether the change comes about in some other way—I have not a doubt in the world that a change will occur.[200]**

Chapter 8.
Partnership in the Natural-Resources Program, 1953–1955

> **The best natural resources program for America will not result from exclusive dependence on Federal bureaucracy. It will involve a partnership of the States and local communities, private citizens, and the Federal Government, all working together. This combined effort will advance the development of the great river valleys of our Nation and the power that they can generate. Likewise, such a partnership can be effective in the expansion throughout the Nation of upstream storage; the sound use of public lands; the wise conservation of minerals; and the sustained yield of our forests.[1]**
>
> **—Dwight D. Eisenhower**

The convening of the 83d Congress on January 3, 1953, and the inauguration of Dwight Eisenhower as the 34th President of the United States 17 days later began an upheaval in the Federal Government. During the almost 20 years since the last Republican President, the Democrats controlled both houses of Congress, except in the 80th of 1947–49, and Cabinet officers, with few exceptions, were Democrats. During those two decades of peace and war, the United States had changed economically, politically, and socially. America's gross domestic product had grown sixfold, the net national income increased sevenfold, and the national debt rose ninefold. The Nation's view of the world changed as well; the so-called rugged individualism of Hoover's day gave way to social consciousness, and internationalism succeeded isolationism. The United States, emerging from World War II as the world's dominant superpower, became the largest contributor to the rehabilitation and development of impoverished nations. At the same time, America's distrust of the globe's other superpower, the Soviet Union, developed into a worldwide cold war against the forces of communism and fueled a fear of Communist activities at home. The Federal Government's operations also shifted markedly in those decades. New agencies arose and existing ones grew to provide more and improved public services, conservation and natural-resource planning received increased emphases, new commissions recommended improvements in economy and efficiency, foreign aid and technological assistance expanded, and a new national foundation now supported science and science education.

Eisenhower's concept of the Presidency differed from that of his two direct predecessors in office and in some ways resembled Hoover's. Both Roosevelt and Truman exerted strong personal leadership and were personally involved in management, but Eisenhower had spent all but 3 years of his 37-year professional life as a career officer in the U.S. Army. Eisenhower claimed he was nonpolitical and abhorred what he termed the partisanship and patronage of the Roosevelt and Truman administrations. The new President admitted only later that he had lived and prospered in the most political organization in the United States—the Army. Charles Pach, Jr., and Elmo Richardson, in evaluating Eisenhower's Presidency,[2] noted how he organized his administration along the lines of a military staff as he had done as commander of Allied and then North Atlantic Treaty Organization (NATO) forces in Europe and as U.S. Army Chief of Staff. Now Commander in

Chief as well as President, Eisenhower would make the ultimate decisions but leave the details of planning and implementation to his Department Secretaries and their supporting echelons. The effectiveness of Eisenhower's approach would depend largely on the persons he appointed to his Cabinet and to other high-level offices.

Eisenhower's Cabinet selections, influenced by Herbert Brownell, Jr., and Lucius Clay, signaled a change in the Federal Government's operations. All but one of the original Cabinet members, most of them successful lawyers or businessmen, had little or no experience in the inner workings of the Government. The liberal *New Republic* described the new Secretaries as eight millionaires and a plumber but passed over the similar service of Averell Harriman and other wealthy people to former Presidents. The appointment of John Foster Dulles to succeed Dean Acheson as Secretary of State reflected Eisenhower's commitment to internationalism. Dulles, the head of a Wall Street law firm and the grandson and nephew of Secretaries of State, participated in U.S. diplomatic efforts during the peace negotiations after World War I. He helped to prepare the Dumbarton Oaks charter, served as a delegate at the San Francisco Conference, and represented the United States in the United Nations (U.N.) General Assembly from 1946 to 1949. Dulles also advised Secretary Acheson, who entrusted him with working out the peace treaty with Japan, and became one of Eisenhower's principal advisers during 1952. Allen W. Dulles, Foster Dulles' younger brother, was a lawyer who had advised the League of Nations and served with the Office of Strategic Services. At Truman's request in 1946–47, Allen Dulles helped two colleagues draft the Central Intelligence Agency's (CIA's) portion of the National Security Agency's legislation and formulated ways to improve CIA operations. In January 1951, CIA Director and former Lt. General Walter Bedell ("Beetle") Smith, earlier Eisenhower's Chief of Staff and then Ambassador to the Soviet Union, made Allen Dulles the CIA's Deputy Director of Plans. When Smith, confirmed as Under Secretary of State on February 6, 1953, left the CIA 3 days later, Allen Dulles succeeded him as Director.

The other millionaires in the Cabinet also were long-time Republican businessmen. Among them, George Humphrey, the new Secretary of the Treasury, formerly headed the M.A. Hanna Company; as a disciple of Robert Taft, Humphrey believed the country was headed for bankruptcy and chaos because of poor planning and overspending by the Roosevelt and Truman administrations. Eisenhower selected Herbert Brownell as Attorney General. Ezra Taft Benson, Eisenhower's Secretary of Agriculture, acted earlier as an agent for farm cooperatives and supported Taft for President in 1952. Sinclair Weeks, the Secretary of Commerce and the son of a Secretary of War, was a banker and manufacturer, a former Chairman of the Republican National Committee, where he briefly replaced Senator Henry Lodge, Jr., and even more conservative than Humphrey. Charles Erwin ("Engine Charlie") Wilson left the presidency of General Motors Corporation (GMC) to succeed Robert Lovett as Secretary of the Department of Defense (DoD). Wilson achieved immediate notoriety during his confirmation hearings for his reply to a suggestion from a member of the Senate Committee on Armed Services that his extensive holdings of GMC stock might represent a conflict of interest. Wilson, echoing Humphrey's probusiness stance, mused that what was good for the Nation was good for General Motors and vice versa.

The new President considered nominating Earl Warren, then in his third term as Governor of California, as Secretary of the Interior. When Warren demurred, the President promised to appoint him to fill the first vacancy in the U.S. Supreme Court. Eisenhower then turned to Oregon's Senator Guy Cordon, who switched his support from Taft in 1952 and became Eisenhower's principal adviser on public-land, mineral, and water issues. When Cordon asked to stay in the Senate, he recommended his State's Governor J. Douglas McKay for Interior, the fifth-most senior post in the Cabinet. McKay farmed and sold insurance and automobiles in Salem before being elected the city's mayor in 1932, a State senator in 1934, and

Dwight David Eisenhower (1890–1969), the 34th President of the United States (1953–61), was educated at West Point and rose from 2d Lieutenant in 1915 to General of the Army (five stars) in 1944. He also served as Columbia University's president (1948 to 1953), during which tenure, he took a leave of absence to lead the North Atlantic Treaty Organization (NATO) in 1951–52. President Eisenhower achieved armistices in Korea and during the Suez Crisis; eventually opposed Joseph McCarthy's demagoguery; proposed "Atoms for Peace"; strengthened national defense; and authorized direct or indirect U.S. interventions in Cuba, Guatemala, Indochina, and Lebanon. He also signed legislation supporting farmers, housing, and reforms of Social Security and the internal revenue code; approved the interstate highway system, the St. Lawrence Seaway, and U.S. participation in the International Geophysical Year and the international treaty on Antarctica; authorized aerial spying on the Soviet Union; signed civil-rights legislation and supported it; and warned the Nation about the dangers from its military-industrial complex. The Air Force Academy; the Second Hoover Commission; the Department of Health, Education, and Welfare; and the National Aeronautics and Space Administration were established during Eisenhower's two terms of office. (Photograph by the *New York Times*, 1954, from Library of Congress, Prints and Photographs Division, 3c04961.)

Governor in 1948. McKay reluctantly agreed to serve and took his oath of office as the Interior Department's 35th Secretary on January 21, 1953.

McKay, like Eisenhower and Cordon, believed the new administration would best represent business and industry by promoting a smaller bureaucracy, greater rights for States, increased freedom for private interests, and a public-private partnership to develop the Nation's natural resources. McKay also felt that most of the public lands and their resources would be administered more economically and efficiently if they passed from Federal to State control and (or) private ownership. Water's importance for irrigation, the President and the Secretary agreed, often outweighed preserving natural features. Hoping to encourage private enterprise, they opposed creating a Columbia River Authority similar to the Tennessee Valley Authority (TVA) and opposed building the public-funded Hell's Canyon dam on the Snake River in Idaho. McKay, seen by many as a foe of conservation and public-power development, favored building dams elsewhere in the West, including those at Flaming Gorge, Glen Canyon, and eight other sites planned by the U.S. Bureau of Reclamation (USBR) in the 1940s as part of the Colorado River Storage Project.

Among these proposed dam sites was one, approved by Secretary Chapman in 1950, on the Green River at Echo Park in Colorado. That dam's reservoir would flood much of the 238-square-mile area of Dinosaur National Monument that enclosed the upstream portions of the scenic canyons and parks of the Green and Yampa Rivers. Conservationists, now fearing that no federally protected site would be safe if the Echo Park dam were built, rallied much more support for saving that locale from construction than they did for California's Hetch Hetchy Valley some 50 years earlier. On December 22, 1953, the *New York Times* alerted its readers to the dangers posed by the proposed dam and its reservoir. Eisenhower approved, on March 20, 1954, McKay's recommendations for joint Federal-State development of the Upper Colorado River Basin, including the Echo Park and Glen Canyon dams, and promised legislation would be offered in Congress to establish a fund for construction to benefit agriculture, industry, and municipalities. Wallace E. Stegner edited "This is Dinosaur"[3] in 1955 as a brief for the defense led by the Sierra Club's David Brower. A year earlier, Stegner's more comprehensive polemic for the whole arid region appeared in "Beyond the Hundredth Meridian—John Wesley Powell and the Second Opening of the West."[4] In 1956, the Echo Park preservationists won a partial victory.[5] The Eisenhower administration secured statutory authority for comprehensive development of the Colorado River and Upper Colorado River Basins to regulate flow, control floods, store water for beneficial consumption, apportion it among the States—Arizona, Colorado, New Mexico, Utah, and Wyoming—of 1948's Upper Colorado River Basin Compact, reclaim arid and semiarid lands, and generate hydroelectric power. No dam or reservoir would be built within a national park or monument. Neither would water impounded by any new dam be used for agriculture for at least 10 years, unless the Secretary of Agriculture deemed it necessary for national security.

Interior Secretary McKay shared with Defense Secretary Wilson a tendency toward careless verbosity, but McKay did not exhibit Wilson's indecisiveness. McKay quickly replaced all five of his deputy managers. Ralph A. Tudor, a San Francisco civil engineer, designer of the Bay Bridge, and former Colonel of Army Engineers, succeeded Richard D. Searles as Under Secretary. McKay appointed Fred G. Aandahl, former Governor (1945–51) of and Representative (1951–53) from North Dakota, as Assistant Secretary for Water and Power Development. Lawyer Orme Lewis of Phoenix, Arizona, became Assistant Secretary for Public Land Management. McKay selected Felix E. Wormser, who entered the mineral industry after graduating from Columbia and rose to be an executive in a lead company, as Assistant Secretary for Mineral Resources. Wormser and U.S. Geological Survey (USGS) Director Wrather were old friends, whose association dated from their memberships in the American Institute of Mining and Metallurgical Engineers and other professional societies. Otis Beasley took Vernon Northrup's place as Administrative Assistant Secretary. McKay also began looking critically at some of the leaders of Interior's agencies.

Eisenhower had his own ideas about how best to structure the Federal Government. On January 24, 1953, he appointed a President's Advisory Committee on Government Organization.[6] The members of the new Committee included Chairman Nelson A. Rockefeller, the former Assistant Secretary of State for American Republic Affairs and later Eisenhower's Special Assistant; Milton S. Eisenhower, the President's younger brother, who founded the War Relocation Authority, served with the Office of War Information, and now presided at Pennsylvania State University; and Arthur Flemming, Administrator of the Economic Stabilization Agency and Director of the Office of Defense Mobilization (ODM). Before March 31, Eisenhower used the authority of the Reorganization Act of 1949 to submit to Congress 10 reorganization plans, including 1 to establish a new Department of Health, Education, and Welfare (HEW) to take over functions of the Federal Security Agency. Congress' joint resolution approving the new and 10th Department became effective on April 11. Eisenhower named as the HEW's initial Secretary Oveta Culp Hobby, who led the Women's Army Corps during World War II and, later, while president and editor of the *Houston Post*, campaigned for him. Nelson Rockefeller became the HEW's Under Secretary. On July 10, Eisenhower and the 83d Congress established a second Commission on Organization of the Executive Branch of the Government, with a staff and provisions for expenses, "to promote economy, efficiency, and improved service in the transaction of the public business."[7] Herbert Hoover chaired the new, 11-member Commission, as he had its predecessor during the Truman administration. Hoover's colleagues on his second Commission included Attorney General Brownell and Administrator-Director Flemming; Senators H. Styles Bridges (R–NH) and John L. McClellan (D–AR); Representatives Clarence J. Brown (Sr., R–OH) and Chester E. Holifield (D–CA); James A. Farley, Franklin Roosevelt's Postmaster General and now with the Coca-Cola Company; Solomon C. Hollister, Dean of Cornell's College of Engineering; Joseph P. Kennedy (Sr.); Sidney A. Mitchell, a banker and director of American Electric Power Company; and Robert G. Storey, Dean of Southern Methodist University's School of Law. The 12 Task Groups in Hoover's second Commission included one for Water Resources and Power, led by Admiral Ben Moreell, who also chaired Jones and Laughlin Steel's Board of Directors.

Eisenhower set forth the aims of his new administration in his inaugural address on January 20, 1953, and his State of the Union Message on February 2. The new President devoted his inaugural remarks entirely to foreign policy.[8] "The world and we," Eisenhower said, "have passed the midway point of a century of continuing challenge,"[9] the current ones being the dangers of war and aggressive communism. He promised an unceasing effort to seek worldwide peace, an especially urgent goal because

> **[s]cience seems ready to confer upon us, as its final gift, the power to erase human life from this planet.[10]**

That peace, the President held, could be achieved by possessing strength sufficient to deter aggression and, ultimately, to make possible a drastic reduction in armaments. As Eisenhower spoke, relations with the Soviet Union remained difficult, those with the People's Republic of China (PRC) continued to grow increasingly strained, and the hot war continued in Korea, where the total of American casualties and those missing in action now exceeded 125,000. More than 7 years after the end of World War II, peace treaties with Germany and Austria remained to be signed. Other conflicts of varying intensity continued in Burma, Cyprus, Indochina, Indonesia, Kenya, Malaya, Oman, Trieste, and Tunisia.

Eisenhower outlined the philosophy of his administration, citing "four ruling purposes." The executive branch would apply "America's influence in world affairs with such fortitude and such foresight" that it would "deter aggression and eventually secure peace." The President and his associates also would build a national administration of integrity and efficiency, encourage "incentives that inspire creative initiatives in our economy,"[11] and seek the well-being of all citizens and equal opportunity for all. U.S. business, except in time of crisis, should be left to the workings of natural economic law. He would strive to trim the planned deficit and balance the budget by "reducing expenditures to the safe minimum." Eisenhower considered debt reduction more important than decreasing taxes, and so first he planned to eliminate the national debt. He pledged to "check the menace of inflation."[12] Nor would Eisenhower ask Congress to extend the material, product, wage, and price controls due to expire on April 30, "except with respect to defense priorities and scarce and critical items essential for our defense."[13] As "only a combination of loyalty and reliability promises genuine security," he noted, "all principal new appointees to [Federal] departments and agencies have been investigated at their own request by the Federal Bureau of Investigation."[14] Later background checks by the FBI were authorized by an Executive order on April 27 that established investigations to ensure that "all persons employed by the Federal service be reliable, trustworthy, of good conduct, and of complete and unswerving loyalty to the United States."[15] Eisenhower also called for extending Social Security; ending segregation in the Federal Government, including the armed forces, and in the District of Columbia; and approving immediate statehood for Hawaii but not for Alaska.

The 83d Congress continued to work on its own agenda. High on the legislators' list were the goals of reducing taxes, de-emphasizing foreign affairs, and purging all subversive influences from the Government. On the session's opening day, Representative Daniel A. Reed (R–NY), Chairman of the House Committee on Ways and Means, filed a bill to eliminate on July 1 the 11-percent increase in income taxes adopted to support America's effort in the Korean war. The Bureau of the Budget's Director Joseph M. Dodge, formerly president of the Bank of Detroit, offered little hope for drastically reducing the Truman administration's last budget, cutting taxes, or balancing Eisenhower's initial budget. The President still chose eliminating the deficit as his initial goal. Two weeks after the State of the Union Message, Reed's committee, undeterred by Eisenhower's declared choice, favorably reported the bill while stating that tax reduction remained its initial order of business. On January 7, John Bricker (R–OH), Chairman of the Senate's Committee on Interstate and Foreign Commerce, proposed a constitutional amendment to limit the scope of international treaties and to impose controls on the power of the President to negotiate treaties. As for alleged subversives, Eisenhower, like Truman, believed that the executive branch, not Congress, held primary responsibility for keeping them out of the Federal Government. Nonetheless, four congressional committees, headed by Senators Joseph McCarthy of Government Operations, William E. Jenner (R–IN) of Rules and Administration, and Alexander Wiley (R–WI) of Foreign Relations and Representative Harold H. Velde (R–IL) of Un-American Activities, launched separate investigations of suspected Communists and their influences within the Government.

The 83d Congress did agree with the Eisenhower administration's interest in Federal jobs for Republicans. One Representative, intent on placing more Republicans in Federal employment, inserted in the *Congressional Record* at the session's start a report on political affiliations as an example of those he thought should be supplanted. The Interior Department's portion of the report listed the names of 282 employees, including 26 from the USGS. The agency's roll included the Director's immediate staff, the Division heads, the Branch chiefs, and administrative officers.

Were these persons corrupt, or inefficient, or simply tainted by service under a Democratic administration? Many decades had passed since a form of the spoils system had been applied to professional scientific positions. The Representative and his supporters soon discovered how difficult it would be to displace current employees because the overwhelming percentage of Federal jobs were under Civil Service, including the agency directors, associate directors, and assistant directors placed there by the Reorganization Act of 1946. The solution, worked out by the end of March, directed the Civil Service Commission to review all positions with confidential or policymaking responsibilities for possible reclassification in Schedule C, a new category for high-level posts in which job protection would be inimical to the requirements of the new administration.

The new personnel policy provoked a firestorm about the heads of Commerce Secretary Weeks and Interior Secretary McKay when the national media discovered that long-term career scientists in high-level positions were being replaced in efforts to appease the Republican desire for jobs and propitiate the American business community. On March 31, while Eisenhower arranged to authorize these dismissals, Secretary Weeks announced that he had requested and obtained the resignation of physicist Allen V. Astin, who began work at the National Bureau of Standards (NBS) in 1930 and now was its Director. Weeks' move might have been considered a routine administrative change by an incoming administration had not the NBS antagonized a California manufacturer by declaring as worthless its battery additive AD–X2 that it wanted to sell to the Government. The additive, Weeks announced, had been used by his own company, and outside tests supported the manufacturer's claims. Astin, in response, defended his Bureau's integrity. Newspapers and journals immediately featured the story; on April 17, *Science* declared that the "scientific work in the government has been placed in jeopardy."[16] Weeks retained Astin temporarily while the National Academy of Sciences (NAS), at Weeks' request, evaluated and then validated the NBS' conclusion.[17] On August 21, Weeks reinstated Astin, for what Weeks termed were the best interests of the NBS and the public.

Secretary McKay's recommendation, announced a few days earlier than Weeks' original decision, that John Forbes, a 40-year career public servant, be replaced as Director of the U.S. Bureau of Mines (USBM) then took on new significance. The United Mine Workers protested, and Representative Augustine B. Kelley (D–PA) accused McKay of trifling with the lives of miners. Then McKay fed the flames by announcing the resignation of Marion Clawson, Director of the Bureau of Land Management (BLM) and another career man. Clawson denied that he had resigned and called on McKay to state the reasons for his dismissal in accordance with Civil Service regulations. Newspaper editorials chided McKay for his haste. The rumored severance of Albert Day, a long-serving career officer, as head of the Fish and Wildlife Service brought more outraged protests. Senator William Fulbright brought to the attention of his legislative colleagues a charge by the *Washington Post* that career men with long experience and high professional competence were being replaced by political appointees. USGS Director Wrather, who celebrated his 70th birthday on the day of Eisenhower's inauguration, also might have been vulnerable to the effects of this policy had Wrather served 15 or more years in the Federal Government. The administration did not anticipate the reaction to resignations of Astin and Forbes and the other proposed moves. McKay kept Forbes and Wrather but reassigned Day, at a yearly salary reduced by $1,400, as an Assistant to new Director John J. Farley of Washington, and replaced the BLM's Clawson with Edward Woozley of Idaho. Forbes left the USBM in November 1955.

Eisenhower, in his State of the Union Message also claimed conservation as a Republican issue, proposing that "We must more than match the substantial achievements in the half-century since President Theodore Roosevelt awakened the Nation to the problem." Although Eisenhower invoked the elder Roosevelt's name, he did not share Roosevelt's broad view of conservation and remained primarily concerned with farmlands. The new President called for a "strong Federal program in the field of resources development," but he suggested that major projects be timed to assist in "leveling off peaks and valleys in our economic life." The best natural-resources program, he asserted, would "involve a partnership of the States and local communities, private citizens, and the Federal Government, all working together."[18] Exactly what partnership Eisenhower proposed, he did not make clear, but during the campaign in 1952, he had used the term to describe his intention of rearranging initiatives and participation in resources use. Frank E. Smith (D–MS), who served in House during 1951–62 and on its Committee on Public Works, later recalled in his "The Politics of Conservation" that partnering represented an attempt to reach common ground between the goal of developing river basins and the view that government should not generate and sell electric power. The plan proposed using government funds for the part of multipurpose dams used for flood control, navigation, and other nonreimbursable operations; private companies would pay for and gain title to the part used to generate electric power.[19] Partnership, like fiscal responsibility, one of Smith's contemporaries observed, again was being redefined to fit specific issues.

Congress seized upon the partnership idea in regard to ownership of the Nation's tidelands, and their natural resources, which, as the Republicans' 1952 platform emphasized, belonged to the States. A joint resolution was introduced to give the coastal States the offshore lands within the 3-mile limit, except for the more extensive seaward boundaries of Florida and Texas. After the Republicans quickly pushed the bill through the House and the Senate, managed in the latter by Guy Cordon, Eisenhower signed the measure on May 22 and opened the way for immediate exploitation by private interests. Congress and the President intended the Submerged Lands Act to "confirm and establish titles of the States to lands beneath navigable waters [nontidal and tidal out to 3 geographical miles from the coasts] within State historic boundaries and to the natural resources within such lands and waters, to provide for the use and control of said lands and resources [especially oil and gas], and to confirm the jurisdiction and control of the United States over the natural resources of the seabed of the Continental Shelf seaward of State boundaries."[20] Under the new law, the Federal Government retained the rights to navigation, flood control, and power production. Likewise, it retained "in time of war or when necessary for national defense * * * the right of first refusal to purchase at the prevailing market price, all or any portion of the said natural resources, or to acquire and use any portion of said lands by proceeding in accordance with due process of law and paying just compensation therefore."[21] Section 10 of the statute revoked part of Truman's Executive order of January 16, 1953, setting aside the Continental Shelf's submerged lands as a Naval Petroleum Reserve, which applied in the new statute to lands beneath navigable waters.

The Outer Continental Shelf (OCS) Lands Act followed less than 3 months later on August 7. The new law provided "for the jurisdiction of the United States over the submerged lands of the outer Continental Shelf" and authorized "the Secretary of the Interior to lease such lands for certain purposes."[22] The new law applied to all submerged shelf lands and their resources seaward of the now State-owned lands on the inner shelf and seaward to a depth of 200 feet. The statute authorized the Secretary to award, via sealed competitive bids, mineral leases, including those for oil and gas, for compact areas of up to 5,760 acres within 5 years and with royalties of 12.5 percent of production. For areas with sulfur deposits as determined by the Secretary, leases required development within 10 years at not less than 5 percent of production. The Federal Government retained the same right of first refusal to purchase OCS minerals in time of war or by the

President's decision. The statute validated the existing leases by the States. The law also authorized the President to withdraw from disposition any of the nonleased OCS submerged lands; reserved to the United States all uranium, thorium, and other fissionable materials on OCS lands; and repealed the remainder of Truman's Executive order of January 16, 1953. On March 15, 1954, the U.S. Supreme Court confirmed the coastal States' jurisdiction over their Continental Shelves out to 3 miles from their shores, and Federal authority beyond that, and increased proprietorship for Florida and Texas to 3 leagues, or 10.3 miles, in the Gulf of Mexico. The decision in *Alabama* v. *Texas et al.*,[23] holding as constitutional 1953's Submerged Lands Act, gave the States parity in political standing and sovereignty. On April 1, Eisenhower transferred control of the OCS-derived funds from the Navy Secretary to the Interior Secretary.[24] Matters pertaining to the resources of the world's Continental Shelves and their overlying waters, including both mineral and living resources, were considered at the Tenth Inter-American Conference of the Organization of American States, held at Caracas, Venezuela, in 1954. Attendees recognized the subject's complexities and the amount of background information required for an adequate understanding of the problems involved. They resolved to call an Inter-American Specialized Conference on the conservation of natural resources, especially those of Continental Shelf and marine waters.

The new executive policies initially lopped $5 billion off the Federal budget for fiscal year 1953–54 and then another $5 billion by April 1953 that lowered the total to $63.2 billion. Those reductions jeopardized the budgets requested for the Interior Department and the USGS. For 1953–54, the Truman administration asked for $621.5 million for Interior and $31,070,000 for the USGS. The agency's portion included substantial increases for topographic surveys, geologic surveys, and water-resources investigations and small raises for other activities, including soil and moisture conservation. The largest increase, $3.6 million for topographic surveys, was more apparent than real, as, by agreement with the DoD, another effort was being made to have funds for military mapping appropriated directly to the USGS. The USGS expected the Eisenhower administration to reduce its budget request.

The House subcommittee began hearing testimony on Interior's budget for fiscal year 1953–54 on February 24, 1953, before the Eisenhower administration completed revising the budget submitted by its predecessor. Iowa's Benton ("Ben") Jensen returned as chairman, joined by fellow Republicans Hamer H. Budge of Idaho and Pennsylvania's Ivor Fenton. Ohio's Michael Kirwan and Arkansas' William Norrell continued to represent the Democrats. Secretary McKay emphasized his strong support

> **for the conservation of resources, and I do not mean locking them up as some people think, but we must get the most out of our natural resources.[25]**

McKay said that he "was surprised * * * [by] some of the things which this Department takes in. It is really terrific. I do not think," he continued, "there is any department more essential to the welfare of the people." He promised to "do the very best I can to do a good job"[26] as Secretary. Jensen renewed his stands for soil conservation on the public lands, timber conservation, and more efficient management of Interior's personnel. He then mentioned that, while the Truman budget was being revised, John Taber (R–NY), the returning Chairman of the House Committee on Appropriations, requested all subcommittees to schedule first the smaller or less important agencies and place nearer the hearings' end those agencies whose budgets might be controversial or require major revision. McKay appeared briefly startled when Jensen noted that he had scheduled the USGS representatives to be heard the next day. The USGS "is a very important agency," said Jensen, who added his opinion that the subcommittee "has always had the highest regard for the efficiency and economy which has been practiced in this agency."[27] McKay, recovering quickly, agreed "Yes * * * It [the USGS] is very good."[28]

The House subcommittee's hearings on February 25 for the USGS budget proved no less amiable under Chairman Jensen than they had been under Chairman Kirwan. Director Wrather, whose successful career in the oil industry continued to impress subcommittee members old and new, said at the outset that he recognized "the imperative need for all feasible economy in Government expenditures," while providing proper support to the most meritorious and urgent Federal functions. "Any request for increased support," Wrather continued

> **can be justified only if it can be shown that the national need for greater service by the Survey transcends even the need for economy.[29]**

"There is a growing realization that the functions performed by the Geological Survey should be greatly extended to support the rapidly developing civilian economy, and this is even more necessary in times of national emergency," an opinion, Wrather noted that "has been most recently expressed by the Paley commission."[30]

Most of the subcommittee members' questions centered on the changes in the military mapping program, which Chief Topographic Engineer Gerald FitzGerald explained as the results of reordering priorities in the DoD. The Army transferred $4.9 million to the USGS during fiscal year 1951–52, FitzGerald pointed out, but the shift suggested that future funds should be in the agency's own budget. Last year, he continued, the USGS asked for the necessary amount and got only $3 million. After conferring with the DoD, the Topographic Division curtailed its program as much as possible "to accomplish the highest priority mapping with this year's funds"[31] and was spending more than 50 percent of its current appropriations on work for the military. The USGS asked for an increase to nearly $3.68 million for its topographic work "to recapture in our budget the amount to cover military mapping."[32] Representative Budge then voiced his concern about possible duplication in work by the USGS, the Bureau of Reclamation, and the Department of Agriculture. Assured by FitzGerald that there was none, Budge passed on to what seemed excessive work by the USGS for the military. When FitzGerald responded that the USGS was not in a position to evaluate the military's demands, Budge said that Congress should do so. Later, after Budge approved Wrather's responses to the economic questions and the budget's reduction of USGS average grade classification from 6.6 to 6.5, the Representative specifically queried the accuracy of USGS groundwater studies, its work for the Federal Power Commission, the effect of silting on the useful life of high dams, soil- and moisture-conservation investigations, the status of special-area studies for the National Security Resources Board (NSRB), and the reasons for the regional changes in the topographic-mapping program for the DoD. The modification, Wrather and FitzGerald explained, started after the DoD, beginning in January 1952, identified critical zones within the larger areas, assigned higher priorities to them, and also added new areas. These changes called for a shift in emphasis in mapping operations to expanded and larger scale coverage of the growing industrial concentrations on the East Coast, at the expense of the allocation in the fiscal 1952–53 justification for work on the Pacific Coast and around the Great Lakes. The types of mapping changed, they said, more than the amount of available funds. The 1952–53 justification called for $800,000 for engineering and $2.4 million for topographic and geologic mapping in the Pacific Coast region; the USGS actually expended $1,380,000 and $1,525,000, respectively, for those purposes.

Toward the session's end, Chairman Jensen said, almost wistfully, that "While this committee wants to give the Geological Survey everything it needs that will help you do the great and important job that you have to do, and which is your responsibility, we always, of course, are hopeful that by new methods and by possibly a little reorganization we can save a few dollars here and there. Do you have any suggestions," Jensen asked, "as to how you can make your agency more efficient with possibly less personnel and how you can consolidate some of your activities? If there is anything that you can think of that might save some dollars for the taxpayers and will permit you to carry on this great and important work," Jensen continued, "we would like to know it."[33]

Ordinarily the Senate waited to take action on executive-budget requests until the House passed the appropriations bills, but, in 1953, the Senators began hearings about the Eisenhower administration's revised version on April 14, several days before the House committee submitted its report. Secretary McKay presented to the Senate appropriations subcommittee the new budget for all Interior agencies except the USBR, which was still being worked on. Senator Cordon now chaired the subcommittee, whose other Republican members included returning Senators Henry Dworshak, William Knowland, and Milton Young. Carl Hayden, now ranking minority member, Dennis Chavez, Harley Kilgore, and Patrick McCarran continued to represent the Democrats and were joined by Warren Magnuson. Overall, the Eisenhower budget slashed Interior's funds for fiscal year 1953–54 by $69 million, or 18 percent, from the Truman version. McKay asked for $307 million for Interior, excluding the USBR and the power agencies, a reduction reflecting the wish to give "certain activities * * * careful examination before undertaking additional programs or expanding existing programs." Program goals, McKay explained, would be achieved "at lower cost through more efficient utilization of manpower and other management practices."[34] Of that total, the USGS would receive $27,750,000, a loss of slightly more than 10 percent. The $3,320,000 reduction, McKay, noted, would be achieved principally by decreases of $1,950,000 in topographic surveys, leaving the request still $1.6 million above that for 1952–53; $750,000 in geologic surveys; and $460,000 in water-resources investigations but also by smaller reductions in other activities. The revised estimate would still give the USGS nearly $2.3 million more than its funds for surveys, investigations, and research (SIR) in fiscal 1952–53.

On April 20, Director Wrather repeated to Senator Cordon's subcommittee his "sincere conviction, that with the need for all possible economy, there is a genuine urgency for the requested strengthening of the Geological Survey."[35] Chairman Cordon agreed, although he remarked that expenditures had to be cut somewhere "until we could use our funds for our own welfare first."[36] When that stricture renewed the old argument about appropriations to the agency doing the work versus appropriations to the agency deriving the benefit of the work, both Cordon and Hayden favored the latter. Wrather interrupted the discussion to assert USGS "responsibility for maintaining a competent technical staff. We have to maintain an organization which is soundly supported by our own appropriation,"[37] Wrather emphasized, "but more or less questionably supported by transferred funds, unless the funds are earmarked in the original budget for transfer to the Geological Survey." The operational problem involved keeping technical personnel adequate to do the job, Wrather cautioned, "and if we cannot do it, I do not want the job."[38] Senator Cordon saw the point; the ideal, he thought, "would be the original appropriation direct to the Geological Survey, but divided as to the beneficiary so that one could clearly see * * * who is to receive the benefits of the work done" and also "be able to separate that portion of the work done that would primarily be the responsibility of your agency."[39] Senator Hayden said that he believed that Congress was concerned with the purpose of the appropriation.

Wrather then pointed out the current situation. When economy was necessary, the USGS did not know, and might not know for another 2 or 3 months, how much it would receive of the estimated $19.5 million in Federal-transfer funds, yet it had to maintain a competent organization. "Yes, you have got to have a primary appropriation directly to the Geological Survey," Cordon agreed, "and to a great extent it ought to be a general appropriation, one elastic enough to permit the maintenance of a qualified, highly technical personnel, even though there might be a month or 2 months or 3 months * * * that the personnel would be caring for only the general program, but in advance of the amount of work generally scheduled. So that you could turn it at any time in any direction for these other services."[40] "That would involve also fluidity of funds with the administrator,"[41] Wrather responded, and "will almost require interchangeability of funds so that we could modify our work as the program progressed."[42] Again, Cordon agreed.

Cordon and Hayden then queried Wrather about the largest requested increase in the USGS budget, slightly more than $1,693,000 for the largest program, topographic surveys and mapping. The discussion focused, as before, on completeness and adequacy. FitzGerald emphasized the lack of both for the United States. Although 70 percent of the Nation's land area was now mapped at various scales, only maps for 30 percent of it were deemed adequate for present uses. Of the 6,000 quadrangles now being worked on nationwide, FitzGerald reported, only about one-half were being mapped at the standard scale of 1:24,000. National coverage, he told the Senators, as he had cautioned the Representatives, would not be achieved for decades unless they significantly increased funding each year. The rate, coverage, and accuracy of USGS topographic mapping, FitzGerald also hoped, would increase markedly when the agency got its ellipsoidal reflector-55 (ER–55) projectors "into full production."[43]

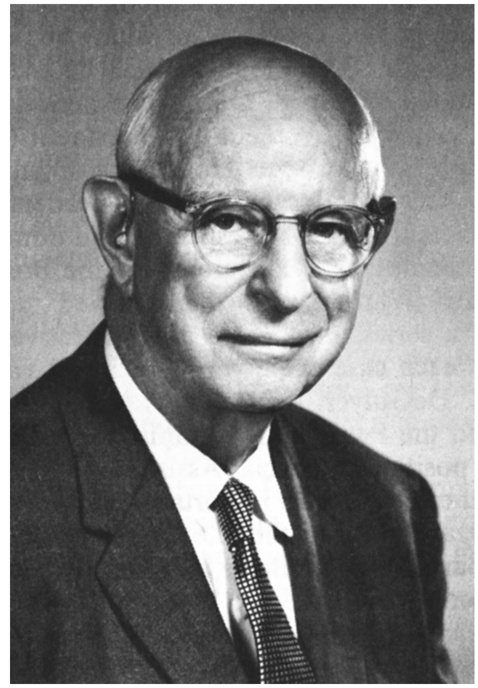
Three days after these exchanges, the House subcommittee submitted its report on Interior's appropriations bill. The subcommittee's members wanted to promote conservation and to ensure the best use of the Nation's natural resources, while making necessary reductions in budget requests, eliminating all present and future expenditures not required for the wise-use resource program, and increasing Federal tax revenues. The subcommittee adopted a somewhat different view of partnership in conservation than the President outlined in his February 2 address. Where Eisenhower called for a strong Federal program involving a partnership of the States, local communities, and private interests with the Federal Government, the House subcommittee held that partnership should come into effect only where private enterprise was unable to completely develop resources without assistance. The Interior Department, the subcommittee asserted, should concerned itself only with those functions or activities that private enterprise could not or would not undertake. Where private enterprise needed aid to completely develop natural resources, the members urged it to enter a working partnership with the Federal Government. Private interests should then discharge their obligations to the fullest in serving the public interest and placing additional property on the Nation's tax rolls. These decisions led to a suspension in the development of a national minerals policy.

The House subcommittee allowed for the USGS $27,750,000, the full amount of the Eisenhower budget, but it specified that the reduction of the Truman budget by $3,320,000 would be applied to the topographic-mapping effort and not to any of the $55,000 reduction proposed in the $100,000 originally requested for the soil- and water-conservation program. The subcommittee's report particularly criticized the military mapping program. The hearing disclosed that the military mapping priorities, which required the large increase in the USGS mapping program for 1953, were altered during the year, and the authorized funds were diverted to other priority work determined by the military. The subcommittee complained that it could not appropriate funds intelligently if priority programs presented in justification of budget estimates were not in fact priority programs. If the military program presentations to the USGS were going to continue as unreliable as this example, the subcommittee declared that it was reluctant to appreciably increase the military mapping program carried on by the agency. The House accepted its subcommittee's recommendations and passed the Interior appropriations bill on April 28. The Senate subcommittee recommended an appropriation for SIR of $26,380,000 for the USGS in fiscal year 1953–54, cutting $1,370,000 from the estimate for topographic surveys in the Eisenhower budget but still providing some $1,017,000 more than in 1952–53. The conference committee agreed on the Eisenhower budget's amount of $27,750,000,[44] an increase of about $2,387,000, and the President signed the measure on July 31.

Republican zeal to eliminate alleged waste in Federal operations continued unabated after the passage of appropriations for fiscal year 1953–54. To increase coordination, economy, and efficiency within Interior, Secretary McKay discontinued, by the end of fiscal 1952–53, the Department's Program Staff and its Divisions of International Activities, Land Utilization, Minerals and Fuels, and Water and Power. He transferred their responsibilities and staffs to the three programmatic Assistant Secretaries or to the agencies. McKay established, within the Secretary's Office, a Technical Review Staff, an Office of Legislative Counsel, and a public-relations unit. He also reformed the Department's field committees by appointing responsible regional officials from the bureaus as chairmen to replace the former full-time chairmen and their staffs, made his Solicitor responsible for all legal activities, and established committees to investigate the operations of each of Interior's agencies. On August 5, 1953, McKay directed Assistant Secretary Wormser to form a specific group to evaluate the USGS and its programs. Although McKay did not intend his Secretary's Survey Committee on the Geological Survey to be a rubber-stamp body, the USGS employed four of its six members at one time or another during 1908–51.

J. Robert Van Pelt, since 1951 president of the Montana School of Mines, Director of the Montana Bureau of Mines and Geology, and Battelle Institute's director of research education, chaired McKay's new Committee, and Samuel Lasky served as its executive secretary. Committee members included Horace M. Albright, cofounder and former Director of the National Park Service (NPS), and now president of U.S. Potash Company; Donald M. Davidson, a USGS field assistant in 1927, a mining geologist, and now director of the E.J. Longyear Company; William Heroy (Sr.), the USGS, Board of Economic Warfare (BEW), and Petroleum Administration for War (PAW) veteran, Geotechnical's president since 1952, and a current member of the USGS Science Advisory Committee; and John C. Frye, who worked for the USGS during 1938–41 and who now was State Geologist of Kansas but would leave to head the Illinois State Geological Survey later in 1954.

Wrather immediately asked his Division Chiefs to form small groups to prepare and circulate for internal review the summaries of administrative and operational goals, methods, and products that might be useful to Interior's new Committee. The Van Pelt Committee met with Assistant Secretary Wormser on September 1, 1953, and began its work on September 16. During the next 7 weeks, the Committee heard testimony from members of Interior's staff, from members of the USGS and its Divisions, and from persons outside the Federal Government. Committee members regarded "this assignment as a privilege, for each one of us has long held the Geological Survey in high esteem,"[45] but that appreciation did not prevent them from completing a thorough and critical review. On February 12, 1954, the Committee reported an "unsurpassed record of integrity, ability, and devotion to duty" by the USGS "that should be carefully conserved and encouraged." While crediting USGS management with "many important adjustments to the new conditions" during the agency's sixfold increase in size and corresponding growing complexity of its duties in the past 15 years, the Van Pelt Committee, like the Interior Committee-Princeton group in 1950, emphasized that USGS "structure and practices have not kept pace."[46]



Geologist William Heroy ([Sr.] 1883–1971), like William Wrather a colleague and friend of Everette DeGolyer, left the USGS in 1919 after a decade's service to join the petroleum industry. Consulting for the Board of Economic Warfare led to work with DeGolyer in the Petroleum Administration for War. In 1946, Heroy joined the Geotechnical Corporation (later Teledyne-Geotech) and, with Roland Beers (Sr.), founded Beers and Heroy. During postwar years, Heroy also served on the USGS Science Advisory Committee and participated in the Van Pelt Committee's critical review of USGS organization and performance at the request of Interior Secretary Douglas McKay. In 1965, Heroy retired to an active post at Southern Methodist University. (Photograph from Conselman, 1974.)

The growing need for topographic mapping, geologic research, and mineral discovery is expected to place still greater strains on the Survey in the next ten or fifteen years. The structure and practices of the Survey must be geared, therefore, not only to present conditions, but to more severe future demands.[47]

The Van Pelt Committee followed that general endorsement by pointing out nine "major points of weakness":[48] (1) distance from a national minerals policy; (2) inadequate supervision in some Divisions and Branches; (3) insufficient in-service training for staff, especially of the younger and less experienced scientists; (4) reduced coordination between administrative units and their projects; (5) too many uncompleted projects; (6) too much nonspecialist-administrative work required of scientists and engineers; (7) tardy publication of geologic reports; (8) unimproved relations with cooperating agencies and the public; and (9) excessive housekeeping activities by the technical (programmatic) Divisions. Some of these deficiencies, the report continued, reflected undue caution by the USGS; other infirmities mirrored departmental action, lack of space in facilities, congressional-appropriations practices, and work, including "spot jobs," for other agencies.

To address these problems, the Van Pelt Committee offered 46 specific recommendations for improvements,[49] to be implemented, if approved, in ways that would not disrupt current operations. The report recommended reorganizing the USGS administratively, so that each regional programmatic or support chief would lead four operational or administrative branches in each of six geographic, but not geologic, areas: (1) a 16-State Eastern Region, from Maine west to Ohio and south to South Carolina, with headquarters in or near Washington; (2) a 9-State Central Region, including Tennessee, Kentucky, Missouri, and north, with headquarters at Rolla; (3) a 7-State Rocky Mountain Region, comprising Kansas, Colorado, and north, with headquarters at Denver; (4) a 9-State Southern Region, from Florida west to New Mexico; (5) a 7-State Pacific Region, including Arizona, Utah, Idaho, and west, with headquarters in Menlo Park; and (6) the Territory of Alaska. Hawaii was not mentioned. The USGS would select, guided by the report's chapter on implementation, locations for the headquarters of Regions 4 and 6.

In the proposed table of organization, Regional Geologists led branches for plans and coordination, geologic mapping, basic geology, and applied geology. Regional Topographic Engineers directed branches for plans and coordination, field survey, photogrammetry, and cartography. Regional Hydrologists managed branches for plans and coordination, surface water, groundwater, and quality of water. Regional Conservation Chiefs oversaw branches for plans and coordination, oil and gas leasing, mining, and land classification. A new publications division would operate "to consolidate the processing, manufacture, and distribution of publications";[50] its Regional Chiefs also would manage the library branches transferred administratively from the Geologic Division but not merged physically. The Regional Administrative Officers oversaw branches for organization and management. In each region, the regional Division heads constituted a Regional Coordinating Committee, already operating in Denver, chaired by a person appointed by and reporting, informally but directly, to the Director and aided by the Regional Administrator as permanent secretary. Regional Division heads would continue to report formally to their Division Chiefs, who also retained control of their nonregionalized topical and (or) administrative branches, which contained the headquarters of the regionalized branches. The Director would retain six Assistants, those for Inspection, External Coordination, Reorganization, Program, Operations Analysis, and Publications. The Geologic Names Committee, appointed by the Director, would report to the Assistant for Publications. The Chief Counsel's position would be abolished and its work done by Interior's Solicitor. The Van Pelt Committee, unlike the Interior Committee-Princeton group in 1950, did not recommend establishing Regional Directors.

The Van Pelt Committee also recommended other changes: (1) establishing a map-reproduction plant for Denver; (2) consolidating land-mapping activities; (3) ensuring better coordination between the USGS and the BLM in administering the mineral-leasing laws; (4) avoiding joint Federal-State purchase of equipment; (5) maintaining (and annually reviewing) programs for at least 6 years; (6) obtaining, through Interior, security for funds through each field season; (7) appointing a coordinator of in-service and bureauwide training; (8) seeking legislation to permit federally supported university training of selected scientists and engineers; (9) appointing an Assistant Director for Publications; (10) extending the concept of the Geologic Staffing Committee to all Divisions; (11) asking the Water Resources Division to establish a General Hydrology Branch; (12) separating the delegation of contracting authority for emergencies from that required for routine procurement; and (13) preparing an orientation manual for USGS employees and desk books of organizational and administrative detail for the USGS and its Divisions.

Assistant Secretary Wormser approved the Van Pelt Committee's report on April 27, 1954, Secretary McKay signed off on the 28th, and the document passed to Director Wrather. Wormser placed in Wrather's hands "full responsibility * * * for carrying out the provisions of the report," while concurring with it "that a considerable period of time will be required for the implementation * * * and that certain phases are dependent upon a successful solution of the space problem." Wormser planned to ask the Department's staff to consider appropriate action on five of the specific recommendations: (1) as urgent Interior policy and action, obtaining "at the earliest practicable date, a building for the Geological Survey in the suburban Washington area"; (2) in so doing, recognizing "present space requirements for scientific and technical work, for trends toward larger equipment, and * * * the growth trend of the Survey"; (3) ensuring that USGS libraries would not be merged with other collections in Interior and "any plans for centralized administration be given most careful consideration before adoption"; (4) asking the Interior Secretary's Office, "to improve programming and to reduce operational inefficiency" by working "out means of securing continuity of funds during the field season"; and (5) seeking legislation "to permit university attendance of carefully selected [USGS] scientists and engineers" to conduct "studies of direct interest and value to the Government."[51]

Wrather began modifying his agency's existing organization, management, and regional structure before the Van Pelt Committee issued its report. To maintain "sound bureau-wide organization," his Administrative Circular of June 29, 1953, formalized a policy and established a procedure for "effecting changes in the organization." "All changes in the bureau's organizational structure down to and including section or equivalent level," and all those "in a Division or Branch-level staff organization"[52] now required Director's approval. Any changes in organization or duty assignments down to Branch level also now needed Secretarial confirmation. Wrather required Division Chiefs to send to him, with an explanatory memorandum, any plan for organizational changes before beginning the process of job classification. To expedite final approval, Wrather asked for outlines for preliminary review, but he specified that each plan must contain a statement of objectives, a table of organization, the location of field offices, brief descriptions of the new positions, and an estimate of their number. He reminded his managers that they must continue to obtain Director's approval "before filling key positions"[53] and that his two memorandums, to the Secretary, on December 21, 1950, and to the Division Chiefs, on December 1, 1952, remained the basic guides to field organization.

A subsequent Administrative Circular, dated September 11, 1953, codified "redelegations of authority which have been made by the Director to subordinate officers and employees of the Geological Survey." Acting officials, the Circular confirmed, needed no special redelegation to act with full authority, and Survey orders would not be so issued, except when "necessary to publish a redelegation in the Federal Register."[54] The second part of the Circular described special redelegations of authority in mineral leasing for applications for suspending operations to Regional Supervisors for Oil and Gas and for Mining, and for appeals by persons aggrieved by those supervisors' actions. The third and last part listed existing general redelegations for personnel management; appointments and status changes of specific positions in the General Schedule (GS) and Crafts, Protective, Custodial (CPC) Schedule; contracts, with the approval levels required for amounts up to $1,000, $5,000, and $25,000; errors in bids; leases in the continental United States and its territories and possessions; approval of and limitations on travel; oaths; and personal-property management.

Wrather, while discussing regionalization as part of the budget request for an additional $900,000, beyond the previous 2 years' funding, in capital outlay for building space, reminded the House subcommittee's members on February 25, 1953, that "We early recognized the fact that we were going to have to establish service centers at various parts of the Country."[55] Glendon Mowitt, the USGS Executive Officer and, since February 17, Chief of the agency's new Administrative Division[56]—including the Budget, Organization and Management, Accounts, and Services and Supply Branches—then described the status of the agency's regional facilities in the Washington area and those at Rolla, Denver, and Palo Alto in California. After alterations to the building at Denver that required an expected $2.1 million, and an additional $297,000 to cover inflation, space was now available to install $70,000 worth of purchased equipment. In selecting the Pacific Coast and other sites, Mowitt continued, "We have tried, in every case, to stay out of the high-cost rental areas."[57] For the Pacific Coast Center, the contract signed by the General Services Administration (GSAd) specified a USGS building of some 40,000 square feet in the Palo Alto area, near Stanford University, to be constructed by a private firm and rented yearly at $1.31 per square foot. The $250,000 requested for the Pacific Coast Center would provide laboratory equipment, library and storage shelving, movable partitions, and additional plumbing and other utilities required by the GSAd but one fewer wing than originally planned.

In the Washington metropolitan area, the USGS staff continued to be housed in 397,000 square feet of space in 15 buildings, including the Naval Gun Factory, home to some of the staff that worked on projects for the U.S. Atomic Energy Commission (AEC). "We have found," Mowitt reported, "that private capital would be more than willing to build a building in which we would consolidate those people." The USGS, the GSAd, and the Bureau of the Budget (BoB) agreed not to ask Congress for additional appropriations for rent because the USGS planned to "relinquish high-cost downtown space to compensate for it."[58] The USGS required some 440,000 square feet for a building for its national and eastern-region headquarters, "on the outskirts of Washington," that would enable the agency "to maintain contact and liaison with other Government groups" and "plan a more orderly conduct"[59] of its operations. Part of the $900,000 would fund continued planning. As part of the future contract, the USGS hoped to arrange a 25-year lease, an interval about equal to the building's half-life, at $1.25 million per year, with an option to purchase the building for $1 when the lease ended. The building, the GSAd estimated, could be constructed for $27.1 million, not including maintenance but minus the taxes. To avoid disruptions in construction and staff, the USGS asked approval for funds to replace obsolete printing presses; the new equipment would be ordered in fiscal year 1953–54 and installed in 1954–55. The capital-outlay request also included $231,000 for the new building's laboratory benches and other fixed installations. The remaining $360,000 would fund new equipment at Denver, Palo Alto (later Menlo Park), and Washington.

While the Van Pelt Committee evaluated the USGS and Wrather improved decentralization of the agency's operations, but successfully avoided similar administrative changes, the Eisenhower administration's foreign policy gained successes and endured failures in wars hot and cold. The areas of principal concern continued to be Europe, Iran, Korea, and Indochina. Early in May 1953, Eisenhower established Project Solarium, supervised by the National Security Council (NSC) and managed by Robert Cutler, the President's Special Assistant for National Security Affairs and head of the NSC's Planning Board. George Kennan plus an Air Force general and a Navy admiral chaired Solarium's three task groups formed to reassess national-security policy before the administration finalized its 1954–55 budget. On September 23, Spain and the United States signed a 10-year agreement for mutual-defense assistance, by which Franco's government received economic and military aid in return for providing the United States with bases on Spanish soil, even through Spain remained outside NATO. President Eisenhower, Prime Minister Churchill, and French Premier Joseph Laniel met in Bermuda during December 4–7 to discuss international political and military issues, including defending the West, improving relations with the Soviet Union, and organizing Austria and Germany. On December 8, Eisenhower asked the United Nations General Assembly to establish an International Atomic Energy Agency (IAEA), under U.N. aegis, to which all of the nuclear powers would make joint but modest contributions from their stockpiles of uranium and other fissionable materials. The President also encouraged worldwide research using the IAEA-controlled materials, peaceful applications of atomic energy, further reductions in remaining national stockpiles,[60] and new channels for discussion and new approaches for solving problems related to the nuclear-arms race. When the Council of Foreign Ministers convened in Berlin during January 25–February 18, 1954, they did not agree to reunify Germany or adopt a Soviet-sponsored security treaty that would include all European nations but assign the United States and the PRC only as observers.

Eisenhower, in his second State of the Union Message to Congress on January 7, 1954, recommended "measures to advance the security, prosperity, and well-being of the American people."[61] The President proposed to use the strategic initiative gained during the past year "to promote three broad causes: First, to protect the freedom of our people; second, to maintain a strong, growing economy; third, to concern ourselves with the human problems of the individual citizen."[62] Eisenhower then discussed foreign assistance and trade, his atomic-energy proposal to the U.N., national defense, internal security, the economy, a balanced budget, spending and tax reductions, agriculture, and conservation. He promised to make recommendations for a "uniform and consistent water resources policy," a "revised public lands policy," and a "sound program for safeguarding the domestic production of critical and strategic metals and minerals."[63] The President completed his review by covering many other topics, including national highways, statehood for Hawaii, and voting rights for citizens from 18 to 21 years old and all those in the District of Columbia.

On January 12, Secretary Dulles provided more specific information on national- and global-defense policies, worked out by Eisenhower and his economic, scientific, and military advisers to replace Truman's policy of containing communism. NSC 162/2, a policy report approved by Eisenhower on October 30, 1953, emphasized the need for a strong economy, a military capability for massive retaliation, and the liberation of Eastern Europe by peaceful means. The massive-retaliation policy relied on nuclear weapons as a means of deterrence, while avoiding a garrison state and bankruptcy through huge expenditures for defense. Dulles promised that all aggressors, not just the Soviet Union, would face instant and massive retaliation from nuclear weapons delivered by the Strategic Air Command's (SAC's) bombers. To support this doctrine, the Eisenhower administration continued trying to improve the Nation's nuclear deterrent. Edward Teller; Princeton's

John L. von Neumann, another Hungarian-American, who participated in the Manhattan Project and then helped to develop MANIAC and other electronic computers; and other scientists, engineers, and technicians aided this work. In 1953, Teller and von Neumann suggested to the U.S. Air Force's Science Advisory Board that a smaller version of the thermonuclear device could be fashioned as a bomb weighing only 1,500 pounds. The new device, they proposed, also might be used as a warhead for ballistic missiles to be launched from land sites or, as Philip Abelson suggested in 1946, from nuclear-powered submarines.

As planning began for these lighter warheads and seaborne delivery systems, other countries continued testing nuclear weapons or joined the thermonuclear club. On August 12, 1953, the Soviet Union, again aided by information from its spies, secretly tested its own hydrogen bomb of several 100 kilotons, an achievement the CIA failed to predict with any accuracy. Foster Dulles' brinkmanship policy, based on continuing U.S. nuclear superiority but criticized at home and abroad, required extensive persuasion of the Governments of Britain, Italy, and Turkey before they agreed to station on their soil U.S. intermediate-range ballistic missiles. France refused to do so and began to develop her own separate deterrent force. When Eisenhower reorganized the U.S. Atomic Energy Commission in 1953, investment banker Lewis L. Strauss returned as its Chairman, replacing Gordon Dean. Von Neumann joined Willard Libby, also a new appointee, and holdover Thomas E. Murray as Commissioners. Strauss, as a Commissioner during 1946–50, clashed over policy with Lilienthal and Oppenheimer; as Chairman, Strauss continued to favor private control of nuclear power and testing nuclear weapons in the atmosphere. On March 1, 1954, the AEC announced the first of a new series of nuclear-test explosions—a 15-megaton Bravo air device—at its Pacific proving grounds in the Marshall Islands. Radioactive fallout from these aerial tests devastated the crews of several Japanese fishing vessels. That autumn, Soviet nuclear tests above ground also created additional broad areas of fallout. In April 1955, the Soviets agreed to help the People's Republic of China build the atomic bomb whose production Mao ordered in January.

Crises in both hemispheres continued to test the Eisenhower administration's foreign policy. Events in Iran still endangered Anglo-Iranian's operations that supplied 60 percent of the world's oil. Allen Dulles and the National Security Council emphasized for Eisenhower dangers of the unrest in Iran and the growing Soviet influence with Premier Mossadegh,[64] *Time* Man of the Year, and his government. The CIA's 5-percent share of Marshall Plan funds helped to fuel its global covert operations. The agency, legally authorized to oppose or overthrow unwanted regimes, pursued the administration's goal of not just containing but stopping and, where possible, rolling back Soviet gains. In February 1953, Allen Dulles met with the Chief of British Intelligence to formulate definite plans to oust Mossadegh with the aid of royalist Iranians. Eisenhower, who authorized withholding American aid on June 29, approved the operation on July 11.[65] Royalist troops overthrew Mossadegh on August 19. The Shah returned to Tehran, and Iran received $45 million in U.S. aid on September 5. Foster Dulles sent Herbert Hoover, Jr., to Tehran to repeat his Venezuelan success by negotiating a long-term agreement for a new oil consortium to oversee Iranian production and royalties. The agreement with Iran was signed and ratified by October 29, 1954. As Daniel Yergin later reported, the new consortium combined British Petroleum[66] (BP), 40 percent; Aramco's four U.S. companies, 8 percent each; Gulf, 8 percent; Shell, 14 percent; and a French company, 6 percent. Oil shipments resumed on October 30 when a British tanker left Abadan. Yergin called the new arrangement one of the oil industry's major watersheds.[67] Although the change left the United States as the most significant participant in Middle Eastern petroleum trade and politics,[68] he continued, the United States and Europe remained dependent on the region's oil. Iran joined Britain, Iraq, Pakistan, and Turkey in the Baghdad Pact in 1955 over the Soviet Union's objections that it endangered peace and security in the Middle East.

In Korea, 2 years of advances and retreats on the battlefields produced few lasting geographical changes, as each side tested the other's resolve in close combat and face-to-face negotiation. The stalemate continued in 1953 along a battle line now 20 miles or more north of the 38th parallel, except in the far west. General Maxwell D. Taylor, who led the 101st Airborne Division in General Matthew Ridgway's XVIII Airborne Corps during World War II and later served as Army Deputy Chief of Staff for Operations and Administration, took over the 8th Army on February 11 and continued Ridgway's way of waging the war. Stalin's death on March 5 offered some hope of improved relations with a Soviet Union under new leaders and perhaps a negotiated end to the Korean war. First Deputy Premier Lavrenti Beria did not long survive Stalin. In the ensuing struggle for power, Georgy M. Malenkov emerged as Chairman of the Council of Ministers, or Premier, and First Secretary of the Communist Party's Central Committee but quickly yielded the second post to Nikita S. Khrushchev. Marshal Nikolai Bulganin resumed his roles as Deputy Secretary and Minister of Defense. In June, Malenkov, Khrushchev, and other members of the Presidium, backed by Red Army leaders, arrested Beria. Promptly imprisoned and then executed, Beria was tried and convicted in absentia in December. Walter Ulbricht, opposed by Beria but now supported by Khrushchev, became President of the German Democratic Republic in March 1954.

As Ulbricht took over East Germany, a still-divided Korea had been uneasily at peace for some 7 months. On March 28, 1953, North Korea's Premier Kim Il Sung and General Peng Teh-huai (Peng Dehuai), the PRC's commander in Korea, agreed to arrangements for prisoner exchanges, and the opposing forces completed a preliminary and limited swap in April. On July 10, after the United Nations overrode objections by South Korea's President Rhee to any continued division of Korea and the 8th Army contained another Chinese offensive, the Communists agreed to resume negotiations. President Eisenhower kept his options open in July when Task Force 77, continuing its operations offshore, received nuclear weapons. Representatives from the warring commands agreed to an armistice at Panmunjom on July 27 that General Mark Clark signed for the United Nations. The truce's terms provided for a demilitarized zone, a 2.5-mile-wide separation of the 155-mile-long battle line, between the two Koreas; repatriation of some 90,000 prisoners; and a joint military commission to monitor the armistice. The arrangement gave South Korea some 1,500 square miles of additional land and terrain advantages along the zone. During the war, U.S. forces suffered more than 147,000 casualties, or 30 percent of the 476,000 killed, wounded, captured, and missing incurred by the U.N.'s 15-nation units. The conflict cost the Chinese and North Koreans, and their Soviet advisers, an estimated 1.6 million total casualties in battle, 60 percent of them Chinese, and another 400,000 elsewhere. They, in turn, inflicted total losses of about 300,000 on the South Korean forces, not counting the killed or injured civilians. During the conflict, the United States rebuilt her military power. By the war's end, U.S. forces worldwide totaled 5.8 million, of whom 440,000 were in or near South Korea. In January 1954, the Senate approved a U.S.-South Korea Mutual Defense Treaty. In the following year, the United States increased its economic and military aid to the Republic of Korea, maintaining there at least one infantry division and its supporting units.

The United Nations settled for a draw in Korea, but France lost its coeval war in Indochina. The United States, expecting France to win the struggle and hoping to keep France active in NATO, contributed more than three-fourths of the financial and material cost of fighting the Indochina conflict. During 1950–53, seven French Governments numbered their existence in months, not years. Beginning in October 1953, operations by the Viet Minh rose in frequency and intensity; in one action, they ambushed and destroyed the veteran but road-bound French battalion sent to Tonkin from Korea after the armistice. To try to repeat on a larger scale the French victory at Na San, 15,000 French and Colonial troops established an air-land base at Dien Bien Phu, near the border with Laos and more than 200 miles from Hanoi. Against the defensive perimeter surrounding the airstrip, General Giáp deployed four full Viet Minh divisions and artillery that vastly outnumbered and outgunned the French troops and their artillery. In trying to resupply their garrison during the siege that began on November 20, some 40 percent of French aircraft, many supplied by the United States and some flown or serviced by U.S. personnel, were lost to or damaged by Communist antiaircraft batteries. Dien Bien Phu's airstrip fell on March 27, 1954, further reinforcement and resupply by parachute mostly failed, and Viet Minh artillerists, engineers, and infantry continued to reduce the French bastions.

While French forces struggled to hold Dien Bien Phu, Premier Laniel's government sought to end the war in Indochina. On April 26, 1954, preliminary sessions of a peace conference opened in Geneva to try to terminate the conflict. Admiral Arthur Radford, Chief of the Joint Chiefs of Staff (JCS) since June 1953, and other military and civilian officials urged Eisenhower to intervene militarily at Dien Bien Phu and elsewhere in Tonkin. Radford asked for approval to begin Operation Vautour (Vulture),[69] by ordering strikes by B–29s and B–50s from the Philippines and Okinawa and by using nuclear weapons. As part of the logistical planning for any increased American deployment in Indochina, Jack Rachlin, of the USGS Military Geology Branch (MGB), prepared for the Army Engineers a study of potential sites for new airfields. Eisenhower, although he feared losing Asia to a domino effect and declared on March 24 that the Communists in Southeast Asia must be defeated, decided not to intervene militarily in what he termed a jungle sinkhole. He would so do only with the support of the JCS, where only Radford favored intervention; Congress, which did not approve; Britain, where Churchill and Eden remained opposed; and the United Nations. On May 7, Viet Minh forces captured the remaining fortifications and nearly all the survivors at Dien Bien Phu; fewer than 100 men escaped the trap.[70]

Formal sessions at Geneva began on May 8, 1954, among the representatives of Britain, Cambodia, France, Laos, the PRC, the Soviet Union, the United States, the two Vietnams, and eight other nations.[71] During the meetings, Secretary of State Foster Dulles, the U.S. delegate, refused to shake the hand of Chinese Foreign Minister Zhou Enlai. Under Secretary Walter B. Smith, who went to Britain to get support for the French, replaced Dulles. On July 21, the delegates agreed to an armistice by which Tonkin and Annam were separated by a demilitarized zone along the 17th parallel to be monitored by an International Control Commission. The arrangement also enabled citizens to choose freely their country of residence; scheduled general elections throughout Vietnam for 1956, aimed at reuniting the country through a plebiscite supervised by Canada, India, and Poland; prohibited foreign bases or alliances; and limited the numbers of foreign military advisers. The accords also recognized Cambodia and Laos as politically independent states. In June 1954, Pierre Mendès-France's new government, replacing Laniel's, agreed to complete independence and free association with France for Bao Dai's southern regime. There, also in June 1954, Ngô Dình Diêm, a prominent member of the Catholic minority in the predominantly Buddhist country, replaced Prince Bau Loa as its premier. The Eisenhower administration then rejected the Geneva accords and recognized Bao Dai's government in August 1954. Eisenhower and Dulles hoped to restore U.S. prestige in Asia and, by replacing France, keep the southern half of Vietnam and other areas in Indochina out of Communist hands. They decided to support Diêm, even after General Joseph Collins, the President's special representative in South Vietnam, advised against it in April 1955.

To contain communism in the region, the United States also joined Australia, Britain, France, New Zealand, Pakistan, the Philippines, and Thailand in signing the Southeast Asia Collective Defense Treaty in Manila on September 8, 1954. The treaty led to the formation in 1955 of the Southeast Asia Treaty Organization (SEATO). A separate and secret protocol extended SEATO's protection to Cambodia, Laos, and South Vietnam, which were prevented by the Geneva accords from full participation, and France declared them economically and financially independent on December 29. The SEATO agreement did not create unified forces and a command like NATO's, but the Governments of these three Indochinese nations agreed to accept French military advisers and American economic and military aid. They also made the Mekong River that crossed their territory a free waterway. The Americans, French, and South Vietnamese proposed to reorganize South Vietnam's army under French direction and assisted by U.S. military personnel. Communist China's responses to SEATO included participating in a conference of 28 other "unaligned" nations from Africa and Asia held in Bandung, Indonesia, during April 18–24, 1955, to discuss their role in gaining peace, self-determination, and influence worldwide.[72] There, Zhou declared that the PRC would negotiate about Taiwan and other conflicting issues rather than fight the United States, which had ratified a mutual-security pact with the Nationalist Chinese Government on February 9. The U.S. 7th Fleet completed on May 18 a 9-month evacuation to South Vietnam of local military personnel and civilians who did not wish to remain in Communist North Vietnam. Diêm survived a civil and military revolt between late March and early May, trounced Bao Dai in a referendum on October 23, and declared the Republic of Vietnam 3 days later. Hõ's regime began preparing to use its remaining units and infrastructure in the south to subvert and overthrow Diêm's government by a campaign of terrorism and guerilla war to reunite all Vietnam under Hõ's leadership. By then, some of the French forces released from Vietnamese captivity by the Geneva settlement were veterans of a year's counter-insurgency operations in French Algeria.

Closer to home, the CIA, encouraged by its success in Iran, helped to overthrow the land-reforming and socialist Guatemalan Government of Jacobo Árbenz Guzmán, elected in 1950. The CIA again acted to protect U.S. trade and investment interests after the Árbenz government seized most of United Fruit's land, sought Czechoslovakian weapons to outflank a U.S. arms embargo, and claimed that the United States planned an invasion. The CIA's Richard M. Bissell, Jr., a former economics professor at Yale and Economic Cooperation Administration (ECA) Deputy Administrator, who succeeded Allen Dulles as Deputy Director of Plans, led the operation, which Dulles authorized in December 1953. Jack Rachlin, of the USGS Military Geology Branch, completed, at 1:1,000,000, a preliminary estimate of the suitability of sites for airborne operations in Guatemala. Nicaragua's dictator Anastasio Somoza provided training bases for a revolutionary group led by cashiered Colonel Carlos Castillo Armas. When the CIA reported Soviet influence on and involvement in the Árbenz government, the Eisenhower administration authorized a U.S. blockade of Guatemala's coasts. Castillo Armas' nearly comic-opera force invaded Guatemala from Honduras on June 18, 1954. Defeated, they were saved by the intervention of the U.S. Ambassador to Panama and bombing missions by three aging P–47 Thunderbolts flown by CIA-hired U.S. pilots. Árbenz fled, and Castillo Armas' military junta took over the country on June 27. The CIA touted its success but did not assess for Eisenhower how the region's peoples might now view the U.S. positions on democracy and international law.[73] On September 1, the United States and Guatemala signed a technical-assistance agreement that brought to that country a full Point Four Program; a military pact followed in 1956.

As the increasingly dictatorial regime stabilized Guatemala in 1956, Fidel A. Castro Ruz, his younger brother Raúl, Ernesto ("Che") Guevara, and nearly 80 Cuban nationalist-socialist dissidents landed on the coast of Oriente Province, then the island's largest and the Castros' birthplace. On December 2, this small force, about half the size of the one fielded by Castillo Armas, resumed Fidel Castro's earlier attempt to overthrow the increasingly corrupt government of President Fulgencio Batista. The United States supported Batista in part to keep Cuba safe for American involvement in the island's agriculture, tourism, and mining (especially the extraction of chromite and manganese). When the 1956 invasion failed, like the assault on Santiago in 1953, the Castro brothers, Guevara, and the nine other survivors escaped into Oriente's Sierra Maestra, to recruit and continue the military and propaganda war against the Batista government.[74]

At home, the administration's mineral policy began to emerge during the spring of 1954. In 1953, the Illinois State Geological Survey's Morris Leighton extolled the United States' dominance in mineral production. Of the world's output of minerals and related commodities, he asserted, the United States produced 42 percent of the aluminum, 1.75 times as much as Canada; 32 percent of the cement, 4 times Britain's output; 37 percent of the coal, 1.8 times as much as the Soviet Union; 31 percent of the copper, twice Chile's production; 40 percent of the iron ore, 2.5 times the Soviet Union's production; 53 percent of the oil, nearly 5 times Venezuela's output; 42 percent of the phosphate, 3 times French Morocco's production; and 90 percent of the sulfur, 25 times as much as Italy.[75] "Technology," Leighton continued, "employing minerals of many kinds, has an importance to our present economic welfare that transcends all government efforts."[76] Leighton urged researchers to explore for new mineral deposits, to find new uses for mineral substitutes, and to develop new and more exacting methods of beneficiation. Leighton, like USGS Directors King, Walcott, and Mendenhall, reminded his readers that basic research advanced science and its applications that aided the States and the Nation. Leighton's figures also showed deficiencies in domestic production and the United States' continuing dependence on minerals from sources abroad. The prices for some of these mineral commodities rose as well. After Truman lifted World War II's price controls in 1947, oil increased from $1.81 to $2.76 per barrel. After Eisenhower ended Korean war controls in March 1953, prices for crude oil from the U.S. Gulf of Mexico Coast rose to $3.11 per barrel in 1954.

After Eisenhower took office in January 1953, some of his advisers urged him to adopt a mineral policy based on the Paley Commission's report of June 1952.[77] That report, emphasizing the dangers of near-term shortfalls in beryllium, cobalt, columbite, nickel, tantalite, and tungsten, recommended buying less expensive and (or) foreign supplies.[78] In December 1952, the President-elect had notified Horace Albright, who earlier suggested convening a resources conference, that he might call for another conservation conference like Theodore Roosevelt's in 1908. By the time of Eisenhower's inaugural, most of the domestic mining industry opposed a Paley-like policy; the industry had expanded rapidly to meet defense needs during the Korean war and now faced serious readjustments due to surplus production and new discoveries, especially in lead and zinc. In March 1953, the President released to the press a letter to Albright in which he encouraged competent private organizations, like Resources for the Future, Inc., to study and promote nonpartisan discussions of these and other national issues.

In May 1953, Eisenhower appointed Clarence B. Randall, the author of "A Creed for Free Enterprise," as Chairman of the President's Commission on Foreign Economic Policy; Randall, another ECA veteran, led the opposition by Chicago's Inland Steel and the rest of the industry to Truman's seizure of the mills in 1952. The Randall Commission's other members included Senator Eugene D. Millikin (R–CO), nine additional Members of Congress, and seven persons from business and labor. Eisenhower asked Randall's group to study international trade in relation to sound domestic economy, foreign economic policy, and the trade aspects of national security and foreign policy. The Randall Commission held public hearings, deliberated, and reported to Eisenhower in January 1954.[79] Randall's group agreed with the Paley Commission that the United States, although it held reserves of lead and zinc for 10 years, and copper for 20 years, faced increasing dependence on imported raw materials, especially chromite, nickel, platinum, and tin from Indochina, the Philippines, and other countries. The USBM agreed, listing asbestos, chromite, cobalt, columbium-tantalum, industrial diamonds, tin, and tungsten as its seven vital but deficient materials. These commodities must be developed abroad, Randall's group urged, unless geochemical and geophysical methods revealed presently unknown and unsuspected deposits or continued research and technological advances enabled the economic use of low-grade ores or provided substitutes. An intensified development of foreign minerals was not only necessary, the Randall Commission concluded, but also a means of promoting foreign economic development. Avoiding tariffs, supporting the domestic suppliers with DoD subsidies, and increasing stockpiles would mitigate price fluctuations in commodities. Randall's team, agreeing with Defense Secretary Wilson that U.S. allies against communism should be tied by mutual economic interests, called essential the retention in the free world of countries like copper-rich Chile. Millikin, who chaired the Senate's Committee on Finance and the Joint Committee on Internal Revenue Taxation, dissented and called for greater domestic production to offset U.S. dependence on outside sources. Congress did not warm to the Randall Commission's recommendation of increased trade with the Soviet bloc to boost Western Europe's economy, but the legislators did like the Eisenhower administration's repeated call for less aid and more (but not full free) trade. Randall's "A Foreign Economic Policy for the United States" appeared later in 1954, and Congress extended the existing reciprocal-trade agreements the following year for another 3 years.

While the Randall Commission deliberated, the 83d Congress and the President agreed on new measures to promote minerals security and fiscal responsibility. On July 31, 1953, they stopped providing major funds for stockpiling additional amounts of strategic and critical materials. Since the July 1946 amendment of the 1939 statute, a total of nearly $5 billion had been appropriated for this purpose, including the $204 million approved for acquisitions in fiscal year 1952–53. Only once during those 7 years, in fiscal 1949–50, were funds reduced, by $100 million, after being authorized, but they still totaled $465 million for that year. Now, with the armistice in Korea holding, Congress and the President decided to supply not more than $30 million in fiscal 1953–54 and to use it to liquidate existing obligations for stockpiling. On August 1, by Reorganization Plan No. 7, a statute established the Foreign Operations Administration[80] (FOA), under a Director nominated by the President and confirmed by the Senate, to replace the Mutual Security Agency in directing all Federal foreign-aid projects. Six days later, to reduce the United States' dependence on "overseas sources of supply" of strategic and critical minerals, Eisenhower signed the Domestic Minerals Program Extension Act. The President and Congress intended the new law to "encourage the discovery, development, and production of tungsten, manganese, chromite, mica, asbestos, beryl, and columbium-tantalum-bearing ores and concentrates in the United States, its Territories, and possessions." The statute required each Federal department and agency "charged with responsibilities concerning the discovery, development, production, and acquisition of strategic or critical minerals and metals" to "undertake to decrease further and to eliminate where possible the dependency of the United States on overseas sources of supply of each such mineral." The act also extended for at least 2 years "all purchase programs designed to stimulate the domestic production"[81] of these ores and concentrates, but it did not apply to the purchase abroad of sources of columbium-tantalum. On August 14, an Executive order abolished the Defense Materials Procurement Agency (DMPA) and transferred its functions, assets, and staff to the General Services Administration's

Emergency Procurement Service (EPS).[82] On October 1, Eisenhower also abolished the National Production Authority (NPA) and replaced it with the Business and Defense Services Administration (BDSA), which remained in the Commerce Department until the BDSA's termination in 1970.

"One of the essential problems before our country," Eisenhower asserted on October 26, 1953, "is the establishment of a national policy relating to the production and utilization of minerals and metals" that he considered "indispensable to the operation of an active economy and a sound defense."[83] To recommend how to avoid recurrences of past chronic shortages in emergencies, secure adequate supplies now and in the future, and alleviate current depressed economic conditions in domestic metal-mining districts, the President on that day established a Cabinet Committee on Minerals Policy, composed of Secretary McKay (Chairman), Secretaries Dulles and Weeks, and ODM Director Flemming. Treasury Secretary Humphrey and the Budget Bureau's Director advised McKay's Committee. Eisenhower, stressing the "depressed conditions within numerous metal mining districts,"[84] especially lead and zinc, asked McKay to report before March 31, 1954, when the U.S. Tariff Commission's assessment of the Nation's lead and zinc industries and their imports would go to the House Committee on Ways and Means and the Senate Committee on Finance. The Cabinet Secretaries named alternate members from among their Assistant Secretaries. McKay chose Wormser, the mineral industry's chief contact in the Federal Government, who continued to supervise the USGS, the USBM, the Defense Minerals Exploration Administration (DMEA), the Division of Geography, and the Division of Oil and Gas, to which the Petroleum Administration for Defense transferred petroleum and gas mobilization functions. To aid the Oil and Gas Division's work, McKay established, by Secretarial order on April 30, 1954, a Military Petroleum Advisory Board,[85] as Truman suggested in 1946. Wormser, or his alternates, also represented Interior on the Council on Foreign Economic Policy, the Interdepartmental Materials Advisory Committee, the ODM's Titanium Committee, the Secretary of Commerce's Advisory Committee on Export Policy, and several interdepartmental committees on mineral problems and policy. To Wormser fell the task of organizing and supervising the staff work and meetings of other Secretarial alternates required to prepare position papers for the Cabinet Committee. Among the assignments was a month-long initial and confidential survey by the Legislative Review Task Force, which included members from State, Interior, and Commerce; the survey passed to Wormser on December 31, 1953.

In May 1953, the National Science Foundation (NSF) was operating from the Cosmos Club's former quarters,[86] after renovations by the GSAd, at 1520 H Street, N.W., in Washington, D.C. The NSF established an Advisory Panel for Earth Sciences, whose 12 members included seismologist Hugo Benioff of the California Institute of Technology (Caltech), USGS geologist James Gilluly, Shell's King Hubbert, USGS hydrologist Luna B. Leopold, Walter H. Munk of the Scripps Institution of Oceanography (SIO), USGS geologist William Pecora, Salt Lake City consulting geologist Philip Shenon (who left the USGS in 1946), and vertebrate paleontologist George Gaylord Simpson of the American Museum of Natural History (AMNH). The NSF also formalized its temporary committee of 1952 by establishing an Advisory Committee on Minerals Research, as recommended by the Paley Commission, to inventory "existing scientific and technical knowledge," determine "subject areas of greatest need for further research and development," "devise a coordinated program," and "estimate the cost and extent"[87] of required Federal funds.

The NSF chose for the permanent Advisory Committee on Minerals Research 18 geologists, geophysicists, and chemists from the mining and petroleum industries, universities, and government; 6 of the members were current or former employees of the USGS. James Boyd, who became Kennecott Copper's exploration manager after leaving the USBM in 1951, chaired the new Committee. Its members included NBS Director Allen Astin, who also served on the Inter-Agency Committee on Scientific Research and Development; John G. Bartram, a consultant formerly with Stanolind Oil and Gas; Yale and USGS geologist Alan Bateman; Arthur Bunker of Climax Molybdenum; Gordon L. Davis of the Carnegie Institution of Washington's (CIW's) Geophysical Laboratory (GL); Maurice Ewing, Director of Columbia's Lamont Geological Observatory (LGO); Paul D. Foote of Gulf Research and Development; Harvard's Louis Graton, who served full time with the USGS during 1903–09; John K. Gustafson, of the M.A. Hanna Company; Wisconsin's Charles Leith, who also served with the USGS and National Research Council; Thomas Nolan, William Rubey, and William Wrather of the USGS; Louis B. Slichter, Director of the Institute of Geophysics of the University of California at Los Angeles (UCLA); John W. Vanderwilt, president of the Colorado School of Mines; Battelle's Clyde Williams; and Paul Zinner, head of the USBM's Minerals Division and later Assistant Director for Programs.

Four topical subcommittees, on which academia, industry, and government were all represented, aided the Advisory Committee's deliberations. The 14-member Subcommittee on Geological Research included USGS geologists Charles A. ("Andy") Anderson and Thomas Lovering, Columbia's Charles Behre, Jr., Arthur Buddington of Princeton and the USGS, Harvard's Hugh McKinstry, and Vincent D. Perry of Anaconda Copper. USGS geologists Robert Garrels and Earl Ingerson, Konrad Krauskopf of Stanford and the USGS, Columbia's John L. Kulp, and Utah's Edwin W. Roedder formed the Subcommittee on Geochemical Research. USGS geologists James Balsley and Henry Faul, Harvard's A. Francis Birch, Sigmund Hammer of Gulf Research and Development, Penn State's Benjamin F. Howell, Jr., and Patrick M. Hurley of the Massachusetts Institute of Technology (MIT) served on the nine-member Subcommittee on Geophysical Research. Howell, Kulp, and Roedder were among the earth scientists who received research grants from the NSF in 1953–54. Charles Hunt, now Executive Director of the American Geological Institute (AGI), and Howard Meyerhoff, still the Executive Director of the Scientific Manpower Commission, formed the Subcommittee on Scientific Manpower.

The Advisory Committee completed an outline "as a guide to division of effort among its subcommittees and a sample catalog of the kinds of problems facing the Nation in the mineral research field," including for completeness those inappropriate for the NSF's direct financial support but important for "its evaluation and policy-making functions."[88] The Committee recognized "the importance of Federal support of research and training," but industry, the Committee added, should "support the preponderate amount of research in this field, especially applied research and development."[89]

In March 1954, as the Cabinet Committee on Minerals Policy finished its report, Eisenhower signed an Executive order intended to improve economy and efficiency in, and develop a national policy for, "basic research and education in the sciences."[90] The order authorized the NSF to recommend policies for promoting and supporting basic research and education. Eisenhower asked the NSF to assess present and foreseeable needs for personnel, facilities, and funds; review, with the agencies concerned, the federally sponsored programs; provide increased support through contracts and grants; study, with the agency heads and HEW's Commissioner of Education, the effects of Federal policies and administration of the financial aid on education; and coordinate Federal activities in improving the dissemination, as security considerations allowed, of scientific information. Eisenhower also requested the heads of Federal scientific-research agencies to ensure that their managerial, organizational, and fiscal practices facilitated consultation with and review by the NSF and that their agencies, whenever possible, shared major equipment and facilities. No such agency, the President cautioned, should procure new major equipment or facilities without determining if existing inventories or facilities might meet their needs. Eisenhower also designed his Executive order to "to strengthen the conduct and support of vital research and development in the several agencies where science is important in achieving their assigned missions."[91]

In the same month, the President's Cabinet Committee on Minerals Policy discussed its basic proposals with Eisenhower. On March 26, 1954, Eisenhower announced, as the Committee recommended, an expansion of the stockpiles of strategic minerals to serve better the Nation's security and, as Alfred Eckes, Jr., later observed, specifically to aid the domestic producers of lead and zinc. The Cabinet Committee's report of November 30, approved by the President on December 1, emphasized that its members had used the lead-zinc situation as a test case. Meeting the newly established stockpile objectives for those two commodities required additional purchases and additional efforts to "maintain domestic production at a reasonable level."[92] The announcement of the new stockpile policy firmed up the lead and zinc markets. In June, as purchases began under this new policy, market prices for lead and zinc rose 20 and 24 percent, respectively, above their low points in February, increases the Committee hoped would meaningfully aid that domestic part of the Nation's mobilization base. The Committee recommended a periodic review of the two minerals and some others.

The Cabinet Committee on Minerals Policy took as its guides three major concerns—having mineral raw materials available "to meet any contingency during the uncertain years ahead," meeting "the ever-growing mineral requirements of an expanding economy," and preserving "the added economic strength represented by recent expansion of facilities by the domestic mining industry." As with oil, the report emphasized prudent use and development of mineral resources at home and "assured access to necessary sources abroad."[93] The Cabinet Committee's overriding concern in considering "policies relating to mineral production and utilization" remained "the security of the Nation."[94] Its members agreed on recommendations they believed would "foster a full and orderly program"[95] for developing and conserving these resources. As of June 30, 1954, $4.3 billion worth of 75 materials, of which 55 were metals and minerals, being stockpiled were on hand, out of the minimum objective of $7 billion. Significant commitments for stockpiling, at least cost whenever possible, were among those funded by the more than $6 billion already "made to expand supplies of materials to meet defense purposes."[96] The Committee recommended preparing studies, on a case-by-case basis, to determine the proper levels of domestic mineral production for each mineral commodity as a basis for mobilization planning. Instead of continuing to emphasize foreign sources, the Committee backed a new, long-term program of stockpiling that gave preference to newly mined metals and minerals of domestic origin. Its members also supported (1) reviewing and modifying the tax structure and the mining statutes to remove deterrents and stimulate discovery and production of minerals and (2) strengthening and expanding the DMEA's financial assistance to private industry for exploration. The Committee also urged strengthening and widening Interior's abilities in mapping and research, especially those "that must precede or supplement private exploration,"[97] activities now supported by the implementation of measures suggested by the McKay-generated reviews of the USGS and the USBM. The Cabinet Committee proposed increasing acquisitions of some 35 to 40 strategic and critical metals and minerals, from domestic sources whenever and wherever possible, to eliminate the risk of future shortfalls. The ODM should review with Interior, Commerce, and other concerned departments and agencies, the report continued, the tasks of building and maintaining the metals-minerals mobilization base and delegate authority as required "to assure full coverage of mobilization planning."[98] Wormser, expecting ODM authorization, arranged for a series of mineral-mobilization studies; an analysis of fluorspar followed the one on lead and zinc completed by the end of fiscal year 1953–54. On November 12, 1954, as recommended by the Cabinet Committee, the ODM delegated to Interior responsibilities for developing preparedness measures for a comprehensive list of minerals and fuels and McKay passed them to Wormser.

The $27,750,000 in SIR funds authorized on July 31, 1953, for USGS operations during fiscal year 1953–54 represented almost $2.4 million more than in 1952–53. The Interior Department also received a $500,000 supplement[99] on August 7 to carry out its continuing functions under the Defense Production Act. The USGS appropriation included more than $686,000 for general administration, to which about $444,000 for similar overhead was added from the funds advanced or reimbursed by other Federal agencies for program expenses, for a total of about $1,130,500, a $29,000 increase from 1952–53. The SIR funds also contained some $98,500 for investigations of soil and moisture conservation. At year's end, the USGS reported nearly $48,486,000 in total funds received, about $430,000 more than in 1952–53. These monies included nearly $27,034,000 in SIR appropriations; some $5,622,000 from nonfederal sources, mostly from States, counties, and municipalities; and slightly more than $15,622,000 from other Federal agencies. The SIR funds now represented nearly 56 percent of the total, up by 4 percent from fiscal 1952–53; 32 percent, or a 4-percent loss, came from other Federal agencies, mostly from the AEC, the Army, and the USBR; and nonfederal sources provided the same 12 percent as in the previous year. Those funds supported salaries and operations by the more than 6,500 full- and part-time employees in the USGS. The staff's numbers varied in budget estimates and year-end reports according to how their positions were counted—by time worked, as more than 80 percent were employed full time, or by the sources of their salaries and operations, as about 70 percent were funded by SIR monies.

In November 1953, the USGS began operations at Menlo Park in California. The General Services Administration aided the USGS in locating a 4.5-acre site in Menlo Park adjacent to 83 Federal acres under lease to Stanford under the Lanham Act. During the first week of November, the USGS started to occupy the 33,370 square feet of the two-story Building 1 on Middlefield Road as the initial unit of office and laboratory facilities in the USGS Pacific Coast Center. Building 1, constructed under a GSAd build-lease contract, cost $550,000; the agreement also required holding open adjacent space for any needed additional building. Building 1's contract provided for an initial 5-year lease to the GSAd, for use by the USGS, that could be extended for sequential 5-year terms and it passed to the GSAd's control in 1960. The USGS intended its new regional office and grounds as a campus for a bureau field center on the West Coast that would include a library of 25,000 books and serve field operating offices of the Divisions in the Western States. By the end of January 1954, about 120 people, mostly mineral-resources specialists, moved into Building 1. Thomas Osborne transferred from the GSAd to the USGS to lead the latter's Administrative Division office at Menlo Park. The USGS formally changed the name of its new western headquarters, led by David Gallagher, to the Pacific Coast Center on September 9.

Also in November 1953, Nolan asked Wrather to be relieved from his nearly decade-long service as Assistant Director and to be returned to research. As Wrather pondered Nolan's request, Nolan sought William Heroy's advice in January 1954 about staying on as Assistant Director and who would best succeed the now seriously ill Wrather when the Director retired. Beginning in February and continuing throughout the remainder of 1954, Nolan renewed his plea for reassignment in correspondence with Wrather, Wormser, and McKay, a wish also motivated by

James Douglas McKay (1893–1959), the 35th Secretary of the Interior (1953–56), stands at the far right in this group portrait. McKay, an Army veteran of World Wars I and II, also was an automobile businessman before entering politics. He served in Oregon as mayor of Salem (1933–34), State senator (1935–49), and Governor (1949–52). McKay succeeded Oscar Chapman on January 21, 1953, and continued as Interior Secretary until his resignation became effective on April 15, 1956. This photograph, taken in the White House on March 3, 1954, on the occasion of the 75th anniversary of the U.S. Geological Survey (USGS), also includes (from left to right) President Eisenhower, USGS Director William Wrather, and Felix Wormser, McKay's Assistant Secretary for Mineral Resources. (USGS photograph, Public Inquiries Office 50–4a [1c]; published in Society of American Military Engineers, 1954.)

Nolan's view on November 5 that his departure would resolve an unstated conflict between the USGS and Interior. Nolan now formally requested from Wrather a reassignment that returned him to work on mineral exploration, especially at Eureka and elsewhere in the Great Basin. Nolan suggested that the NAS be contacted for advice on choosing a successor.

In 1954, as Wrather struggled with his infirmities and Nolan with his responsibilities, the USGS marked its 75th year of public service. Wormser, a friend of Eisenhower who worked with him while he presided at Columbia, urged McKay and Wrather to call on the President at the White House on March 3. "The President," Wrather later recalled, "was in a relaxed and chatty mood. During his early military career he had been given assignments which had brought him in contact with the Survey and its work. * * * He was interested in some bits of Survey history and kept asking questions, ignoring the wig-wagging of his assistants" trying to return him to his schedule. After mentioning annoying activities by one of the bureaus that originated in the USGS, Eisenhower, chuckling as the group rose to leave, told Wrather that he "wish[ed] you had them back again."[100] A group photograph also recorded the visit.

John Rabbitt, after incautiously asking about ongoing plans for activities to be held on the occasion of this USGS anniversary, found himself appointed to lead the agency's planning and preparations for several events and publications. John and Mary Rabbitt arranged for a weekly series of brief news releases about USGS operations to be issued between March and May 1954. Director Wrather's single-page notice of the anniversary, in *Science* for March 5, emphasized the agency's pledge to look "ahead to increasing opportunities to contribute to the advancement of science and to the common welfare of the Nation,"[101] thereby also trying to build its own health in the coming years. The Rabbitts coauthored, for *Science* on May 28, a brief history of the agency.[102] Mary Rabbitt, whom James Balsley selected to become Assistant Chief of the Geophysics Branch that year, discussed current work by the USGS in the Colorado Plateau Province in the June issue of *Scientific Monthly*.[103] Unlike the 25th anniversary in 1904, the USGS held no commemorative dinner. The 75th anniversary's major event took place in the auditorium of the Old Interior (later the GSAd) Building in Washington during the evening of April 21, 1954. There, the Washington Society of Engineers and the District of Columbia Council of Engineering and Architectural Societies sponsored a program to commemorate 75 years of scientific investigations by the USGS. McKay, Wormser, Mendenhall, and Wrather formed the quartet of honored guests. Brief remarks by the first three men preceded Wrather's presentation on "75 Years of Scientific Investigations." Wrather reviewed USGS history and current work by the agency's more than 6,500 employees, some two-thirds of whom were classified as engineers and scientists. In closing, he claimed that the USGS consistently chose throughout those 75 years to remain an unbiased fact-finding and investigative professional agency. Wilmot ("Bill") Bradley, Harold Duncan, Carl Paulsen, Gerald FitzGerald, and Robert Moravetz then mentioned some of their units' personnel and aspects of their responsibilities and operations.

For the Geologic Division, Bill Bradley managed more than $16,466,000 during fiscal year 1953–54, nearly $494,000 more than in the previous year and a total that exceeded the Topographic Division's monies in 1953–54 by some $439,000. The AEC's transfer of $7,192,000, a raise of more than $24,000, remained well above the Division's SIR appropriation of almost $6,340,000, an increase of about $783,000 from the amount provided in 1952–53. Some members of the Geologic Division were uneasy about the increasingly large transfers from the AEC. The Army and its Engineers transferred $1,067,500, the FOA added about $451,000, the Navy supplied $409,000, and the DMEA shifted $344,000. The USBR, the States and their political subdivisions, and the Government Printing Office (GPO) furnished a total of some $437,500; the GPO provided its monies specifically for map reproduction. The GSAd, the U.S. Air Force (USAF), and the Bureau of Indian Affairs (BIA) together gave $117,500. An additional $98,000 funded classified work for several Federal agencies. The USBM transferred less than $2,300.

In the new fiscal year, Olaf Rove relieved Esper Larsen 3d as Assistant Chief Geologist for Operations. The Division restyled as "Publications" its Geologic Information and Reports unit. A series of Survey orders, beginning on January 11, 1954, and signed by Nolan as Acting Director, retroactively confirmed the reorganization, in September 1953, of four of the Geologic Division's Branches—Fuels, Geochemistry and Petrology, Geophysics, and Mineral Deposits—that represented the initial major modifications since the end of World War II.

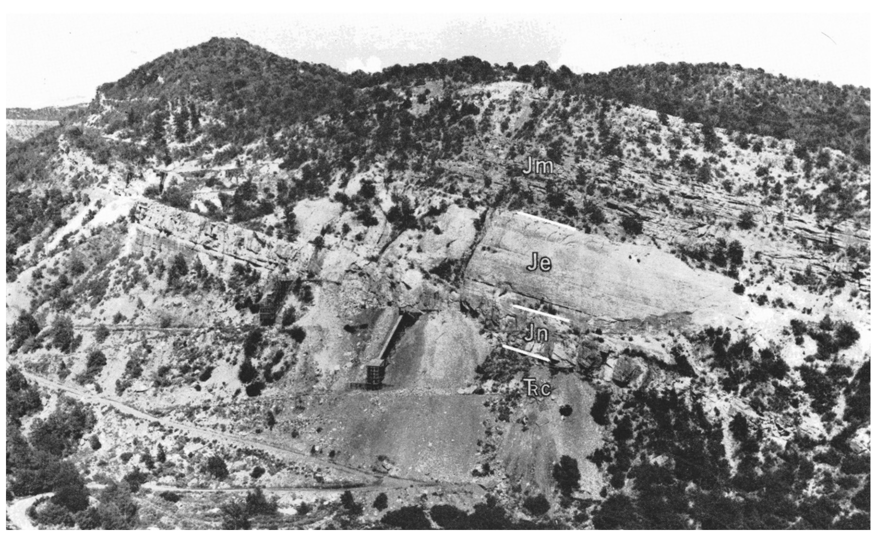
The Survey order that reorganized Ralph Miller's Fuels Branch established "four operating units based upon field centers"[104] to decentralize Branch operations and to promote more effective planning for and review of programs and their publications. Paleontologist Curt Teichert left the New Mexico School of Mines in 1954 to start and lead the Branch's new Fuels Geology Laboratory. During fiscal year 1953–54, Fuels geologists pursued 45 projects, principally those on oil and gas, in 23 States, and concentrated on areas that most needed exploration and those not fully explored by industry. Howard Rothrock's team issued its preliminary report on the geology of the Scurry Reef as Oil and Gas Investigations Map OM–143, at 1:48,000, in 1953.[105] By the end of 1952, the reef-limestone fields in Texas' Scurry County and adjacent Kent County alone had produced more than 139 million barrels of oil, and the nonreef fields yielded another 2.6 million barrels. Production from fields in adjacent Borden and Howard Counties to the west added 39 million barrels by the end of calendar 1953. New fields continued to be discovered in the rocks of the late Paleozoic Horseshoe Atoll during the remainder of the 1950s. Other Branch geologists also mapped areas on the oil-exploration frontier, including those in the Pacific Northwest and the deeper Paleozoic rocks in the midcontinent region, while investigating the hydrodynamic accumulation of oil and gas. For the Navy, Branch geologists examined Eocene oil shales and estimated their reserves in the Naval Oil Shale Reserve No. 2 in eastern Utah, extended that work south and east to similar deposits in Utah and Colorado, and continued studies of Devonian oil shales in New York. Branch geologists mapped coal-bearing stratal sequences in selected areas as part of 18 projects in 12 States. They completed and issued 10 reports on coal fields in Indiana, Kentucky, Montana, North Dakota, and Pennsylvania. A progress report by Paul Averitt's group summarized the ongoing reestimation of the Nation's coal resources, work then complete for about half of the States. They also published new detailed estimates of statewide resources in Colorado and Indiana and continued to prepare reports for those in Alabama, Arkansas, Kentucky, and Oklahoma. In the spring of 1954, the USGS and the USBM agreed to shift responsibility, by the beginning of fiscal 1955–56, for all of their long-standing shared work on coal resources to the USGS.

The next Survey order reorganized Earl Ingerson's Geochemistry and Petrology Branch by establishing three operating groups, each with "a common interest in a major realm of scientific investigation,"[106] and a fourth group to provide technical services. Branch members advanced the application of X-ray fluorescence in determining concentrations of niobium, selenium, thorium, and other elements; developed spectrographic and chemical techniques for thorium and rare-earth elements; and improved the field-test method for germanium. The Branch began operating its trailer-borne laboratory to improve its efforts in geochemical and geobotanical prospecting.[107] To increase the understanding of mineral-formation processes, Branch scientists used a punch-card computer in applying the new Hauptman-Karle method to calculate the atomic structure of crystals of boron-bearing colemanite. They also experimented with synthesizing uranium and vanadium, developed an apparatus to study acidity and oxidation changes in ores leached by natural waters, and devised methods to estimate the temperature of formation from liquid inclusions in crystals. The radiocarbon laboratory, during its initial full year of operation, contributed to wider efforts to sort out sequences of late Pleistocene glacial events. The Branch also operated two mass spectrometers to determine isotopic ages of minerals and their depositional processes and began applying modern statistical methods to field-geology problems.

Another Survey order, effective August 19, 1954, centralized the Geophysics Branch's administrative functions and confirmed the continuation of its three surveying Sections—Airborne, Ground, and Radiation.[108] As authorized by Bill Bradley's earlier memorandum, James Balsley replaced Henry Joesting as Chief of the Geophysics Branch on November 2, 1953. When Balsley reorganized the Branch in December, Louis C. Pakiser succeeded William Dempsey (Sr.) as Acting Chief of the Ground Surveys Section. Ground-based members of the Pick and Hammer Club's show in May 1953 had again burlesqued the Branch's growing program in airborne geophysics, which now operated two aircraft, in "Aces Wild," using the "Army Air Corps" song of 1939, and later the Air Force's own:

> **Off we go into the wild blue yonder,**
> **Seeking out sources of ore.**
> **As you know, we are equipped to ponder**
> **Problems that others abhor.**
> **In a glow over the funds we squander,**
> **All complaints we can ignore.**
> **We steer our kites by magnetite;**
> **Nothing can stop the Survey Air Corps.**[109]

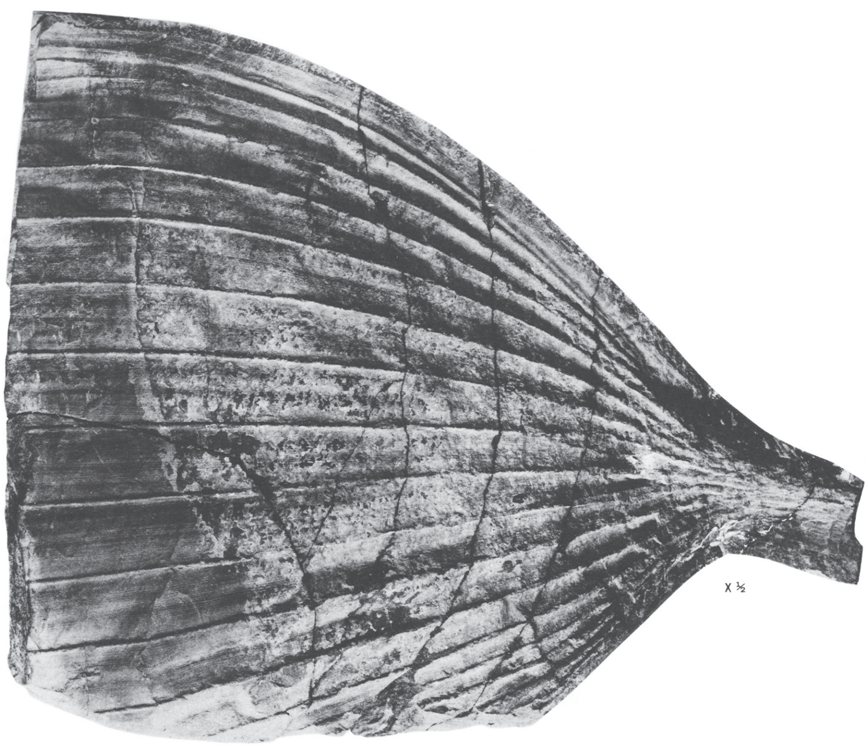
Branch members flew aeromagnetic surveys in six States and Alaska and 30,000 traverse miles of radioactivity surveys for uranium-thorium deposits in eight States during 1953–54. Recording large radioactivity anomalies during the latter surveys led to the discovery of ore-grade material in north-central Arizona and in South Dakota's Black Hills. Electrical, gravity, magnetic, and seismic ground surveys in 10 States, Alaska, and Greenland gathered data on subsurface stratigraphy and structure to apply in studies of engineering and military geology, mineral resources, and water supplies. Gravity and aeromagnetic studies in California's Mojave Desert disclosed information about the geologic structures under the Quaternary alluvial deposits. Investigations on the Colorado Plateau continued to contribute to a better understanding of its regional geology and the occurrence of uranium. The Branch's



This photograph shows the geologic section at the west end of the Rifle Mine on the east side of East Rifle Creek in Garfield County, some 13 miles northeast of Rifle, in western Colorado. The Mesozoic rocks exposed in this section belong to the Chinle Formation (Triassic, Ꞩc) and Jurassic strata of the "Navajo(?)" (Jn), Entrada (Je), and Morrison (Jm) Formations. The Rifle Creek area produced "about 750,000 tons of vanadium-uranium ore, mostly from the deposit in the Navajo(?) and Entrada sandstones." Richard Fischer, accompanied by USGS colleagues, returned to this area in 1954 to study and interpret its "structural features, ore habits, and geochemical relations" for the U.S. Atomic Energy Commission's Division of Raw Materials. Fischer suggested that the ore was formed contemporaneously with deposition of the sandstones, "under conditions that selectively mineraliz[e]d a small part of a nearly homogeneous host and permitted the fractionation of the five elements—vanadium, uranium, lead, selenium, and chromium—that are enriched in the ore layers." (Quotations and photograph from Fischer, R.P., 1960, p. 1, 2, and pl. 5.)

shallow-reflection seismograph made possible detailed mapping at depths of 50 to 1,000 feet below the ground surface. Hope continued high that the shallow-reflection methods would be as useful in mineral exploration and studies of groundwater and engineering geology as the deeper reflection technique for structures below 500 feet. The Branch obtained an IBM 701 computer in 1953 to aid in processing seismic data.

Andy Anderson replaced Olaf Rove as Chief of Mineral Deposits Branch after Rove became the new Assistant Chief Geologist for Operations. A Survey order, effective October 22, 1954, reorganized the Branch to provide "four project centers and eight field offices for DMEA activities."[110] Under Anderson's general direction, Branch members worked on 90 projects in 25 States, 9 in cooperation with State agencies. Branch geologists continued to participate in exploratory drilling in Utah's Tintic district, in the Mojave Desert, and on the Colorado Plateau, where field studies also continued for the AEC that yielded significant new deposits and extended known reserves. On May 5, 1954, Pick and Hammer players borrowed Ted Koehler and Harold Arlen's 1931 song "Between the Devil and the Deep Blue Sea" to remind their audience of the continued dangers of working for the AEC:



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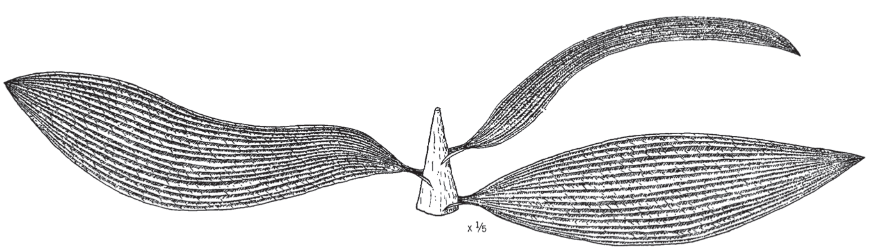


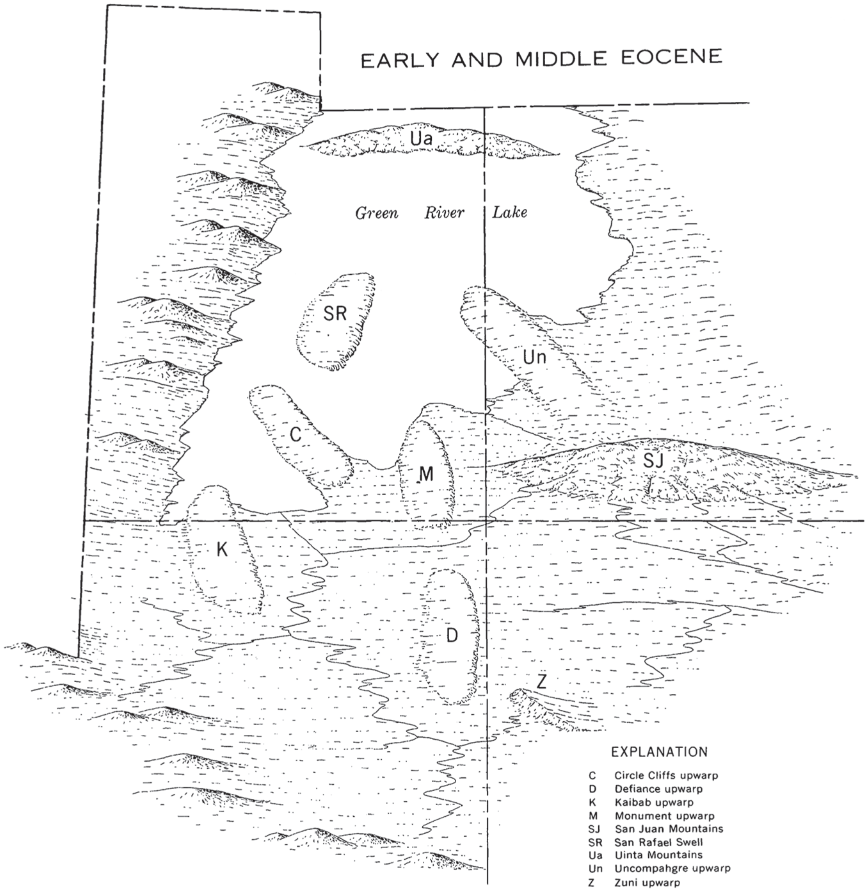
The specimen shown in the photograph (above) of *Sanmiguelia lewisi*, a palmlike plant whose broad leaves had parallel veinlets between the ribs, was collected during 1953–55 by USGS paleontologists G. Edward Lewis and Roland W. Brown from an outcrop of the Dolores Formation (Triassic), near Placerville in southwestern Colorado. The reconstructed plant is shown in the sketch (below). Brown termed these fossils primitive palms or palmlike monocotyledons and "the earliest known angiospermous flowering plant." Many large land-plant and land-vertebrate fossils were dated and correlated by their stage of evolution or associations with microinvertebrates and megainvertebrates, unless the ages of their enclosing rocks or sediments could be determined by the lead-uranium or other radiometric geochronologic method. Plants and vertebrates often were just as important as invertebrates as indicators of past environments. (Quotation, photograph, and drawing from Brown, R.W., 1956, p. 205, pl. 33, fig. 2, originally shown at × 0.5, and text fig. 29, originally shown at × 0.2.)

They ought to cross us off their list,
Yet we'd hate to have them slam the door;
A million would be hardly missed–
So we come running back for more.

We don't use it,
But we'd hate to lose it,
We're always in between
The devil and the AEC.[111]

Mineral Deposits Branch personnel also advanced regional studies of mineral resources for two interagency committees—one for rivers in New England and New York and the other for the Arkansas-White-Red Rivers. Branch scientists found, for the DMEA and the EPS, mercury reserves at California's New Idria Mine equal to nearly 32 percent of U.S. production during 1952. Continuing investigations near Idaho's Sugar Pine Creek disclosed a 15-foot-thick section of high-grade phosphate rock. Other specialists working in Minnesota's Cuyama Range subdivided into mappable units a stratigraphic sequence that contained two iron-bearing formations to aid exploration for new deposits. Modifying the field test for titanium, Branch specialists also developed a rapid means of estimating iron content. The Geochemical Prospecting Unit's laboratory similarly produced a quick and accurate field technique for columbium. Branch geologists found a talc deposit in a part of Vermont previously thought to lack that commodity. Mineral Deposits Branch and other Division geologists expected their initial application of modern statistical methods in field analyses to aid mineral exploration.

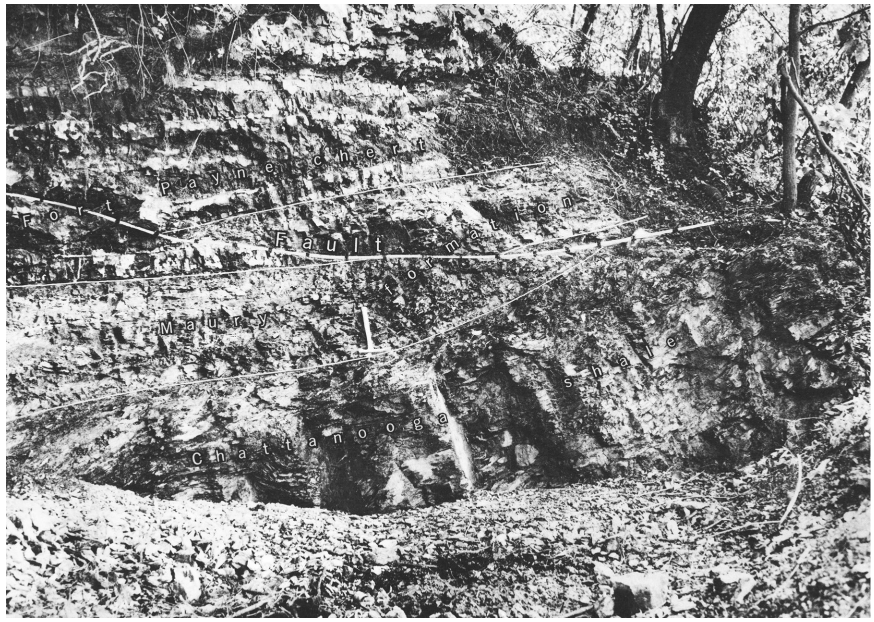
Personnel in Edwin B. Eckel's Branch of Engineering Geology were involved in 25 field investigations in 10 States during fiscal year 1953–54. They concentrated on mapping large urban or rural areas to provide geologic information to use in the planning and construction stages of engineering projects. Branch members continued to work in Denver, Knoxville, Los Angeles, Oregon's Portland, the San Francisco Bay area, and Seattle. Their efforts also contributed to the long-range program to revise existing small-scale geologic maps of the Nation or to complete the mapping at larger scales. Their colleagues completed three projects in the Missouri River Basin and continued cooperative mapping in Massachusetts and Rhode Island. General and specific studies of landslides and landslide problems continued near Washington's Lake Roosevelt, South Dakota's reservoir (Lake Francis Case) behind Fort Randall Dam, and two of the Navy's radio and ordnance stations elsewhere. Similar work involved investigations of building-foundation conditions in Colorado near Colorado Springs, for the Federal Housing Administration, and a road being relocated near Marshall, for the State's Highway Department. Eckel, Laurence P. Buck, J. Mark Cattermole, Ernest Dobrovolny, Glenn R. Scott, Donald E. Trimble, and Richard Van Horn, all of the Geologic Division, and Harold Thomas of the Water Resources Division's Ground Water Branch combined to produce, as a guide to interpreting geologic maps for engineering purposes, six maps at 1:62,500, with 20-foot contour intervals, of the Hollidaysburg quadrangle, south of Altoona, in Pennsylvania. The authors chose this quadrangle "for interpretation only because the [Geologic Atlas] folio [227, by Charles Butts] was recently published [in 1945], hence easily available by purchase" or "borrowed from or consulted in most public and university libraries." The team's six maps showed topography, general-purpose geology, foundation and excavation conditions, construction materials, water supply, and site selection for engineering works. The site-selection map illustrated the problems connected with three projects—a railroad tunnel, two power dams, and a road. The authors prepared these maps "to show the kinds of information, useful to engineers, that can be derived from ordinary geologic maps."[112] They field checked their interpretations; only the scenic-view points and slope angles of artificial cuts were not determined from maps.



This map shows the Colorado Plateau's physiography during the early and middle Eocene, as reconstructed by USGS geologist Charles Hunt. "Downwarping of the Uinta Basin produced the [huge] Green River lake," into which the surrounding upwarped areas contributed sediments to form the varved deposits. The lake's strata and fossil biotas were studied by Wilmot ("Bill") Bradley, Hunt's colleague and also his supervisor while Bradley served as Chief of the Military Geology Unit and later as Chief Geologist. Hunt deciphered the Cenozoic history of the Colorado Plateau and displayed the physiography at 10 intervals in its development—Late Cretaceous, early Paleocene, late Paleocene, early and middle Eocene, late Eocene, Oligocene, early Miocene, middle Miocene, late Miocene to middle Pliocene, and late Pliocene to Recent. (Quotation and map from Hunt, 1956, fig. 56 and caption.)

During fiscal year 1953–54, members of Charles Hunt's General Geology Branch pursued 24 field studies in 16 States and the Territories of Alaska and Hawaii. Mapping and analyzing the geology of phosphate- and uranium-bearing formations in South Carolina yielded information that advanced the Division's continuing search for these minerals and efforts to understand their origin and distribution. The series of Geologic Quadrangle Maps of the United States began including 1:24,000 maps with the appearance in 1953 of the Niota (GQ–18) and Athens (GQ–19) sheets, both in Tennessee and both by John Rodgers and dated 1952. As the remaining smaller scale geologic maps in the series appeared, the number of geologic quadrangle maps at 1:24,000 increased, and that scale later became the new standard.[113] That change reflected the Topographic Division's shift to orthophotographic maps at 1:24,000 to provide national coverage at greater detail. Hugh Miser moved to the Director's scientific staff in 1954; that year the USGS published his geologic map of Oklahoma, at 1:500,000, prepared in cooperation with the Oklahoma Geological Survey.

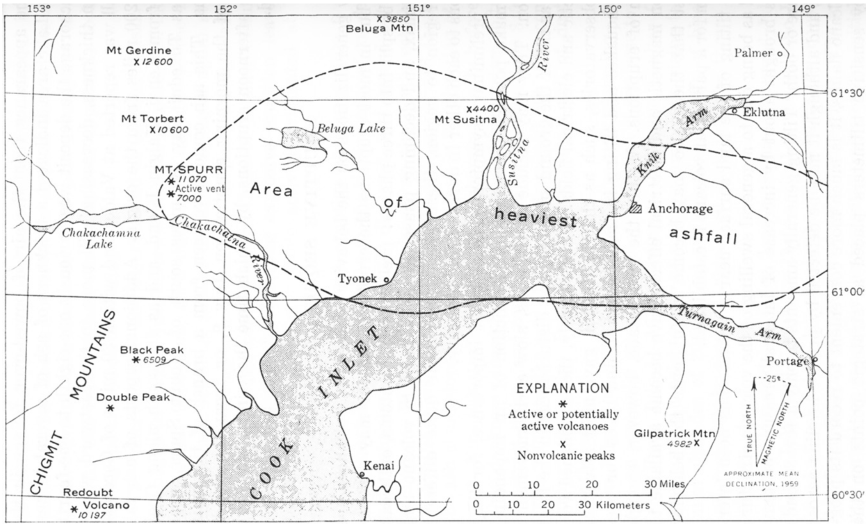
Work by members of the General Geology Branch in Alaska and Hawaii involved, as before, studies of volcanoes and volcanic rocks. During the 1953 field season, studies of an eruption by another of Alaska's historically dormant volcanoes enabled USGS geologists to increase their understanding of these events beyond that already gained at Novarupta-Katmai, Okmok, and Trident. At 5 a.m. on July 9, a relatively small but especially violent eruption began at Crater Peak (a subsidiary vent) on the southern flank of Alaska's Mount Spurr, a stratovolcano in the Tordrillo Mountains, some 75 miles west of Anchorage. Four officers in two jet aircraft on patrol from Elmendorf Air Force Base observed the eruption and the growth of its cloud for about an hour and returned with ash-frosted Plexiglas windows. The cloud rose rapidly to 70,000 feet and passed east on the prevailing winds



This photograph shows the type section of the Chattanooga Shale (Upper Devonian) at Cameron Hill, in Chattanooga, Tennessee. USGS geologist C. Willard Hayes coined the name "Chattanooga black shale" in 1891 for a unit widespread in the interior of the United States and adjacent Canada. In 1944 and in 1947–49, Wilbert Hass and his USGS colleagues investigated the phosphate nodules, the uranium deposits, and the brachiopods, conodonts, and other fossils in the Chattanooga Shale and the overlying Maury Formation (Lower Mississippian) in central Tennessee and adjacent States for the U.S. Atomic Energy Commission's Division of Raw Materials. As the Chattanooga Shale's type section exposed only a part of the formation, Hass, Louis Conant, and Vernon Swanson measured a complete standard section some 7 miles east of Smithville in DeKalb County, Tennessee. Hass based his age and correlation of the Chattanooga Shale principally on his descriptions and analyses of the formation's several distinct conodont faunas. (From Hass, 1956, pl. 5.)

to shower a quarter-inch of ash on Anchorage, Elmendorf, and Fort Richardson, as part of a 25-mile-wide swath that extended as far east as Valdez. The commanding officers of the Alaskan Command and the Alaskan Air Command provided transport for aerial and ground observations of the volcano during July 11–16 by USGS geologists Werner Juhle and Henry W. Coulter, who had been working at Katmai in cooperation with the NPS and the DoD. Ray Wilcox completed on July 27, for the two Alaskan military commands, a preliminary report on the eruption and the ash fall on Anchorage that disrupted air traffic for 2 days. Juhle, Coulter, and Wilcox determined the general sequence of events at Mount Spurr.[114] Increased fumarolic activity began late in May. The seismological observatory at College, some 300 miles northeast, recorded on the evening of July 8 and early on July 9 relatively short oscillation intervals that Wilcox termed characteristic of volcanic earthquakes and possible precursor signals. Microseismic swarms started a few minutes before the eruption began at 5 a.m. on the 9th and continued to 9 a.m. and resumed between 3:30 and 5 p.m. Coeval heavy rains caused flooding on the Chakachatna River that formed a temporary debris-dam lake 5 miles long.

Ray Wilcox's summary report in 1959 offered a preliminary primer for evaluating volcanic hazards. He emphasized that the eruptions of Novarupta-Katmai, Trident, and Spurr occurred in the absence of any historic record of previous events since the 1770s; future eruptions from the remainder of Alaska's some 40 volcanoes could well come from those still considered dormant. He discussed eruptive symptoms—earthquakes, ground tilt, and local disturbances of electrical and magnetic fields—and eruptive sequences—preliminary, outbreak and climax, and decline. He plotted distribution maps for the ash falls from Java's Gunung Kelud in 1919, Iceland's Hekla in 1947, Novarupta-Katmai in 1912, Okmok in 1945, Parícutin in 1943, Chile's Quizapú in 1932, Spurr in 1953, and Trident in 1952. Wilcox also noted meteorological factors in Alaska, emphasizing the effect of rainfall, as well as wind direction and speed, in determining the distribution of ash falls. He suggested that wind-rose diagrams compiled from upper-wind data at specific Alaska stations could provide preliminary estimates of the distribution of ash from future eruptions of specific volcanoes. Wilcox also reviewed the harmful and short-term effects of eruptions on agriculture, buildings, communication, public health and safety, transportation, utilities, and water supplies and the long-term beneficial influence on crops, soils, and vegetation.[115]



The dashed line on this map (originally at about 1 inch = 23 miles) encloses the area of the heaviest ash fall during the eruption in 1953 of Mount Spurr in the Alaska Range's Tordrillo Mountains, about 75 miles west of Anchorage. At 5 a.m. on July 9, 1953, after a few minutes of harmonic tremor, "a glacier-filled vent [at an elevation of 7,000 feet] on the south flank of Mount Spurr erupted with tremendous violence, shooting a mushroom cloud * * * to a height of 60,000 or 70,000 feet in * * * some 40 minutes." Volcanic ash began falling on Anchorage and its airfields about noon; one-eighth to one-quarter inch accumulated by the morning of July 10. Ash falls extended eastward to Valdez. In his summary report in 1959, USGS geologist Ray Wilcox also reported seasonal wind directions during 1948–53 at altitudes of 5,000, 10,000, 20,000, 30,000, and 40,000 feet at Adak, Anchorage, Dutch Harbor, and Kodiak, and he prepared wind roses centered on Redoubt Volcano in the Aleutian Range for altitudes above 40,000 feet. (Quotation and map from Wilcox, 1959, p. 420 and fig. 63.)

In Hawaii, Gordon Macdonald, seismologist Jerry P. Eaton (newly joined after completing a doctorate at Berkeley), and other members of the Hawaiian Volcano Observatory's (HVO's) staff combined monitoring facilities with mapping and geochemical and petrological analyses of samples. They used Eaton's pioneering methods for monitoring volcanoes and active fault zones in studying a 5-day eruption of Kilauea during May–June 1954. At the HVO from 1952, as Thomas L. Wright and Taeko Jane Takahashi later recalled, "Eaton introduced the first true seismic network at Kilauea, where field seismometers were hard-wired to recorders." Eaton "developed a generalized crustal model for Hawaii" to "properly locate earthquakes from the new network" that led by the 1960s to "an annual catalog of reliably-determined earthquakes." He "also introduced a network of sensitive water-tube tiltmeters, which quickly replaced the seismographic method of measuring ground tilt."[116]

Paleontologist and Branch Chief Preston Cloud, Jr., received double attention in the May 1953 Pick and Hammer Show. To the tune of "The Saga of Jenny," from Broadway's 1941 musical "Lady in the Dark," by Kurt Weill, Ira Gershwin, and Moss Hart, the songsters traced Cloud's rise to lead the Paleontology and Stratigraphy Branch:

> **Preston made up his mind at thirty-six**
> **That as a Survey branch chief he would get in his licks.**
> **He reorganized the work and left no man in the lurch,**
> **So that Pres is now the only one with time for research.**[117]

The players expanded that message with the verse that followed George Gryc's ode in "Home Groan Blues," sung to the tune of Irving Berlin's "This Is the Army":

> **This is the Survey, Mr. Cloud.**
> **Private consulting's not allowed.**
> **We've made exceptions but folks got sore,**
> **So you can't go to Spain anymore.**[118]

Cloud convened 40 members of his Paleontology and Stratigraphy Branch (PSB)[119] and visiting colleagues in Washington during April 19–21, 1954, to speak in five sessions of a meeting arranged to evaluate objectives, methods, and progress in the PSB's program. In a sixth session, nine invited observers appraised the reports on the status of the paleotectonic-maps project, the geologic-names lexicon, and work by the PSB's four units—Lower Paleozoic, Upper Paleozoic, Mesozoic, and Cenozoic. The visitors' critiques emphasized the value of Branch members' studies derived in part from the 40,000 fossils, from 31 States, Alaska, and 14 areas abroad, received during fiscal year 1953–54, sent in by USGS geologists and others for examination and report that also provided additional specimens for new basic studies. The visitors hoped for additional monographic studies of the structure, biologic organization, life associations, and time ranges of large or significant fossil groups. The products would be added to those resulting from the three other principal special and collaborative investigations: (1) stratigraphic and paleoecologic studies of rock sequences, community associations, and areas; (2) morphologic and stratigraphic analyses of inadequately known but potentially important groups, such as airborne and planktonic forms, that might be widely distributed in brief time intervals, cross facies boundaries, and be well adapted to quantitative analyses; and (3) studies toward preparing regional field handbooks of selected distinctive suites of fossils in their stratigraphic context. Studies during the year of faunas from some of the subsurface rocks in the Williston Basin of Montana and the Dakotas provided a better understanding of these oil-bearing sequences. Faunal investigations of the Floridian-Bahamian carbonate province also improved ideas about its formation.

On May 5, 1954, the Pick and Hammer players used Shamus O'Connor and John J. Stamford's "Macnamara's Band," more widely known since Bing Crosby's 1946 recording, to comment on the PSB's use of the new electronic computers in the year-old paleotectonic project and the resulting maps:

Oh, me name is J. Gillhooley, I'm the leader of the band,
Although we're small in number, we are planning to expand.
With paleotectonics we are making history,
We've got the hottest project, boys, outside the A. E. C.

We're working on a system that we hold in high regard,
To tabulate our data on a little bitty card,
And if you have a theory that everyone extolls,
We'll put your theory on the card and punch it full of holes.

We show the rocks in orange and the thicknesses in blue,
The facies are in orchid and the climate in ecru,
With over here a touch of red and there a dash of green,
By golly, it's the loudest map that man has ever seen!

We show everything that's happened, from a bit below the Belt
Right up to and including the hiatus of Van Pelt,
But if you try to decipher it your mind is bound to snap,
We've put the hist'ry of the world upon a single map.[120]

Initial plans by Cloud and James Gilluly called for paleotectonic maps for the Jurassic, Triassic, Permian, and Pennsylvanian Systems, each prepared with the aid of the new computers. The nine maps, including seven at 1:5,000,000, for the Jurassic System, prepared by Edwin D. McKee, Ralph W. Imlay, and several of their PSB colleagues, appeared in the USGS series of Miscellaneous Geologic Investigations Maps as I–175 in 1956.

Studies during fiscal year 1953–54 by geologists in George Gates' Alaskan Geology Branch concentrated on the Territory's mineral resources (especially those strategic and critical) and coal and oil deposits. Continuing work on Alaska's minerals included reconnaissance geologic mapping in the lower Kuskokwim area; a dip-needle survey of magnetites near Klukwan (southwest of Skagway); and investigations of copper mineralization around Prince William Sound and on the upper Maclaren River east of Denali, scheelite mineralization near Nome and tin deposits elsewhere in the Seward Peninsula, and antimony near Ketchikan and in the Katmai National Monument (the last study was done in cooperation with the NPS). The Branch operated a seasonal radiometric laboratory at College. Branch personnel continued coal investigations in the Matanuska field, in the Little Susitna district, and, as part of the USBM's drilling operations, at Wishbone Hill. They also completed work in Tertiary deposits in the Yakataga district that disclosed oil seepages in the Samovar Hills and structures favorable for accumulation, continued studies in the Nelchina area of the Talkeetna Mountains, and worked in other parts of interior Alaska and on the Alaska Peninsula. Members of the Alaskan Geology Branch, like their colleagues in General Geology and those elsewhere in the Geologic Division, continued to refine their work in photogeology by adding its results to existing information in beginning preliminary geologic maps using the 1:250,000-scale topographic bases. New investigations began of construction materials and engineering problems, including the route for the proposed Denali Highway, the Alaska Railroad, and power sites on the Kenai Peninsula. In 1953, closeout operations in Naval Petroleum Reserve No. 4 (NPR–4) involved eight USGS projects—six funded by the Navy and two by the USGS—"to bring the geologic surveys to a logical stopping place and to collect sufficient information for the final report."[121] Between early June and early September, field parties traversed areas at and near the Kiligwa and Nula Rivers, including the Brady anticline; Cretaceous sequences along the Killik and Colville Rivers; Cretaceous strata along Carbon Creek and the Utukok River; the Carter Creek anticline; the upper Paleozoic and Mesozoic rocks of the Corwin-Cape Lisburne area; the Kongakut and Firth Rivers; the Paleozoic and Triassic sequences of the central Brooks Range; and Koyukuk River.

Members of Frank Whitmore's Military Geology Branch finished more than 50 studies of domestic and foreign regions and other special reports and maps during fiscal year 1953–54. As before, these terrain studies and related summaries contained a number of regularly covered topics. Among them were airborne operations, airfield construction, climate, coasts, construction materials, cross-country movement, drainage, engineering geology, geophysics, groundwater, landforms, mineral resources, permafrost, road construction, rock mechanics, rock types, seasonal variations in moisture and snow cover, soils, special physical phenomena (including earthquakes, volcanoes, and landslides), surface water, terrain intelligence, underground installations, and vegetation. Alfred Clebsch, Jr., and his colleagues made maps, at 1:10,000, 1:25,000, and 1:100,000, and evaluated problems in constructing assault-type airstrips at Fort Bragg in North Carolina and Fort Campbell in Kentucky and Tennessee. Other MGB personnel taught or otherwise contributed to the advanced-training program for Army Engineer officers at Fort Belvoir in Virginia. William Davies conducted prediction tests of trafficability at Fort Knox in Kentucky. MGB personnel completed sections on surficial materials and engineering aspects for two chapters in Army Technical Manual (TM) 30–10, "Terrain Analysis." The Army's declassification of its "Geology and Its Military Applications" (TM 5–545), issued in 1952, publically credited the USGS with its preparation. Members of the MGB's Arctic program, the second long-term effort begun in 1946, continued to investigate, for the Army Engineers, the geologic and related terrain conditions in the region, especially in Alaska. For the Engineers, the Alaska Road Commission, and the Alaska Railroad, specialists in the MGB's Alaska Terrain and Permafrost Section reported on engineering aspects of river ice, roads, and bridges in the Yukon Flats and along the Delta and upper Kuskokwim Rivers. They also worked in the Bristol Bay area, the southwestern Copper River Basin, the central Kenai Peninsula, and the Susitna-Maclaren Rivers district and along the Tote Road from Iliamna to Cook Inlet. In Greenland, they aided a joint project of the Engineers and the Army Transportation Corps.

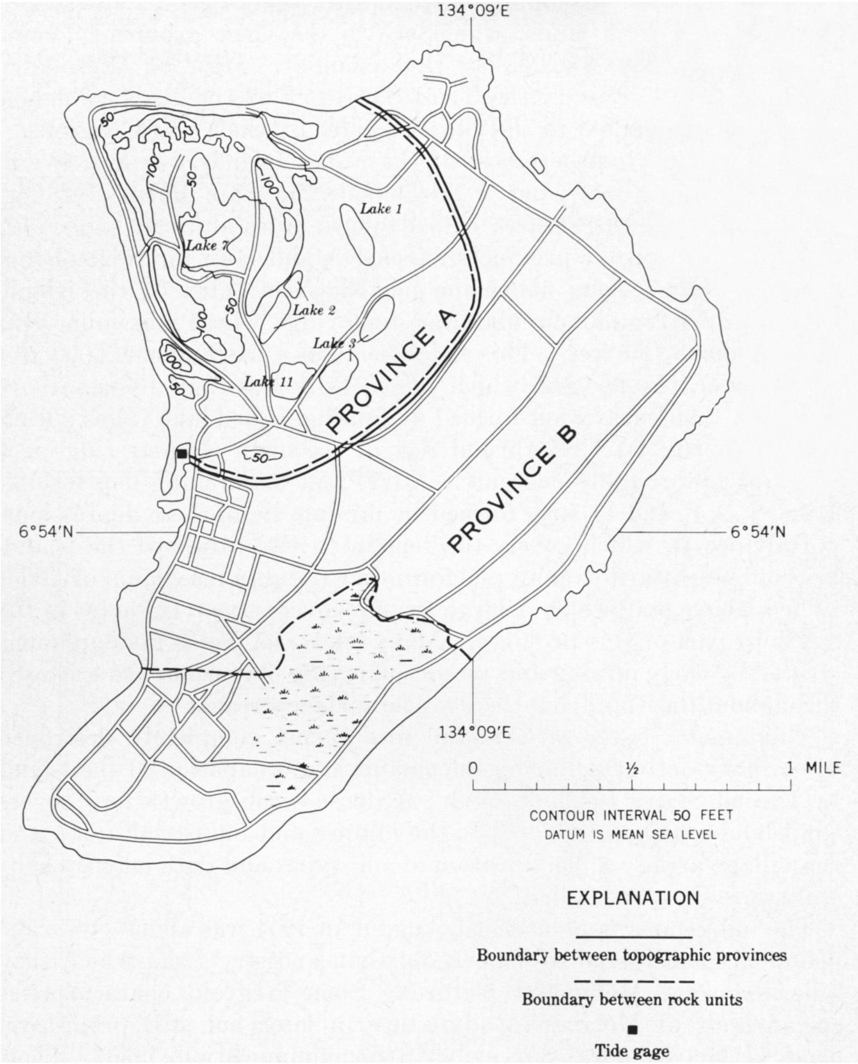
Work by members of the Military Geology Branch also continued in the Far East and in Europe during fiscal year 1953–54. To aid field studies, Theodore Sumida translated into English an extensive list of place names in China, Japan, and Korea. The Trust Territory of the Pacific Islands' three departments moved from Honolulu to Ponape (Pohnpei), to Truk (Chuuk) in the Caroline Islands (Federated

States of Micronesia), and to Guam. The High Commissioner's office relocated to Guam in June 1954. Eisenhower's Executive order of July 17, 1953, transferring the northern Marianas (except Rota) from Interior to the Navy became effective in October.[122] Charles Johnson succeeded Sherman Neuschel as head of the MGB's Pacific Geologic Mapping Program in 1953. On Guam, Joshua Tracey's team completed in November 1953 the detailed mapping of that island's geology and water resources; related studies continued into December 1954. The reports on Guam's terrain and environment, the engineering aspects of the island's geology and soil, and the tactical aspects of its coasts and inland terrain, at 1:25,000 and 1:50,000, appeared in 1959; authors of the reports were Tracey, David I. Blumenstock, David B. Doan, Kenneth Emery, F. Raymond Fosberg, Harold May, Seymour Schlanger, John T. Stark, and Carl Stensland. Porter E. Ward and Joseph W. Brookhart's supplement on Guam's water resources followed in 1962. Schlanger, who joined the Pacific program to conduct petrologic studies of limestones and ocean sedimentation on Guam, passed to investigations of Ulithi Atoll, northeast of Yap in the western Carolines. He also studied Enewetak as part of the program's operations in the Northern Marshalls, and his report appeared in 1956. Schlanger, with Allen Nicol, also completed a preliminary manual of engineering geology. The Pacific geologists also finished a report on antimony deposits in Okinawa and geologic summaries of three additional atolls in the Carolines. Groundwater geologist Ted Arnow assessed the effects of phosphate mining on Angaur in the southern Palau Islands.

In Europe, Frederick Betz, Jr., a USBM veteran who joined the USGS in 1943 and later served as one of Frank Whitmore's Assistant Branch Chiefs, now led the MGB's team. Betz's group aided for a second year the Army Engineer Intelligence Center by helping to prepare terrain studies and working up a model map for Army personnel tasked with making additional terrain-evaluation maps. His European Team also finished, at 1:100,000, a special report on trafficability in the Frankfurt area. In Britain, Arnold Orvedal, who assessed the general military requirements for cross-country maps, joined Esther Aberdeen and Morris Austin in comparing MGB and other test studies of trafficability, especially for tracked vehicles, and airfield sites in the Norwich area.

With assistance from the FOA and the State Department, members of William Johnston's Branch of Foreign Geology participated in cooperative projects during fiscal year 1953–54 in 16 countries in Latin America, the Middle East, and Asia. John Dorr 2d continued to lead the iron-resource investigations in Brazil's Minas Gerais. Max G. White and Gene E. Talbot advanced the uranium reconnaissance in Brazil begun in fiscal 1952–53. Monta E. Wing continued the Branch's investigation, renewed through the Point Four Program in 1952, of Chile's mineral resources. The Branch's work in Latin America also involved studies of mineral resources in Colombia, Cuba, Ecuador, and Mexico. Branch members also conducted, with aid from national and local officials, an engineering study of landslides and their mitigation in La Paz, Bolivia.

In the Middle East, members of the Foreign Geology Branch continued fieldwork in Jordan and Iran but concluded their efforts in Egypt and Saudi Arabia. Louis Gardner spent several months investigating stratigraphic sequences in Jordan. Russell Gibson continued Dwight Lemmon's study of Iran's mineral resources. The USGS completed its analysis of Egypt's metallic-mineral deposits to help its Government's long-range plans for their development. George Rozanski prepared a manuscript hydrologic map of Egypt at 1:2,000,000. In Saudi Arabia, the passing of King Ibn Saud significantly affected American and USGS work in the Kingdom. To treat the ailing King, Truman sent, in April 1950 and again in August 1952, his personal White House physician and other specialists. Eisenhower continued to promote good relations that would ensure the continued flow of Saudi oil. At the White House on March 2, 1953, the President and Prince Faisal discussed matters



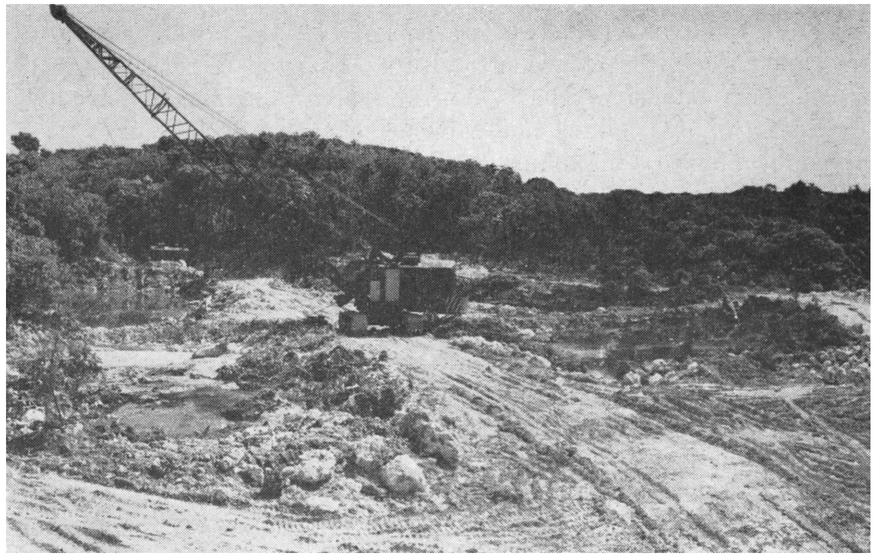
This map and the two photographs (facing page) show Angaur Island, the southernmost of the Palau Islands and part of the Trust Territory of the Pacific Islands, whose administration was granted by the United Nations to the United States after World War II. Phosphate, principally from the guano of Pliocene–Pleistocene sea birds, was mined on Angaur during 1900–44. Mining resumed in 1946 and created large lakes that filled with brackish or saline water. The map (originally at 1 inch = 0.6 mile) depicts topographic provinces A and B and the lakes on Angaur Island. In 1951, 3 years after USGS military geologists mapped Angaur's geology and soils, USGS hydrologist Ted Arnow studied samples from test holes and observation wells to determine if the lakes' water would spread and adversely affect the island's agricultural lands and water supplies. As Angaur's two topographic provinces functioned as independent units, mining in province A's coralline limestones did not affect province B's groundwater. The top photograph on the facing page shows a locality near lake 1 as strip mining began on July 14, 1952. The bottom photograph shows the same area after backfilling was completed on October 4, 1952. Backfilling the lakes significantly reduced water salinity in province A within 1 year, "as a layer of fresh water was built up at the water table" and continued to enlarge through May 1955. (Quotation, map, and photographs from Arnow, 1961, p. A–2 and figs. 2, 14, and 15.)

of mutual interest to their countries. When Ibn Saud died on November 9, Crown Prince Saud became King and made Faisal the new Crown Prince, Prime Minister, and Foreign Minister. Saudi oil seemed ever vital but, on December 24, Everette DeGolyer, with his company's secret study of Saudi reserves now complete, a decade after his initial assessment, decided that

> **[t]he Middle East is rapidly getting into a condition which has been almost chronic in the United States since the earliest days of the industry, that is, the problem becomes market rather than production.[123]**

Glen Brown, Richard Bogue, and Gus Goudarzi continued geologic mapping and mineral studies in the Arabian Shield for a while after Ibn Saud's death, but King Saud terminated the USGS Mission in July 1954. Brown returned to the United States and joined Roy Jackson and other colleagues in compiling a 1:4,500,000 geologic map of Saudi Arabia. Brown's group also began preparing geographic and geologic maps of Saudi Arabia at 1:500,000 with place names in both English and Arabic.

In Asia, Interior Department geologist Frederick N. Ward resumed U.S. investigations of India's manganese and other mineral resources, principally as a consultant to that country's geological survey. John Straczek continued his aid, begun in fiscal year 1950–51 for the Technical Cooperation Administration, to institutional



development within the Geological Survey of India. Earl Irving, Ronald Sorem, and Arthur Kinkel, Jr., advanced their investigations of mineral resources in the Philippines. Biostratigraphers Harold E. Vokes and J. Marvin Weller, professors, respectively, at Johns Hopkins and Chicago, continued their cooperative evaluation for the Branch, begun in late 1952, of the Philippines' coals. Related studies began on Taiwan. Branch personnel also trained in the field and laboratory 34 young scientists and technicians from Afghanistan, Brazil, Burma, Chile, Colombia, Cuba, India, Mexico, Norway, Paraguay, Peru, and the Philippines.

Gerald FitzGerald's Topographic Division drew on nearly $16,028,000 in total funds during fiscal year 1953–54, a sum about $295,000 less than that received in 1952–53. The new total included about $11,573,000 in SIR monies, representing a $483,000 increase; almost $1,657,000 in reimbursements and direct payments from States, counties, and municipalities, or a loss of about $90,000 but, as before, matched by an equal SIR amount in 50:50 sharing; and some $1,166,500 from the USBR, a decline of more than $702,000. Both the Air Force and the Navy reduced their transfers by a total of almost $50,000, but the Army provided about $259,500. The AEC transferred nearly $199,000, the FOA and the GPO furnished a total of about $84,500, and other Federal agencies and miscellaneous sales added another $211,000. The Division maintained its operations in Arlington, Rolla, Denver, and Sacramento. The Western Mapping Center worked on plans to move from Sacramento to Menlo Park as soon as facilities became available. The funding shortfall reduced the number of personnel-years at those four locations by 5 percent, but the Division increased by 25 percent the number of square miles mapped or revised in the continental United States.

The Topographic Division continued to concentrate its efforts on completing the topographic atlas of the United States and its Territories and possessions. Division members finished 64,500 square miles at 1:24,000 and completed an additional 37,000 square miles at 1:62,500. The Division claimed that good-quality topographic maps now covered some 33 percent of the 48 States but that 2.5 to 5 years were required to survey and publish a quadrangle map. Cooperative domestic programs involved 30 of the States, including Arizona for the first time since 1927; Alaska, at 1:63,360; Hawaii, at 1:24,000; Puerto Rico, at 1:30,000; and the Virgin Islands, at 1:24,000. After President Eisenhower authorized the private-sector Samoan Airlines in April 1954, the USGS arranged with a New Zealand company to provide airphoto coverage for mapping American Samoa's 7 islands and its 73-square-mile area. The USGS cooperatively mapped at 1:24,000 more than 12,000 square miles in Kentucky, 1,700 more than in 1952–53; more than 9,000 square miles in California, with another 6,100 at 1:62,500; and nearly 4,800 square miles in Florida. The Division published a new base map for California at 1:500,000 and new base maps for Connecticut, Indiana, Massachusetts, New Hampshire, Rhode Island, Vermont, and Wyoming at 1:1,000,000. The Kentucky Project, with its field surveys now 90-percent complete, published 90 maps to raise the total issued to 328 of the Bluegrass State's 707 7.5-minute quadrangles. Division topographers, aided by Army Engineer ground surveys and Air Force and Navy photographic crews, also mapped some 19,500 square miles in Alaska. The Division also began revising its 1:250,000 and 1:2,500,000 maps of Alaska.

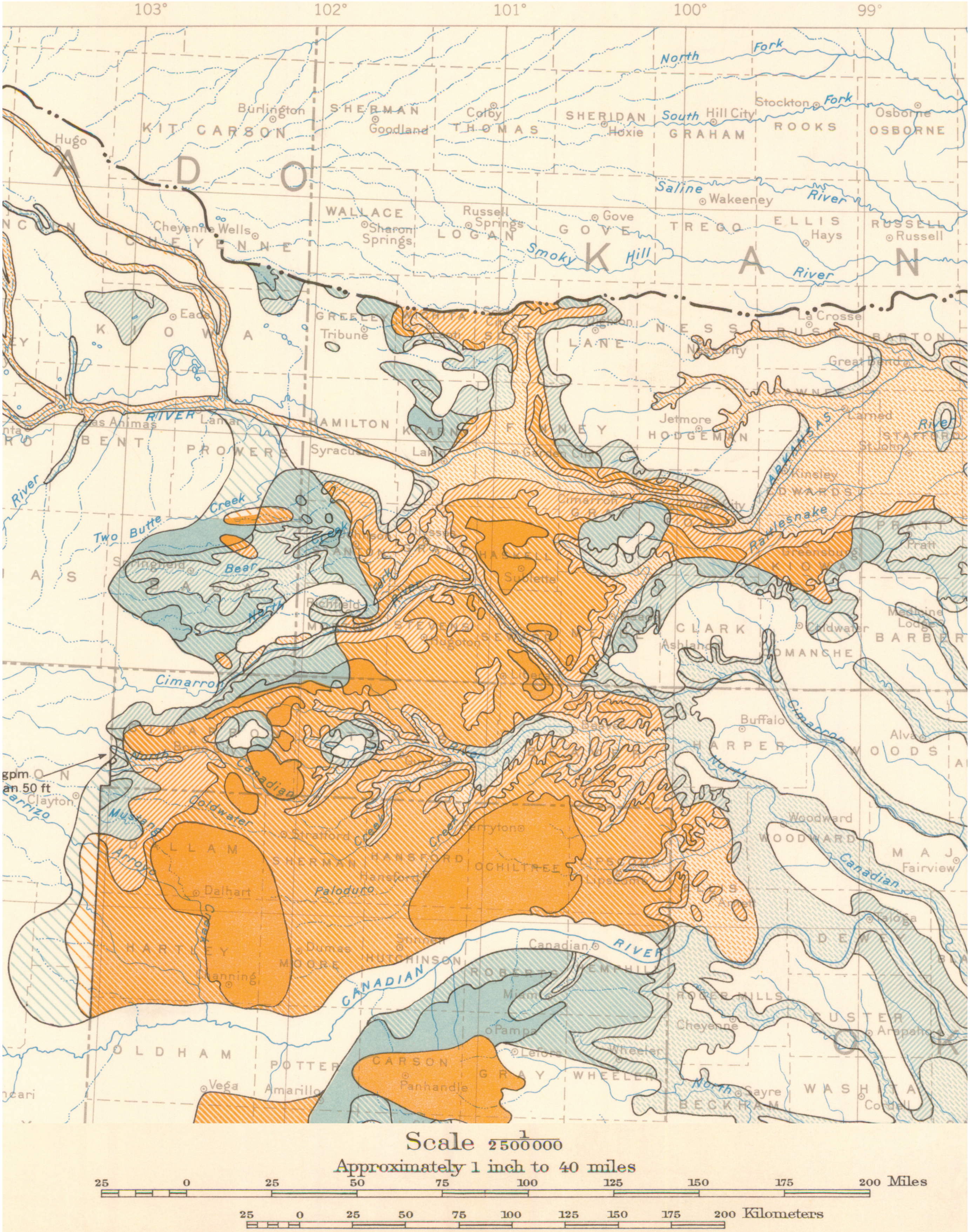
All this mapping added 3 percent to the Topographic Division's coverage of the continental United States during the year, but the Division's further progress toward its domestic goals continued to be delayed by the need to keep existing large-scale maps up to date and to satisfy the immediate needs of the Department of Defense. At the DoD's request, the Division expanded its 6-year program of mapping strategic areas that began in fiscal year 1950–51. The Air Force asked the Division to map, aided by USAF photos, 70 bases, which required depicting a total area of about 40,000 square miles. The Division let contracts for 112,500 square miles of aerial coverage, received 115,000 square miles of aerial photography for its maps, and reduced its unit cost by 21 percent of the sum required in fiscal 1952–53. The Special Maps Branch continued to prepare some components for the USAF's worldwide aeronautical charts and compiled or scribed maps for the Geologic Division, the AEC, the FOA, and the Office of Naval Petroleum and Oil Shale Reserves (ONPR). Some Division maps were compiled for the U.S. Coast and Geodetic Survey, the U.S. Forest Service, and the TVA. The Division continued to publish and distribute the civilian edition of the Army Map Service's coverage of the United States on 468 sheets at 1:250,000. Division photogrammetrists and topographers, supported by the FOA, began or continued mapping and training local specialists in Burma and other countries, as well as advising U.N. personnel.

The Topographic Division's decade of photogrammetric research and development culminated during fiscal year 1953–54 in a viable system of twin low-oblique photography based principally on the ER–55 projector and the Twinplex plotter. The Division planned to have the new photogrammetric system replace the vertical method throughout the Division late in 1954. The new photogrammetry depended on the development of six major elements: (1) twin low-oblique photography; (2) ER–55 projectors and Twinplex plotters; (3) improved diapositive printers for principal reduction ratios of 153:30, 153:55, and 153:153; (4) high-precision cameras with nearly distortion-free lenses; (5) multicollimator camera calibrators; and (6) precision pantographs, to compile map detail at or near publication scale. The Division also began experiments in applying scribing to the field-survey and stereo-compilation stages of mapmaking to try to simplify further the whole process of compiling and finishing maps. Members of the Special Maps Branch also tested in Louisiana and elsewhere the stereotemplet method, which used fewer points to establish horizontal control, in areas where flight patterns, difficult terrain, and meager horizontal control precluded the use of other techniques. During the year, the Division began courses on photogrammetric applications for geologists, as recommended by a joint committee of the Topographic and Geologic Divisions.

Carl Paulsen's Water Resources Division received $13,566,000 for fiscal year 1953–54, an increase of about $391,000 over the sum authorized in 1952–53. The SIR appropriation for 1953–54 rose by $617,000 to nearly $6,732,000. All 48 States, led by California, and joined by Guam, Hawaii, counties, and municipalities, added nearly $3,823,500, a $220,000 increase, in reimbursements and direct payments, exceeding the Division's SIR-funds limit of $3.7 million available only for the cooperative program. Interior's Office of Territories supplied more than $14,000 for the Division's detailed work in American Samoa after the reconnaissance survey of its surface water and groundwater early in 1953 led to recommendations for a continuing program to obtain water data and to find ways to improve the quantity and quality of its water supplies. Other Federal agencies transferred about $2,914,000, of which the Army and its Engineers shifted $1,070,000, a $38,000 gain; the USBR contributed a little more than $807,000, a $352,000 loss, reflecting fewer investigations in the Missouri River Basin; the AEC gave $260,568, a $77,000 increase; and the FOA shifted about $229,000, or nearly $161,000 more than the Mutual Security Agency transferred in 1952–53. Highlighting the Nation's ever-increasing need for water-resources investigations, the Business and Defense Services Administration queried the USGS for water-resources data on the Nation's critical centers of industrial production, and *Fortune Magazine* published in its March 1954 issue an article that asked "How Are We Fixed For Water?" By then, the Division operated 102 principal field offices nationwide to support the operations of its three programmatic Branches. Division investigations of stream sediment, based on 50,000 samples collected at some 130 sites nationwide and analyzed at 15 laboratories, continued to assess its effect on dam reservoirs to aid the future design and operation of water-control structures. Sediment studies were concentrated on the basins of the Colorado, Missouri, and Rio Grande Rivers but also included cooperative work with Kentucky, Ohio, Pennsylvania, and Virginia. Division specialists continued to apply the results of reservoir-evaporation studies at Lake Mead and began similar work on botanical evaporation-transpiration along the Little Blue River near Fairbury in Nebraska. For the National Security Resources Board, the Division published studies of flood protection, pollution control, and water supply in six large industrial centers and continued work on eight others.

For the FOA during fiscal year 1953–54, Division hydrologists began or continued investigations in and the training of specialists from Afghanistan, Egypt, India, Iran, Jamaica, Libya, Pakistan, and Saudi Arabia. In the fall of 1953, Karl J. Ketter resumed the Division's studies of Iran's groundwater and surface-water resources. George B. Maxey continued his investigations, begun for the Technical Cooperation Administration in late 1952, of water resources in Libya; he was aided by Harold A. Whitcomb, who carried on when Maxey left Libya at the end of fiscal 1953–54. George C. Taylor, Jr., continued to lead similar work in India, begun in 1951, and was assisted by Arthur A. Garrett. George La Rocque, Jr., and F.D. Bertleson investigated Pakistan's water resources between June and December 1953. Thomas Eakin, following his tour in Iran in 1952, examined water resources in Thailand from April through June 1954. The United Nations supported the Division's streamgaging operations and other preliminary investigations of Jamaica's water resources.

During fiscal year 1953–54, Joseph Wells' Surface Water Branch recorded data at 6,400 gaging stations in the 48 States, Alaska, Guam, and Hawaii, in cooperation with 187 agencies of the States, and their political subdivisions, and 15 Federal agencies, including, as before, the Federal Power Commission (FPC),


103°
102°
101°
100°
99°
North Fork
South Fork
Burlington
SHERMAN
Goodland
Colby
THOMAS
SHERIDAN
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GRAHAM
Hill City
Stockton
ROOKS
Osborne
OSBORNE
KIT CARSON
Hugo
Saline
Wakeeney
River
WALLACE
Sharon Springs
Russell Springs
LOGAN
Gove
GOVE
TREGO
ELLIS
Hays
RUSSELL
Russell
Cheyenne Wells
CHEYENNE
Smoky Hill
River
GREELEY
Tribune
LANE
NESS
La Crosse
BARTON
KIOWA
LANE
Jetmore
HODGEMAN
Larned
STAFFORD
St John
River
RIVER
Las Animas
Lamar
BENT
PROWERS
HAMILTON
Syracuse
ARKANSAS
Kinsley
EDWARDS
River
Two Butte
Creek
Rattlesnake
Pratt
Springfield
Bear
Sublette
Richfield
North
Hugoton
CLARK
Ashland
Coldwater
Medicine Lodge
BARBER
COMANCHE
Cimarron
Buffalo
HARPER
Cimarron
Alva
WOODS
North
Canadian
Clayton
Carrizo
Mustang
Coldwater
Stratford
Creek
Perryton
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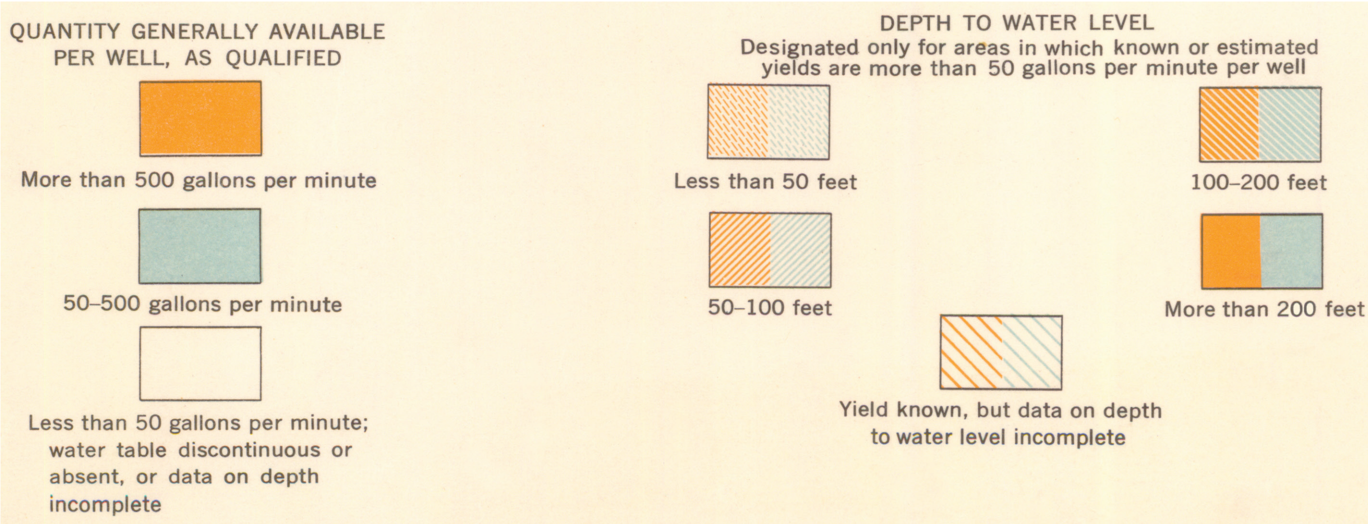
Fairview
Canadian
Arroyo
DALLAM
SHERMAN
HANSFORD
Hansford
OCHILTREE
Lipscomb
Dalhart
Paloduro
Arnett
Taloga
HARTLEY
Dumas
MOORE
HUTCHINSON
Canadian
RIVER
ROBERTS
HEMPHILL
ROGER MILLS
CUSTER
Arapaho
Miami
CANADIAN
Cheyenne
Pampa
Lefors
Wheeler
Channing
OLDHAM
POTTER
CARSON
GRAY
WHEELER
North
Sayre
BECKHAM
WASHITA
Cordell
Vega
Amarillo
Panhandle
Scale $\frac{1}{2\,500\,000}$
Approximately 1 inch to 40 miles
25 0 25 50 75 100 125 150 175 200 Miles
25 0 25 50 75 100 125 150 175 200 Kilometers



This map (originally at 1:2,500,000) shows the general availability of groundwater (yield in gallons per minute) and depth (in feet) to water level in the northwestern part of the Arkansas, Red, and White River Basins of Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. The heavy dashed line marks the northern boundary of the basins. USGS hydrologists Stanley Lohman and Verle M. Burtis, assisted by members in the Ground Water Branch's district offices and in cooperation with members of State agencies in those States, prepared this map as USGS Hydrologic Investigations Atlas HA–3; it supplemented their map HA–2, which showed (at the same scale) the areas of principal hydrologic investigations in the same basins. The new Hydrologic Investigations Atlas (HA) series began with the multisheet HA–1, a report on the hydrology of the San Bernardino and eastern San Gabriel Mountains in California; see Troxell and others, 1954. (From Lohman, S.W., and Burtis, 1953 [but not issued until 1954].)

11 interstate compacts, and the American-Canadian International Joint Commission. The Branch tested a new electronic low-velocity flowmeter that was available commercially, powered by battery, and designed to increase measurement accuracy. Its personnel also designed, for production elsewhere, a high-speed electronic computer to aid processing of surface-water records. In 1954, completion of the Branch's 2-year compilation of streamflow records collected before 1950 neared 50 percent. Branch members finished a flood-frequency report for the Iowa State Highway Department and continued or completed similar studies in 11 other States. The Branch also sent to similar departments in other States hydraulic data on 86 sites proposed for new bridges, published the results of a laboratory study of flow through bridge openings, and continued work on flow through culverts and over dams.

Nelson Sayre's Ground Water Branch's cooperative investigations operated in 43 States and advanced 30 projects related to the national interest and (or) other Federal agencies during fiscal year 1953–54. The State-Territorial collaborations included studies of areas large and small in Alaska, Arizona, and California's Central Valley; the basins of the Arkansas, Red, and White Rivers; and river basins in New York and New England. Other investigations encompassed artificial recharge in Arkansas; economical dewatering of mining districts in Alabama, Arkansas, Michigan, Nevada, Pennsylvania, Tennessee, and Wisconsin; and recovery of water used by phreatic plants in the arid West. Branch specialists also completed a nationwide reconnaissance to outline saline-water areas for future desalinization by the techniques being developed in academia and government that drew comment from the writers for the Pick and Hammer Club. In the Club's show for May 1953, the third verse of "Home Groan Blues," sung as before to Irving Berlin's "This Is the Army," cautioned Sayre, like Gryc and Cloud, to remember that:

> **This is the Survey, Mr. Sayre,**
> **We know that water's everywhere.**
> **We've got the ocean outside your door,**
> **So we don't need your branch anymore![124]**

The Branch also used electronic computers to solve complex quantitative problems, especially those involving boundary conditions. Branch members also completed an electrical "slide rule" to determine theoretical drawdowns caused by pumping, developed a new meter for more accurately fixing moisture content in soils to determine how water moves through unsaturated materials above water tables, tested methods to discover how radioactive wastes enter streams, and continued developing better techniques for collecting water samples specifically for analyzing their radioactivity.

Kenneth Love's Quality of Water Branch placed greater emphasis on studies of mineral pollutants, including analyses of trace metals, and began expanding its field centers, operating by 1957 those at Denver, Fort Collins, and Menlo Park. In fiscal year 1953–54, the Branch's 15 laboratories analyzed more than 85,000 samples. The national program emphasized chemical-quality investigations in the basins of the Colorado, Columbia, and Pecos Rivers, in States in New England, in New York, and in Alaska, looking carefully at how trends in mineral content affected irrigation projects. In cooperation with agencies in 17 States, Branch members collected daily surface-water samples at nearly 230 sites and intermittently collected samples at some 200 others. Robert A. Krieger, James L. Hatchett, and Joe L. Poole continued a study of the Nation's saline waters, and a more detailed one of those in Texas, to determine their sources. Other Branch specialists began collecting and analyzing, at a single laboratory, data on radioactive substances in water nationwide.

In fiscal year 1953–54, Harold Duncan's Conservation Division remained the USGS programmatic unit with the highest proportion, 98 percent, of direct appropriations to the total funds available to support its work. Of the total of almost $1,640,000, an increase of nearly $200,000 from 1952–53, SIR funds supplied some $410,000 for land classification, a gain of about $50,000, and nearly $1,195,000 for supervising mining and oil and gas leases, a $174,000 increase. For supervising leases, the Navy added $33,000; for both operations, other Federal agencies transferred a total of only $700, representing a $5,200 loss, and no funds arrived from the States and their political divisions.

Benjamin Jones, John Northrop, and Howard Smith, three of the Conservation Division's Chiefs, retired in 1954. J. David Cerkel, Jr., succeeded Northrop as Chief of the Mineral Classification Branch. Cerkel's mineral classifiers, working from field offices in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming, processed more than 27,700 cases, prepared original or revised definitions of 52 producing oil and gas fields, determined the leasehold relations to the productive limits of 9 such fields and reported the discovery and geologic significance of 150 others, handled 16 appeals from the BLM, and completed nearly 130 reports on the mineral potential of specific lands. Arthur Johnson replaced Jones as Chief of the Water and Power Branch. Johnson's staff, operating from field offices in Denver, Oregon's Portland, Sacramento, and Tacoma, mapped and appraised waterpower resources and storage possibilities of 280 channel miles of streams and 11 dam sites in Alaska, California, Colorado, Idaho, Montana, New Mexico, Oregon, and Washington. Classifications by Branch members added more than 225,000 acres to power-site reserves, increasing them to nearly 7.2 million acres in 23 States and Alaska. They also supervised 960 power projects for the Federal Power Commission and handled some 5,800 hydraulic cases for the FPC and the Interior Department. Members of the Mining Branch, where Joe D. Turner succeeded Smith, supervised operations in 1953–54 on about 1,460 lease, permit, or license properties in Federal lands in 32 States and Alaska. The 17.9 million tons of coal, lead, phosphate, potash, sodium, uranium, vanadium, zinc, and other mineral resources produced from these lands, valued at $119.4 million, provided the Treasury with nearly $4.5 million in royalties.

The staff of Harold Barton's Oil and Gas Leasing Branch, deploying from its 20 district offices in California, Colorado, Louisiana, Montana, New Mexico, Oklahoma, Utah, and Wyoming, oversaw the discovery, development, and production of some 87,500 properties on nearly 66 million acres in 23 States and Alaska. In October 1953, Duncan and Wrather joined Wormser in McKay's party to inspect several wells off Louisiana and also to examine the district by air. Production from wells on the public lands rose significantly from that of 1952–53 to 108 million barrels of petroleum, 238 billion cubic feet of natural gas, and 201 million gallons of gasoline and butane. Royalties from these resources and those from acquired and Indian lands, and Naval Petroleum Reserve No. 2 (NPR–2), increased from the previous year by some $18.1 million to nearly $68.5 million in 1953–54. The Branch approved 80 new unit plans and terminated 48 others, leaving 301 plans in operation on 5.2 million acres. A Survey order dated November 6, 1953, but effective on May 1, transferred supervision of oil and gas operations in Oregon and Washington from the Northwestern Region's chief in Casper to the California Region's manager in Los Angeles.[125] The order also renamed, effective on July 1, the California Region as the West Coast Region to reflect more accurately its two new States and its older components, California and the Alaska Territory.

The budget for fiscal year 1954–55 that President Eisenhower transmitted to Congress on January 21, 1954, extended his administration's reductions of the previous year. Current estimates for 1953–54 all were lowered below the Truman administration's numbers by $12.5 billion in appropriations requests, $11 billion in new obligated authorities, and $7 billion in expected expenditures. For 1954–55, the President proposed additional reductions of $4.4 billion in obligations and $5.5 billion in estimated expenditures. Tax reductions would total nearly $5 billion and leave a budget deficit of $2.9 billion, compared to $9.4 billion in 1952–53 and the original estimate of $9.9 billion and the revised estimate of $3.3 billion in 1953–54. Eisenhower's budget specialists now projected obligated authorities for $56.3 billion and expenditures of $65.6 billion in fiscal 1954–55. As part of proposed tax reforms, the President asked for an end to the double taxation of business income, approval of firms' deduction of research and development expenses, and extension from March 1 to April 1 of the deadline for filing individual returns. Eisenhower's "New Look" in national-security policy required developing improved nuclear weapons and their guided delivery systems to secure adequate defense. Reaching those goals would be at the expense of conventional forces. The new approach would slash $5 billion, or 14 percent, from Defense Department expenditures but would increase U.S. air power. The greater effectiveness of the Republic of Korea's armed forces, Eisenhower asserted, would enable two Army divisions to be withdrawn from Korea. When the authorized funds were redistributed among the three armed services, the Air Force received an 8-percent increase, and the Army's share fell by the same percentage. By comparison, the AEC's expenditures would "rise in the fiscal year 1955 to the highest point in our history."[126] Progress in the stockpiling of "about 50 of the 73 strategic and critical materials objectives," Eisenhower expected, would be "virtually completed"[127] by expending $585 million in 1954–55 to produce $5.5 billion worth of on-hand emergency supplies. The 1954–55 budget also included $66 million for the Soil Conservation Service's continuing improvements of agricultural land and water resources. The President asked for an additional $858 million for conserving and developing the Nation's mineral and other natural resources by the Interior Department and other Federal organizations. Eisenhower renewed the request he made in his State of the Union Message for legislation to establish a Federal corporation for cooperative work with Canada on the St. Lawrence Seaway and asked for $555 million for highway construction, of which some $150 million would support projects in the interstate system. In May, Congress approved nearly $2 billion for highways during the next 2 years and a St. Lawrence Seaway Development Corporation; in June, Eisenhower gave the latter's direction to Defense Secretary Wilson.

Ben Jensen's House subcommittee began hearings on Interior's budget request for fiscal year 1954–55 on January 31, 1954. Secretary McKay reported the results of his continuing changes in management and operations. Calling his Secretarial staff too small for its work, McKay continued to seek a solution that would reduce the burden on the Assistant Secretaries. He transferred the functions of the former Divisions of International Activities, Minerals and Fuels, Land Utilization, and Water and Power to one technical-review staff. Each field committee would now be chaired by a bureau representative. The Secretary's Office now reviewed all contracts larger than $10,000 and required all bureaus to report weekly on purchases and contracts between $500 and $10,000. McKay, reflecting on the mixed results of his efforts to oust some of his agency chiefs in 1953, recalled encountering "our greatest difficulty" in reforming his bureaus, where "most of the incumbents in policy determining positions were under civil service." McKay asserted his firm belief in civil service but added that "there is a point beyond which civil service should not be used. * * * [W]e must have flexibility of appointment," he cautioned, "if we are to have flexibility of policy with each succeeding change of administration." McKay found some persons in top positions "who did not measure up to the standards we demanded" and others, although able in a technical sense, "were so imbued with a philosophy conflicting with that of the new administration that they were incapable of doing a good job under our new policies."[128] He excepted the rank and file, lauding their devotion to duty and objecting to unwarranted criticism of them, hoping that public confidence and employee prestige could be reestablished. McKay then highlighted the reductions he achieved in Interior's personnel. His directive of February 9, 1953, required all but a few new appointments to be reviewed by his office. By November, Interior shed 3,980 employees and their salaries of $18 million. McKay, warning the House subcommittee about the dangers of an unbalanced Federal budget, also touted the 20-percent reduction of Interior's allotment by $109 million during his first year in office and noted that the fiscal 1954–55 estimate of a little more than $422 million would save another $12.5 million. He expected Interior's revenues in 1954–55 to reach $259 million, or $13 million more than in 1953–54. Budget Bureau employees cut Interior's request for the year from $538 million to $434 million. They shaved the USGS portion from $29,020,000 to $27,335,000, ostensibly a reduction of $415,000 from its appropriation for 1953–54 but actually a loss of $1,890,000 because the Bureau of Reclamation asked for a transfer of base of $1,475,000 of its proposed funds to the USGS for its continuing work in the Missouri River Basin.

When Jensen's subcommittee examined the USGS budget on February 2, Assistant Secretary Wormser accompanied Director Wrather. The USGS representatives shaped their presentations by using the experience gained in dealing with the new administration during the past year. The agency gave "Close attention," Wrather claimed, "to achieve practical economy without too greatly hampering essential work."[129] The USGS looked at each element, he continued, to determine if the work should be done by the Federal Government, done now, and done at the requested rate. As an example, the formal justification for geology included a discussion of the philosophy behind the program that allowed Chief Geologist Bill Bradley to discuss the dollar value of his Division's work, as he had done at several earlier hearings. He said, "in general, the money the Government puts into this program is paid back in terms of new wealth several times over. I never tried to cast up the figures until the other day." Bradley continued, "I find that a rough estimate of how much, exclusive of transferred funds, the Government has put into the geologic work of the Geological Survey since it was founded 75 years ago is somewhere between $75 and $80 million. Then if one casts up on the other side of the ledger," Bradley compared "the total estimated value, at today's prices, of a few of the deposits whose discovery can be attributed to this geologic work, you come up with an amount 27 times the amount put into the surveys. That only includes five discoveries actually that were attributed directly, quite directly, to the work of the Geological Survey in this program."[130] Germanium, hafnium, zirconium, and other rare metals now in demand, Bradley added, were being given priority in geologic mapping and investigations. In view of the difficulties faced by the mineral-procurement agencies during World War II, Ivor Fenton asked "Are we proceeding fast enough in this program?"[131] No, replied Wrather, the proposed expenditure for geology during fiscal year 1954–55 was just a little more than $5 million. "[I]f this geologic mapping and appraisal program is stepped up to an amount of approximately $24 million a year for about 25 years," Wrather estimated, "we would have adequate basic information."[132]

The House subcommittee then passed to the funds requested by the USGS for work on water resources, in the Missouri River Basin, and on conservation and for a new home. Adequate supplies of water remained a critical issue, Paulsen emphasized, due to the "tremendously increased use in industry, by municipalities and for agriculture," and because of the recurring drought "in several parts of the country for several years."[133] The Interior Department continued to support efforts to convert saline to potable water. Individuals and organizations in U.S. academia, industry, and government, and their counterparts in Europe, pursued commercially significant techniques of desalinization by distillation based on electrical, low-temperature, osmotic-cell, phase-separation, solar, solvent-extraction, and vapor-compression methods. Regarding the Missouri Basin work previously funded by the USBR, Fenton raised the old issue about placing appropriations with the requesting agency or with the operating bureau. "You cannot maintain," Fenton stated, "a high-grade technical organization at a normal level to take care of needs unless you have a firm financial base,"[134] as good personnel cannot be let go and then rehired when needed. Fenton, noting the 50-percent increase to $100,000 requested for supervising offshore oil and gas leases on the Continental Shelf, asked if boats or aircraft were needed for the work off Louisiana, the initial producing area in the Gulf of Mexico. Harold Duncan offered his hope that the USGS "will not have to have a navy."[135] Duncan's Conservation Division would need more employees to handle this work, but the numbers remained to be determined pending the advent of firm regulations and the Federal agreement with Louisiana and Texas. Wrather pointed out the inadequacies of the Old Interior Building, calling its auditorium a regular bat roost, but he could report only minimal progress toward a move to the consolidated headquarters in the Washington area favored by Wormser and Jensen. As Jensen suggested in the previous year, a bill to acquire land and authority to plan the new building had been prepared, then cleared Interior after discussions with the GSAd, and subsequently went to the BoB.

Just before the House subcommittee closed its hearings, Wormser announced that Wrather would receive the John Fritz Medal on February 4, 1954, the latest of his distinctions that included honorary doctorates awarded during 1945–52 by Southern Methodist University, the Colorado School of Mines, the University of Kentucky, and the Montana School of Mines. Four national engineering societies—the American Institute of Electrical Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Civil Engineers, and the American Society of Mechanical Engineers—established the Fritz gold-medal award in 1902, named for John Fritz (1822–1913), a pioneer in the Nation's iron and steel industry, and also honoring "notable scientific or industrial achievement."[136] Lord Kelvin received the Fritz Medal in 1905; among the subsequent 47 awardees were Vannevar Bush in 1951, Everette DeGolyer in 1942, Herbert Hoover in 1929, and Frank Jewett in 1939. "We all know," Jensen added, "that he [Wrather] is entitled to that fine recognition,"[137] but that opinion did not affect the subcommittee's decision to reduce still further to $25,362,685 the USGS appropriation for fiscal year 1954–55.

When the Senate subcommittee's hearings began on April 12, Secretary McKay complained to Chairman Cordon about both the Budget Bureau's and the House subcommittee's reductions of the Interior Department's estimates for fiscal year 1954–55. The BoB cut out projects and imposed ceilings, slashing more than 13 percent from Interior's total and reducing the estimate for the USGS from

$29,020,000 to $27,335,000; the House chopped off another $1,972,315. Interior's own reductions in expenditures, McKay emphasized, demonstrated that he was "for economy in Government," but he was also "strong for efficient and effective Government." The House bill made it impossible, without major changes in the Department, to meet its responsibilities "efficiently and with dispatch."[138] Interior's surveys of its agencies, aimed at improving economy and efficiency, and including the now-completed one for USGS, cost $90,000 but were expected to pay for themselves in future savings.

Wrather appeared before Cordon's subcommittee on April 16 to specify how the House's cut would curtail the agency's programs, reducing their funding well below the level of fiscal year 1953–54. Wrather requested a restoration of $497,315. Of these replaced monies, $372,315 would fund water-resources investigations to achieve the least dislocation of work on the water problem that Senators Cordon and Hayden agreed "was getting worse and worse."[139] Restoring $65,000 to topography and $60,000 to geology, Wrather agreed with Cordon, would "not break or make"[140] either program, but so much work remained backlogged that the USGS needed and wanted every penny it could get. FitzGerald described the Air Force's recent request to map some 850 quadrangles; most of them were not included in the current program, but they contained airports that must be reactivated in emergencies. To Hayden's query about progress in national topographic mapping, FitzGerald reported that it was now 31 percent completed and forecast a yearly progress rate of 2 percent.[141] At that rate, Cordon estimated, and FitzGerald agreed, completion would take almost 35 years. Wrather suggested that future cost cutting, better technology, and faster operations would allow mappers to cover more territory and reduce the time required to prepare maps. Bradley added that photogeology and other new techniques doubled, from 20,000 to 40,000 square miles each year, in the past 2 years the rate of mapping the Nation geologically. The House allowed the full amount requested by the USBR but there would be no transfer of funds for the Missouri River Basin program. The House also rejected placing that sum in the USGS appropriations, although Cordon still favored it. Cordon agreed with Fenton and Wrather that year-to-year stability of trained staff was vital for the USGS and maintaining it posed a problem if the amount of transfer funds fluctuated significantly.

During the subcommittee's hearing, Wrather reminded the Senators that the USGS continued to occupy 16 different buildings in the Washington metropolitan area, some with fire hazards and others not suitable for the agency's needs. He urged subcommittee members to concur with the House decision on procuring adequate centralized housing to improve communication and management. He asked to keep $75,000 of the unexpended balance from 1953–54 to continue planning for the new headquarters building. The phantom building also continued to draw attention in the Pick and Hammer Club's annual shows. In May 1954, the players sang, to "You're Just in Love," from Irving Berlin's "Call Me Madam" of 1938:

> **I hear music when Tom Nolan's there,**
> **I see money, though our cupboard's bare,**
> **Dream of buildings rising in the air.**
> **I wonder why, I wonder why.[142]**

The Senate and the conference committee restored all but $125,000 of the cuts, and Eisenhower signed the Interior bill on July 1, 1954. The new statute gave the USGS $25,735,000 in SIR funds for salaries and operations in fiscal year 1954–55. That total represented $2,015,000 less than the sum provided in 1953–54, the first significant decline in direct appropriations, but not including those supplemental, since fiscal 1942–43, and the initial one of more than $1 million in the agency's history. Up to $75,000 of the SIR amount for 1954–55 was "continued available until expended for preparation of plans and specifications for a building or buildings to meet the special needs of the Geological Survey in the metropolitan area of Washington, D.C."[143] The USGS appropriation supplied about $750,000 for general administration, to which $524,000 for similar overhead was added from the funds advanced or reimbursed by other Federal agencies for program expenses, for a total of $1,274,000, or $143,500 more than during 1953–54. The USGS also received directly nearly $101,000 for investigations of soil and moisture conservation. At year's end, the USGS reported almost $46,859,000 in total funds received during its 75th year, nearly $1,627,000, or 3 percent, less than during 1953–54, but the proportions derived from the three principal sources remained the same. About 56 percent of USGS funds came from direct appropriations, other Federal agencies transferred 32 percent, and direct payments and reimbursements from nonfederal sources supplied 12 percent, of which States, counties, and municipalities supplied 99.6 percent. The total funds supported salaries and operations by the agency's now more than 7,000 full- and part-time employees, a total well past the 6,472 persons reported as of December 16, 1953.

On January 6, 1955, Secretary McKay established within the Interior Department the Office of Minerals Mobilization (OMM) and made it responsible for solid fuels and metals and minerals, except for domestic-mineral exploration.[144] The OMM received functions that McKay had delegated elsewhere in Interior in 1954. Solid fuels passed to the USBM on July 1 and metals and minerals shifted to the Office of Defense Mobilization on November 12, except for responsibilities he delegated to the General Services Administration on December 22. McKay appointed Spencer S. Shannon as OMM Director on May 4, 1955; operating funds became available on July 1. Assistant Secretary Wormser's office and the OMM coordinated USBM and USGS studies of mineral-mobilization problems. During May–June 1955, Wormser traveled through Europe and the Middle East to gain information on those regions' oil industries.

Significant changes occurred in the membership of the USGS Science Advisory Committee. When Morris Leighton retired from the Illinois State Geological Survey and the Advisory Committee, John Frye replaced Leighton in both posts. Major General Herbert Loper joined the USGS advisers in 1955 after retiring from the Army. Since 1949, Loper served as Deputy Chief of the JCS Joint Intelligence Group, Deputy for Atomic Energy to the Acting Chief of Staff G–4, Army Member (later Chairman) of the AEC's Military Liaison Commission, Deputy Commander of the Joint Task Force, Chief of the Armed Forces Special Weapons Project, and Assistant to the Secretary of Defense. Eliot Blackwelder, who had led Stanford's Geology Department until 1945, retired from the USGS advisers in 1955. Vertebrate paleontologist George Gaylord Simpson, of the American Museum of Natural History, replaced Blackwelder on the Committee. Horace Albright, who still led the U.S. Potash Company, also served as one of the USGS advisers. Continuing on the Committee were William Heroy, Donald McLaughlin, and Abel Wolman, professor of sanitary engineering at Johns Hopkins, who also advised the AEC, the Army Surgeon General, the NSF, the NSRB, the State Department, the TVA, the United Nations, the U.S. Public Health Office, and the World Health Organization.

On December 16, 1954, two Survey orders by Wrather established, respectively, USGS Committees for Program Planning and for Program Analysis. The Director's Staff Assistants for Program Planning and for Program Analysis chaired the new Committees, and they each served ex officio as a member of each other's Committee. The Committees included a representative from each Division, who served, in alphabetical order of their last names and when necessary, as Acting Chairmen. Wrather asked the program planners to "review jointly bureau and division objectives and short-range and long-range plans in their formative stages" for conformance with agency and division responsibilities, to assure interdivisional coordination, and to consider how programs "related to budget ceilings and allowances."[145] He directed the program analyzers "to develop a bureau-wide system of project reporting, cataloging, and approval and to assist in compiling and maintaining program schedules."[146] Both advisory Committees reported to the Director through the USGS Executive Committee. Commenting on the flurry of USGS committees recently established, geologists in the Pick and Hammer Club's show in the April 1955 show wondered why:

> **Committees are the thing today—the bosses think they're great!**
> **They send us questionnair[e]s to find out how we operate,**
> **They look for ways to streamline and to cut our work in half:**
> **Then start another office which poor Andy has to staff—**
> **And every processed manuscript needs one more autograph![147]**

The Geologic Division drew on nearly $14,342,000 in fiscal year 1954–55; that sum represented a loss of nearly $2,125,000 and the only major one incurred that year by the USGS four operating divisions. Of the new total, the SIR appropriation supplied $5,346,000, representing a decline of $993,000. The remainder of the overall loss reflected principally the $1,374,000 reduction by the AEC, but it also included cuts of $93,000 by the USBR, and $104,000 by the Army and the Navy together. Increases in funds transferred by the USAF, the DMEA, the FOA, the States and their smaller political entities, and the USBM only totaled about $103,000. On January 6, 1955, Wrather's Survey order, effective November 10, 1954, reorganized the staff in the Office of the Chief Geologist, Bill Bradley.[148] The order retained the two Assistant Chief Geologists (ACGs), one for Operations, where Dwight Lemmon replaced Olaf Rove, and the other for Program, still directed by Harold Bannerman. Establishing an ACG for Trace Elements, and appointing Lincoln Page to the post, emphasized the shift from discovery and appraisal of uranium-thorium resources to a program of longer range geologic studies. The order also established three new staff positions—Publications, Research Operations, and Scientific Personnel—and filled them, respectively, with John Rabbitt, Wilbur Irving, and Robert Bryson. Williams Postel remained Chief of the Office of Geologic Reports.

During fiscal year 1954–55, the Geologic Division's program, as before, emphasized developing new and improved methods of exploring for mineral resources, accelerating geologic mapping, and conducting cooperative investigations with Federal and State agencies, each supported by basic-research components. On July 17, 1954, another self-promoting article about the USGS, Harold H. Martin's "Uncle Sam's Treasure Hunters," appeared in the *Saturday Evening Post* to publicize the agency's continuing efforts to aid the search for strategic and critical minerals.[149] Martin noted the importance of USGS techniques for discovering deposits of columbium (needed for strength in steel alloys for jet engines) and germanium (used in transistors and now priced at $350 per pound but recently found in Pennsylvania coals and factories' smokestack soot). Martin also emphasized USGS geochemical field tests that detected amounts of these commodities as small as 1 part in 10 million and other techniques that used air photos taken in spring to identify concentrations of Patterson poisonvetch (*Astragalus pattersoni*) and other plants as guides to selenium and uranium deposits.

During fiscal year 1954–55, members of the Mineral Deposits Branch and those in other Branches in the Geologic Division, in cooperation with USBM engineers, continued to provide technical data and evaluation for the Emergency Procurement Service's programs as well as those of the Defense Minerals Exploration Administration. On November 1, 1954, Wrather's Survey order reorganized, as of October 22, the Mineral Deposits Branch. The order provided for "four project centers and eight field offices for DMEA activities"[150] and made staff assistants in

This photograph shows dead specimans of Patterson poisonvetch (*Astragalus pattersoni*), a leguminous weed with a deep taproot, that USGS geologist Helen Cannon demonstrated in the early 1950s was "useful in fall and winter in deciding where to [diamond] drill" on the Colorado Plateau to confirm uranium deposits indicated by the results of two methods of botanical prospecting combined with those from geological and other investigations on the surface. Cannon showed that the ash from tree-branch tips that contained "[g]enerally more than 1 part per million of uranium" and maps of indicator plants, whose distribution depended on the association of calcium, selenium (*Astragalus*), and sulfur with uranium, were "useful in semiarid country in prospecting for ore-bearing beds at depths as much as 70 feet." She described and illustrated with drawings and photographs of living specimens of species of "[f]ifty indicator plants commonly associated with carnotite deposits and plants tolerant of mineralized ground." (Photograph and quotations from Cannon, H.L., 1957, fig. 74 and caption and p. 399. See also the live *A. pattersoni* shown in Cannon's figs. 76 and 77.)

Washington responsible for all resource activities related to metals, nonmetals, uranium, and the DMEA. For the FOA, Branch and Division scientists studied mineral resources in Latin America, Asia, and Africa. They continued the broad program of investigating fissionable-mineral resources, mapping terrain, and conducting other strategic studies for the Army Engineers and served as advisers and consultants to the NSF, the ODM, and the DoD. During the year, Branch members conducted these and related field studies of mineral deposits in 84 projects in 23 States. Branch geologists completed a regional investigation of mineral resources for the New England-New York Interagency Committee. A mining company discovered an ore body in Wisconsin's lead-zinc district on a geologic structure revealed by USGS mapping. Diamond drilling near New Market, Tennessee, extended the limits of a major zinc deposit. Geologic maps of Arizona's Globe-Miami project showed a well-defined mineral belt and stimulated active prospecting in its parts concealed by younger rocks. Exploratory drilling continued at Tintic in Utah, in the Mojave Desert, and on the Colorado Plateau. Arnold L. Brokaw, the Colorado Plateau Project's District Geologist since 1952, became the District Supervisor at Grand Junction in 1954 and then Project Chief. Geologic mapping continued toward providing large-scale coverage of the Plateau, supported by more specific studies that found new uranium deposits of significant size and extended the known reserves of other deposits. Work increasingly shifted to the program of longer range geologic studies to determine the geologic setting of the carnotite and similar uranium deposits and the factors controlling their distribution and localization.[151] Detailed investigations of the distribution of chemical elements in sandstone-type uranium deposits revealed a statistical relationship between the sizes of uranium deposits and the concentrations of their elements.

Investigations by members of the Fuels Branch in fiscal year 1954–55 involved surface mapping in 15 States and subsurface mapping in 11 States. Branch geologists studied coal resources in 12 States, including those in the Tennessee River Valley, the Missouri River Basin, and other areas that required steam coal to provide the additional electric power beyond the capacities of hydroelectric sources. In investigating coal in older mining areas, they discovered a thrust fault on the north side of Pennsylvania's Southern anthracite field that repeated the coal-bearing rock sequence and suggested the possibility of additional deposits. Summary studies of coal resources were underway in Arkansas and Kentucky and concluded in Alabama, Colorado, and Oklahoma. James F. Pepper, the Branch's Eastern Region Supervising Geologist; Wallace de Witt, Jr.; and David F. Demarest published a regional analysis, begun by the USGS in 1943 in cooperation with State geological surveys, of the paleogeography and sedimentation of two Lower Mississippian formations—the Bedford Shale and the overlying Berea Sandstone—formed in one sedimentary cycle in a 47,000-square-mile area of the Appalachian basin in contiguous parts of Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia. The trio's study showed areal variations in the oil- and gas-bearing Berea's thickness and lithology as a guide to potential sites for additional drilling. Fuels geologists also continued field investigations of and a core-drilling program in the oil-shale deposits of the Naval Oil Shale Reserve No. 2 in eastern Utah and completed their study of the Tertiary geology and oil-shale resources of northwestern Colorado's Piceance Creek Basin.

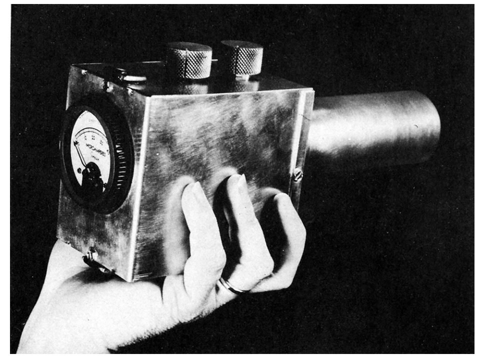
The Engineering Geology Branch's 25 continuing projects operated in 11 States in fiscal year 1954–55. For the Kansas Highway Commission, Branch geologists studied part of the proposed Kansas Turnpike and added investigations of structural-foundation conditions for the National Park Service to those ongoing for the Navy Ordnance Laboratory.

William Benson replaced Charles Hunt as Chief of the General Geology Branch during fiscal year 1954–55. During the 1954 field season, Branch scientists completed work on Unalaska. The geologists and geophysicists at the USGS facility on Adak, having finished studies for the DoD, ended their operations. At Denver, Ray Wilcox continued his work in what geologist John Fournelle later called "'applied volcanology,' tephrochronology." Using "his background in optical mineralogy," Wilcox "developed the spindle stage and then the dark field masking technique to compare the minerals and glasses from different ash layers."[152] HVO scientists decided that Kilauea would erupt during the winter of 1954–55. Although a flank eruption in February destroyed more agricultural land than any Hawaiian event since 1868, the prediction and subsequent evacuation prevented loss of life and minimized property damage. Jerry Eaton and Gordon Macdonald's analysis of the events served "as a model for all eruption studies"[153] at the HVO. Other Branch scientists finished stratigraphic studies of Florida's phosphates; completed geologic investigations in Nevada's Carson Desert, Utah's La Sal Mountains, and the Appalachian's Great Smoky Mountains; and worked up the results of similar efforts in Glacier National Park in Montana.

A revised Survey order of May 19, 1955, effective May 1 and signed by Nolan as Acting Director, again modified James Balsley's Geophysics Branch; this order abolished its Radiation Section and transferred the Section's staff and remaining projects to the Ground Surveys Section.[154] Branch members continued to develop, test, and improve their instruments and techniques, including jeep-mounted and hand-portable scintillation loggers, a liquid scintillation core scanner, and shallow-seismic-reflection equipment used to locate buried river channels in Ohio. They also used radiowave-frequency-propagation, induced-polarization, and electromagnetic methods. Regional gravity and aeromagnetic surveys continued to provide information on groundwater in the Salt Lake and Utah Valleys, uranium on the Colorado Plateau, and iron in the Lake Superior area. Investigations of radon in well water in Utah's Salt Lake Valley indicated that buried faults influenced concentrations and that radon-content contours defined fault traces. Studies of Colorado Plateau cores indicated that uranium-ore emplacement in two or more geologic settings was related to pore-water content and permeability, promising more utility from electrical-resistivity surveys. During the year, Branch specialists flew some 70,000 miles of airborne magnetic and radioactivity surveys; their reconnaissances for radioactive raw materials in 9 States included initial examinations of radioactivity patterns associated with oil and gas fields and varied terrains and their vegetation. For the EPS, they began detailed precision geophysical surveys of chromite in Cuba's Camaguey Province to increase reserves of refractory grade.

The Geochemistry and Petrology Branch developed X-ray fluorescence equipment that its members expected would produce quantitative analyses of very small grains of ore minerals. The equipment would enable comparisons of individual particles in thin and polished sections and analyses of elementary constituents in the powdered minerals in the spindles used for X-ray diffraction. Branch personnel built a mobile spectrographic laboratory for rapid geochemical analyses in the field. Studies of uranium in coal, oil, and other carbonaceous materials generated data about its migration and concentration, while work on radioisotopes of copper, lead, uranium, and zinc provided information about their age and genesis. Mass-spectrographic studies of hydrogen isotopes in surface water and groundwater increased the understanding of atmospheric and oceanic circulation. Radiocarbon determinations helped to establish a more accurate chronology for the Pleistocene's Wisconsinan Stage and to measure the addition of carbon dioxide to the atmosphere. Neutron bombardment of zircons and copper samples, at Oak Ridge, and coals, at Brookhaven, showed aspects of how they were formed and changed with age. During 1955, Edwin Roedder joined the Branch to lead its Solid State Group.

Alaska enacted, on March 15, 1955, an oil- and gas-conservation statute similar to laws passed during 1931–55 in California, Mississippi, Pennsylvania, and Wyoming. The Bureau of Land Management leased more than 500,000 acres of potential oil lands in Alaska during fiscal year 1954–55, while drilling continued



USGS geologist Henry Faul and three of his USGS colleagues (managed by Lincoln Page and advised by several specialists in two of the U.S. Atomic Energy Commission's laboratories) designed, developed, and began field-testing this prototype "integrating (total intensity) scintillation counter." They intended this smaller and lighter version to replace their earlier portable scintillation counter (12 inches tall and weighing 7 pounds) that was used extensively in 1953's field season in place of the larger and heavier Geiger-Müller meters. The new instrument and its batteries fit in a case measuring 4 by 4.5 by 3 inches "with a probe 2 inches in diameter projecting 5½ inches from the front"; the whole device weighed less than 3.5 pounds. The new counter used "the same high voltage supply" but simplified the counting circuit to measure "the total intensity of light emitted by the [sodium-iodide] crystal" to read more accurately the total dosage rate in gammas rather than the number of disintegrations. (Photograph and quotations from Wilson, E.E., and others, 1954, fig. 7 and caption and p. 5 and 9.)

around Cook Inlet and in the coastal area east of Cordova. The Interior Department asked Congress and the Navy to modify Public Land Order 82 to open to exploration 25 million Federal acres outside Naval Petroleum Reserve No. 4. The Navy approved, provided that the work did not affect the status of lands in NPR–4. By fiscal year's end, the USGS had mapped photogeologically more than 100,000 square miles of Alaska, including NPR–4, and more than 10 percent of the Territory's 1:250,000 quadrangles. Airborne-magnetometer surveys began in southern Alaska to gain additional information about oil possibilities in the rocks of its sedimentary basins. Alaskan Geology Branch geologists demonstrated that the Lower Cretaceous rocks of the Nelchina area, northeast of Anchorage, extended eastward under the adjacent Copper River Tertiary basin. Their colleagues completed mapping in the Nenana coal field and the greater Anchorage area, used power augers to obtain samples from four localities in the Little Susitna and Homer districts, and briefly worked along the Beluga River west of Anchorage. Mineral studies included those in the Lituya Bay-Lynn Canal Traverse Belt, the southern Prince of Wales Island, the Seward Peninsula's tin and tungsten deposits, and the northeastern Nutzotin Mountains. Branch members also examined routes for the proposed Denali and Brown-Nenana Highways, during the Alaska Road Commission's 50th year, and waterpower sites for the Conservation Division. George Plafker looked at sites flanking Taku Inlet, near Juneau, in 1954. Frederick A. Johnson and Kenneth S. Soward checked locales in the Kenai Peninsula's Bradley River Basin in 1955 and examined two lakes on Baranof Island in 1956.

Members of the Military Geology Branch continued to work in North and Central America, Europe, Asia, and the Pacific during calendar year 1954–55, producing more than 70 reports and maps. Louis C. Peltier, a specialist on the Pleistocene, completed assessing requirements for worldwide information about military geography. In Alaska, MGB personnel made reconnaissance studies of terrain, geology, and (or) permafrost in areas in or around the Copper River Basin, Cook Inlet, the southwest Talkeetna Mountains, and the Brooks Range's North Slope. John R. Williams finished a special report on the Beaver area along the Yukon and mapped trafficability, at 1:130,000, in the Big Delta Military Reservation. The USGS Trace Elements Planning and Coordination Office (TEPCO) sponsored an MGB study of possibly commercial deposits of diatomaceous earth in the northern Kenai lowlands. Werner Juhle and Henry Coulter completed special reports for the NPS on their studies of the terrain and volcanic activity in Katmai National Monument. For the BLM, MGB members evaluated permafrost and groundwater conditions at reservations for town sites in the Glennallen area of the Glenn Highway. At Barrow, Arthur Lachenbruch continued his studies, begun in 1952, of the thermal properties of permafrost. At Fort Hood in Texas in 1954, MGB personnel assessed, at 1:50,000, the Army post's climate, landforms, state of ground, and vegetation. A related study, at 1:250,000, of the possibilities of cross-country movement in Louisiana appeared in 1955. MGB members also taught a 2-week course in military geology to 20 Army Engineers at Fort Belvoir. Allen Nicol, Richard W. Lemke, Alfred Clebsch, Joseph H. Hartshorn, and other specialists prepared Engineer Intelligence Studies of areas at Thule (at 1:100,000), Nunatarssuak, and southern Inglefield Land in Greenland. Jack Rachlin and his colleagues finished terrain studies at 1:100,000 of British Honduras (Belize), Costa Rica, El Salvador, Honduras, and Nicaragua; they were similar to those for Guatemala. In 1955, Frederick Betz's team in Europe, working at headquarters in Heidelberg and Salzburg, began issuing a set of cross-country-movement maps of West Germany, at 1:100,000, that displayed information about drainage, landforms, soils, trafficability, and vegetation; they were completed in 1958 with input from the Soil Conservation Service. The team also prepared a terrain study of Austria on 14 maps, at 1:50,000, 1:250,000, and 1:500,000, and the Army Signal Corps sponsored a morphometric analysis of

Cyprus. Cornelia Cameron completed a lithologic map, on 2 sheets at 1:2,000,000, of Europe in 1955.

Among the Military Geology Branch's work in the Far East and the Pacific during 1954–55, Jack Rachlin and his colleagues completed for the Army's G–2 Section a 20-page handbook on Indochina and special reports on possible airfield sites within 150 miles of Saigon and the French naval base at Cam Ranh Bay, at 1:2,250,000, about sources of timber for construction in the Red River delta and surrounding area, and on construction materials near Nha Trang, the French administrative center, just north of Cam Ranh. MGB members also assessed construction materials and water resources in Burma, China (except Hainan and Manchuria), and Indonesia. They revised a 30-page brief on "Manchuria," including Manchuria, Korea, northern China, the Shantung (Shandong) highlands, and the southeastern coast of Siberia. For Army headquarters in Tokyo, MGB personnel evaluated the water resources of campsites for the 7th Infantry Division; studied installation development at Fukae, east of Nagasaki, and on Mi-shima, off Hagi in southwestern Honshu; and assessed the relation of volcanism to water resources and base facilities on Iwo Jima. During July–September 1954, the Pacific Geologic Mapping Program's Gilbert Corwin led Lawrence Bonham, Maurice J. ("Ric") Terman, and George Viele in mapping the general and engineering geology, at 1:25,000, of Pagan, the island just north of Saipan in the Marianas. The Program's report on Saipan's engineering aspects and an analysis of the island's beaches and terrain, also at 1:25,000, appeared in 1955. The summary of Saipan's water resources, by Preston Cloud, Robert George Schmidt, and Harold Burke, followed in 1959. The five-volume report on the engineering aspects, geology, soils, trafficability, and water resources of Okinawa, at scales from 1:25,000 to 1:250,000, by Corwin, Cornelia Cameron, Delos Flint, Allen Nicol, Raymond Saplis, Carl Stensland, and soils-scientist A. Joseph Vessel, appeared between 1957 and 1959. Program members issued their description of the tactical and engineering aspects of Tinian's terrain in 1960. During November 1954–July 1955, John Stark, David Blumenstock, Max Carson, Richard L. Hay, Harold G. May, James E. Paseur, and Elmer D. Patterson mapped and studied the terrain, geology, climate, and hydrology of Truk Atoll in the central Carolines. The team published a summary report, with maps at 1:25,000, about Truk in 1958 and a water-resources supplement, by Santos Valenciano and Kiyoshi Takasaki, in 1959. Members of the Pacific program also briefly examined Ponape.[155]

During fiscal year 1954–55, members of the Branch of Foreign Geology began or continued investigations and training in Latin America, Africa, the Middle East, and Asia for the AEC, the FOA, and the EPS. Jacob E. Gair, Robert F. Johnson, and Samuel L. Moore joined John Dorr 2d's mineral-appraisal group in Brazil's Minas Gerais, while Helmut Wedow and William W. Vaughn helped Max White and Gene E. Tolbert's reconnaissance of that country's uranium resources. Bolivia's Government used the results of Branch members' studies of geologic-engineering features in La Paz to mitigate construction hazards and plan for the capital's future development. George Ericksen, as USGS Mission Chief, began advising Chilean Government officials about founding a national geological survey and initiating a countrywide program to investigate and develop the nation's copper and other mineral resources. Parker Trask briefly aided these mineral investigations and Raymond L. Parker arrived to succeed Monta Wing. William R. Hemphill provided photogeologic and other support for Benjamin Webber's investigation of mineral resources in British Guiana. Gus Goudarzi, having completed his work in Saudi Arabia, began a long-term investigation of Libya's mineral resources as USGS Mission Chief and as adviser to the government of King Idris. Britain's and the United States' treaties with Libya in 1953–54 gave them 20-year rights to maintain military forces and installations in that country in return for economic and other monetary subsidies; the United States promptly began to expand Wheelus Air Force Base. In

India, Branch members introduced the newest USGS techniques in geochemical prospecting to their local colleagues. Harley Barnes and Frank Spencer extended the studies by Harold Vokes and Marvin Weller of coals in the Philippines.

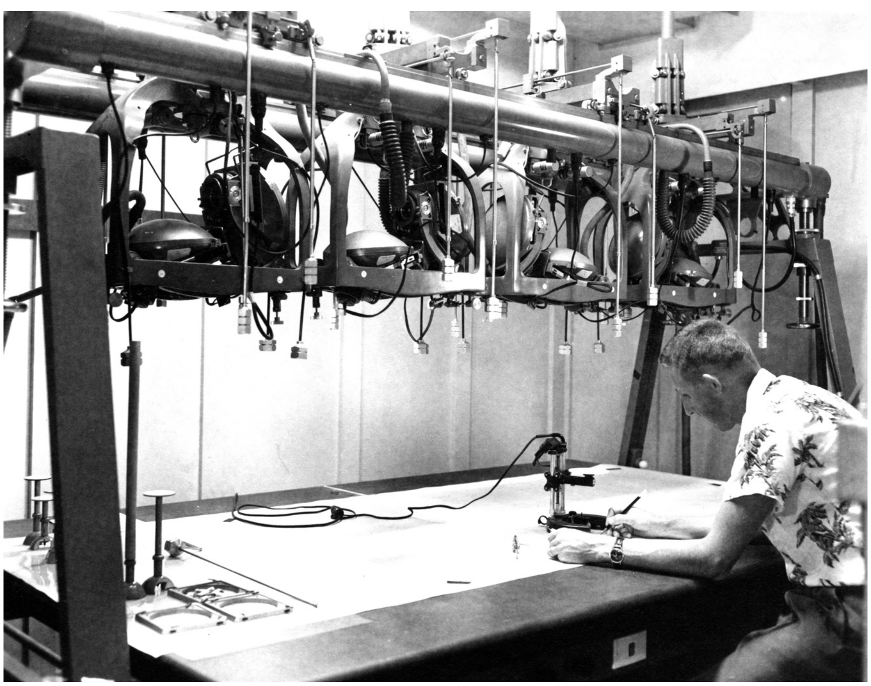
USGS personnel returned to Antarctica in the austral summer of 1954–55 when geologist William Davies accompanied the Navy's first deployment to the continent since Operation Windmill in 1947–48. After the Navy completed Windmill, the CIA notified the State Department that U.S. passive claims now covered most of coastal and inland Antarctica. The State Department tried but failed in June 1948 to arrange for an international settlement of all claims on the continent. In April 1949, Truman approved Highjump II, the Navy's third Antarctic Developments Project. Highjump II, to be led by Rear Admiral Richard Byrd, would extend U.S. claims, expand aerial mapping of the continent, test new equipment, and advance scientific knowledge. Lloyd Berkner, as a radio engineer-operator on Byrd's initial expedition to the Antarctic in 1928–30, completed in May 1949 a report for the National Academy of Sciences that recommended a coordinated program of U.S. scientific research in Antarctica. Berkner's report drew support from the new interagency Technical Advisory Committee on Antarctica. Three months later, Truman, seconded by Defense Secretary Louis Johnson, decided to save funds, and at the same time remind Senator Harry Byrd that he opposed Truman's reelection in 1948, by canceling Highjump II.

In April 1950, Berkner attended a party held at physicist James A. Van Allen's home in Silver Spring, Maryland, to honor Oxford geophysicist Sydney Chapman.[156] Van Allen, a Navy veteran, now supervised Johns Hopkins' High Altitude Research Group. During the festivities for Chapman, Berkner proposed to organize and hold a third International Polar Year, whose program would be patterned on but expanded far beyond the studies conducted during its 1882–83 and 1932–33 predecessors. In June, the Soviet Union claimed priority from Fabian von Bellingshausen's voyage in 1819–21, which overlapped and encountered that of American Nathaniel Palmer in 1920–21.[157] The Soviets wanted to participate in any international meeting convened to settle Antarctic claims and would not recognize the legality of any agreement that they did not help to formulate. When the International Council of Scientific Unions (ICSU) met in Amsterdam in October 1952, Chapman suggested changing the new polar year's name to the International Geophysical Year (IGY). In July 1953, the ICSU established the Comité Spécial de l'Année Géophysique Internationale (CSAGI), whose directing Bureau included Berkner, Chapman, Belgium's Marcel Nicolet, France's Jean Coulomb, and Soviet economic and structural geologist Vladimir V. Beloussov. Chapman, who left Oxford in 1953 for research in Alaska and at the University of Colorado's High Altitude Observatory, was appointed the Bureau's president. Berkner, who led the Associated Universities consortium that included the Brookhaven National Laboratory, served as vice president and Nicolet became the secretary general. Within 2 years, the IGY gained international approval and participation. Plans for the IGY called for participating scientists, from many more nations than during the two earlier Polar Years, to work in both polar areas but especially in Antarctica, along the equator, in three pole-to-pole areas flanking selected meridian strips, and in space. Astrophysical, geodetic, geophysical, glacial, gravimetric, meteorological, oceanographic, seismological, and other observations would be made at and above (via balloons and sounding rockets) many ground sites during the 18-month interval in 1957–58 of maximum sunspot activity in that 11-year solar cycle. Vice Admiral Archibald Day, the Royal Navy's former Hydrographer, was brought in as the IGY's Coordinator in 1956 to oversee the programs and the world data centers.

The U.S. National Committee for the IGY, established by the National Academy of Sciences and the National Research Council (NAS–NRC) in March 1953, replaced the earlier informal group founded in 1950. UCLA physicist-geophysicist Joseph Kaplan, an NSF consultant who also served on the ICSU's Committee on

Space Research, chaired the U.S. IGY Committee. NBS physicist Alan H. Shapley served as the Committee's vice chairman and the NBS's Hugh Odishaw was its executive secretary and later director. The U.S. IGY Committee included among its members Allen Astin; Lloyd Berkner, also a rear admiral in the U.S. Naval Reserve (USNR); Lyman Briggs; Laurence Gould; Paul Siple; Athelstan F. Spilhaus, at the Woods Hole Oceanographic Institution; and Merle Tuve of the Department of Terrestrial Magnetism (DTM) at the Carnegie Institution of Washington. Berkner supervised the Committee's rockets and satellites program, and Gould chaired its Antarctic group; these were 2 of the Committee's 18 working groups and technical panels. To support U.S. activities for the IGY during fiscal year 1954–55, the NSF supplied $2 million. The Army Engineers founded in 1953 an Arctic Construction and Frost Effects Laboratory by combining their Snow, Ice, and Permafrost Research Establishment with their Frost Effects Lab. Before April 1954, the State Department created an ad hoc interdepartmental committee to coordinate U.S. policy for and claims in Antarctica and expected Admiral Byrd to fill any gaps during the 1954–55 expedition.

In July 1954, NSC 5424 persuaded Eisenhower that the IGY, especially its work in Antarctica, would be significant for peaceful as well as military uses by the United States, even though the NSC estimated the continent's strategic and resource value as low. Scientific programs there would add to the administration's ongoing efforts to reduce international tensions while also helping to enforce existing U.S. rights and monitor Soviet activity. The President approved the paper's recommendations to increase exploration and mapping, establish permanent stations, and begin scientific investigations. He asked Congress for supporting funds, and the Navy continued its logistical aid. When the CSAGI met again in Rome during September–October 1954, its members considered a list of nearly 30 proposed stations in Antarctica, including those at Little America, on Marie Byrd Land, and at the South Pole suggested by the United States. During January–February 1955, 276 men, including William Davies; seismologist Daniel Linehan, director of Weston Observatory of Boston College; and Highjump veteran Walter Sullivan, of the *New York Times*, sailed to the Ross and Weddell Seas in Navy icebreaker *Atka*,



This view, taken in 1957, shows USGS cartographer Dean Edson using a Twinplex stereoscopic plotter at the Topographic Division's Western Region headquarters in Sacramento, California. Members of the Topographic Division widely used Twinplex stereoplotters, with ER–55 projectors, in compiling maps from aerial photographs in the late 1950s and early 1960s. Bausch and Lomb produced its Balplex as the commercial version of the Twinplex. The Division abandoned further development of the Twinplex after the advent of successful super-wide-angle photography, which eliminated the problems associated with using convergent or transverse low-oblique photos in aerotriangulation. The Orthophotoscope subsequently replaced the Twinplex. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., pef00223, https://www.sciencebase.gov/catalog/item/51dda09de4b0f72b4471ddab; published in Yochelson and Nelson, C.M., 1979, p. 34.)

Topographic engineer and photogrammetrist Russell Kerr Bean (1900–76) originally worked for the USGS in 1923–26. He spent subsequent years in industry and with the Army Engineers and later worked for the Tennessee Valley Authority in its cooperative mapping with the USGS before rejoining the USGS in 1941. He led the Arlington (Virginia) office of the Topographic Branch (later Division) during 1944–47, the Photogrammetry Section (later Branch, 1947–59), the Research and Design Laboratory (1958–59), and the Research and Design Branch (1959–60), before becoming Assistant Chief Topographic Engineer and Chief of the Office of Research and Technical Standards (1960–63). Bean retired in 1963. Bean and his colleagues improved the Kelsh plotter and developed the ER–55 projectors used in the double-projection Twinplex plotters that replaced the Multiplex units. In 1950, Bean and his team began developing the Orthophotoscope. The new instrument subsequently revolutionized map compilation and production and facilitated the completion in 1991 of topographic coverage (at 1:24,000) of the conterminous United States. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Last Name A–B" folder as Public Inquiries Office 63–05; see also Radlinski, 1985, and Evans, R.T., and Frye, 2009, fig. 26.)

the Coast Guard's former *Southwind*. From February 1, *Atka* formed part of Task Force (TF) 43, the Naval Support Force Antarctica (NSFA), led by Rear Admiral George Dufek, retired but now also reactivated like Byrd. TF 43 drew aid from the Navy's month-old Air Development Squadron 6. The NSFA assumed responsibility for supporting all U.S. efforts in Antarctica on February 1, 1955. Davies examined the geology of several locales, and Linehan assessed ice thicknesses as part of the cruise's evaluation of ice conditions and selection of potential sites, including one at Kainan Bay for the next Little America, for U.S. participation in the IGY.[158]

The Topographic Division, to its SIR appropriation of nearly $11,500,000 for fiscal year 1954–55, added $3,180,000 from other Federal agencies, nearly all of which came from the $1,045,000 transferred by the Army and its Engineers and the $979,000 shifted by the Air Force. The USBR transferred $902,000, representing a loss of $264,500, and the AEC shifted $159,000, or $39,500 less than the previous year. States, counties, and municipalities supplied about $1,233,000. The Topographic Division survived the cuts by Congress and the transfer agencies far better than the Geologic Division; the former's total of $16,019,000 for 1954–55 represented a loss of only some $8,400 compared to 1953–54. Continued technological improvements enabled the Division to reduce its permanent staff by 6 percent while increasing its square-mile coverage by 15 percent. The mapping program in fiscal 1954–55 continued to be directed largely toward national-defense requirements, but plans were made to begin mapping in areas related to implementing portions of the new Watershed Protection and Flood Prevention Act[159] of August 4, 1954, and to accommodate the anticipated priority requirements of civil defense. During the year, overall coverage of the continental United States increased to 73 percent. Good-quality maps now showed 37 percent of the same surface, representing a 4-percent increase. By fiscal year's end, 142 maps, including 5 for the Hawaiian Islands, of the 1:250,000 U.S. civilian series were made available to the public. Total new mapping, including surveys in the Territories, reached almost 133,000 square miles, of which 36 percent was at 1:24,000; revisions involved more than 9,000 square miles. The 5-year cooperative mapping project in Kentucky was almost finished by year's end, and State officials began a program of maintenance for maps that depicted more than 40,000 square miles. The DoD requested dual coverage, at 1:25,000 and 1:50,000, of an area of 16,600 square miles in Texas. The DoD also asked for an early completion of Alaska's 1:63,360 maps; as a result, 31,000 square miles were mapped in Alaska during 1954–55. The DoD also wanted a new 1:250,000 series of the Territory. The Topographic Division published new revised-base and shaded-relief editions of Alaska Map E at 1:2,500,000.

During 1954–55, the Topographic Division also let contracts for nearly 183,700 square miles of precision aerial photography, of which some 133,400 was of the more efficient twin low-oblique type, to support its mapping program. One of the largest contracts called for photographing the 121,800 square miles of Alaska's Brooks Range to support a pioneer venture in 1:250,000 mapping from transverse low-oblique photographs. In addition, the Division obtained from the Air Force about 118,000 square miles of photographic coverage. The Twinplex plotter, patented on December 14, 1954, entered production during the year. Design work by Russell Bean and his team on the Orthophotoscope neared completion; the new instrument converted conventional-perspective photographs to the equivalent of orthographic photographs. By simple or differential rectification, the Orthophotoscope eliminated the image distortions on air photos caused by camera tilt and terrain relief. Two new KC–1 (formerly T–12) aerial cameras were delivered to the Division. Some commercial-contract work used federally owned T–12 cameras, equipped with nearly distortion free lenses, and the Division began a new system of checking contractors' cameras to determine their acceptability before they were used in Division projects.

The Water Resources Division's funds for fiscal year 1954–55 rose by $345,000 to a total of $13,901,000. The Division received more than $6,658,000 in SIR funds, a loss of $73,000 from the previous year, of which $3.8 million was limited to the cooperative work with the States and their smaller political entities. Other Federal sources provided about $12,857,000. The largest transfers included $1,049,000, a $21,000 reduction from the previous year's contribution, from the Army and its Engineers, and $723,000, an $85,000 loss from the USBR. The Division received nearly $4,077,000 in reimbursements and direct payments from States, counties, and municipalities; as before, California, Texas, and New York provided the largest amounts of these cooperative funds. In September 1954, Carl Paulsen transferred the Columbus (Ohio) Equipment Development Laboratory (CEDL) from the Office of the Chief of the Surface Water Branch to the Office of the Chief Hydraulic Engineer; in December 1955, he assigned the CEDL to the Technical Coordination Branch. Arthur Frazier became the local representative in Columbus of the Technical Coordination Branch's Research Section, and Keith S. Essex shifted from Denver in June 1956 to lead the CEDL.

On May 13, 1954, Eisenhower signed legislation that established the Saint Lawrence Seaway Development Corporation,[160] modeled on the TVA and earlier supported by Truman, to construct the seaway in cooperation with a similar organization in Canada. In June 1955, the 25-member U.S. Commission on Intergovernmental Relations, formed by Eisenhower in September 1953, and chaired by Clarence E. Manion, Dean of Notre Dame's Law School and manager of the Manion Forum, reported its findings to the President. The Manion Commission recommended providing greater initiative and responsibilities to the States for water-development projects, including those involving more than one basin.

The Surface Water Branch obtained records of streamflow data at more than 6,800 sites in the 48 States and in Alaska, Guam, and Hawaii. Those records included 4,400 collected in cooperation with 187 agencies of States and their political subdivisions and 1,700 for other Federal agencies. Studies included water use by industry, frequency of floods, and flow in open and constricted channels. Field tests began on battery-powered, electronic, low-velocity flowmeters in locations where the standard units were insufficiently accurate. Compilation of all streamflow records in the United States between 1888 and 1950 increased to 57 percent of completion. Branch members continued to measure available water to help fulfill the U.S.-Canadian treaty on their boundary waters and the 17 existing interstate contracts for apportioning and dividing interstate waters; they also planned to contribute to the 2 other interstate contracts being negotiated. The U.S. Supreme Court appointed Paulsen as the Master for the Delaware River; as such, he administered the Justices' decree for diverting water from the Delaware to supply New York City and the release of water to improve the river's low flow.

The Branch's preparation of special reports on floods continued in 17 States, and Branch hydrographers began a nationwide study of flood frequency as part of the Division's responsibility, shared with the Weather Service, for collecting basic data to carry out provisions of the Watershed Protection and Flood Prevention Act. That statute, cosponsored by the two Republican chairmen of the congressional Committees on Agriculture and Forestry in the 83d Congress—Kansas' Representative Clifford Hope and Vermont's Senator George D. Aiken—authorized "the Secretary of Agriculture to cooperate with States and local agencies in the planning and carrying out of works of improvement for soil conservation and for other purposes."[161] The new law provided for coordinated programs in small-watershed districts, those not larger than 250,000 acres, in cooperation with the Soil Conservation Service. The statute enabled watershed reservoirs to be built only for flood control and irrigation. Subsequent Congresses appropriated $29.5 million to carry out these measures and passed comprehensive amendments and new legislation to allow the addition of municipal and industrial water supply, fish and wildlife development, and recreation facilities as appropriate components of the projects.

The Branch continued its comprehensive sediment-monitoring programs in the Colorado, Missouri, and Rio Grande Basins and similar projects in conjunction with the Soil Conservation Service in small watersheds in Kentucky, Nebraska, North Carolina, Oklahoma, Texas, and West Virginia. The Branch released a report by Bruce Colby and Charles H. Hembree on the Niobrara River's total sediment discharge near Cody, Nebraska; the results were based on improved and simplified methods for computing those numbers. In a similar report, these authors analyzed sediment sources and erosion processes typical of areas like the upland gullies in Nebraska's Dry Creek Basin. Research projects underway included those on aggradation and degradation in alluvial channels, sediment transport, the radioactivity of natural water supplies, the backwater effects of channel constrictions, the distribution of flow in multiple-opening river crossings and through culverts, new techniques for measuring water loss from reservoir and land surfaces, and more rapid computation of streamflow records.

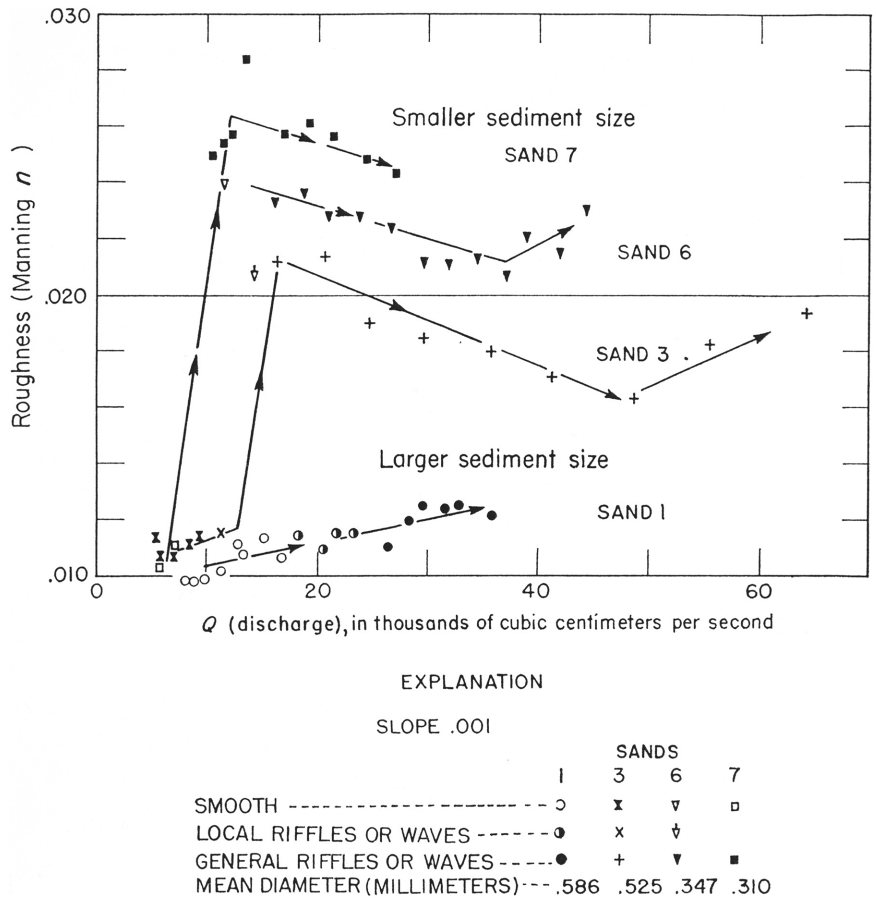
Members of the Ground Water Branch were involved during fiscal year 1954–55 in more than 500 projects, in 40 States, Guam, and Hawaii, that involved determining the occurrence, quantity, quality, and recharge potential of underground water resources; the occurrence and quality of inland saline waters; the nature and extent of saltwater encroachment in coastal areas; the hydrological details of mining areas and oil fields; and the amount of water lost to phreatophytic vegetation of no direct benefit to humans. One of the most significant of these groundwater studies involved the Minidoka pumping project in Idaho, the initial Federal reclamation development in the United States based on groundwater. USBR and USGS studies were designed to provide data for local decisions on tapping for irrigation the water in the basalt beneath the Snake River Plain. During the year, the Branch issued a series of areal geologic maps, bringing the total to 89 quadrangles mapped at 1:62,500 in cooperation with the Bureau of Indian Affairs; the maps depicted most of the 20,000 square miles of the Navajo and Hopi Indian Reservations in Arizona, New Mexico, and Utah. These maps were intended primarily for use in developing well-water supplies and were also for use in locating mineral and fuel resources. Ongoing research and development projects involved factors in the artificial recharge of groundwater and the design and development of geophysical-exploration units and electrical-analog analyzers for water wells. Herbert E. Skibitzke and Geraldine M. Robinson developed a method that used resistor-capacitor model analogs for solutions of nonsteady flow to solve a flow problem in groundwater systems.

During fiscal year 1954–55, members of the Quality of Water Branch determined the chemical quality of some 64,000 water samples, most from about 450 regular stations; 9,000 of these samples came from wells and springs. The Branch issued a two-volume compilation, by chemist Edwin W. Lohr and Kenneth Love, of the industrial utility of America's public water supplies during 1952; these books contained the results of chemical analyses of water from 1,315 of the Nation's larger cities that superseded a similar report published in 1932. The new report formed the initial publication of a new series intended to provide comprehensive information about the chemical quality of surface water used for irrigation in the United States. Branch members hoped that long-term records would aid in determining water quality prior to irrigation development, the extent of water-quality impairment due to drainage return, the requirements for maintaining proper salt balance, and methods for a more equitable distribution of water supplies. Continuing to assert that increasing amounts of radioactive waste affected the real and potential contamination of water, they compiled data on background levels of radiation and continued their research on techniques aimed at producing a limited program of systematic radiometric sampling and interpretation. Branch members

This view of the Saskatchewan Glacier, looking west, was taken from Parker Ridge on July 11, 1952. To increase the understanding of water in its solid form, USGS geologists resumed the work of the agency's François Matthes (1874–1948) on glacial characteristics, mechanisms, and deposits. In 1952, Mark Meier began a 3-year study of surface- and depth-flow velocities and modes at 51 stations on the Saskatchewan Glacier, the principal outlet of the Columbia Icefield, in Banff National Park in Canada's Alberta Province. A seismic survey of the valley glacier's bedrock channel by Clarence R. Allen (Caltech) in 1952 aided Meier's investigation. (From Meier, 1960, pl. 6.; also available in the USGS Denver Library Photographic Collection as Meier, M.F., mmf00010, https://www.sciencebase.gov/catalog/item/51dd8abbe4b0f72b4471c2e0. See also Colbeck, 1996.)

continued to contribute to the Division's inventory of the occurrence and quality of all of America's saline-water resources, but they concentrated on detailed evaluations of those in North Dakota and Texas. The Division advanced an investigation, begun at the request of the National Security Resources Board and renewed in 1953 by the Business and Defense Services Administration, of the Nation's critical areas of industrial production by issuing reports on Indianapolis, Mobile, Oregon's Portland, San Francisco, Steubenville in Ohio, and Wheeling in West Virginia. Comparative studies also began or continued of the amount of water estimated to be required and the amount actually used by the acetate-fiber, aluminum, carbon-black, copper, paper-pulp, petroleum, and rayon industries.

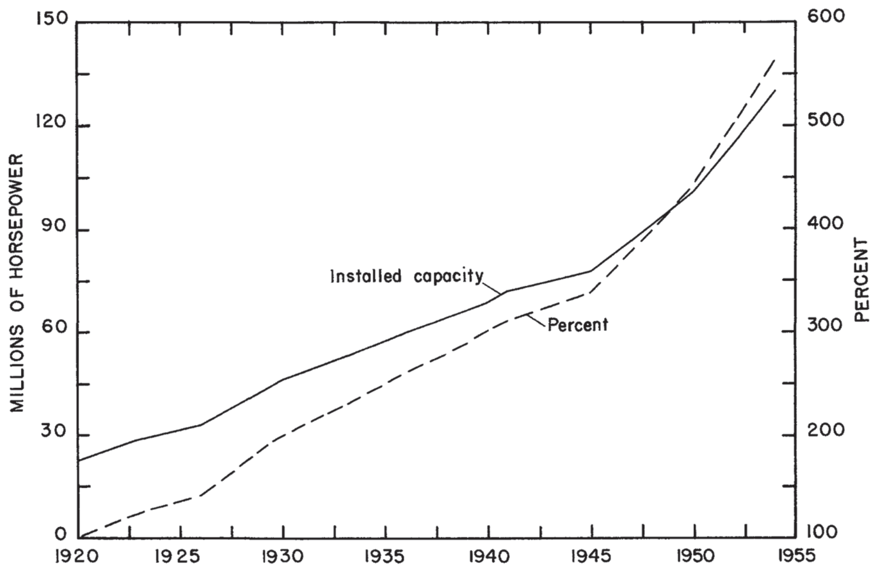
Members of the Water Resources Division continued investigations in U.S. possessions and in areas outside American jurisdiction, the latter with the FOA's continuing support. The Division's ongoing detailed assessment of American Samoa's water resources became more significant as American Samoa gained regular services by sea and by air. Longer term projects abroad involved seven groundwater and two surface-water studies. In 1954, Mark F. Meier, aided by Charles R. Allen's 1952 seismic investigation of the Saskatchewan Glacier's bedrock channel in Alberta, completed a 3-year study of flow modes in the glacier, the principal outlet of the Columbia Icefield. Allen earlier investigated the Taku Glacier near Juneau in Alaska. In May 1955, Robert J. Dingman began a long-term study of Chile's groundwater resources. Work in Africa and Asia included a groundwater reconnaissance in the Anglo-Egyptian Sudan (the Republic of the Sudan from 1956) and the continued gathering of water-resources and flood-control data in India, where USGS hydrologist Luna Leopold and Thomas Maddock, Jr., the Chief of the Bureau of Reclamation's Irrigation Division and chief irrigation analyst for the second Hoover Commission, spent the spring of 1955 with George C. Taylor, Jr.'s USGS investigation. Roger Baker joined the Division's FOA-supported and continuing investigation of Pakistan's water resources. During October 27–November 20, 1954, Philip LaMoreaux and six colleagues from Thailand's Geological Survey and its Royal Irrigation and Public Health Departments completed a reconnaissance of geological and mineral resources of the Khorat Plateau in the



This graph shows the relations of flume-bed roughness, measured by Manning's *n* (roughness factor), and water discharge (*Q*) for four sands of different diameters. Hydrologists Luna Leopold (USGS) and Thomas Maddock, Jr. (Bureau of Reclamation, later USGS), derived the relations by analyzing published data from studies at the U.S. Waterways Experiment Station. In the hydraulic geometry of river and steam channels (principally in the Western United States), they demonstrated, "for the same slope and discharge, the effect of decreasing particle size is a tendency to increase the roughness even when the condition of the bed is observed to remain the same." They also noted that "with no change in particle size, a change in bed configuration may violently change bed roughness and its effect may be of the same or greater order than the effect of differences in particle size." Depth, suspended load, velocity, and width determined the shape of natural stream channels, and these hydraulic factors varied "with discharge as simple power functions." As average river channel-systems developed, they produced "an approximate equilibrium between the channel and the water and sediment it must transport * * * even in headward ungraded tributaries and in a given cross section for all discharges up to the bankful stage." (Graph and quotations from Leopold and Maddock, 1953, fig. 30 and title page and p. 1 and 41.)

northeastern part of the country. Division personnel also trained colleagues on field projects in Egypt and other countries; hydrologists from Canada, Colombia, Cuba, Egypt, and Thailand improved their expertise while with the USGS in the United States.

The Conservation Division received $1,746,000 during fiscal year 1954–55, a sum that represented a gain of $106,000 from 1953–54. The new total included SIR funds of $411,000 for classifying mineral and waterpower lands and more than $1,291,000 for supervising mining and oil and gas leases. Two new laws enacted during the fiscal year influenced the Division's work. On August 13, 1954, a statute amended the mineral-leasing and mining laws "to provide for multiple mineral development of the same tracts of the public lands."[162] A second statute, signed on June 16, 1955, authorized "agricultural entries under the nonmineral land laws of certain mineral lands * * * to increase the limitation with respect to desert entries"[163] from 160 to 320 acres. During the year, members of the Mineral Classification Branch handled over 24,000 cases, nearly 4,000 fewer than in 1953–54, and made required reports on field examinations of geologic structures, coal fields, oil and gas fields, and dam sites in California, Colorado, Kansas, Louisiana, Montana, New Mexico, Washington, and Wyoming. Specialists in the Water and Power Branch evaluated the power resources and storage possibilities of 13 dam sites along 242 channel miles of rivers on Federal lands in Alaska, California, Colorado, Montana, New Mexico, Oregon, and Washington. A general survey of the world's developed and potential waterpower accompanied the completed reports of specific earlier surveys. New additions of some 7,250 acres and elimination of about 67,000 acres left the power-site reserves in Alaska and the conterminous States at about 7.1 million acres, a subtraction of almost 60,000 acres from the



This diagram shows the global growth of waterpower facilities during 1920–54. The installed capacity of U.S. waterpower plants rose from 7.5 million horsepower in 1920 to 34.7 million horsepower in December 1954, while the world's capacity increased at a greater percentage from 23 million to 129.7 million horsepower. The United States' share of the world's total installed capacity fell during the same interval from 32.6 to 26.8 percent. After World War I, the USGS studied the world's waterpower installations and their capacities. The subsequent report on the world's waterpower formed Part II of the "World Atlas of Commercial Geology," a reference used at the First World Power Conference in London in 1924 (see Rabbitt, M.C., 1986, p. 217, 249–250). In the 1950s, specialists in the USGS Conservation Division resumed these investigations. (From Young, 1955, fig. 1, based on data in table 1.)

previous year's total. The Mining Branch supervised leases on about 1,810 properties in Alaska and 32 States that produced more than 18.8 million tons of asbestos, bentonite, coal, feldspar, lead, manganese, mica, phosphate, potash, quartz crystals, quartzite, sand and gravel, sodium, and zinc. That output returned to the Treasury more than $5.4 million in royalties, a year's gain of more than $956,000. The Oil and Gas Leasing Branch oversaw nearly 95,900 oil and gas properties on the public lands in Alaska and 23 States, some 3,700 acquired land leases, and 10,900 leaseholds on Indian lands. Initial sales of offshore oil and gas leases began on October 13, 1954. Royalties from the oil, natural gas, gasoline, and butane produced from all leases totaled about $60.5 million, about $7.9 million less than in 1953–54.

Eisenhower continued to pursue peace while enhancing America's defenses against the growing challenges from the Soviet Union and the People's Republic of China. In July 1954, as the delegates in Geneva reached an agreement about Indochina, the two Chinas continued their low-level conflict. In August, Zhou Enlai announced his country's continuing intent to liberate Taiwan; Eisenhower replied that the U.S. 7th Fleet would repel any attempted invasion. In September, Communist Chinese forces shelled the Nationalist-held islands of Quemoy (Jinmen) and Matsu, just off the mainland and of symbolic value only. In return, Nationalist artillery struck a nearby island held by the Communists. Although Chiang's government signed a mutual-defense treaty with the United States on December 2, the agreement with the Republic of China did not include American protection of the small, Nationalist-held islands along the Communist coast. On January 22, 1955, Congress authorized the President to use force to protect Taiwan and the Pescadores (Penghu Islands) from attack. After the U.S. 7th Fleet helped the Nationalists to evacuate, during February 6–13, 1955, the less defensible Tachen (Taizhou) Islands, Secretary Dulles announced on March 3 that U.S. protection would be extended. The Chinese Communists discontinued their attacks on the other offshore islands held by the Nationalists to lessen the risk of a general war. On January 1, the United States began providing economic assistance to Cambodia, Laos, and South Vietnam. Zhou's offer to negotiate with the United States and Taiwan arrived in April.

On August 30, 1954, Congress and the President revised the Atomic Energy Act of 1946 to help foster the peaceful uses of atomic energy by authorizing the AEC, or its licensees, to distribute abroad, at domestic costs, to any nation or individual special nuclear, source, and byproduct material, unless it "would be inimical to the common defense and security."[164] All such export licenses would be suspended in times of war or national emergency. The modified law required the AEC and the President to approve all nuclear cooperation with other nations or regional defense organizations. The statute also allowed private power companies to develop peaceful atomic-energy projects, to own reactors and nuclear materials, and to take out patents to be shared for 5 years with other companies. The TVA could not then accommodate both the growing demand for power for the AEC at Oak Ridge and the rapid growth of normal consumer demands in the Tennessee River Valley, without enlarging its generating and transmission facilities. The administration preferred that the TVA not be allowed to do so. Instead, Lewis Strauss's AEC awarded a Federal contract on October 5 to Middle South Utilities, Inc., and the Southern Company (the Edgar Dixon-Eugene Yates group) to build a generating plant at West Memphis, Tennessee, and feed power into the TVA system and supply the Memphis metropolitan area. The AEC's action gave the Democrats a major issue for the midterm elections.

The Eisenhower administration's "New Look" in national-security policy did not end interservice rivalry over funds and turf, especially for guided missiles. As historians Walter Boyne and Michael Neufeld described, each of the three services claimed dominion over most of those new weapons.[165] The Army and Navy portrayed them as longer range artillery, and the Air Force promoted them as pilotless bombers. The Truman administration gave the USAF operational control of surface-to-surface strategic missiles, while the Army received responsibility for tactical and anti-aircraft missiles. Counsel for the USAF's effort came from its Science Advisory Board, established by General Arnold during World War II and still chaired by Theodore von Kármán, who also led Caltech's Jet Propulsion Laboratory. On June 30, 1953, General Nathan F. Twining succeeded General Vandenberg as the USAF's Chief of Staff. In response to the Soviet Union's successful test of its hydrogen bomb in August, the Executive Secretary of the National Security Council recommended in NSC 162/2 to the President and the Joint Chiefs of Staff that the Strategic Air Command's nuclear arsenal would be the Nation's first and best deterrent defense. Convair and Martin developed, respectively, the Atlas and Titan liquid-fueled intercontinental ballistic missiles (ICBMs), whereas Douglas developed Thor, an intermediate-range ballistic missile (IRBM). The USAF sponsored these strategic missiles to counter those being developed in Soviet Union and also to supplement SAC's bomber force.

USAF Colonel Bernard A. Schriever (Kármán's coworker) realized that the 1,500-pound thermonuclear device proposed by Teller and von Neumann in 1953 might become a warhead on a lighter weight, and thus longer range, ICBM. Von Neumann succeeded Kármán as chairman of the Science Advisory Board in January 1955; he also led the Strategic Missiles Evaluation Group, also known as the "Teapot Committee," that included Hans Bethe, George Kistiakowsky, Edward Teller, and Jerome B. Wiesner, the Radiation Laboratory and Los Alamos veteran who now directed MIT's Research Laboratory for Electronics. The Teapot Committee advised Air Force Secretary Harold E. Talbott, in whose office Trevor Gardner, another of Kármán's colleagues, served as Assistant Secretary for Research and Development. Talbott, Gardner, and Twining supported Brigadier General (later Major General) Schriever as Assistant Chief of the Air Research and Development Command and head of the Western Development Center, the Ballistic Missile Division from 1957. Schriever proved to be, like Generals Leslie Groves and Curtis LeMay (who earned his fourth star in 1951), a talented manager of a systems program that grew to have more funds and personnel than the Manhattan or B–29 projects.

In February 1955, the NSC and Eisenhower received a requested report from the Technological Capabilities Panel (TCP) of the ODM, formed in April 1954 and chaired by James Killian, Jr. Noting the Soviet Union's own improving, but still medium-range, piston- and jet-engined bombers, ICBMs, and IRBMs, the TCP members warned in their report that their use in a surprise attack might, as Eisenhower believed, inflict a thermonuclear Pearl Harbor. TCP members recommended giving the highest priority to producing and deploying the U.S. ICBMs and future versions underground, developing land- and sea-based and solid-fuel IRBMs, dispersing SAC's forces, developing a high-altitude reconnaissance aircraft, completing the Distant Early Warning (DEW) radar line across Canada to gain better intelligence, planning to fight limited wars as alternatives to a nuclear Armageddon, developing antiballistic missiles, putting reconnaissance satellites into orbit, and strengthening support for basic-science programs and their application.

To provide early warning of intruding aircraft, the United States built and linked, during 1949–55, computer systems, radar sites, aircraft, and surface-to-air missiles in a Semi-Automatic Ground Environment (SAGE) Defense System. Three radar lines were finished during the same interval—the DEW Line, which extended 3,000 miles along the 69th parallel from Alaska's Barter Island to Thule in Greenland; the Pinetree Line, which was 1,000 miles south of the DEW Line; and, between them, the Mid-Canada Line. Detecting incoming aircraft and alerting SAGE, the Air Defense Command, and SAC would give LeMay the minimum 15-minute warning required to get his standby bombers aloft. Planning, with USGS input on site selection, started toward constructing stations in Alaska and at Thule to detect Soviet ballistic missiles inbound over the north-polar region.

During the early 1950s, the U.S. Army began deploying its own missiles to intercept hostile aircraft, strike targets on battlefields, and deliver warheads to short- and medium-range strategic sites. Bell, Western Electric, and Douglas combined efforts to produce the Nike-Ajax, a two-stage solid- and liquid-fueled missile with three proximity-fused warheads and a range of 30 miles, which entered service in 1952. Work continued on the Nike-Hercules, a nuclear-capable, all-solid-fueled successor, planned to intercept groups of aircraft at altitudes of up to 70,000 (later 100,000) feet and ranges of some 50 (later 90) miles. The Army transferred Wernher von Braun's team from Fort Bliss, Texas, to its Redstone Arsenal at Huntsville, Alabama, and shifted its launch facility for surface-to-surface missiles from White Sands, New Mexico, to Cape Canaveral in Florida. At Huntsville, von Braun, supervised by Army Ordnance Colonel John B. Medaris, led the Guided Missile Development Division's effort to design a nuclear-armed successor to the V–2 and reduce its range to 250 (later 175) miles to increase its payload. Chrysler's Redstone, also powered by a liquid-fueled engine and carrying a separable 4-megaton thermonuclear warhead crafted for smoother reentry, was finally launched successfully in August 1953. Regular production began in 1955, as the Soviets tested their own megaton thermonuclear device. Medaris, now a Major General, took over the renamed Army Ballistic Missile Agency, von Braun became a naturalized U.S. citizen, and he and his team continued work on the Jupiter, a successor missile with a range up to 1,850 miles, to give the Army its own IRBM. NSC 5520, like the Killian report, contained recommendations for developing and placing U.S. satellites in space.

The U.S. Navy also developed a series of cruise and ballistic missiles as it acquired an atomic-powered submarine and planned for similarly powered surface warships, installed its own underwater detection system, placed surface-to-air missiles on a cruiser and a destroyer, planned for aircraft carriers larger than the *Forrestal* class, armed carrier aircraft with air-to-air and air-to-surface missiles, and built wholly new classes of combat and support vessels. On September 30, 1954, the Navy commissioned the initial nuclear-powered submarine, the USS *Nautilus*. In response to a 1950 report of a committee (chaired by Rear Admiral Francis S. Low) that identified the Soviet Union's submarines as the greatest threat to U.S. security, the Navy began deploying its Sound Surveillance System, a network of hydrophone arrays connected to cables in the Atlantic, Caribbean, and Pacific.

The Navy also began building amphibious-assault ships, each designed to embark one marine battalion and its equipment. Beginning in 1954, some Navy submarines sailed on patrol armed with the Regulus I, a liquid-fueled, turbojet-powered, nuclear-armed, and subsonic cruise missile that could be launched, but only when the boat surfaced, on targets initially up to 500 miles distant. The Navy established late in 1955 a Special Projects Office to develop a longer range and solid-fueled IRBM that could be fired from submerged submarines. Lockheed developed the Polaris IRBM to replace the Regulus and perhaps also the Navy's liquid-fueled and surface-launched Viking. On May 24, 1954, the latest version of the Viking research rocket lofted 825 pounds of camera and meteorological equipment to an altitude of nearly 160 miles. The Naval Research Laboratory and Martin hoped to use the Atlas guidance system to enable Viking to reach higher speeds and heights and also longer ranges. Eleven days later, Navy Secretary Charles S. Thomas set 1965 as the limit for developing Polaris.

Senator McCarthy began a national tour in February 1954 to expose what he termed two decades of treason by members of the Federal Government. George Kennan, speaking at Notre Dame, responded by decrying the anti-Communist hysteria. Superpatriotism, Kennan claimed, led toward totalitarianism. Eisenhower worked mostly behind the scenes to oppose McCarthy, especially after the Senator suggested that the President sheltered real or potential subversives. Eisenhower, his own authority now directly challenged, ordered Defense Secretary Wilson to withhold from McCarthy's Permanent Subcommittee on Investigations (of the Committee on Government Operations) information about and testimony by executive branch staff and advisers. For Eisenhower and Attorney General Brownell, the Constitution's separation of powers validated the assertions of executive privilege invoked initially by George Washington in 1796. McCarthy's hunt for Red witches and warlocks, real and imagined, culminated in the Army-McCarthy hearings held by McCarthy's subcommittee and televised, at Eisenhower's request, beginning late in April 1954. McCarthy failed to substantiate his charges of subversives in the Army and elsewhere in the Federal Government. On June 9, before a television audience later estimated at 20 million persons, McCarthy broke a verbal agreement between his staff and Joseph N. Welch, the Army's special counsel, not to slander further a former employee of Welch's law firm. Welch, calling McCarthy cruel and reckless, asked the Senator if he had any sense of decency. Representatives of the press rushed from the chamber to report Welch's puncturing of McCarthy's image and tactics.[166]

Ten days later, Julius and Ethel Rosenberg, convicted and sentenced to death in 1951 as nuclear-weapon spies for the Soviet Union, were executed after Eisenhower refused to commute the sentences to imprisonment.[167] Some thought the Rosenbergs innocent, but one of their three codefendants, convicted and sentenced to 14 to 30 years' imprisonment, and their Soviet spymaster later confirmed the guilt of Julius Rosenberg and Klaus Fuchs. Meanwhile, the Eisenhower administration and Congress continued to test citizens' loyalties. On June 1, the AEC's investigating panel, against the advice of many leading scientists, withdrew the security clearance of Robert Oppenheimer, now Director of Princeton's Institute for Advanced Study, and ended his work as an AEC consultant. Eisenhower himself initiated the investigation when he learned that information received from Teller and others indicated that Oppenheimer was not disloyal although he still might be a security risk. In hearings held that spring, Oppenheimer stood accused of lacking enthusiasm, as did others, unlike Teller and his coworkers, for the hydrogen bomb. The anti-Communist hysteria continued in the United States after McCarthy's fall. On August 24, the Communist Control Act[168] outlawed the Communist Party and further restricted the civil rights of Communists in the United States. The Civil Service Commission reported on October 11 that more than 2,600 persons accused as security risks had been dismissed from Federal jobs and another 4,300 individuals had resigned before their cases were completely evaluated. The Senate examined McCarthy's actions during 1954 and then voted overwhelmingly to censure him for unbecoming conduct contrary to Senate traditions.

Meanwhile, the United States held its regular midterm elections. As before, events and problems abroad and at home influenced the outcome of the November 1954 balloting for the 84th U.S. Congress. The economic recession and higher unemployment that began in 1953 embarrassed the Eisenhower administration and alienated many voters. These factors were augmented by civil rights, or the lack of them, gaps between government and private wages, and alleged corruption in the Eisenhower administration. The Democrats regained control of both houses, gaining a 29-seat majority in the House but only a single-seat edge in the Senate.[169] In July 1953, Eisenhower offered the post of U.S. Solicitor General to Earl Warren, who accepted but did not serve. After Chief Justice Fred Vinson died on September 8, Eisenhower nominated Warren as Vinson's replacement, and the Senate confirmed Warren on March 1, 1954. Less than 3 months later, the Warren Court, in *Brown* v. *Board of Education*,[170] of Topeka, Kansas, unanimously reversed the 1896 doctrine of separate-but-equal facilities in public education as an abridgment of equal protection under the law. Eisenhower did not endorse the decision, but he agreed to obey in carrying out his constitutional responsibilities. In 1955, after the Court ordered nondiscriminatory admission, to be achieved with all deliberate speed, Southern States pledged and acted to maintain their segregation of the races. The National Association for the Advancement of Colored People (NAACP) responded in part by organizing its own boycotts, including opposition to segregated bus service in Montgomery, Alabama, led successfully by the Rev. Martin Luther King, Jr., and others, and supported by the Justices, but opposed, often hatefully and sometimes violently, by some lesser officials and ordinary citizens.

To respond to salary inequities among Federal employees, the 83d Congress and President Eisenhower agreed on September 1, 1954, to amend further the Classification Act of 1949,[171] to ensure that no positions would be placed in or removed from General Schedule (GS) 16 or 17 unless approved by the Civil Service Commission (CSC) or placed in GS–18 unless agreed by the CSC and the President. The new law limited the GS–16 positions to 400, the GS–17s to 115, and the GS–18s to 35. The statute changed the Federal Employees Pay Act of 1945, as amended, to provide compensation for overtime work, call-back overtime, time-in-travel status, and night and holiday work. The law also established work schedules, the basic workweek, criteria for incentive and other awards and promotions, uniform allowances, and a 30-day limit on unused annual leave for which employees would be paid at severance. Additional legislation enacted on August 14, 1957, added five additional supergrade positions—two GS–18s, one GS–17, and two GS–16s—to the Federal rolls. The USGS later gained authority for advancing some of its most productive scientists to the Scientific and Professional 3104 (later ST–3104) positions that were GS–16 equivalents. Nonetheless, the USGS and the rest of the Federal Government lost to industry and academia increasing numbers of its employees in the early 1950s as the pay gap increased, especially after 1953, between the Federal and private sectors. On June 28, 1955, the Federal Employees Salary Increase Act[172] adjusted upward the yearly compensation in the steps of the GS pay scale and those for the corresponding Custodial Services (CS) scale. Under the new schedule, GS–1s started at $2,690 per year and GS–18s earned a single salary of $14,800. Another statute, enacted 2 days later, provided funds for the pay raises and $200 million for mutual-security programs during fiscal year 1954–55. The Critical Skills Reserve Act of 1955 also helped the USGS and the rest of the Federal Government to retain trained personnel.

The nature of the Dixon-Yates (Southern Company) negotiations also received renewed attention during and after the 1954 congressional campaign.

In the new 84th Congress, hearings by the Joint Committee on Atomic Energy disclosed in February 1955 that Adolph H. Wenzell, a consultant to the Bureau of the Budget, participated in the these negotiations while he was vice president of the First Burton Corporation, Dixon-Yates' financial agent. A report by the staff of the Subcommittee on Antitrust and Monopoly, of the Senate's Committee on the Judiciary, summarized the embarrassing Dixon-Yates affair. After the City of Memphis voted to build its own steam-generating plant, President Eisenhower canceled the Federal contract with the two private-power companies on July 11.

Six months earlier, on January 6, 1955, Eisenhower's report on the State of the Union reflected the new domestic political reality: the Democrats controlled the 84th Congress. "We shall have much to do together," the President promised the legislators, hoping that "we shall do it in harmony and good will." If not, perhaps the majorities would not be large enough to override vetoes. Eisenhower reminded Congress that he still held the Federal Government to have three main purposes. "First," the President asserted, we must "maintain justice and freedom among ourselves" and "champion them for others so that we may work effectively for enduring peace." "Second," he continued, we need "to help keep our economy vigorous and expanding, thus sustaining our international strength and assuring better jobs, better living, [and] better opportunities for every citizen." "Third," the President concluded, we have "to concern ourselves with the human problems of our people so that every American may have the opportunity to lead a healthy, productive and rewarding life."[173] Other messages that expanded domestic- and foreign-policy initiatives followed quickly. On January 6, Eisenhower sent to the Senate the mutual-defense treaty between the United States and the Republic of China. His special message of the 11th[174] proposed significant changes in Federal personnel management that not only included pay-scale adjustments but also voluntary group health insurance, adequate and comprehensive training, improved personnel practices overseas, and an increase in travel per diem. The national-security message of January 13[175] sought an extension of the draft for 2 years of active duty in the Army, plus several years in some Reserve capacity, but it also offered as an alternative 6 months of active-duty-for-training, followed by 7.5 years in the Ready Reserve. On the 17th, Eisenhower requested authority for $58.6 billion for fiscal year 1955–56, less than the estimated expenditures of $62.4 billion and receipts of more than $60 million, a $1 billion increase, to aid the administration's continued efforts to balance the budget. Of that total, $40.5 billion, or 65 percent, would support national defense. About $952 million would go to natural resources, $180 million less than in fiscal 1954–55, including $673 million for developing land and water resources. During the year, the President expected U.S. stockpiles of strategic materials to reach 78 percent of completion.[176]

On January 31, Secretary McKay appeared before the House subcommittee on Interior's appropriations, again chaired by Representative Michael Kirwan, to defend the Department's budget request for fiscal year 1955–56. William Norrell continued to serve on the subcommittee, as did Republicans Ben Jensen, who reverted to his earlier role as the subcommittee's ranking minority member, and Ivor Fenton. McKay reported receiving bids of $144 million for drilling rights on the Federal submerged lands and he expected subsequent oil and gas production from new offshore wells eventually to generate $6 billion in royalties, bonuses, and rents. Interior, he estimated, would be able to transfer to the Treasury $57 million in royalties from the $570 million in oil and gas production from the public lands during 1955–56. As the ODM delegated to the Department of the Interior (DoI) the responsibility "for detailed mobilization planning for the production of minerals and metals,"[177] McKay asked for $300,000 for his new OMM and its core staff to evaluate and coordinate resource data received from the USBM and the USGS. McKay and the BoB asked for nearly $424.5 million, a gain of $17.1

million, for the new fiscal year, a sum more than balanced by expected revenues of $428 million, for the DoI's nearly 43,300 employees. "There is no department in America," McKay emphasized, "more important than the one * * * responsible for the natural resources."[178] Interior's budget contained for the USGS $26,285,000, or $1,050,000 less than the sum sought for 1954–55, to support a staff expected to be required to shed 27 of its 5,432 full-time or full-time-equivalent employees, while Interior's total increased by 42. Among the unexpected departees was USGS geologist Robert Garrels, who left for Harvard in 1955.

Kirwan responded by outlining a return to a former policy for conducting the subcommittee's hearings that reflected significant changes in approach and length. He expected complete cooperation from Interior's staff, earlier and more organized submission of estimates and justifications, direct answers to questions, and a limited number of witnesses to facilitate briefer testimony that would require less comment. The Chairman, "never strong for supplementals," promised "to make every effort" to see that the Secretary received "every dime for which you make a request."[179] Kirwan, whose fiscal philosophy was well known by now, supported larger expenditures for the Nation's principal needs. "Again I tell you," he replied, "as I have told the Congress before, there is not anywhere near the money spent on America that there should be. We see today that there are great efforts being made to spend $100 billion on the roads and highways. Well, it is needed, but needed far more than $100 billion for roads is $50 billion for water."[180] Jensen said that he agreed 100 percent.

Kirwan's subcommittee began hearing Assistant Secretary Wormser and the USGS delegation on February 1. Assistant Director Nolan substituted for the ailing Wrather. After reading Wrather's statement into the record, Nolan repeated the Director's view "that the demand for our products seems to be continually increasing."[181] USGS managers faced an increased workload generated by many Federal sources. The President's Cabinet Committee on Minerals Policy recommended an enlarged program of topographic and geologic mapping. Water-resources and energy-resources groups and the Watershed Protection and Flood Prevention Act required additional water-resources information and basic mapping. The President's proposed interstate highway program and other public works needed topographic mapping, engineering geology, and streamflow data. The AEC continued to request information about domestic uranium deposits. Other work resulted from the growing interest in the mineral and energy resources of the public lands, especially those on the Outer Continental Shelf. Nolan expected USGS investigations to produce a better theoretical understanding of groundwater that would facilitate predictions of its movement, contribute to improving and increasing recharge, and determine how best to use any surplus. The new highways, Kirwan noted, would change runoff patterns; as less water would flow into the ground, some kind of action was needed. Kirwan suggested that the USGS "should ask for $50 million,"[182] to study U.S. lands and resources before the next civilian or military crisis occurred.

Before the House subcommittee reviewed the monetary requests by each USGS Division, Nolan concentrated on the agency's regional activity, increasing their operational development as recommended by the Van Pelt Committee in 1954. The Denver Center neared full operation and early work continued at Menlo Park, where, in 1955, the USGS gained title to 7 of the 83 Federal acres adjacent to the 4.5-acre site of Buildings 1 and 2. Efforts toward expansion started in Rolla, and planning progressed for the new building needed for the national center. Nolan requested another $350,000 for detailed planning for the latter project, but he cautioned that the site and building costs were not represented in that amount. Only a day earlier, the General Services Administration's Public Buildings Service informed the USGS that the new national center was one of four buildings on the list for the Washington metropolitan area sent to the Bureau of the Budget. The GSAd would handle, through the recently enacted lease-purchase legislation, the costs of the new national center. Nolan thought the four centers would increase operational efficiency, enabling the USGS to serve better the Nation. During the April 1955 show, the Pick and Hammer players asked, in their "Constructional," sung to that year's "Where will the Dimple Be?," about the new national center: would it be nearby and "[w]ill they build it fore we die?" They decided that "it'll be an awful blow / If it's run by the G.S.A[d]."[183]

Amidst continued requests by members of the subcommittee for increased economy in USGS operations, Kirwan emphasized that the "saving of dollars is not the saving. The saving that you are going to provide, in the way of discovery of minerals, [is] because the real wealth is mineral wealth, whatever it is, when it is discovered."[184] Kirwan, following a philosophy he applied Governmentwide, also hoped that the USGS would match dollar-for-dollar the sums offered by the States for cooperative work in topography and water resources. Jensen renewed his interest in the agency's topographic-mapping program by asking about progress of national coverage and the cost and possible duplication of aerial mapping by Federal agencies. Jensen claimed he was "not critical," and, like the subcommittee's other members, continued to hold the USGS "in high regard." Jensen, as before, emphasized pursuing the consolidation of "most, if not all, of the mapping offices under one agency."[185]

The Senate subcommittee on Interior's budget, meeting with the public-works subcommittee, heard McKay on February 28, 1955. Carl Hayden, again the Chairman, joined three returning Democrats—Dennis Chavez, Harley Kilgore, and Warren Magnuson—and new colleagues Earle C. Clements (KY) and Spessard L. Holland (FL), both of whom had been Governors of their States. Henry Dworshak, William Knowland, and Milton Young continued as Republican members of the subcommittee. McKay, in supporting his bureaus, emphasized that of the additional $399,000 requested for the USGS (the difference between the 1955–56 budget and the adjusted appropriation for 1954–55), one-half represented "a modest increase in water resources investigations."[186]

Wormser and Nolan appeared before the Senate subcommittee on March 4; Wrather remained indisposed. Chairman Hayden, in questioning three relative transfers totaling $184,780 in Federal funds to and from the USGS during fiscal year 1954–55, wanted to know which agency actually got the appropriations. The USGS, Nolan responded, received $167,970 of the total provided. Hayden renewed his preference for transfers over permanent changes. He then asked about the $46.6 million projected to be appropriated for or transferred by other agencies to the USGS in 1955–56, a loss of nearly $1.1 million from 1954–55. Nolan ascribed nearly all of the decrease to monetary reductions expected from the AEC's support for USGS geologic and mineral-resource surveys and mapping, principally due to the huge growth in private exploration for uranium on the Colorado Plateau. By 1955, some 800 mines were producing high-grade ore from 12 principal deposits, and new rushes were underway in areas beyond the Plateau. Yes, Hayden agreed, "some people fear we will have uranium running out of our ears here before long."[187] The $6.2 million the USGS planned to receive from the AEC during 1955–56, Nolan hoped, would be used to continue long-term research on the localization of uranium ores, prepare for future increases in demand, and improve geochemical and other methods of prospecting. The completion of the Kentucky project accounted for all but $40,000 of the projected loss of $235,000 in State funds for cooperative topographic mapping. The USGS asked for an additional $200,000 to meet the increased sum offered by the States for cooperative investigations of water resources. Duncan estimated that oil wells on public and Indian lands would produce petroleum worth close to $400 million, including $50 million in royalties. Without an expenditure of $2 million to $3 million, Duncan estimated, USGS monitors could no longer visit each oil and gas field, but Hayden approved the effectiveness of the overall methods by which the USGS closely verified records on well production and pipeline runs. Duncan added that the $1.3 million, the same sum as the previous year, the USGS required for supervising the mining and oil and gas leases alone ought to return more than $40 million to the Treasury. Nolan, after meeting on March 2 with Donald E. Doyle, Chief of the Public Buildings Service's Projects and Sites Branch, reported less concern about facilities dispersal and confirmed that the proposed national center building for the USGS was "very high on the list of the ones that they are considering"[188] sending to the BoB. The GSAd and the DoI would have to agree on the building's exact location, but Nolan hoped it would be about 10–15 miles from Washington to avoid the congested area, keep the needed close contacts with other Federal agencies in the Capital, and avoid losing employees unwilling to commute to a more distant site. Hayden agreed that it "has to be a suitable location and nearby."[189]

The House-Senate conference committee agreed to provide the USGS with $26,635,000 in SIR appropriations for fiscal year 1955–56. Eisenhower signed Interior's appropriations bill for the year on June 16, 1955.[190] With the $1.65 million in supplemental SIR funds added on May 19, 1956,[191] the USGS reported total funds available to support its staff and operations during 1955–56 of about $49,269,000, some $2,410,000, or 5 percent, more than in 1954–55. Of the total funds available for 1955–56, nearly $27,859,000, or 57 percent, represented SIR monies; some $6,425,000, or 13 percent, came via reimbursement or direct payments from nonfederal sources, and $14,985,000, or 30 percent, came by transfers from other Federal agencies. For a second year, the U.S. Comptroller General continued to be concerned about the effectiveness of the agency's overall accounting methods, and the General Accounting Office's Civil Accounting and Auditing Division began an audit and review of USGS financial administration during fiscal 1954–55.

The second Hoover Commission issued its seven-volume final report just before the beginning of fiscal year 1955–56. The Commission's task forces suggested that properly disposing of surplus Federal property would return some $10 billion to the Treasury. The Commissioners noted that the problems it faced were "by no means purely financial." In making its recommendations for improving the Federal Government, the Commissioners sought to reach six principal objectives: (1) preserving "the full security of the Nation in a disturbed world," (2) maintaining "the functioning of all necessary agencies which make for the common welfare," (3) stimulating "the fundamental research upon which national security and progress are based," (4) improving efficiency and eliminating "waste in the executive agencies," (5) eliminating or reducing "Government competition with private enterprise," and (6), "perhaps the most important of all, strengthening the economic, social, and governmental structure which has brought us, now for 166 years, constant blessings and progress."[192] In supporting increased funding for military and civilian research and development to achieve the third objective, the Commissioners noted that support for the latter,

so important to our national life,[193]

grew from $68 million in 1946 to the $350 million requested for fiscal 1955–56.

Chapter 9.
The Need for More Research, 1955–1958

> **It is both dangerous and poor economy to wait until an emergency is upon us before developing new methods, new concepts, and new applications of the geologic sciences.[1]**
>
> **—Thomas B. Nolan**

As members of the Eisenhower administration assessed the second Hoover Commission's recommendations for improving the Federal Government, they also took major steps to strengthen the North Atlantic Treaty Organization (NATO) and to foster world peace. On March 29, 1955, the Senate ratified the Paris treaties ending the occupation of the Federal Republic of Germany. The agreements reached Bonn on May 5, and West Germany became a formal member of NATO on May 9. British participation in NATO remained crucial, but Britain's leadership at home changed when Winston Churchill, increasingly ill, resigned on April 5. Anthony Eden, twice Churchill's Foreign Secretary, succeeded him as Prime Minister, and the Conservative Party increased its majority in the House of Commons in the national election on May 26. The Soviets remained concerned about their satellite nations in Eastern Europe (especially in view of the United States' announced policies and uprisings like the one in East Germany in 1953), NATO's strength and unity, and an economically strong and rearmed West Germany. On May 14, representatives from eight nations—Albania, Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, Romania, and the Soviet Union—met in Warsaw and signed a 20-year treaty of friendship and mutual defense known as the Warsaw Pact. Tito's Yugoslavia refused to join the agreement. After prolonged four-power negotiations in Vienna during May, Eisenhower signed on June 25 a peace treaty with Austria that returned sovereignty to the country on July 27. Austria, like Sweden and Switzerland, chose not to join NATO.

To try to secure a more tranquil world, President Eisenhower, Prime Minister Eden, French Prime Minister Edgar Faure, and Soviet Premier Nicolai Bulganin, accompanied by Nikita Khrushchev, the Communist Party's First Secretary, met in Geneva on July 21 to discuss peace and related issues. Khrushchev promptly showed Eisenhower who wielded the real power in the current Soviet Government. Eisenhower proposed a mutual "Open Skies" policy that would encourage the exchange of military information and allow reconnaissance overflights to forestall threats of war or surprise attacks. Neither U.S. radar installations in Turkey and elsewhere around the Soviet perimeter nor the planned reconnaissance surveys by balloons in the Air Force's Moby Dick Project[2] provided coverage sufficient to monitor the testing and deployment of Soviet strategic bombers and missiles. Adequate surety depended on information gained from images taken, during flights over Soviet test sites and bases, by high-resolution cameras made by Edwin H. Land's Polaroid Corporation and installed in a new high-altitude reconnaissance aircraft that could fly without refueling at least 4,000 miles at 430 miles per hour and altitudes of 70,000 feet, as recommended by James Killian, Jr.'s panel. After Killian and Land briefed Eisenhower, the President gave the new project to Allen Dulles'

Central Intelligence Agency (CIA), and its management there passed to Richard Bissell. The unarmed U–2, developed from a modified F–104 fuselage by Clarence L. ("Kelly") Johnson's team at Lockheed's secret "Skunk Works" facility, first flew in August 1955. The initial dozen production models of the new spy plane, a long-winged, glider-like aircraft powered by two turbojets, were deployed in the Far East by the Air Force and the CIA. At Geneva, the new Big Four also discussed the unification of the two Germanys and European security. West German militarization led the Soviet Union to oppose unification and reject the West's proposals for enduring European security. The Soviets unsuccessfully sought a European mutual-defense alliance that included a unified Germany but not the United States.

The Eisenhower administration announced on July 29 that the United States planned, as part of its activities during the International Geophysical Year (IGY), supported by the National Academy of Sciences-National Research Council (NAS–NRC) and the National Science Foundation (NSF), to have Project Vanguard place a dozen scientific satellites in orbit some 300 miles above the Earth. As Vanguard's launch vehicle, Eisenhower approved the Defense Department's recommendation to choose the Navy's scientific, but not yet enhanced, Viking rocket, rather than the Army's more powerful, nuclear-capable, and flight-tested Redstone intermediate-range ballistic missile (IRBM). The Soviet Union declared its intention, in *Science* for October 12, to place in orbit its own IGY satellite.

As IGY planning continued during 1955–56, the U.S. Geological Survey (USGS) moved to centralize and increase its capabilities in using electronic computers in mapping, scientific, and administrative operations, including payroll procedures. On February 27, 1956, an amendment to the Survey order[3] that established the Administrative Division in 1953 now founded within the Division a Computation Branch. The Survey order that followed on March 7, 1956, authorized an Advisory Committee on Electronic Computers that would report to the Director through the Executive Committee. The new five-member Advisory Committee, comprising one representative from each Division and one from the Director's Office, would be led by a chairman designated by the Director. The Advisory Committee was asked to "maintain familiarity with computer equipment and be alert to the application of its techniques to the scientific and administrative functions of the Geological Survey." Its members also would review the coordination of "tabulating and computing problems at such times as the available workload capacity of the [Computation] Branch is to be exceeded."[4]

The USGS appropriations for surveys, investigations, and research (SIR) for fiscal year 1955–56 gave the Geologic Division more than $5,718,000 of the $14,494,000 it received that year. The Division remained, as in recent years, heavily dependent on continued transfers from the U.S. Atomic Energy Commission (AEC), which again reduced its funding but this time only by $238,000 to $5,579,000. To the Geologic Division, the Department of Defense (DoD) transferred $1,361,000, the International Cooperation Administration (ICA) shifted $577,000, the Defense Minerals Exploration Administration (DMEA) provided $441,000, and the General Services Administration (GSAd) sent $259,000. From these and other Federal sources, the Division received a total of $8,539,000. The ICA, established within the State Department on June 30, 1955, pursuant to an Executive order of May 9,[5] replaced the Foreign Operations Administration.

Wilmot ("Bill") Bradley had been Chief Geologist for more than a decade, an interval longer than that served by any of his predecessors, and the Division's staff continued to support him. Players in the Pick and Hammer Club's show in April 1956 rejected attractive offers to leave the Division for higher paying jobs in academia, the AEC, consulting companies, or the oil patch. In the ode "Hi–Fi," sung to tune of "My Heart Belongs to Daddy" from Cole Porter's 1938 "Leave It to Me," Bradley knew, the geologists claimed, that they "couldn't be had":

So I want to warn you laddie,
Though your proposition is swell,
Yet my heart belongs to Bradley,
And our Bradley he treats us so well.[6]

Geologists in Charles ("Andy") Anderson's Mineral Deposits Branch mapped and studied the geology of active and potential mining sites as part of 98 projects operating in 29 States in fiscal year 1955–56. As before, Branch personnel worked to improve their understanding of the genesis and geologic setting of these and other mineral commodities and the physical and chemical factors controlling their localization and distribution in the wider crustal framework. The AEC supported 40 of these projects, but, in April 1956, it ended its support for the USGS search for uranium and vanadium on the Colorado Plateau. That physical-exploration program was the largest yet conducted by the USGS and was rivaled only by the agency's effort in Alaska's Naval Petroleum Reserve No. 4 (NPR–4). Beginning in November 1947, cooperative efforts by the USGS and the U.S. Bureau of Mines (USBM) in mapping, criteria development, diamond drilling, and core analyses discovered nearly 2.3 million tons of ore that averaged 0.34 percent uranium and 2.12 percent vanadium and was valued at about $96.5 million. Industry also adopted concepts developed during the USGS program, including the demonstration that buried stream channels in three sites in the Monument Valley of Arizona and Utah, disclosed by geologic mapping, geophysical surveys, and drilling, were favorable sites for uranium deposits. Related geochemical work in the Black Hills also identified some of its carbonate-cemented sandstones as uranium hosts. Branch members devoted considerable effort to mineral-commodity studies and to reviews of information about these commodities. Several major mining companies joined in an exploration program for Utah's Tintic district that used the results of USGS mapping and studies of rock alteration. Additional exploration by industry disclosed a new zinc-mineral district in Tennessee's Copper Ridge area, and USGS geologic maps aided new discoveries of iron ore in Idaho's Blackbird district and Michigan's Iron River district. Fourteen projects involved the Branch's cooperation with State agencies, and Branch scientists also continued geologic mapping and minerals appraisal with Puerto Rico's Economic Development Administration.

Fuel investigations were underway in 13 States during fiscal year 1955–56. Scientists from Ralph Miller's Fuels Branch and colleagues from the Scripps Institution of Oceanography cooperated in collecting and analyzing living foraminifers and sediments from the Continental Shelf to determine variations in types and numbers of species in different environments to aid in understanding the significance of variations in similar faunas from California's oil-bearing Miocene rocks. The USGS, the West Virginia Geological Survey, and several private organizations collaborated in detailed studies of cores from a West Virginia well, the initial one drilled in the heart of the northern Appalachian oil and gas basin that extended through the sedimentary sequence into the basement complex. Branch geologists finished compiling a new edition of the U.S. oil- and gas-fields map. They also compiled reports on the relation of oil-bearing black shales to other rocks in west-central New York and the spore assemblage of Ohio's oil-bearing Upper Devonian–Lower Mississippian rocks and prepared reports on oil shale in the Green River Formation of Utah's eastern Uinta Basin. The Piceance Creek Basin study led to determining that the amount of oil present in its oil-shale deposits was about double the amount previously estimated. Paul Averitt and his colleagues investigated deposits in 10 coal-producing States, published detailed reports on 14 coal-bearing areas, continued appraising coal reserves in 5 States, and began revising the coal map of the United States. USGS maps of the anthracite coals in eastern Pennsylvania provided geologic data and interpretations used in planning mine development and mine-water control in intensely mined areas. Branch scientists also continued intensive studies of uranium in western coals, particularly in the Dakotas, Montana, and Wyoming. The results stimulated interest in commercial production of uranium from coal and led to the industry's discovery of ore-grade uranium in Tertiary coals in northwestern South Dakota.

Representing the increasing emphasis on marine geology and offshore resources by the Fuels Branch and the Geologic Division, a Branch geologist and three colleagues presented papers at a conference on the conservation of the natural resources of the Continental Shelf and overlying waters in the Americas. The conference, held at Ciudad Trujillo in the Dominican Republic during March 15–28, 1956, followed a call made at the 10th Inter-American Conference of the Organization of American States, the former Pan American Union, 2 years earlier in Caracas. Oceanographer John Lyman, who participated in Operation Crossroads at Bikini in 1946 and now directed the Division of Oceanography in the Navy's Hydrographic Office, reviewed the state of knowledge of Continental Shelves in the Americas. James Trumbull discussed the shelves' relation to continents and ocean basins, James Pepper evaluated their potential mineral resources, and Edwin M. Thomasson assessed specific problems related to developing petroleum resources in the Gulf of Mexico.

In fiscal year 1955–56, geologists of Edwin B. Eckel's Engineering Geology Branch continued their detailed mapping and investigations in several States, in five selected and principal urban areas, and on the site for the new academy for the Air Force. Branch members advanced bedrock and surficial geologic mapping in Massachusetts and Rhode Island and began similar cooperative and systematic mapping of quadrangles in Connecticut. Mapping also continued in support of regional planning for the development of roads, dams, and other major engineering works. Branch members made special studies for the National Park Service and the Federal Housing Administration to determine if construction operations at proposed sites would increase landslide hazards. David Varnes and Glenn Scott led a team—including J. Mark Cattermole, Roger B. Colton, Robert M. Lindvall, Paul P. Orkild, George Rozanski, and four other Branch geologists plus groundwater hydrologists William D.E. Cardwell and Edward D. Jenkins from the Water Resources Division—in continuing mapping and providing advice to the Air Force Academy Construction Agency about test wells, overburden, excavations, foundations, and groundwater at the selected site in Colorado Springs. The Air Force Academy, authorized by the 83d Congress and the President on April 1, 1954, opened in Denver in 1955 and moved to its new and permanent quarters at Colorado Springs in 1958. The report[7] by Varnes and Scott on the general and engineering geology of the Academy's site appeared in 1967, and 3 years later, it earned the Geological Society of America's Burwell Award.

Branch members also began planning engineering studies for the proposed interstate highway system. On June 29, 1956, Eisenhower finally reached another of his long-term goals when he signed the Federal-Aid Highway Act[8] that authorized the primarily military system, one whose need he recognized after accompanying in 1919 the Army's initial transcontinental motor convoy and observing the German autobahns after World War II. The 1956 statute provided $32.5 million over the next 13 years for constructing an interstate system of modern roadways and for completing construction of the Federal-aid system of highways.[9]

During fiscal year 1955–56, when William Benson left to serve as Program Director of the NSF's Earth Sciences Program, James Gilluly succeeded Benson as Chief of the General Geology Branch. Under Gilluly's direction, Branch geologists began studies of surficial geology in California's Death Valley and the adjacent Amargosa Valley astride the California-Nevada boundary, and the structural and volcanic history of the intervening Black Mountains (Amargosa Range), as the framework for investigations of the area's saline deposits. They also continued or completed mapping and studies in parts of Idaho's Mackay district and Snake River Plain, the Browning and Toston quadrangles and the Three Forks area of Montana, Nevada's northern Shoshone Range, and the Kemmerer and Sage quadrangles in Wyoming. Cooperative work with State agencies included studies of the Carlin and Pine Valley quadrangles in Nevada and the Norwich area in Connecticut. Three more State geological maps, prepared in cooperation with their geological surveys, appeared in calendar 1955: New Hampshire, at 1:250,000, by Marland Billings; Montana, at 1:500,000, by Clyde Ross, David Andrews, and Irving J. Witkind; and Wyoming, at 1:500,000, by David Love, Joseph L. Weitz, and Richard K. Hose (which had been issued in 1952 in a preliminary and uncolored edition).

In fiscal year 1955–56, members of James Balsley's Geophysics Branch expanded their studies of the physical properties of minerals and rocks with limited funds but improved facilities for measuring electrical resistivity, dielectric constant, magnetic susceptibility, remnant magnetism, and dynamic elastic moduli. They began investigations of rock strength and elasticity, aided by an in-house analog computer designed and built to simulate the resistance and dielectric constant of a layered Earth. These scientists successfully used or prepared to test three experimental loggers for downhole geophysics—for acoustic, alpha-gamma (radon contamination), induced polarization, and thermal (conductivity) measurements—and developed a scintillation core scanner and a time-interval differentiator to identify isotopes. They used a sonar-type ground transducer to demonstrate that the high-frequency sonic method could determine shallow-depth geologic structures. Arthur Lachenbruch formulated a mathematical solution to heat-conduction problems caused by constructing heated buildings on permafrost. Branch members flew some 45,000 traverse miles of magnetic and radioactivity surveys in 14 States and Alaska. Aeromagnetic surveys of sedimentary basins in Alaska's Bethel and Copper River areas returned new data on their configurations and depths. John Henderson, Jr., and Isidore Zietz prepared an aeromagnetic map of Indiana's Precambrian basement, at 1:500,000, showing the average magnetic intensity by contours at intervals of 50 gammas, from similar surveys of 92 counties made during 1947–50. Radiometric surveys on the Texas Coastal Plain demonstrated that results could aid geologic mapping where poor surface exposures made difficult the fixing of formational boundaries. Branch members also continued to add to their expertise by additional academic training; Randolph ("Bill") Bromery completed a bachelor's degree in mathematics at Howard University in 1956 and then began part-time graduate studies at American University. As the fiscal year neared its end, Balsley's "Evils of Prostitution" memorandum to Bradley noted on June 20 that the Geophysics Branch's "most popular hustler, Airborne Surveys Section, has no time of her own." When the AEC took half of its business elsewhere, Balsley had to find $250,000 from other customers or cut loose some of his staff, and so he said yes to a monetary source in Pennsylvania that demanded more cooperation. Airborne Surveys' dowry in 1946 was $160,000 and all her own, Balsley lamented. Now, although in a $300,000 suite, only $80,000 of it represented SIR funds and all of it was promised to the external cooperators. Section members were unhappy, and Balsley thought they would have to stay that way until at least 1959, although he believed their hearts still belonged to Bradley but "this is just about all."[10]

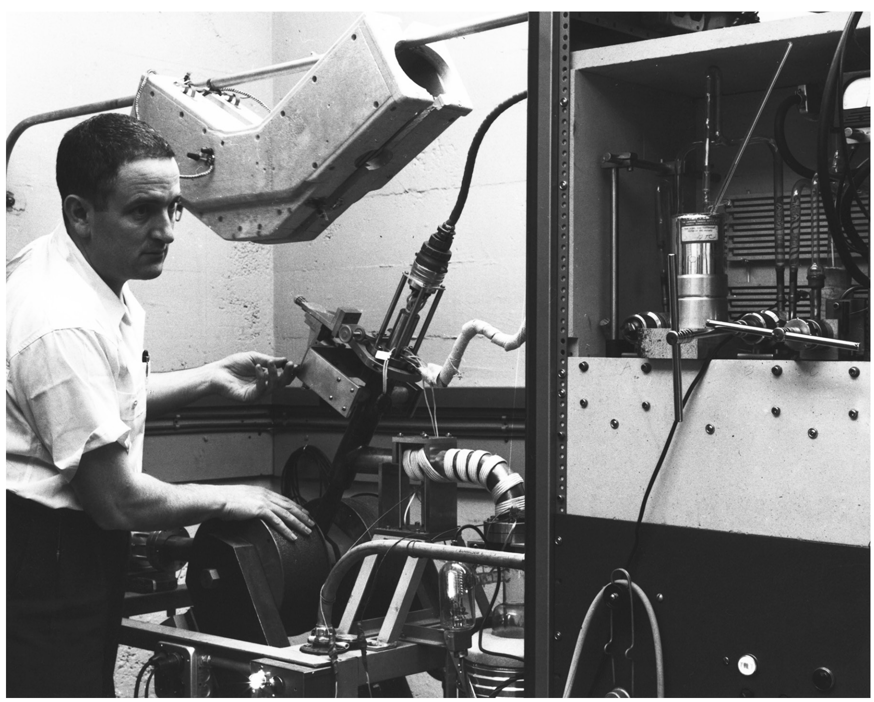
In fiscal year 1955–56, Geologic Division biostratigraphers, geobotanists, geochemists, and petrologists made chemical, mineralogical, paleontological, petrological, radiometric, spectrographical, stratigraphic, and related examinations of about 91,000 samples and specimens from within and outside the United States to support USGS geologic mapping, mineral exploration, and resources evaluation. More specifically, they completed studies of cerium-mineral compositions and all the rare-earth elements as phosphates, began examining methods proposed for disposing of radioactive wastes into geologic environments, and adapted improved instruments and techniques to advance those and related field and laboratory investigations. An X-ray spectrometer used in analyzing substances in thin and polished sections, and in very small samples, saved time. Using a new and rapid optical field


EXPLANATION
Magnetic contours
Contour enclosing area of lower magnetic intensity
LAKE MICHIGAN
Gary
South Bend
Fort Wayne
Tippecanoe
River
Marion
Kokomo
Lafayette
RIVER
Muncie
Anderson
ILLINOIS
OHIO
Richmond
INDIANAPOLIS
Terre Haute
RIVER
Bloomington
FORK
EAST
WABASH
WHITE
Vincennes
New Albany
RIVER
Evansville
OHIO
K E N T U C K Y
N
From Indiana Geological Survey Misc. Map 4, 1953
Compiled by Judson Mead, M. E. Biggs, and P. G. Holloway, 1953
10 0 40 Miles
Contour interval 50 gammas
Relative to arbitrary datum

◀ This map of Indiana (originally at about 1 inch = 33 miles) shows the State's average magnetic intensity by contours at intervals of 50 gammas. After the USGS and the Indiana Geological Survey cooperated in an aeromagnetic survey during 1947–50, the USGS published in 1949–52 magnetic-intensity maps (at about 1:62,500 and with 10-gamma contour intervals) of each of the State's 92 counties. USGS geophysicists John Henderson, Jr., and Isidore Zietz also published an aeromagnetic map of total intensity (at 1:500,000 and with 50-gamma contour intervals); a gravity-intensity map (at 1 inch = about 33 miles and with 5-milligal contour intervals); a same-scale theoretical contour map of the State's Precambrian basement surface, showing structural trends (with 500-foot contour intervals); and 1:250,000 magnetic maps of three counties, showing the correlation of anomalies and oil and gas fields. The USGS began cooperative topographic mapping with the States in 1884. These efforts subsequently expanded to include geologic, geophysical, and hydrologic investigations and maps. (From Henderson, J.R., Jr., and Zietz, 1958, fig. 9.)

test for rare-earth minerals and using automatic sample changer-recorders for the scintillation counters and X-ray diffractometers produced similar savings. Completing investigations of the albite-anorthite-orthoclase and albite-anorthite-orthoclase-water systems promised increased understanding of the geothermometry of feldspar-bearing rocks. Work on the geochronology of Pleistocene terrestrial samples and deep-sea cores produced a reliable sequence of radiocarbon dates for glacial events in North America and climate cycles elsewhere, and initial correlations to the worldwide standard. Checks on lead-alpha radiometric determinations of zircon ages showed them to be about 85 percent valid in rocks with good biostratigraphic control. Results of investigations of oxygen-isotope ratios in carbonates near ore deposits suggested that they might be useful in exploration. A new, inexpensive, rapid, and sensitive analytical method for uranium searches became the latest of the geochemical-prospecting techniques developed by the USGS and then used by governments and industries in other countries.

Reconnaissance investigations of mineral and fuel deposits in Alaska during fiscal year 1955–56 included searches for petroleum in the Lower Yukon-Koyukuk Basin that extended known formations north and west from the Yukon River, geologic mapping in the Nulato-Kateel River area, and studies of potential resources near Puale Bay on the Alaska Peninsula and those around Nelchina northeast of Anchorage. Coal studies, again concentrated in the Alaska Railroad belt, involved additional work in the Matanuska and Nenana fields. Geologists of George Gates' Alaskan Geology Branch continued to map and use systematic geochemical and radiometric techniques in studying mineralized areas, including tungsten and other deposits north of Nome, locales further north in the Baird Mountains, deposits in the Tofty area west of Fairbanks, and those in areas on Prince of Wales Island north of the Kasaan Peninsula and at Bokan Mountain-Kendrick Bay. In addition to continuing the 1:250,000 geologic-map series, they also advanced the glacial map of the Territory and gained improved knowledge of its metallogenic provinces. Thomas Payne published a map, at 1:5,000,000, of Alaska's Mesozoic and Cenozoic tectonic elements.



In this 1958 photograph, USGS geochemist and geophysicist Henry Faul (1920–81) adjusts a sample of biotite at the focal point of a mass spectrometer in the Geologic Division's Nucleonics Laboratory in Washington, D.C. Faul, educated at the Massachusetts Institute of Technology, served with the Manhattan Project (1943–46) before joining the USGS. There, he and other scientists used the mass spectrometer, the single-channel analyzer, and other laboratory instruments to determine the physical and chemical properties of minerals and rocks. By the lead-alpha method, which Faul helped to develop, and other uranium-based techniques, they fixed the radiometric ages of zircons and other minerals enclosed in igneous rocks. These techniques were supplemented by the use of potassium-argon (K-Ar) dating in the early 1960s. Faul left the USGS for posts in academia—the Southwest Center for Advanced Studies in Dallas (1963–66) and the University of Pennsylvania in Philadelphia. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., pef00489, https://www.sciencebase.gov/catalog/item/51dda0a0e4b0f72b4471ddaf; published in Yochelson and Nelson, C.M., 1979, p. 36.)

In fiscal year 1955–56, specialists in Frank Whitmore, Jr.'s Military Geology Branch (MGB) continued their work worldwide, principally for the Army and its Engineers. In 1956, the geologists and soils scientists in Frederick Betz, Jr.'s team in Europe began issuing from Heidelberg a second set of maps of West Germany, at 1:250,000, with data on construction materials, engineering geology, road construction, rock types, and terrain; with Soil Conservation Service (SCS) participation, they completed the maps on 20 sheets in 1961. Betz's team also continued to instruct and direct NATO personnel in the techniques of producing those maps. Mario A. Conti completed a lithologic map of Italy, at 1:1,250,000, that emphasized construction materials and underground installations. Betz's group in Salzburg closed its shop when the four-power occupation of Austria ended in July 1955. The principal request among a large number made by the Far East Engineer Command in Tokyo involved the discovery and evaluation of water resources for military use in the Republic of Korea. Members of the Pacific Geologic Mapping Program, now led by Gilbert Corwin as Charles Johnson's successor, returned to the Ryukyu's Ishigaki, southwest of Okinawa, to extend a military geology and mineral-resources reconnaissance at 1:50,000; Delos Flint and Raymond Saplis completed and issued the results in 1954. During June 1955, a team that included Richard J. Alois, Raymond Fosberg, Helen Foster, Harold May, and Carl Stensland begin mapping and studying Ishigaki's geology, soils, and botany; they completed their work in October 1956. The team finished its final reports on general and engineering aspects, mapped at 1:25,000, and tactical aspects of the terrain, at 1:50,000, in 1959–60. Also in 1960, David Doan, Fosberg, and James Paseur reported their similar investigations, with maps at 1:25,000, in the Ryukyu's Miyako Archipelago, also southwest of Okinawa, completed during November 1955–September 1956. In Alaska, MGB members continued reconnaissance studies for the Army Engineers of the Big Delta Military Reservation, the Gerstle River to the southeast, and areas in the Copper River Basin and on the Arctic Slope. For the Air Force, they resumed construction-related studies of Greenland and other areas in the Arctic.

Members of William Johnston's Foreign Geology Branch worked in fiscal year 1955–56 on projects for which fieldwork was complete, continuing, or beginning in Africa, Asia, and Latin America. With support from the International Cooperation Administration, they also helped to train 36 participants, from 16 countries, in the USGS domestic field program. Branch geologists completed the ICA-sponsored work on Iran's mineral resources. Anomalies disclosed by the USGS-assisted gravimetric surveys near Camaguey in Cuba were drilled for chromite deposits. William Hemphill finished his investigation in British Guiana by the end of calendar 1955. Also in 1955, the USGS began a new map series by publishing USGS biostratigrapher Wendell Woodring's geologic map of the Canal Zone and adjoining parts of Panama (at 1:75,000) as USGS Miscellaneous Geologic Investigations (I) Map I–1; three photogeologic maps of 1:24,000-scale quadrangles in Utah (I–2, I–3, and I–4) were dated 1954 but did not appear until 1955. Geochemist-spectrographer Kiguma J. ("Jack") Murata and economic geologist Charles T. Pierson began contributing their expertise to the ongoing reconnaissance surveys for uranium in Brazil. In Saudi Arabia, Aero Service completed photographing the Arabian Shield in 1955, and the entire Arabian Peninsula 4 years later; third-order vertical and horizontal control and shoran aided the photo compilation. Glen Brown and Richard Bramkamp promptly used the completed photos in detailed planning for a cooperative mapping project, conceived 2 years earlier by Director Wrather, to produce from the USGS and Aramco data a bilingual series of 21 geographic and 21 geologic maps to depict the whole Kingdom at 1:500,000. They planned to supplement this series, prepared with the assistance of Esther A. Holm and Simon H. Kfoury, with a geographic map and a geologic map of the Arabian Peninsula, both at 1:2,000,000.[11] John Reinemund began institutional development work with the

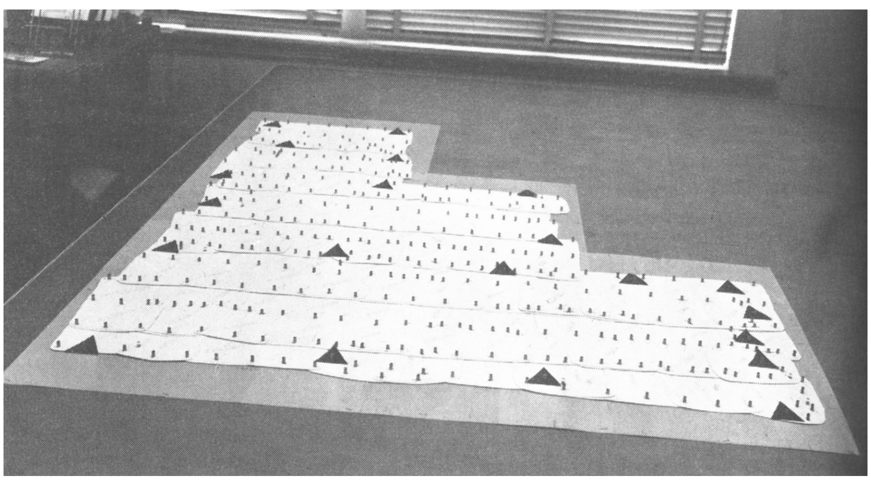
Geological Survey of Pakistan in October 1955. David Andrews started a multiyear examination of Indonesia's mineral resources in July 1955, as Arthur Kinkel, Jr., and Joe Peoples arrived in the Philippines to succeed Ronald Sorem when he completed in September his tour with Earl Irving's mineral-resources project. During the last half of calendar 1955, David Cerkel, Jr., Chief of the Conservation Division's Mineral Classification Branch, studied petroleum resources in the Philippines.

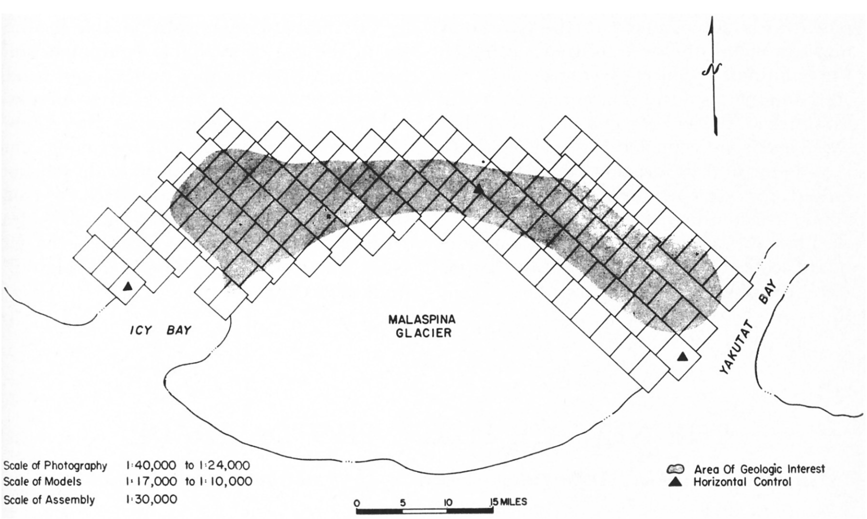
During the austral summer of 1955–56, the USGS returned to Antarctica with the Navy's Operation Deep Freeze, whose 1,800 men and 7 ships of Task Force 43 (TF 43) included attack transport *Wyandot* and three icebreakers—the Navy's new *Glacier*, its older *Edisto*, and the Coast Guard's *Eastwind*. Rear Admiral Dufek[12] led TF 43, accompanied by Rear Admiral Byrd, who flew his flag in *Glacier*, which he helped design, a ship with twice the power as, and 40 feet longer than, the 7 Wind-class icebreakers and carrying aft an enlarged deck for helicopters. Byrd, an early supporter of a strong science component for the IGY, now served as the honorary chairman of the NAS–NRC's U.S. Antarctic Committee and as Officer in Charge of U.S. Antarctic Programs, following his appointment by Eisenhower earlier in 1955. Byrd and his colleagues planned a 4-year Navy program to support preparations for and operations during the IGY. For the first year, fiscal 1955–56, the Navy supplied $17.8 million and the NSF provided $2.2 million from the appropriations for U.S. activities during the IGY that now totaled $39 million. An initial Antarctic Conference of the Comité Spécial de l'Anneé Géophysique Internationale (CSAGI) was held in Paris during July 6–10, 1955; at the first meeting and a second meeting in Brussels during September, Vladimir Beloussov accompanied the Soviet delegation. Ships of TF 43 arrived at McMurdo Sound on December 19. Its personnel constructed and provisioned a permanent base for scientific purposes only—Little America V and its 8,000-foot-long Air Operating Facility on Ross Island and the Ross Ice Shelf. Some 20 flights by two Lockheed P2V–2N Neptunes (modified for polar service) and two 4-engine Douglas R5Ds (the Navy's version of the C–54 Skymaster) explored and continued to drop claim markers on 800,000 square miles of Antarctica before the four aircraft returned to New Zealand on January 18, 1956. In addition to Laurence Gould, Chairman of the U.S. Antarctic Committee, and Paul Siple, Charles R. Lewis (who photomapped with William Hemphill the geology of the Desert Lake 1:24,000 quadrangle in Utah) accompanied TF 43 to study briefly the geology of McMurdo's Balaena Islands and other portions of the continent.[13] When TF 43 left McMurdo Sound in late March, some 90 persons remained to overwinter at Little America V. The Soviet Union's expedition arrived on January 5 to build and staff its Mirnyy Station, on the Queen Mary Coast, and two other stations.

Also in January 1956, Eisenhower personally revised National Security Council Report 5424 (NSC 5424). He deleted its call for mapping and permanent stations in Antarctica, emphasized that work there would be only for scientific purposes, and noted the United States' wish to reach an agreement with all claimants for unhindered exploration and scientific investigation, while also retaining U.S. rights on the continent. Shortly thereafter, when the promoters of the Federal mapping plan requested $56 million for large-scale coverage of Antarctica, the President asked the NSF's Director for the exact nature of the current U.S. commitment. When Alan Waterman cited only the IGY, Eisenhower arranged to delete any specific funds for new mapping efforts in Antarctica from the Federal budget for fiscal year 1956–57. To support U.S. participation in the IGY, the Operations Coordinating Board, the Navy Hydrographic Office, and the USGS agreed to have the USGS begin publishing in 1956 provisional reconnaissance maps, at 1:500,000, of 142,000 square miles in eight additional areas in Antarctica, using trimetrogon and radar photographs from Operation Highjump and subsequent expeditions. The Topographic Division also started compiling a 1:1,000,000 map of the Ross Ice Shelf.

The nearly $15,993,000 the Topographic Division received for fiscal year 1955–56 represented a loss of about $26,000 compared to the previous year's total. The new amount contained about $11,809,000 in SIR funds, a $310,000 increase, and $1,271,000 in reimbursements and direct payments from States, counties, and municipalities. Other Federal agencies transferred $2,783,000, a loss of about $397,000; that sum included $1,019,000 from the U.S. Bureau of Reclamation (USBR) and $1,472,000 from the DoD. The year's topographic-mapping program continued or began work in response to high-priority military and civil-defense requirements. This work included coverage of additional sites proposed for Nike antiaircraft missiles and of Fort Polk in Louisiana and Fort Huachuca in Arizona, the Special Maps Branch's 185 aeronautical charts of areas abroad prepared for the Air Force, the expanded highway program, and the needs of the Federal Civil Defense Administration. The Map Information Office's operations further increased when business and industrial activities again grew during the year. Some of the large rise in the strictly nontechnical use of maps and requests for map information, especially for recreational purposes, reflected the public response to articles in several national magazines advising persons that topographic maps were available from the USGS.

The Division began 1:24,000 cooperative-mapping programs with four new States. Indiana started a 10-year mapping effort by increasing its annual contribution from $50,000 to $200,000, and maps of more than 2,600 square miles were completed or revised during the year. West Virginia, completely mapped at 1:62,500 in 1899–1931, began its 1:24,000 coverage by providing $200,000 to be expended





The photograph (above) shows a stereotemplate system, devised in 1949 by USGS photogrammetrist Marvin B. Scher, for serially arranging aerial images. This system replaced the earlier slotted-template method. Stereotemplates "provided a practical means of accurate control extension" on an area basis. "Stereotemplates, when properly assembled and constrained by given horizontal control, would adjust to a common scale and thereby determine the absolute positions of desired supplemental control." The map (below) was formed by using the Scher stereotemplate assembly. The shaded area on the map represents the Neogene strata that cropped out north of the Malaspina Glacier, between Icy and Yakutat Bays, in southeastern Alaska. These rocks formed part of the oil-bearing sequences in the Gulf of Alaska Tertiary Province mapped by Don Miller and other USGS geologists. The USGS used Scher's stereotemplate system into the 1960s, when automated methods in photogrammetry began replacing it. (Photograph and quotations from Southard, 1984, fig. 11 and caption. Map from Scher, 1955, fig. 9.)

in fiscal years 1955–56 and 1956–57. The Kansas State Geological Survey, now led by Frank Foley as John Frye's successor, raised its contribution by one-third to $23,000, as an initial installment, and the State's highway department provided an additional $100,000 for priority coverage of specific quadrangles. Wyoming, where the Division had earlier mapped some quadrangles at 1:24,000, contributed initial funds to continue the effort in that State. The Division's air-photo coverage of Alaska's Brooks Range rose to 83 percent, and it also published 182 quadrangles at 1:63,360, which increased to 519 those issued for the Territory. Division topographers completed additional mapping at 1:24,000 of all of Oahu, 4 of 17 quadrangles on Maui, and the 3 that covered St. Thomas in the U.S. Virgin Islands. The Division accelerated its mapping of selected metropolitan areas to meet civil-defense requirements and printed maps of 16 cities. Division topographers finished planetable maps of beach and adjacent areas from Bay Shore to Montauk Point on New York's Long Island, as part of a congressionally authorized detailed study of beach erosion and hurricane damage.

The success of early tests of the prototype Orthophotoscope indicated that the new instrument could be applied as well in geologic, engineering, and military uses. Division engineers tested the initial model of their twin-camera mount and then loaned it to the Air Force for additional and more rigorous flight tests. Division members concluded that the new trimetrogon photography, taken with the latest precision cameras, ellipsoidal reflector-55 (ER–55) projectors, stereotemplates that extended ground control for phototriangulation, and vertical control by photoalidade, could be combined to form a photogrammetric unit to produce more accurate small-scale and large-contour-interval maps under the most adverse conditions of flight and available ground control. Efforts also continued to improve the efficiency of control surveys. In addition, the scribing process was extended to field surveys and adapted to stereocompilation work. The adoption of plotting scales equivalent to reproduction scales promised additional economic savings. The Division abandoned further development of the Twinplex plotter after the advent of successful super-wide-angle photography that eliminated the problems associated with using convergent or transverse low-oblique photos in aerotriangulation. Division mappers regularly used a field-survey system that combined technological advances introduced earlier in the decade—the pendulum alidade, the vehicle-mounted elevation meter, the electrical survey net adjuster, and the helicopter.

This photograph shows a cartographic technician tracing contours in ink on metal-mounted paper. The finished sheet was then photographed to produce a film for printing the topographic map; separate drawings were required for each color. Pen-and-ink drawing and aluminum mounts were used after 1942 because copper-plate engraving had to be abandoned when the U.S. war effort required ever-increasing amounts of copper. The consistency of lineweights depended on the skill of the technician, the fluidity of the ink, and the properties of the paper. In the mid-1950s, scribing replaced pen-and-ink drawing; scribers used tools that held modified phonograph needles to remove the colored coating on clear plastic sheets. This change increased economy, efficiency, and legibility in map production, partly because uniform lineweights were produced by the scribing tool. Thereafter, the scribing method "would not change significantly until the introduction of [digital] computers." (USGS photograph, about 1952, Rolla, Missouri; quotation from Stettner and Mathieux, 2008, p. [39].)

Two reports issued in 1955 by Presidential commissions charged with reviewing and revising water-resources policy, to which the USGS and other Federal agencies contributed their expertise, significantly influenced the work of the Water Resources Division. The second Hoover Commission's Task Force on Water Resources and Power, chaired by Admiral Moreell, included 25 other persons organized in 4 task groups to assess Federal water resources and power policies and organization. Moreell made Task Group B responsible for Reclamation and Water Supply. USGS hydrologists Glenn Hoyt and Walter Langbein completed for the Task Group and the Task Force three studies—"Federal Gathering of Basic Water Resource Facts," "Competition for the Use of Water," and "Flood Management Through Zoning, Insurance, and Forecasting." The Presidential Advisory Committee on Water Resources Policy, formed to review Federal policies and programs and recommend improvements in administrative organization to ensure water conservation and best use, aided the deliberations of Moreell's task force at Eisenhower's request. The President founded the new Committee, originally called the Cabinet Committee on Water Resources Policy,[14] on May 26, 1954, just 2 months after his discussions with the minerals-policy committee also chaired by Secretary McKay. McKay's new Committee included Agriculture Secretary Ezra Benson, Defense Secretary Charles Wilson, and their alternates. Commerce Secretary Sinclair Weeks, Health, Education, and Welfare (HEW) Secretary Oveta Hobby, and the Budget Bureau's Director Rowland H. Hughes participated on an ad hoc basis, also as Eisenhower requested. The new Committee received help from the also newly formed Inter-Agency Committee on Water Resources in trying to improve the coordination of existing policies, programs, and activities in investigation, planning, construction, operation, and maintenance by executive departments and their agencies. The reports by Moreell's task force and the second Hoover Commission recommended strengthening and expanding the Inter-Agency Committee on Water Resources by changing it to a "Water Resources Board,"[15] in the Executive Office of the President, composed of five civilians, one of whom would chair; the Secretaries of the Army, Interior, and Agriculture; the head of the Federal Power Commission; and several nonvoting members. The new Board would "determine the broad policies for recommendation to the President, and, with his approval, to the Congress" and "devise methods of coordination of plans and actions of the agencies at Washington * * * and in the field."[16] The second Hoover Commission, repeating a point made by the first Hoover Commission, included "adequate gathering of basic hydrologic data" among its dozen problems common to all branches of water development. Noting that "[m]any costly errors in the past have been due to inadequate data," the second Hoover Commission emphasized that:

> **[t]he importance of adequate hydrologic data cannot be overestimated.[17]**

Among the nine points recommended by the second Hoover Commission as a national water policy to Congress were calls for developing water resources for their "optimum use" and "maximum contribution to the national economic growth, strength, and general welfare." The Commissioners recommended that such development "should be generally undertaken by drainage areas—locally and regionally,"[18] as urged by John Powell and many others since the 1870s. They also resolved that "one Federal agency should be made responsible for collecting and revising the adequacy of hydrologic data."[19]

McKay's Committee on Water Resources Policy submitted its report on water-resources policy to Eisenhower on December 22, 1955. The Committee's members recognized four major problems that they felt continued to work against a more effective policy for developing the Nation's water resources. First, conflicting Federal laws, authorizing agencies to operate programs for different ends,

USGS hydraulic engineer Luna Bergere Leopold (1915–2006), the son of conservationist Aldo Leopold, worked for the Soil Conservation Service (later the Natural Resources Conservation Service) and the Army Engineers, and also served as a commissioned meteorologist with the Army Air Forces, before joining the USGS in 1949. Leopold combined in field and laboratory investigations the processes and results of erosion and sedimentation in river basins and reservoirs in arid and other regions. He served as Royal Davenport's field representative in the Western United States and then moved to Washington in 1955 as a research hydraulic engineer in Davenport's Branch of Technical Coordination. Leopold served briefly as Chief of Program Development in the Water Resources Division (WRD) before succeeding Carl Paulsen as Chief Hydraulic Engineer (later Chief Hydrologist) and Chief of the WRD (1957–66). Leopold increased the percentage of fundamental research in the WRD, while continuing his own and collaborative studies in river morphology and mechanics. Leopold returned to full-time research at Menlo Park in 1966 and moved to the University of California at Berkeley in 1972. He retired from the USGS in 1973 but continued as Professor of Geology at Berkeley. (Photograph from the USGS Denver Library Photographic Collection, Portraits, port1250, https://www.sciencebase.gov/catalog/item/51dda2dce4b0f72b4471dff5; see also Bull, 1986.)

Geohydrologist Raymond Lee Nace (1907–87) joined the USGS Ground Water Division (later Branch) in 1941. During World War II, he led an Army water-supply company and then a battalion in the European Theater of Operations. Nace, discharged as a Major in 1946, then served as the District Geologist in Idaho for the Water Resources Branch (later Division, WRD), led hydrogeologic studies at the U.S. Atomic Energy Commission's National Reactor Testing Station, and served as Regional Coordinator for the Pacific Northwest before becoming the WRD's Assistant Chief Hydraulic Engineer for Operations in 1956. While serving as Associate Chief Hydraulic Engineer during 1957–63, Nace also oversaw international activities. He then returned to research and later moved to North Carolina, but he continued to advise Luna Leopold and Ernest Hendricks, Leopold's successor as Chief Hydrologist, about the WRD's research program. Nace retired in 1977. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Last Name M–R" folder as Public Inquiries Office 64–5 [1a]; see also Heath, 1988.)

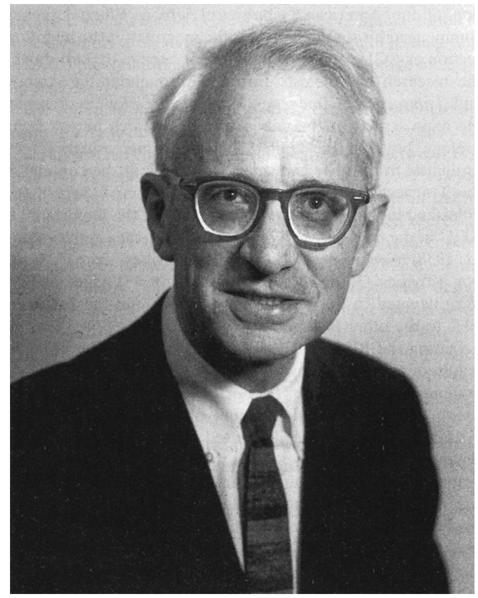
prevented improved cooperation and coordination with efforts by States, counties, and municipalities. Second, it was neither practicable nor desirable, financially or otherwise, for the Federal Government to assume responsibility for the complete development of these resources. Third, the concept of equal contributions for equal benefits continued to be applied unevenly at Federal, State, and more local levels. Fourth, considerable controversy continued unabated among proponents of State versus Federal water rights. The Committee's members, in making their recommendations to resolve the overall problem, recognized that a water-resources policy required "fundamental basic data." They called for an accelerated, more consistent, and better defined program of collecting data on "stream flows, rainfall, soil conditions, hydrology, meteorology, and other elements which control the quantity, the usability, and the desirability of water uses."[20] There was no single national problem or blueprint to resolve it, the Committee's members emphasized, but dozens of concerns that differed between States and areas. They believed, reflecting the administration's long-held views, that the current and predicted problems of each area could only be considered and resolved separately for each river basin, State, and region. The Committee hoped to bring the Federal programs "to a common understanding" and operations "upon a fixed and uniform pattern,"[21] in part by establishing a Coordinator of Water Resources, in the President's Executive Office, who also would permanently chair the Inter-Agency Committee on Water Resources. Eisenhower sent the report to Congress on January 17, 1956, as the Department of the Interior (DoI) began implementing the Committee's recommendations and continued to support resolving some water-resources problems by means of existing and proposed interstate compacts.

The Water Resources Division received during fiscal year 1955–56 about $7,655,000 in SIR funds, an increase of more than $996,000. During the year, California, Texas, New York, and Florida led the remaining 44 States and their municipalities, Hawaii, and Guam in contributing $537,000 more than in 1954–55, to raise the total to $4,614,000. Other Federal agencies supplied in all about $3,612,000, a total that included $1,102,000 from the Army and its Engineers, $996,000 from the USBR, $480,000 from the ICA, and $341,000 from the AEC. The Division amassed some $16,053,000 in total monies for 1955–56, or $2,152,000 more than in 1954–55. On May 3, 1956, Nolan's Survey order approved the reorganization, effective April 4 and for the second time in less than a decade, of the Water Resources Division. Chief Hydraulic Engineer Carl Paulsen's revision, based largely on work by Raymond Nace and Luna Leopold, aimed "to integrate the program planning and the operations of the division, to decentralize its administration and to improve facilities for the increasingly important general hydrological studies." The changes were designed, as Wrather long advocated, to emphasize basic research at the expense of service operations. The order established, in Paulsen's office, Assistant Chief Hydraulic Engineers (ACHEs) for Program and Development and for Operations and an Administrative Officer. While retaining the Division's Branches of Surface Water, Ground Water, and Quality of Water, with their area chiefs in the regions, the order also confirmed the newly renamed Branch of General Hydrology for work on

> **the broad fundamental problems of hydrology and * * * research and studies in specialized fields.[22]**

Paulsen, who planned to retire in 1957, gave the two new appointments as Assistant Chief Hydraulic Engineer to Leopold and Nace. On June 17, 1956, Paulsen appointed Leopold the ACHE for Program and Development. Nace, District Geologist in Idaho but on detail to headquarters in Washington as Staff Coordinator, Pacific Northwest, became the ACHE for Operations on July 18. Luna Leopold, the son of conservationist Aldo Leopold, joined the USGS in 1949, investigated the geomorphologic relations among river depth, width, slopes, and water velocities, and served as Royal Davenport's field representative for the regions west of the Mississippi before moving to Washington in 1955 as a research hydraulic engineer in Davenport's office. After Davenport retired on December 31, 1955, the Technical Coordination Branch got a new Chief, Charles C. McDonald, and, in July 1956, was renamed the General Hydrology Branch to follow the Van Pelt Committee's recommendation.

Paulsen made additional changes in his staff and in the regions. He delegated line and program authority in the Division's four principal geographic areas to the new positions of Regional Hydrologist. To these posts, Paulsen appointed Arthur Piper, for the Pacific Coast Region, originally at Portland but moved to Menlo Park by July 1956; Sherman K. Jackson, for the Rocky Mountain Region, at Denver from March 1957; Henry Beckman, for the Mid-Continent Region, at Rolla from July 1957; and George Ferguson, for the Atlantic Coast Region, at Washington, D.C., until November 1956 and then at Arlington, Virginia. The Regional Hydrologists, who reported directly to Paulsen, were aided by area subchiefs appointed by and representing the Chiefs of the Surface Water, Ground Water, and Quality of Water Branches. In June 1956, Leopold succeeded Ferguson as Chief of the Branch of Program Control, another unit recommended by the Van Pelt Committee, before becoming ACHE for Program and Development. Paulsen discontinued the Program Control Branch and passed some of its functions to Leopold. Paulsen's reorganized office also included Staff Research Scientists and six Sections—Administrative (Frank Barrik, Jr.); Career Development (Roy Oltman); Foreign Hydrology (Thomas Eakin, aided by Roy Jackson); Planning (Kenneth Young); Publications, formerly, Technical Reports (William S. Eisenlohr, Jr.); and Radiohydrology (Victor Stringfield, and including George De Buchanne after his transfer in 1955). A DoI press release made these changes public on September 27, 1956.



Hydrologist Walter Basil Langbein (1907–82) left the Rosoff Construction Company in 1935 to join the USGS. In subsequent years, fieldwork took him to nearly all of the conterminous 48 States. Langbein studied drainage-basin capacities and reservoir storage, flood hydrology, flood-plain zoning, the geometry of stream channels, the hydrological cycle, the design of water-data networks, and water-sediment transportation. His research contributions "to the growth of scientific hydrology * * * introduced original concepts of both theoretical interest and practical importance." Like Luna Leopold and Raymond Nace, Langbein aided planning for and participated in the International Hydrologic Decade (1965–74). Langbein retired in 1968, but he continued to advise several USGS Directors and Chief Hydrologists about current and potential problems in U.S. water resources and research. (Quotation and photograph from Dooge, 1996, p. 2969; photograph also published in Matalas, 1983.)

During fiscal year 1955–56, Foreign Hydrology specialists continued the ICA-assisted, long-term projects in eight countries, and in Jamaica, where they also trained more than 100 local colleagues. Stuart Schoff examined aspects of Nicaragua's water resources during September 1955. John Cederstrom, from July 1955, and G. Chase Tibbitts, Jr., from April 1956, continued the Division's groundwater studies in Libya. Paul Jones succeeded George C. Taylor, Jr., in India during August 1955, as Arthur Garrett extended well-drilling operations. In July 1955, chemist Raymond T. Kiser and geophysicist Raymond E. Miller began work in George La Rocque's groundwater project in West Pakistan.

During fiscal year 1955–56, members of Joseph Wells' Surface Water Branch operated some 6,800 stations in the streamflow network. By year's end, the Branch's compilation of all streamflow records for 1888–1950 rose to 68 percent, and the unit published streamflow data for the lower Mississippi River, the Pacific Slope Basin in Washington, and the lower Columbia River. Branch members continued to develop techniques for relating single measurements of low flow in ungaged small streams to correlative records of flow at streamgaging stations in order to deduce the characteristics of small streams during intervals of low flow. An intensive review of the scope and adequacy of the streamgaging network in the Colorado River Basin produced methods applied in June 1956 in evaluating the national streamgaging network scheduled for completion within a year. Walter Langbein and John E. McCall pursued their inquiry about the value of continued data collection at a given site. The new hydrologic network was designed to aid planning for collecting basic surface-water data. The network consisted of (1) "primary" stations to be operated indefinitely to yield long-term trends, (2) short-term "secondary" stations to give area coverage, and (3) water-management stations. The Branch purchased an electronic computer to tabulate automatically daily discharges directly from the gage charts. Beginning in July 1954, Edgar G. Barron and his colleagues developed a bubble-type pressure-sensing device to activate the stage recorder at streamgaging stations. This device was a less expensive instrument than the float-type recorders and represented a step toward eliminating expensive stilling wells. These gages sensed and recorded river stages by pressure, and so they did not require gage wells of heights equal to the full-stage range of the river. Experimental models were installed for field trials in several Districts between late 1955 and mid-1956.

The Surface Water Branch, as part of its flood and sediment investigations, published flood-frequency reports for Connecticut, Missouri, and Nebraska, continued similar studies in six other States, initiated additional programs with State highway departments, and began collecting and analyzing data for a nationwide study. Branch planners expected the data obtained to provide better definition of the flood-producing characteristics of small streams, knowledge required to design adequate and economical drainage and flood-control structures. Intensive field investigations documented and a preliminary report described the devastating floods of August–October 1955 in North Carolina. Similar studies followed the floods of December 1955–January 1956 in parts of the U.S. West Coast. Branch members regularly measured suspended sediment at some 200 locations and also continued investigating the sources, quantity, and movement of waterborne sediments and their effects on reservoir storage, navigable waterways, diversion works, and irrigation canals. As part of work in the Missouri River Basin, Bruce Colby, Charles Hembree, and Frank H. Rainwater published in 1956 their analysis of sedimentation in Wyoming's Wind River Basin. Rigorous field tests demonstrated a new recorder's ability to register continuously the electrical conductivity of water and promised to advance the more economical collection of additional information about the load of dissolved solids in river waters. Studies completed during the year demonstrated that graphic plots yielded curves showing the relation between the sediment loads of rivers and the rate at which they discharged water. When the graphic relation was supplemented by occasional direct determinations of sediment load, the method was used to compute the total load of sediments discharged during monthly and annual intervals; it proved accurate in solving problems in water-resource development.

Of the 550 investigations underway in Nelson Sayre's Ground Water Branch during fiscal year 1955–56, about 80 percent were in the Federal-State cooperative program, but some 100 concerned problems in which the primary interest was national or in which Federal agencies were directly concerned. The Branch directed the greater part of its effort toward area studies and reports on the geology and groundwater resources of geographic or hydrologic units, commonly of counties or groundwater basins. Supporting studies included research on the occurrence and movement of water in various geologic and hydrologic environments, systematic inventories of the demands on groundwater, and studies of water-level fluctuations. The results, besides adding directly to greater knowledge of hydrogeologic principles and processes, led to improved techniques for analyzing and solving water-supply problems. Inventories kept current provided records of operating experience with groundwater reservoirs. In 1955, Sayre appointed a 10-member Observation Well Committee, chaired by Russell Brown, to review the system of recording and publishing well records; the Committee's recommendations were implemented by the end of 1956. John Ferris and Sayre's "The Quantitative Approach to Ground-Water Investigations," published in *Economic Geology*, traced the history and development of the quantitative concepts and techniques by then widely used in appraising and interpreting groundwater resources.[23] In field studies, hydrologists continued to gain perspective on the factors that affected the artificial recharge of groundwater and the principles that controlled water movement through unsaturated porous media. The hydrologists also used a new electrical analog model for analyzing the hydraulic properties of nonhomogeneous aquifers.

Members of Kenneth Love's Quality of Water Branch analyzed some 65,000 nationwide samples during fiscal year 1955–56. They made detailed chemical-quality investigations of streams in the basins of the Colorado, Columbia, Missouri, and Pecos Rivers; in New York and the New England States; and in Alaska. The Branch maintained a sampling network on streams in the West to determine trends in mineral content that would affect continuing successful operation of the region's irrigation projects. Continuous recordings or daily observations of temperature were taken at more than 400 sites on major streams. Work continued on the inventory of the occurrence and quality of U.S. saline-water resources, as well as the series, begun in 1953, of comprehensive reports on the water resources of industrial-production areas. Branch scientists advanced their development of ways and means for collecting and appraising facts about radioactive substances dissolved in water that emphasized radio-elements in relation to chemical, geologic, and hydrologic factors.[24] They also studied specific terrains in Arizona, Colorado, Idaho, Nevada, and Texas.

Several laws enacted during fiscal year 1955–56 directly or indirectly influenced the responsibilities of and work by the Conservation Division. On July 15, 1955, a new statute provided "for the conservation of anthracite coal resources through measures of flood control and anthracite mine drainage * * * to conserve natural resources, promote national security, prevent injuries and loss of life, and preserve public and private property."[25] The act authorized the Secretary of the Interior to contribute for these conservation purposes up to $8.5 million, if Pennsylvania, which held the Nation's largest anthracite reserves, matched that or a lesser sum. The 84th Congress required the Secretary to report progress on or before each February 1 for the next 4 years; in 1962, an amendment authorized using any funds not expended for flood control to fill and seal abandoned mines. On July 23, 1955, the Multiple Surface Use Act[26] amended 1947's Mineral Leasing Act for Acquired Lands, and the general mining laws, to facilitate multiple use of the surface and subsurface resources of single tracts of public lands. Congress and the President intended the new law to prevent mining claims from being staked or used for nonmining purposes and to prevent timber waste on unpatented mining claims. The new statute authorized Federal management of surface resources, including timber and forage, of all unpatented claims staked after the act's passage and Federal acquisition of rights to surface resources of earlier claims. The law also excluded from the 1872 and other mining laws sand, gravel, and other common mineral materials and placed them under 1947's Mineral Leasing Act to be sold by competitive bids.

Related new laws followed in August 1955. Congress and the President agreed on August 1 to repeal the Timber and Stone Act of 1878 and its subsequent amendments.[27] On August 11, they authorized Arkansas, Louisiana, Oklahoma, and Texas to sign a contract to apportion the Red River's waters.[28] On the same day, a new statute provided "for entry and location, on discovery of a valuable source material, upon public lands in the United States classified or known to be valuable for coal," unless the lands were "embraced within a coal prospecting permit or lease." The new law authorized these actions and also those governing the discovery of the valuable source material, primarily uranium and other fissionables, "occurring within any seam, bed, or deposit of lignite."[29] The statute permitted entry under the mining and mineral-lease laws, provided a copy of a notice was filed within 90 days in the Bureau of Land Management's (BLM's) office in the State of location and claimants reported annually to the USGS Mining Supervisor the amount of lignite mined or stripped in recovering the more valuable source materials and paid for the former at 10 cents per ton. No extralateral rights conveyed. All lands subject to the new law would be withdrawn from all forms of entry under the act after 20 years, or 30 years as the President might order. Also on

August 11, the passage of the Mining Claims Rights Restoration Act permitted "the mining, development, and utilization of the mineral resources of all public lands withdrawn or reserved for waterpower development."[30] The new statute opened those lands covered by the Pickett Act of 1910[31] to entry for these purposes, but it reserved their waterpower rights to the United States. The law affected more than 7 million acres in 23 States and Alaska Territory. The measure also gave the Secretary of the Interior three options in assessing placer claims made under the act: (1) complete prohibition: (2) permission only if the claim's surface would be restored to its premining condition; and (3) a general, but not further specified, permission.

In 1956, Eisenhower continued to foster development of the public lands. On February 17, the President vetoed the proposed amendments that would have diluted the requirements of the Natural-Gas Act. He signed on April 11, despite significant opposition from conservationists and preservationists, and from participating projects, a bill that provided $760 million for the Colorado River Storage Project,[32] the USBR's irrigation-reclamation effort that involved four dams and reservoirs, powerplants, and transmission facilities. Eight months earlier, plans for a single dam in Hell's Canyon replaced those for three smaller dams elsewhere on the Snake River.

The Conservation Division, still the smallest of the USGS' four major programmatic units but the one continuing to be the least dependent on outside financing, drew on a little more than $1,840,000 during fiscal year 1955–56. That amount represented an increase of more than $94,000 over the sum available in 1954–55, but nearly $53,000 of the new total came from other Federal and non-federal sources. Members of David Cerkel's Mineral Classification Branch handled nearly 28,900 cases during the year. The Branch's geologic reports and maps for official use were based on specific investigations by Branch geologists intended to aid engineers in planning and recommending to Federal lessees and other persons more efficient methods of recovery of the products involved. Branch members continued their regular work on fuel fields and unit plans, leasehold production limits, lease-sale recommendations, and the geologic significance of new discoveries. They also completed reports on seven power-dam sites in Alaska, a mineral-resources map of Washington, a report on the geology of dam sites on the upper Columbia River, structure-contour maps of Montana's Fort Peck Indian Reservation and the Montana Plains, a revised geologic interpretation of the southeastern Powder River Basin in Wyoming, a reconnaissance of phosphate deposits in northeastern Nevada, maps of Colorado's Ragged Mountain coal field and the State's Colorado Plains, a contour map of southeastern New Mexico's Yates Sand, and contour maps of two oil and gas fields—Greenwood in Kansas and East Orlando in Oklahoma. In 1955–56, the usual work by members of Arthur Johnson's Water and Power Branch in seven Western States and Alaska included 350 miles of channel surveys, examinations of 10 dam sites, and action on more than 5,700 hydraulic determinations on Interior and Federal Power Commission (FPC) cases. Branch members also began a program of systematic review and appraisal of land withdrawn for waterpower reserves and assembled material for use in periodic reports about the world's developed and potential waterpower. Members of Joe Turner's Mining Branch supervised almost 2,540 mining properties, about 720 more than in 1954–55, in 32 States and Alaska. Those mines produced more than 19.7 million tons of metals and nonmetals worth some $135.3 million and generated royalties of nearly $5.9 million, an increase of almost $424,000. Members of Harold Barton's Oil and Gas Leasing Branch supervised more than 115,000 properties on public, acquired, Indian, and Navy lands, where produced petroleum, natural gas, gasoline, and butane yielded $65.4 million in royalties, representing a gain of more than $4.9 million over royalties received in 1954–55. In Alaska, the DoI opened to exploration, as part of what it termed its widespread and responsible search for oil, 1.2 million Federal acres in 470 leases in the area between Icy Cape and Cape Fairweather, in the eastern part of the Territory's Gulf of Alaska lands. On the U.S. Outer Continental Shelf (OCS), Branch personnel managed 367 leases originally issued by Louisiana and Texas under provisions of section 6 of the Outer Continental Shelf Lands Act of 1953 and 235 leases issued under section 8 of that statute. Petroleum produced from the OCS during 1955–56 yielded royalties, rents, and bonuses of more than $119.7 million.[33]

In January 1956, Congress began hearings on Interior's budget request for fiscal year 1956–57 and approved the President's nomination of a new Director for the USGS. On January 13, the day that Eisenhower appointed James Killian as Chairman of an eight-member Board of Consultants on Foreign Intelligence Activities (including Lt. General James Doolittle, Joseph Kennedy, and Robert Lovett), Secretary McKay appeared before Michael Kirwan's House appropriations subcommittee. To meet increased demands for Interior's services, McKay asked for $43.6 million more than in 1955–56, including salary increases under the Federal Employees Salary Increase Act of 1955,[34] to bring the Department's total funds to $504.4 million. Of that amount, $31.6 million was marked for the USGS and represented an increase of more than $5.3 million compared to the previous year's request. The latter sum included increases for topographic and geologic mapping and mineral and water-resources investigations "as recommended by the President's Cabinet Committee on Mineral Policy."[35] USGS programs, McKay continued, "have a broad application to our national economy. This service may not be especially spectacular to the layman, but directly or indirectly it provides the base for the future development and use of our mineral, water, and other resources." USGS investigations and research fueled by that money, McKay asserted, "have far-reaching effects"; these funds, he believed, were "truly an investment in the future of the Nation."[36]

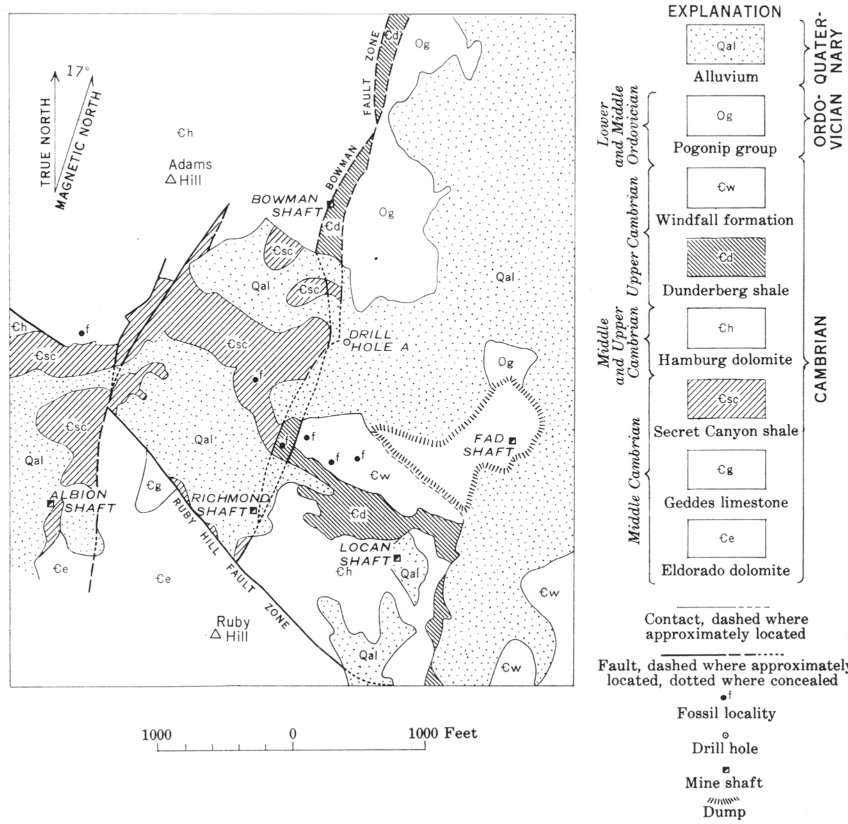
On January 17, Assistant Secretary Wormser again accompanied Acting Director Nolan to the USGS portion of the House subcommittee's hearings. Wormser initially referred to Nolan as Assistant Director and then, prematurely, as Director. Wrather knew he "was in for a long, slow recovery"[37] and tried to retire, but Wormser and McKay refused to act on Wrather's request, hoping that he would soon return to his duties. Finally, McKay visited Wrather at his home, and the Director convinced the Secretary to approve his retirement as of January 4 but effective on the 26th. McKay assured Wrather that he would move quickly to appoint a successor and recommended Nolan. Eisenhower accepted Wrather's resignation on January 18 and sent Nolan's name to the Senate on the same day. Wrather was delighted when the directorship passed to Nolan:

> **I was well pleased by his choice of Tom Nolan, my assistant. I felt that the new Director should again be chosen from the ranks. The Survey had been well shaken up during my incumbency and would profit if given an opportunity to become thoroughly adjusted to the changes we had initiated. Tom was well qualified to carry forward as I had taken care that he was thoroughly posted on everything I had done and was in agreement with the objectives.[38]**

The Senate confirmed Nolan's nomination on January 25, and he took his oath of office as the seventh Director 2 days later. Nolan, during his 11 years as Assistant Director, continued his research on the geology and mineral deposits of the Great Basin and especially those at Eureka. In recognition of the value of Nolan's contributions to geology, the NAS elected him as a member in 1951. For Nolan's "meritorious achievement in advancing the science of tungsten,"[39] Columbia University awarded him its K.C. Li Medal (in gold) and Prize of $1,000 in 1954.

Director Nolan expected the USGS to accrue nearly $51 million in direct and reimbursable funds during fiscal year 1956–57, or $2.3 million more than estimated

This map (originally at 1 inch = 1,000 feet) shows the geology of the area between Ruby Hill and Adams Hill in the lead-silver mining district of Eureka in east-central Nevada. USGS geologist Thomas Nolan concentrated his economic and related geologic studies of the Basin and Range Province on Eureka and the surrounding area, where USGS geologists Clarence King, Arnold Hague, and Charles Walcott established a standard stratigraphic section in the late 19th century. Nolan, while Assistant Director (1944–56), spent a month each summer extending his work at Eureka, aided by several field assistants. In 1956, Nolan, Charles Merriam, and James Williams summarized 22 years of investigations in reporting a detailed and revised stratigraphic section that included Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Permian(?), and Lower Cretaceous rocks and fossils. (From Nolan, Merriam, and Williams, 1956, fig. 2.)



for 1955–56. Nolan now emphasized, as he did in previous year's hearings, the Cabinet Committee's recommendation to expand USGS "work in the minerals field." "Programs for the 1957 fiscal year," he continued, "provide for a start"[40] toward achieving that goal. Just a week ago, Nolan explained, the USGS Science Advisory Committee met in Washington "to review some of the things we are doing and propose to do." The advisers emphasized

> **the need for more research designed to develop principles that could be applied in the search for ore and principles that control the movement of water.[41]**

Kirwan asked Nolan to summarize for the record some of the details, presented as a new subactivity in the USGS printed briefing, of how the agency planned to expend the more than $1 million increase in implementing the national minerals policy. Nolan responded by citing two basic approaches, both of which reflected policies begun by Director King in 1879. Using one-half of these new funds, the USGS intended to prepare "geologic maps of rather large areas that are believed to be potentially mineral bearing," characterized by granitic rocks but in mountainous country "inadequately mapped or not mapped at all."[42] The other half of this new money would support "research on methods of ore finding—the business of getting new ideas on what controls the localization of ore."[43] Nuclear weapons and power, the petrochemical industry, the jet engine, automation, and other technological developments, Nolan claimed, continued to change concepts of available mineral resources. Nolan cited the value to industry and the Nation's mineral reserves of the geochemical and geophysical methods recently developed by the USGS and his hope that newer work on oxygen-isotope ratios, which reflected distances from ore bodies, would prove useful guides in prospecting. The additional $607,000 for a new hydrology program, Nolan replied to Kirwan's next query, would not "solve the water problem," but it would "help attack it" by determining "the principles that control the movement, the occurrence, and the quality of water, both on the surface and underground."[44] Water, Kirwan and Nolan agreed, remained the Nation's "most serious threat" and simultaneously its "best friend."[45] "We hope to find out how we can work with it," Nolan responded, "rather than continually to battle it."[46]

Kirwan then queried Nolan about the status of USGS facilities, especially about progress toward obtaining a new national center in the Capital area. The delay, Nolan replied, reflected uncertainties about the Office of Defense Mobilization's (ODM's) dispersal requirements to preclude major damage in an attack, which conflicted with USGS wishes to remain close enough to continue to deal effectively with the rest of the Federal Government in Washington. Within the last 2 weeks, the USGS and ODM's Lt. General Willard S. Paul agreed on a site they hoped would be approved and still "be within the intent of the directive for a building in the metropolitan area of Washington."[47] The USGS planned to move from Old Interior some seven blocks west to the even older Christian Heurich Brewery in Foggy Bottom. The Heurich Brewery, built in 1894, and subsequently enlarged, occupied the block bounded by 25th and 26th Streets and D and Water Streets, N.W., southeast of the present Kennedy Center, but the brewery had recently ceased operations. The Pick and Hammer Club's show on April 27, "Peter Pun, or The Light That Nearly Failed," burlesqued the lengthening search for a new national center building. "Pun," played by James Balsley, wired to "fly" across the stage, and three of the "Lost Boys" wondered, in "A Lot to be Thankful For," sung to "Floating Crapgame" from Frank Loesser's "Guys and Dolls" of 1950, "Where's the building?" and "Where's the spot?" They trusted Nolan to find a location for "the oldest established permanent floating Bureau in D. C."[48] Nolan, Pun, and the Boys knew that the USGS would neither occupy the brewery nor choose the site for the agency's new building.[49] Nolan reported better progress at Menlo Park, California, where the GSAd approved and the contractor recently broke ground for the USGS' second building, projected to contain 40,000 square feet. Planning continued for a same-sized third building, for topographic-mapping facilities there, at an estimated cost of $415,000. A total of 200,000 to 250,000 square feet, Nolan projected, would be needed to house USGS personnel and equipment at each of the Denver and Menlo Park centers.

Other members of the House subcommittee asked Nolan about continuing work by the USGS in water-resources investigations and topographic mapping. William Norrell asked about water problems in Arkansas' rice lands. Norrell, following Kirwan's guidelines to avoid extended replies, requested, for the record and himself, a statement about USGS cooperative work on that topic. To extend the submitted justifications, the agency described, under the title "Artificial Recharge Experiments in the Grand Prairie Region," its natural-laboratory studies were intended to develop fundamental principles of recharging groundwater reservoirs and apply them in this critical area. When Benton ("Ben") Jensen reiterated his long-standing concern for consolidating Federal mapmaking and favored doing so within Interior, Nolan reported progress both general and specific. The USGS, Nolan noted, was

> **essentially the only agency that prints and distributes the civilian edition of the topographic maps that are produced by Government agencies. No matter who has made any of the maps the average citizen can now get his map by writing to one place.[50]**

Nolan responded to Jensen's query of the previous year about cooperation with the Soil Conservation Service by assuring him that joint meetings already held would lead to continuing liaison to determine SCS needs and "schedule them much more effectively."[51] The requested increase of $200,000 for the mapping program in Alaska, Nolan continued, would fund, as requested by the DoD, revisions of the

Geologist Arthur Alan Baker (1897–1996), an Army veteran, joined the USGS in 1921. He worked briefly in Alaska before shifting to the Fuels Section for areal mapping and studies of economic geology, stratigraphy, and structure in Montana and then on the Colorado Plateau. There, Baker's investigations emphasized areas in southeastern Utah, and his results were used in part for public-land administration. Baker served as Hugh Miser's untitled assistant in supervising war-related fuels programs during 1941–46. Baker became a staff geologist in the Director's Office in 1952 and succeeded Julian Sears as Administrative Geologist in the following year. From 1956 to 1969, Baker served as USGS Associate Director, a new post, where he was responsible for oversight of the Conservation and Geologic Divisions and the Publications Office (later Division). Baker was subsequently Special Assistant to the Director. He retired in 1973. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0286 (originally Public Inquiries Office 63–1 [1a]), https://www.sciencebase.gov/catalog/item/51dda264e4b0f72b4471df4d; published in Love and others, 1999.)

Topographic engineer Robert Henry Lyddan (1910–90) transferred from the Interstate Commerce Commission to the USGS in 1933. He mapped in Puerto Rico and in the Eastern United States before serving as Chief of Plans and Coordination (1946–55) in the Topographic Branch (later Division) and managed a fourfold increase in map production. In 1956, after a year as Atlantic Region Engineer, Lyddan became USGS Assistant Director and was responsible for oversight of the Administrative, Topographic, and Water Resources Divisions. He succeeded George Whitmore as Chief Topographic Engineer in 1968 and assumed responsibility for expanding the national mapping program, applying new technologies to mapping, and completing the National Atlas and national topographic coverage at 1:24,000. Lyddan retired in 1977. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Lyddan, Robert H.," folder as Public Inquiries Office 68–7 [1a].)

1:250,000 series and advance progress on the 1:63,360 series, especially the latter's quadrangles east of the 160th meridian.

The Senate appropriations subcommittee on Interior and its agencies heard Secretary McKay on February 27. McKay asked Senator Hayden's subcommittee to restore the $20.6 million the House cut from Interior's request and thus enable the Department to "keep pace with the increased demand on our resources"[52] and continue to respond to recommendations by the President's policy advisers for minerals and water resources. The USGS needed no similar request because the House approved unchanged the agency's request for $31,602,000, nearly $5 million more than the SIR appropriation for fiscal year 1955–56 and divided between salary increases of $1.4 million required by the Federal Employees Salary Increase Act of 1955 and expanded operations by the Geologic, Topographic, and Water Resources Divisions. On March 1, Wormser and Nolan repeated to Hayden's subcommittee McKay's and their recent emphases on the Nation's need for increased support for research on minerals and water resources. Wormser added his own request to provide adequate space and working facilities for the USGS, including those for adding trained personnel and improving the skills of all employees as recommended in January in the President's economic report. Nolan, as in the House hearings, introduced detailed justifications and the Senators asked fewer questions. The Nation's demand for water, Interior projected, would nearly double by 1975, from 250 billion to 450 billion gallons each day if the population doubled in the century's second half as it did in the first. Among conservation measures being considered, Hayden especially wanted to know if USGS tests could demonstrate if removing water-consuming plants, especially salt cedars and other phreatophytes in Arizona, would increase streamflow and produce more grass.

The USGS budget for fiscal year 1956–57 remained intact when Congress passed Interior's request to the President. When Eisenhower signed the measure on June 13, 1956, the SIR appropriation for the USGS was $31,602,000,[53] of which $5,070,000 could be used only for cooperation with States, counties, and municipalities in water-resources investigations. The USGS reported that it received total funds during 1956–57 of about $53,076,500, or $3.8 million more than the past year's sum. Of the new total, SIR funds actually received provided slightly more than $31,180,000, or 59 percent; States, counties, and municipalities paid directly or reimbursed nearly $7,397,000, or 14 percent; and other Federal agencies transferred almost $14.5 million, or 27 percent. For general administration, the USGS received $950,000 in SIR monies and nearly $534,500 in reimbursements from other agencies. The higher wages in the new Federal pay scale introduced in 1957 applied immediately to chemists, exploration geophysicists, physicists, and engineers. The scale temporarily omitted biologists and geologists, creating morale problems for the latter specialists in the USGS.

Nolan, promptly after becoming Director, urged Wormser and McKay to establish an Associate Director's post that McKay approved. On February 28, 1956, Arthur Baker, the former Administrative Geologist, filled the new position, with its day-to-day oversight responsibility for the Conservation and Geologic Divisions and the Publications Office (later Division). Although Nolan read many manuscripts himself, Hugh Miser continued to review all manuscripts for "Director's Approval"; those Miser questioned were passed to Baker for final decisions. As Assistant Director, Nolan selected Robert Lyddan, the Topographic Division's Atlantic Region Engineer since July 1955, who began serving in his new post on May 6, 1956. Lyddan oversaw daily operations by the Administrative, Topographic, and Water Resources Divisions. In 1957, Luna Leopold detailed hydrographer John Horton, the son of Albert Horton, as Lyddan's temporary staff assistant. Nolan followed these appointments by asking Wormser, on March 28, 1957, to approve the designation, as required by Interior's Manual, of persons to act, in succession, for the Associate and Assistant Directors. Wormser approved on April 3 the two separate sequences of replacement. Two days later, a Survey order designated the positions whose occupants would serve (in succession) as Acting Associate Director: (1) the Director's Office Staff Coordinator (John Reed [Sr.]), (2) the Chief Geologist (Bill Bradley), and (3) the Chief of the Conservation Division (Harold Duncan). For Acting Assistant Director, the sequence would be (1) the Staff Coordinator, (2) the Chief Topographic Engineer (Gerald FitzGerald), and (3) the Chief Hydraulic Engineer (Carl Paulsen).[54]

Less than 6 months after Eisenhower nominated Nolan to lead the USGS, the President chose and the Senate confirmed a new Secretary of the Interior. On June 8, 1956, Frederick A. Seaton, who owned newspapers and television stations in Kansas, Nebraska, and South Dakota, took his oath of office to replace Douglas McKay as Interior Secretary. McKay resigned as Secretary on March 9 (effective April 15) to run for Wayne Morse's seat in the Senate but McKay lost the fall election to the incumbent. Seaton served as secretary to Alfred Landon in the Republican's campaign for the Presidency in 1936, was a Nebraska legislator during 1945–49, represented his State in the Senate in 1951–52, was a legislative assistant to Defense Secretary Wilson during 1953–55, and served as an administrative assistant and then a deputy assistant to Eisenhower in 1955. Seaton, like McKay, worked to meld private and Federal power organizations, but Seaton dealt more effectively with people and proved a better manager and a more moderate politician than McKay. Wormser continued as Assistant Secretary for Mineral Resources and directed the preparation of the Department's long-range minerals program that Seaton passed to Congress on June 4, 1957.

Frederick Andrew Seaton (1909–74), the 36th Secretary of the Interior (1956–61), was a newspaper publisher and an executive in broadcasting and banking prior to beginning his public service. He was Assistant Secretary of Defense for Legislation (1953–55) before becoming in 1955 an administrative assistant and then a deputy assistant to President Eisenhower. Seaton succeeded Douglas McKay as Secretary of the Interior on June 8, 1956, and served until he resigned on January 20, 1961. On December 6, 1960, in Public Land Order 2214, Seaton reserved about 8.9 million acres in Alaska as the Arctic National Wildlife Range. To preserve the Range's wildlife, wilderness, and recreational values, the Alaska National Interest Lands Conservation Act of December 2, 1980 (94 Stat. L., 2371) doubled its size, renamed it a Refuge, and prohibited oil and gas leasing and development. (Photograph from the Library of Congress, Prints and Photographs Division, 3c25772.)

While Seaton settled in at Interior, the General Accounting Office (GAO) completed its review of USGS financial practices during fiscal year 1955–56. Ellsworth H. Morse, Jr., the Director of the GAO's Civil Accounting and Auditing Division, sent to Nolan, on June 27, 1956, the report of the audit conducted, with USGS cooperation, in Washington and at 11 selected field offices. The document, which also drew on the Van Pelt Committee's report, focused "principally on budgeting, accounting, and property management." Morse emphasized how the USGS could improve its allotment accounting structure, whose large number of accounts reflected responsibility "carried to the lowest level of operation," by exercising fund control "at a higher level and thereby afford management with a greater flexibility in the use of funds." Morse said the audit showed

> **a great need for a stronger central office administrative organization with authority equal to its responsibility in all phases of financial administration.[55]**

The GAO's report recommended "a vigorous program of administrative inspection and review of field office financial administration by the Administrative Division and by the internal auditor."[56] Specific suggestions involved (1) preparing and maintaining an accounting manual; (2) ensuring all accounting work was performed under the Administrative Division's jurisdiction; (3) including in budget requests the full disclosure of the costs to the operational funds of supporting work by the Director's Office and the Administrative Division; (4) conducting, with Interior and the GAO, "a comprehensive study to identify and classify direct and overhead costs," as the basis for adopting and maintaining "a well-designed and uniform system of accounting"[57] for headquarters and field offices; (5) strengthening the procedures for handling, reporting, and accounting for map sales; (6) obtaining Interior's approval for free distribution of maps; (7) improving practices and procedures in accounting for field-office property; and (8) enlarging and making permanent the agency's internal-audit unit. The report also repeated the finding, sent to Administrative Assistant Secretary Otis Beasley on December 6, 1955, from the audit of the Casper field office of the Conservation Division's Oil and Gas Leasing Branch. Billings for royalty charges to lessees were deferred until the Branch completed verifying the lessees' own computations, a practice that the GAO auditors believed compromised reliable and timely lease-account balances.

In the new fiscal year 1956–57, Nolan initiated corrective responses to the deficiencies noted in GAO's audit, aided by the internal-audit capability and other changes derived from the Van Pelt Committee's report. He also addressed recommendations for improving Federal training procedures, as recommended in the President's economic report in January 1956. Nolan established, on June 25, 1957, a USGS Committee on Training[58] composed of one representative from each Division and one person from the Director's Office. Nolan, who designated the Committee's chairman, asked its members to evaluate training needs agencywide and to provide coordination for and investigate the application of systems for the purpose of reporting, evaluating, and recording individual and group accomplishments. The Training Committee reported to the Director through the Executive Committee. Nolan expected the new Committee to address agency needs and methods for improving employee expertise, but the sing-along "Wonderments" that introduced the Pick and Hammer Show in April warned that:

> **Committee rule is with us, and we think you will agree,**
> **That upper level brass now shuns responsibility.**
> **Committees make the programs, policies, promotions too:**
> **There's hardly any function that the Brass now has to do.**
> **We thought they had been chosen for their brains and "derring-do."[59]**

The Geologic Division gathered for its work in fiscal year 1956–57 some $15,012,000, about $517,000 more than during the previous year. Of the new total, $6,776,000 represented the SIR appropriation; nearly $330,000, or almost $93,000 more, came from nonfederal sources; and other Federal agencies transferred almost $7,906,000, a loss of $633,000 but one offset by the gain in SIR monies. The Division continued to depend heavily on external funding (now almost 55 percent of total funds), especially the transfers of about $4,896,000 from the AEC and nearly $1,096,000 from the Army and its Engineers. The AEC's transfer again declined, by about $683,500, but increases in other transfers, especially an additional $197,000 from the ICA, almost made up the difference.

The research program in Bill Bradley's Division for 1956–57 supported the Eisenhower administration's national minerals policy by continuing existing efforts and beginning several new projects. On July 19, 1956, Eisenhower signed Congress' augmentation of the Defense Minerals Production Act of 1953; the new law provided "for the maintenance of production of tungsten, asbestos, fluorspar, and columbium-tantalum"[60] by purchase, before December 31, to add to the strategic and supplemental stockpiles. Congress and the President approved this legislation to provide for maintaining production of those materials in the United States and its territories and possessions. The new law authorized the Interior Department to establish and maintain a program to purchase those strategic commodities. On July 31, another statute made $21 million available until December 31, 1958, to Interior's Office of the Secretary for the necessary expenses in acquiring these strategic minerals.[61] Seaton delegated to Wormser's office the principal responsibility for administering those statutes, and all the available funds for producing and stockpiling tungsten and asbestos were spent by the end of fiscal year 1956–57. The Division expected its investigations of those and other strategic commodities to contribute, as did earlier and similar efforts, to a better understanding of the geologic processes involved in the formation and localization of ores.

To aid this work, the revised Survey order of June 14, 1957, modified the organization of the Mineral Deposits Branch.[62] Nolan and Bradley abolished the positions of staff assistants for metals and nonmetals, established a staff assistant for mineral resources, and discontinued the Division's DMEA field offices in Beltsville, Maryland, and Madison, Wisconsin. The Branch continued to reorient its AEC program toward long-range studies of the geologic processes that governed the emplacement of uranium and thorium to gain new data on the size, shape, and mineralogy of these deposits. These investigations included the thermodynamic properties of ore- and rock-forming minerals, the physical properties of earth materials, the distribution of minor elements in intrusive rocks, the environment and geochemistry of ore-forming solutions, and the distribution of stable isotopes. Geologists in these projects established laboratories, devised testing procedures, and calibrated instruments, and they also began research on new or modified geophysical methods, on the use of color photography in photogeology, and on hydrogeochemical prospecting. The Division also began a series of geochemical, geophysical, and engineering studies of preshot and postshot conditions in the area affected by operations at the AEC's Nevada Test Site, as the shift to underground nuclear testing began in September 1957. For the Office of Minerals Mobilization (OMM), Division commodity geologists helped to prepare detailed materials surveys and summary reports on seven specific commodities and reviewed a number of others. Related work also continued on barite, beryllium, chromite, graphite, gypsum, magnesium, manganese, niobium-tantalum, platinum, potash, selenium, silica, titanium, and tungsten. Branch geologists also conducted 26 of their field projects, more than one-third of the total, in cooperation with the States.

During fiscal year 1956–57, William Pecora replaced Earl Ingerson as Chief of the Geochemistry and Petrology Branch as its geochemical studies increased in number and scope. By spectrographic analysis, Branch members determined amounts of uranium and thorium to as low as five micrograms in zircon crystals. They also finished a structure-contour map of Washington's Metaline lead-zinc district. Continued analyses of oxygen-16/oxygen-18 ratios, which varied with the distance from terrestrial hydrothermal conduits, distinguished those deposits from marine sedimentary minerals. Studies of oxidized zinc ores in California, Colorado, Nevada, and Utah disclosed large reserves of low-grade ore. Detailed

USGS geologist Gershon ("Robby") Robinson is shown here examining in 1958 some of the sandstones and shales in the Chinle Formation (Triassic), near the junction of the South and Middle Forks of Cimarroncito Creek, in northeastern New Mexico. USGS geologists, as part of regional mineral-fuel investigations, mapped, sampled, and studied the rocks, fossils, and physiography of this region; the historic and scenic area is popular with tourists and includes the Philmont Scout Ranch, where Explorer Scouts' skills were tested. During 1956–59, Robinson, William H. Hays, M.E. McCallum, Charles Read, and Alexander A. Wanek joined their work in a 1:48,000 geologic map of the Philmont country. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., 654; published in Robinson and others, 1964, fig. 71*A*, and also in Yochelson and Nelson, C.M., 1979, p. 37.)

mapping by Branch members confirmed the occurrence of zoned ore deposits in New Mexico's Grants-Laguna area. Studies of the Hiland-Clarkson Hill region in Natrona County, Wyoming, demonstrated that its uranium deposits were influenced by southward tilting during the Pliocene and Pleistocene. A newly completed report assigned different geologic ages to the copper deposits of central Cochise County in Arizona. In Pinal County, just to the northwest, the San Manuel Mine, as earlier predicted, began producing copper from its estimated reserves, initially located by the USGS, of 500 million tons of low-grade ore, plus much smaller deposits of gold, molybdenum, and silver. The Pick and Hammer Club's show for 1957 highlighted the Branch's growing work in field geochemistry. Cast members claimed that "Geobotany is here to stay" and urged geologists to "Gather, gather flowers where you may,"[63] including posies (growing above lead) and daffodils (rising above molybdenum). They hailed the "GX" Section, led by Thomas Lovering since 1954, as "the darlings of the Survey" and Bradley's "special pet."[64] The Geochemical Exploration Section also developed methods, aided by its mobile wet lab, for tracing the dispersal patterns of a total of 21 different elements, also including copper, selenium, and silver. To the banjo-strumming tune of "The Yellow Rose of Texas," the GXs crowed:

We don't fret about our budget
Or where we get our dough,
For the whole of Bill's Division
Chips in for what we owe.
We are not a Branch but we don't care
For the Section grows and grows.
We'll soon be big as Minerals
Without financial woes.

* * * * *

We practice our geology
In our own peculiar way.
We feel that rock-collecting
Is certainly passé,
And we find that mapping contacts
Is an easy thing to do
So we leave that to Gilluly
And to his motley crew.[65]

In fiscal year 1956–57, members of the Director's Office and the Geologic Division began referring to Gilluly's General Geology Branch as the unit of "General Service Geology." Branch geologists, aided by the work of Division geochemists, geophysicists, and paleontologists, mapped in 10 areas in the conterminous United States and 1 in southeastern Alaska, largely to support the mineral-deposits programs. Specific mapping concentrated on geologically little-known locales in Alaska, Maine, and Washington. A preliminary version of the geologic map of western Oregon was prepared for publication. Detailed mapping in Montana yielded a better understanding of important structures and their relation to ore-bearing areas. General and engineering geologists finished studies of landslides along the Fort Randall Reservoir in South Dakota. At the Hawaiian Volcano Observatory (HVO), Gordon Macdonald ended his tour as Director in 1956 and joined the University of Hawaii but continued part time with the USGS. Jerry Eaton replaced Macdonald. In cooperation with the National Park Service, Andy Anderson, Gilluly, and Eaton guided the completion of plans for and construction at the HVO of a geochemical laboratory to facilitate systematic studies of the volcanic gases and other products as part of research on chemical volcanology in the national minerals program. William Rubey joined Philip Abelson, Harry Hess, King Hubbert, and six other colleagues as members of the NSF's Special Advisory

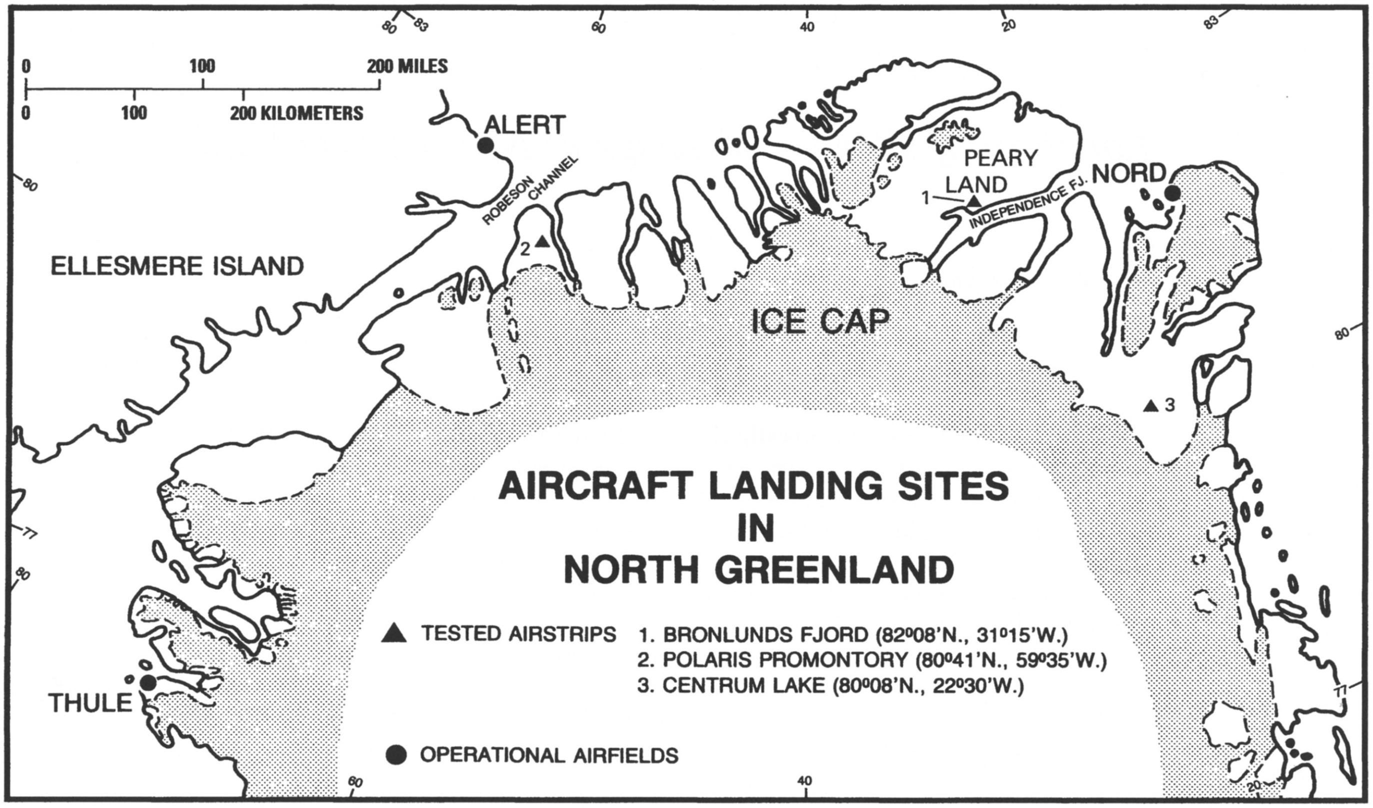
Panel[66] formed, as required by statute, to investigate "the need for a geophysical institute in the Territory of Hawaii."[67] In the Eastern United States, scientists produced a geologic cross section through the potential mineral-producing areas of the southern Appalachians and continued evaluating sea-cliff erosion along the New England coast. Compilers of the bedrock and surficial maps of Connecticut, Massachusetts, and Rhode Island emphasized engineering geology. Large-scale mapping continued in Puerto Rico; maps of six of the quadrangles neared completion, and three others reached 50 percent.

Gilluly's Branch remained responsible for studies of helium, especially those to aid exploration for new sources. The last significant new domestic source of helium dated from 1943. Between 1943–44 and 1956–57, the production of helium almost doubled to nearly 243 million cubic feet per year. In fiscal year 1956–57, Federal agencies accounted for 73.5 percent of that consumption. Domestic reserves, earlier deemed adequate for a century, were reduced to a 10-year supply. Helium's heightened use as a coolant led to the establishment of a Federal interagency group chaired by O. Hatfield Chilson of Colorado (who succeeded Clarence A. Davis as Interior's Under Secretary) and tasked with providing recommendations for the conservation of this gas. The USBM operated four helium plants. On June 2, 1957, the USBM's plant at Exell, some 30 miles north of Amarillo in Texas, began producing helium from new units constructed under contract during September–December 1956. Full production at the Exell plant would raise annual output at the facility from 150 million to 240 million cubic feet of helium. The USBM also increased its number of railway tankers and aided studies by the National Bureau of Standards (NBS) and the Navy of the cost and methods of producing and shipping liquid helium.

During fiscal year 1956–57, the Geophysics Branch again deployed two aircraft for its magnetic and radioactivity surveys, including magnetic surveys flown (in cooperation with the States) over eastern Pennsylvania, northern Wisconsin, and parts of Maine and New Hampshire. The results of aeromagnetic and radioactivity surveys of the Texas Coastal Plain were checked against those derived from field mapping. Branch members continued ground surveys of gravity in eastern California's Death, Long, Owens, and Panamint Valleys and its Mojave Desert; in western Colorado and eastern Utah; and in Minnesota's Cuyama and Mesabi iron districts. James Balsley, who continued his researches while Branch Chief, remained interested in determining the origin of the long, linear negative magnetic anomalies he identified in his aerial surveys of Precambrian to Triassic rocks. In August 1954, Balsley and Arthur Buddington participated in the NSF-sponsored symposium "Anomalous Magnetization of Rocks" held at UCLA's Institute of Geophysics.[68] Gustaf O.S. Arrhenius, Walter M. Elasser, John W. Graham, David Griggs, Lawrence W. Morley, Nagata Takesi, Linus Pauling, S. Keith Runcorn, Louis Slichter, John Verhoogen, and 13 other colleagues attended the symposium. They questioned the significance of the repeated observations in rocks of reverse-remnant polarity that differed from the present orientation of the Earth's magnetic field. Could the field's history be preserved in the geologic sequence of rocks with magnetic minerals? Did these magnetic minerals self-reverse or did the whole field reverse itself? Balsley and Buddington thought that their analyses of Precambrian igneous and metamorphic rocks from New York's Adirondacks favored self-reversal for their magnetite-ilmenite group, as distinct from their normal-oriented hematite-ilmenite group, and published their ideas in 1954.[69] They continued their investigations and summarized the results in a paper[70] presented at the annual session of the Indian Science Congress in Calcutta in January 1957. Balsley sought ways and means to test field reversals versus self-reversals to explain the variations in the studied rocks. Berkeley's Verhoogen began part-time work with the Branch to try to understand how these rocks acquired their remnant magnetism; the NSF supported his research on oxides with a grant of $12,500 during 1955–57.

During fiscal year 1956–57, Fuels Branch geologists conducted surface and subsurface mapping and stratigraphic studies in 22 States that were producing petroleum or that had significant potential for future production; the work included cooperative efforts with 3 of the States. Eugene C. Reed and Richard F. Svoboda (both of the Nebraska Geological Survey) and George E. Prichard and Jeannette Fox (USGS) completed for publication in 1958 a 1:500,000 map of Nebraska that showed test wells for oil and gas, anticlines and basins, oil and gas fields, pipelines, and the areal distribution of pre-Pennsylvanian rocks.[71] Several of their colleagues began subsurface investigations in the eastern part of the State. Research on samples from a deep test well in southwestern Mississippi indicated the presence of a structural uplift of considerable size that extended offshore oil possibilities eastward from Louisiana. Branch geologists also carried on investigations in 11 coal-producing States. Continuing appraisals of reserves in Alabama, Arkansas, Colorado, eastern Kentucky, and western Pennsylvania, they also nearly finished revising the coal map of the United States. The Branch also issued in 1956 the revised map, on two sheets at 1:2,5000,000, of U.S. oil and gas fields, compiled in 1955 by Ann C. Coe, Louis C. Conant, and Sophie Drakoulis.

Members of the Alaskan Geology Branch, making initial tests of hydrochemical and other geochemical prospecting methods, continued or completed mapping and studies of the usual wide range of deposits during fiscal year 1956–57. Geologists investigated the Stampede Mine's antimony, ilmenite in beach sands near Lituya Bay and in layered mafic intrusive rocks near Fairweather Bay, gold and tin placers in the Tofty-Eureka area and around Nome, high-grade limestone on the Alexander Archipelago's Heceta and Tuxekan Islands, nickel in the Funter Bay area, the Lost River Mine's tin, and other minerals around Glacier Bay. They prepared photogeologic maps of the Dixon Entrance, Iditarod, and Talkeetna Mts. 1:250,000 quadrangles and of areas near Juneau, Prince William Sound, and Sitka. Alaska's third oil-exploration boom, which began in 1955, continued unabated. Don Miller (south), Thomas Payne (central), and George Gryc (north) completed fieldwork for their description, presented in preliminary form at an American Association of Petroleum Geologists (AAPG) symposium in 1951, of possible petroleum provinces in the Territory. They published their summary in 1959 with 1:2,500,000 maps of the provinces and Mesozoic–Cenozoic tectonic elements (which superseded Payne's 1955 map) and maps and stratigraphic sections of the Cook Inlet and Gulf of Alaska provinces. Before USGS geologist George Plafker shifted to the oil industry in 1956, he and Miller issued reconnaissance reports on the Tertiary geology of all of the Gulf of Alaska province's Malaspina district and part of its Yakataga district; they were aided by age and paleoecologic determinations by Stearns MacNeil. Their colleagues continued stratigraphic-structure studies of the Nelchina area and completed similar investigations of Cretaceous rocks in the south-central part of Koyukuk Basin, much of which was already leased for oil and gas exploration. During fieldwork, geologists identified more coal resources in the Matanuska and Nenana fields, and the summary report on Alaska's coal regions neared completion. Engineering geology reports issued during the year described conditions in parts of the Fairbanks, Katalla, Nenana-Rex, and Susitna-Maclaren areas. The Alaska Road Commission passed, on September 12, 1956, from Interior to the Commerce Department, where it was reorganized as Region 10 of the Bureau of Public Roads. The Commission, aided by the USGS and other agencies, constructed more than 3,500 miles of roads in the Territory. On March 9, 1957, a magnitude 8.6 earthquake, with a focal depth of less than 20 miles, occurred south of the Andreanof Islands. The quake shook the Aleutians and killed livestock and damaged docks and houses on Adak, Attu, and Unimak. The waves from the resultant Pacific-wide tsunami caused some $5 million in damages on Hawaii, Kauai, and Oahu, but the early warning system established after the magnitude 8.1 event in 1946 prevented loss of life.



This map (originally at about 1 inch = 107 miles) shows locations of three austere landing fields (triangles) for U.S. Air Force (USAF) aircraft encountering emergencies while flying between airbases at Thule and Nord in northern Greenland and at Alert on Canada's Ellesmere Island. USGS geologists William Davies, Donald Klick, Daniel Krinsley, and George Stoertz plus Stanley Needleman (USAF Cambridge Research Laboratories), Lt. Colonel R.H. Wilson (USAF), and their colleagues combined data from aerial and ground photographs with information from published reports and maps in choosing these sites. During 1956–60, they field tested surface conditions, soil strengths, and depths to permafrost at the three sites to confirm their suitability as natural airstrips. At Jørgen Brønlund Fjord (triangle 1 and spelled differently in the map explanation), they sampled and mapped the surface clays and soils along the proposed airstrip in mid-August 1957 and in early July 1960. The frost-free interval at this site began in mid-June and ended in late August. Their test pit, analyzed with a cone penetrometer, reached permafrost at a depth of 24 inches in August 1957. (From Krinsley, 1998, fig. 1.)

The Military Geology Branch's studies in North America during fiscal year 1956–57 for the Army and its Engineers[72] concentrated on Alaska's airstrips, as part of the Austere Landing-Sites Project,[73] and on geology, permafrost, roads, and terrain, as part of Military Programs Arctic that began in 1950. Their efforts also aided the building, directed by Vice Admiral Richard Cruzen, of the third, and most northerly, line of Distant Early Warning (DEW) radar stations that began operations along its 3,000-mile length between Alaska and Baffin Island on July 31, 1957. The DEW line was extended to the Aleutians by 1959, when construction began at Clear, Alaska, on the first of three Ballistic Missile Early Warning Sites. MGB members began reconnaissance studies in the Copper River Basin, along the Johnson River, and in the Thompson Pass area. Donald Nichols, G. Williams Holmes, Troy Péwé, and their colleagues conducted engineering and geothermal studies around Glenallen and at Fort Greely south of Big Delta, completed mapping the geology of the Mt. Hayes D–3 quadrangle, started compiling a map of Alaska's surficial deposits, and advanced work toward a glacial map of the Territory. George E. Stoertz and Stanley M. Needleman reported their 1:50,000 mapping and investigations of ice-free sites in northern and eastern Greenland; their studies for the Air Force's Cambridge Research Laboratories were done in conjunction with test landings of a C–124 Globemaster transport at Jørgen Brønlund Fjord in Operation Groundhog. MGB Special Reports included terrain studies, at 1:250,000, of the 4th Army's area in the Southwestern States.

Members of the Military Geology Branch also completed studies outside North America. George Rozanski, who continued to prepare sheets for the hydrologic map of Asia, completed in 1965, finished a 1:500,000 geomorphic map of Guatemala. The MGB's Special Reports included an evaluation of the geology and engineering strategic structures in Western Europe by Arnold Mason, Perry F. Narten, and Mario Conti; a terrain and materials assessment of northern Greece, adjacent Turkey in Europe, and the northwestern portion of Asiatic Turkey; an investigation of water supplies along Middle East pipelines; a map of the water

The pilot of the U.S. Air Force C–124 Globemaster transport shown in this photograph visited the natural landing field at Jørgen Brønlund Fjord in northern Greenland several days before landing his aircraft there, parking at the airstrip's campsite, and being photographed. Emergency overruns of 500 feet (northwest end) and 700 feet (southeast end) on softer soils extended the harder inorganic-clay-soil airstrip, where flags marked its 5,000-foot length and 200-foot width. The airstrip occupied part of a "flat, dry lake plain or marine embayment" that was 0.5 mile wide, 3 miles long, nearly 10 feet above sea level, and less than 0.5 mile from the fjord. During an hour at the campsite, the 72.5-ton aircraft "produced a rut that was about 0.5 in[ch] * * * deep." (Photograph by George Stoertz, August 16, 1957, from Krinsley, 1998, fig. 6; quotations from Krinsley, 1998, p. 191 and caption of fig. 6.)

resources of Iran and Iraq, at 1:1,750,000; and terrain studies of Aden and adjacent Yemen and of Kashmir. Miscellaneous Papers issued by the Branch in 1956 included Henry Coulter's debriefing on Afghanistan and "Ric" Terman's classification of airfields.[74] Members of the Pacific Geology Mapping Program finished their last fieldwork during fiscal year 1956–57 in the Ryukyus and on Truk's soils and Yap's water resources in the Carolines. The MGB issued Arnold Mason's 1:50,000 summary of the bauxite deposits on Babelthuap in the Palaus. The Pacific mappers advised the Chief Engineer of the Army's Far East Forces, whose headquarters shifted from Tokyo to Hawaii on July 1, 1957, about the discovery and evaluation of water resources for military use in Okinawa, South Korea, and Taiwan. They also aided Navy personnel with engineering problems in the Marshall Islands.

To honor Frank Whitmore's 10th year as Chief of the Military Geology Branch, players in the Pick and Hammer Club Show in April 1957 reworded Gene de Paul and Johnny Mercer's "Jubilation T. Cornpone," from Broadway's "Li'l Abner" of 1956. In "Attack on the Right Frank," they touted Whitmore, who "concocted crises when the battle was won," proved Survey projects for the Army "quite in arrears" but "alleviated their fears," and sold the Army "on the woes of permafrost" and the need for "a map of Fort Knox" when its "interest waned and all support might be lost." He "gets us lots of dough" and "can always get more," the players acclaimed, but they closed with

> **Though the other Branch Chiefs here can keep us all in a buzz,**
> **Who became so classified that no one knows what he does?[75]**

During fiscal year 1956–57, members of the Foreign Geology Branch joined in fieldwork, provided technical advice and assistance to, and (or) trained at home and abroad geologists and mineral-resource specialists in or from 21 countries: Afghanistan, Bolivia, Brazil, Chile, the Republic of China, Costa Rica, Cuba, Ecuador, Egypt, India, Indonesia, Iran, Israel, Libya, Mexico, Pakistan, Peru, the Philippines, Spain, Thailand, and Turkey. In Chile, George Ericksen and Raymond Parker continued their mineral-resource studies and also aided U.S. efforts in planning for a geology department in the national university. The USGS remained almost totally excluded from Saudi Arabia, where King Saud favored Gamal Nasser's approach to the West rather than Crown Prince Faisal's. Sheikh Abdullah Tariki (historian Daniel Yergin's "Red Sheikh") was a geochemist trained at the University of Texas and by Texaco; he led the new Saudi Directorate of Oil and Mining Affairs (later the Ministry of Petroleum and Mineral Resources) established in 1955. Glen Brown kept USGS-Saudi relations active by joining the international experts who advised Tariki at his request. USGS engineering and mineral-deposits geologists spent 4 months aiding the Geological Survey of India. The USGS and the Geological Survey of Pakistan intended their cooperative program, begun under an agreement signed in October 1955 between the ICA and Pakistan's Government, primarily to advance the geologic mapping and resource appraisal of the country. The 30-person program, led by John Reinemund as Chief of Party during 1955–63, included joint geological reconnaissance studies of unmapped areas, detailed mapping and appraisal of mineral districts, and developing facilities and staff to improve the Geological Survey of Pakistan. Reinemund's field parties, including James A. Calkins, William Hemphill, Charles R. Meissner, Jr., Terry W. Offield, and Robert George Schmidt, mostly mapped coals and trained geologists. The joint effort centered on the Hindu Kush Range on Pakistan's northern border with Afghanistan, the North West Province's border mountains, and Pakistan's westernmost panhandle, with the ultimate aim of compiling a geologic map of Pakistan.

During September 4–11, 1956, Assistant Secretary Wormser and a delegation of USGS scientists participated in the 20th International Geological Congress at Mexico City; Jenaro González-Reyna served as one of the two Secretaries General.

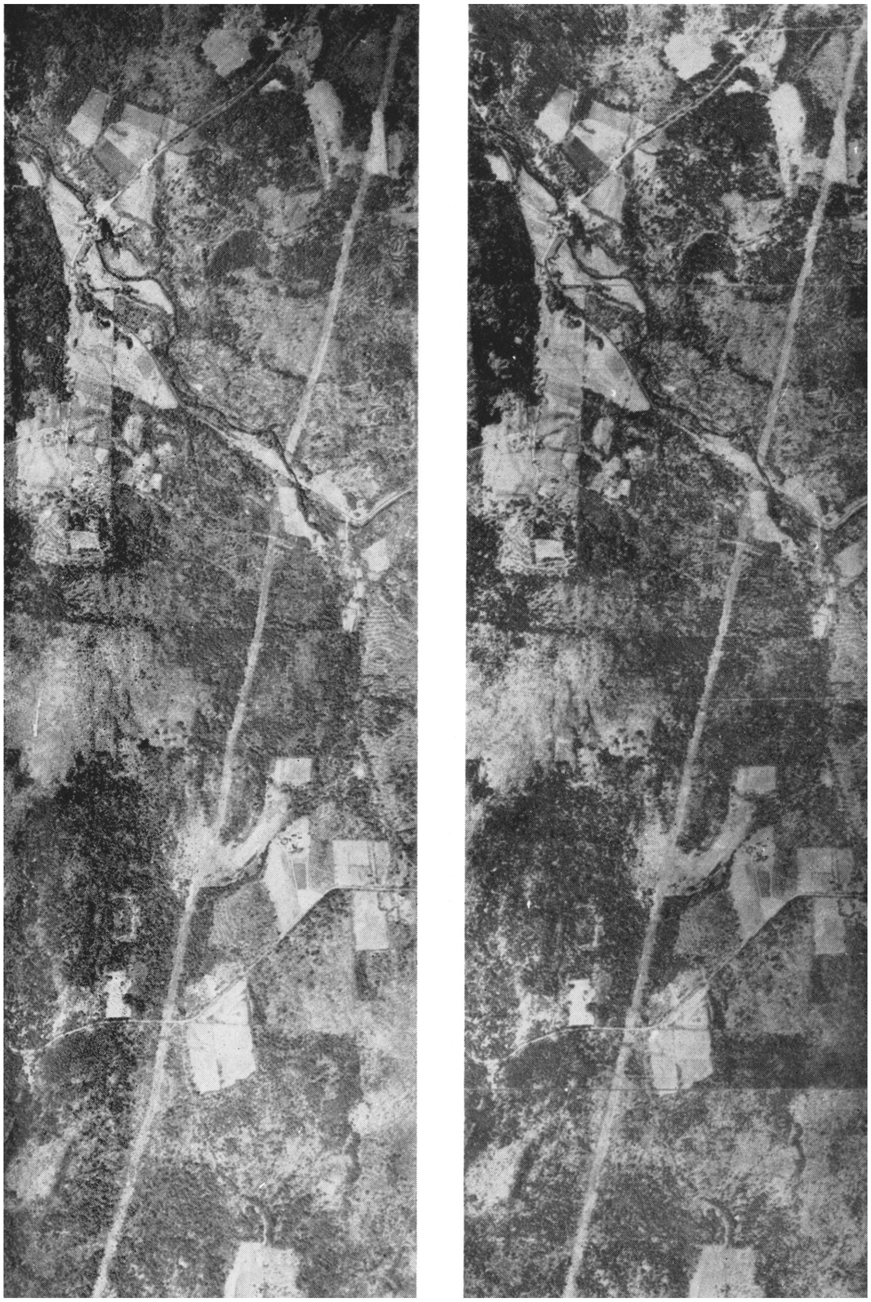
At the 20th IGC, William Johnston, Jr., Chief of the Foreign Geology Branch, officially represented Director Nolan, who could not be present. Other USGS attendees, a mix of full- and part-time employees with varying lengths of service, included Alan Bateman, Arthur Buddington, Helen Cannon, George Cohee, Thomas Dutro, Mackenzie Gordon, David Hopkins, Earl Ingerson, Thomas Lovering, Arnold Mason, Eugene M. Shoemaker, George C. Taylor, Jr., Joshua Tracey, and some 20 others.[76]

In the austral summer of 1956–57, the Navy's Operation Deep Freeze II continued to support U.S. preparations for the IGY, but without Admiral Byrd's direct participation. Byrd, who had intended to supervise the operation on site, stayed in Washington to assist Congress and Eisenhower in their efforts to establish a permanent organization for Antarctic service. Twelve Navy and Coast Guard ships, including icebreakers *Atka*, *Glacier*, *Northwind*, and *Staten Island*, formed part of Rear Admiral Dufek's TF 43, which returned to Antarctica seismologist Daniel Linehan, and journalist Walter Sullivan. During Deep Freeze II, glaciologist Albert G. Crary directed Little America V at Kainan Bay.[77] Other Americans served at bases named for Byrd, on Rockefeller Plateau; Wilkes, on the Windmill Islands, from which traverse parties explored more than 1 million square miles; and Ellsworth, on the Filchner Ice Shelf. Captain Finn Ronne, who led at Ellsworth, continued to airdrop claim markers as late as March 12, 1957. On October 31, 1956, Rear Admiral Dufek and six other officers and enlisted men landed in their R4D aircraft at the South Pole. Navy aircraft, based in New Zealand, carried building materials from Little America V to the Pole, where Paul Siple oversaw construction by Seabees of the new Amundsen-Scott Station and its dedication on January 11, 1957; Byrd died in Boston 2 months later. Three geologists were among the more than 200 persons who wintered over in 1956–57 at the U.S. IGY stations. From Ellsworth, John C. Behrendt, of the Arctic Institute of North America, examined the Filchner and Ronne Ice Shelves and geologized in the adjacent mountains. Johns Hopkins' Walter W. Boyd, Jr., studied glaciology from Little America V. USGS scientist Edward W. Remington investigated glaciology from Amundsen-Scott. Cartographer James D. O'Neal, on detail from the USGS and from Byrd's staff, accompanied a Chilean expedition that worked on the South Shetlands and on the northwestern part of the Antarctic Peninsula;[78] O'Neal transferred to the Army Engineers after his return from Antarctica. Before leaving Antarctic waters on March 29, Dufek's *Glacier* completed the survey of coastal sites begun by *Atka*. At the CSAGI's meeting in Paris in June 1957, the U.S. delegation suggested that scientific work in Antarctica be continued after the formal end of the IGY in 1958.

The Topographic Division drew on a total of about $17,068,000 during fiscal year 1956–57, some $1,075,000 more than in the previous year. SIR funds provided nearly $12,873,000, an increase of $1,064,000. Direct payments and reimbursements from States, counties, and municipalities added $1,554,000, an increase of $283,000. Other Federal agencies transferred more than $2,457,000, a reduction of $325,000, including about $1,071,000 from the USBR, some $658,000 from the U.S. Air Force (USAF), and about $540,000 from the Army and its Engineers. Nolan, Gerald FitzGerald, and George Whitmore began major changes in the Topographic Division by modifying FitzGerald's headquarters office. Under the new plan, John Davidson's Branch of Special Maps reported directly to FitzGerald, who established the two new posts of Assistant Chief Topographic Engineers (ACTEs) to manage two new Branches. Earle Fennell, the ACTE for Program Development, supervised three Program Sections—Planning, where Harold Williams succeeded George Druhot; Coordination, led by Channing Van Camp; and Control, managed by Franklin M. Mann—and Jerome Kilmartin's Map Information Office. Roland H. Moore, the ACTE for Research and Technical Standards, oversaw four Sections—Geodesy and Control Surveys, whose chief was being selected; Photogrammetry, led by Russell Bean; Cartography and Map Editing, directed by Charles Fuechsel; and Instrument Design, under James Buckmaster. Regional Engineers continued to direct operations in their four geographic areas: Atlantic, at Arlington; Central, at Rolla; Rocky Mountain, at Denver; and Pacific, at Menlo Park, where the Division opened a new cartographic office for map-finishing operations. George Druhot shifted there to serve as Special Assistant to Robert O. Davis, new Western Region Engineer, who transferred from Denver after Conrad Ecklund retired; James M. Lawson succeeded Davis.

The Map Information Office in FitzGerald's Division continued to be the central depository for national-atlas maps, now including the 17 maps of climate, farming, population, and topography published by four Federal agencies. The Division, responding to recommendations by the President's policy committees for minerals and for water resources, accelerated its mapping of many quadrangles and selected others for new work to provide the needed base maps for investigations by the USGS and supporting organizations. The Division's defense-mapping program, begun in 1951 and already absorbing a large amount of the unit's mapping capacity, expanded again during fiscal year 1956–57 as the Division received additional priority requests. The new and enlarged cooperative programs yielded substantial increases in the number of projects intended to help meet civilian mapping needs, including those of civil defense. The Division issued new topographic maps, at 1:500,000, of Arizona and Oregon, forwarded for printing those of Colorado and Virginia, and worked on or planned similar maps for seven other States. Division topographers completed mapping Kentucky at 1:24,000 in 1956 at a total cost of $6,360,000, or about 28 cents per acre. The Division, in cooperation with the Kentucky Geological Survey, undertook a revision program in 1958, a year before the last of Kentucky's 707 quadrangle maps was published. In Connecticut, Massachusetts, and Rhode Island, revised maps would appear at 1:24,000, rather than the current 1:31,680 scale, so that all quadrangles in the three States would be converted to coverage at 1:24,000 by the end of fiscal 1958–59. Division topographers prepared for reproduction urban-area maps for 19 cities and advanced work on 16 others. They also continued compiling special-use charts of foreign areas for the Air Force's Aeronautical Chart Information Center. The Division circulated widely during the year its films on topographic-mapping procedures to help train U.S. personnel in military surveying and mapping units, foreign trainees under military and technical assistance programs of the Defense and State Departments, and persons in academia for instruction in engineering, forestry, and geology. These films also were shown at the meetings of professional surveying and mapping organizations throughout the United States. Members of the Division added to the expertise of 4 visiting foreign nationals and provided tours of facilities for 35 others. Some of them also participated in the meetings, held in Stockholm during 1956, of the 8th International Congress of Photogrammetry (July) and the Esselte Conference on Applied Cartography (August).

Better control methods within the Topographic Division led to increased map coverage. In the continental United States, Division employees established nearly 1,300 permanently marked triangulation stations to provide control for areas totaling more than 50,000 square miles. In Alaska, Division engineers completed all field control for the entire 125,000 square miles of the Brooks Range. That work required 30,000 square miles of triangulation and trigonometric leveling by 25 field parties, supported by 6 helicopters and additional fixed-wing aircraft. Despite the difficult terrain, these parties completed their work at a cost comparable to costs for similar efforts in the States. Newer and higher powered helicopters enabled USGS topographers to work in more remote and higher locales; they landed safely on 17 peaks taller than 12,000 feet, including Mounts Rainier and Whitney. The higher operational ceiling for the Bell 47G–2 enabled topographers Charles R. Lloyd, Jack Lyon, and Tovio J. Nelson, aided by a USGS photographer and a

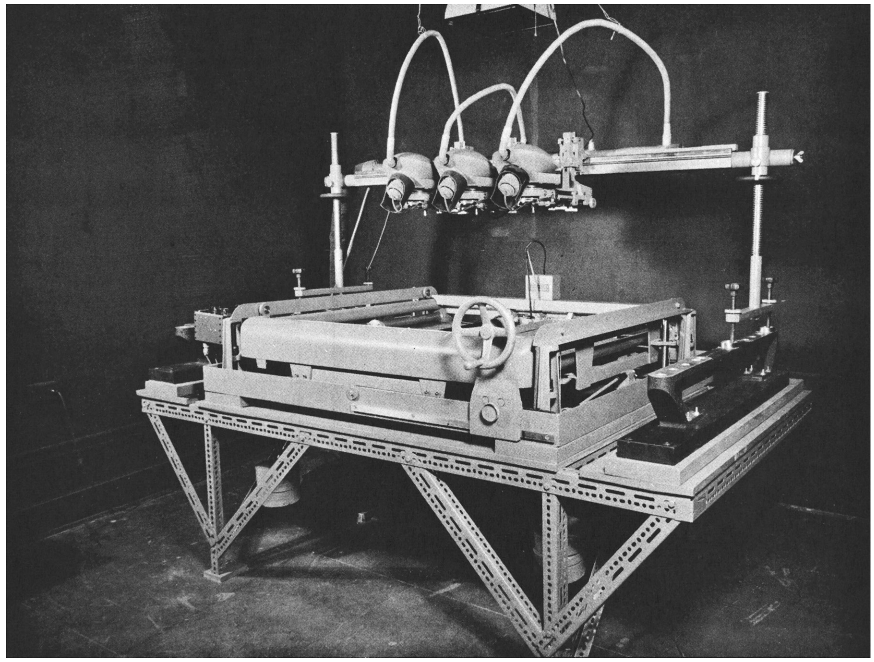


This comparison of a perspective aerial photograph (at left) with an equivalent of an orthophotograph (rectified photograph, at right) demonstrates that relief (elevation) displacement, including the crookedness of the powerline (from upper right to lower left in the photograph), tilt displacement, and lens distortion in the perspective image were eliminated during the preparation and printing of the uniform-scale orthophotograph "with nominal accepted tolerances." (Photograph and quotation from Landen, 1959, fig. 25 and p. 252; also published in Bean and Thompson, 1957, fig. 11, and in Whitmore, G.D., Thompson, and Speert, 1959, fig. 7. For details about the principles of orthophotography and the development of the Orthophotoscope, see Bean, 1955.)

National Park Service (NPS) ranger, to determine more accurately Mount Rainier's height as part of topographic mapping in the surrounding area. By triangulation from three stations north of the mountain, they fixed Rainier's elevation at 14,410 feet, or 2 feet taller than the last USGS measurement in 1913.

Topographic Division members also continued their research and development intended, as before, to produce more economical and efficient methods of map production.[79] They hoped that a newly purchased microwave-radio device for accurately measuring distance (from hundreds of feet to 30 miles) would reduce materially the cost of horizontal-control surveys and also significantly increase accuracy. Division engineers built a barostat to provide an absolute standard for calibrating altimeters. They used a new electronic computer to program some office computation and installed an improved electrical-survey-net adjuster in each of its four regional centers. They also continued developing new photogrammetric

In the 1950s, Russell Bean's team developed the Orthophotoscope from an experimental "breadboard" version to an engineered prototype (shown here in 1956) deployed in the Topographic Division's Special Maps Branch. The Orthophotoscope, with ER–55 stereoprojectors and a photoscanner, produced distortion-free rectified photographic images that met the horizontal accuracy required by the national map accuracy standards. The new images, the equivalents of orthophotographs, were used to produce maps in less time, at lower cost, and with greater accuracy than previous methods. These maps would complete the long-promised national topographic coverage at a single standard scale and also serve as new bases for the compilation of geologic and other data and interpretations. The next (third) model in the development series was patented as the T–61 Orthophotoscope. Bean received a patent in 1959. Older stereoplotters continued to be used for high- or low-relief areas. (From Thompson, 1958, fig. 20. Also published in Bean and Thompson, 1957, fig. 6, and in Landen, 1959, fig. 24. For the experimental version of the Orthophotoscope, see Bean and Thompson, 1957, fig. 3, and Southard, 1984, fig. 12.)



instruments and techniques.[80] A commercial firm, using USGS specifications, produced a transforming printer to make equivalent prints from 20-degree, low-oblique photographs. The Division procured an automatic electronic dodging device and installed it on a projection-type diapositive printer, while developing a system for precisely controlling the geometric characteristics of diapositives to achieve greater accuracy. Division engineers completely redesigned the prototype Orthophotoscope.[81] In cooperation with the Interdivision Committee on Photogrammetric Techniques for Geology, the Topographic Division provided training courses in the fundamentals and applications of photogrammetry for geologists and engineers in other USGS Divisions. By now, the scribing technique was firmly established in stereocompilation, field surveying, and color separation.[82] The Division installed a map-evaluation program to determine the most economical and efficient methods of map production and to ensure that the maps complied with national map accuracy standards.

The Water Resources Division received almost $17,931,000 for fiscal year 1956–57, a gain of $1,877,000 over the previous year's total. The Division's SIR appropriation rose to $8,511,000, an increase of $856,000. Of the SIR funds, $5,070,000 was available only for cooperation with States, counties, and municipalities. These governments supplied a total of $5,133,000, a $519,000 gain, in reimbursements and direct payments. California, Texas, New York, Florida, and New Mexico, in that order, were the five largest contributors. Other Federal agencies transferred almost $4,092,000, which represented nearly $480,000 more than in 1955–56. The Army and its Engineers supplied $248,000 more than in the previous year, for a total of about $1,350,000, and the USBR's funds rose by almost $117,000 to $1,112,000. The largest proportional increase in funds, from about $182,000 to nearly $338,000, came from the U.S. Department of Agriculture (USDA). The Division now depended on outside sources for 53 percent of its overall funding.

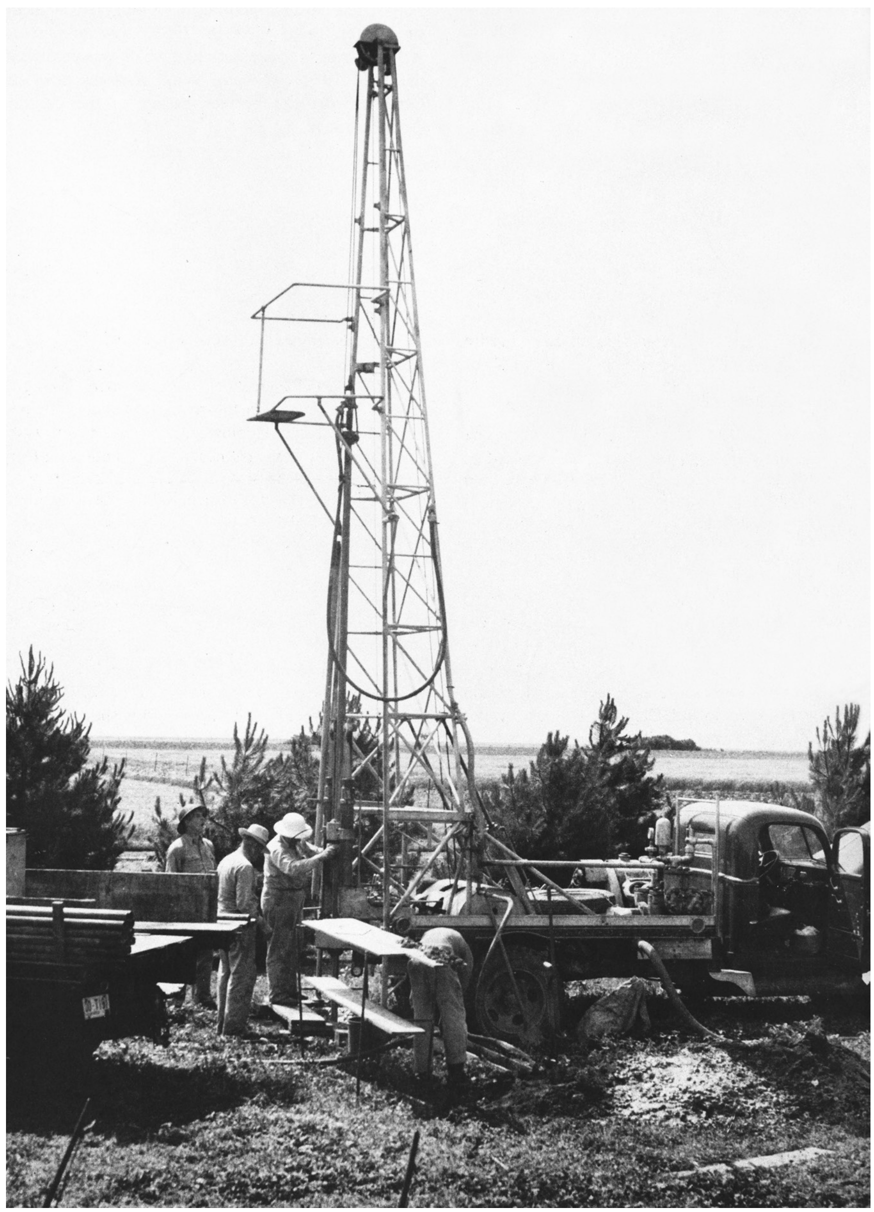
During fiscal year 1956–57, the Division continued its second major reorganization since the end of World War II. Nolan and Paulsen designed the rearrangements to improve program planning, better integrate intradivisional operations, and facilitate general-hydrology investigations under a new Chief. On April 18, 1957, Nolan advised the Division Chiefs that Paulsen would retire when he reached age

70 on the 22d. On April 30, Paulsen ended nearly 44 years of service with the Division, but he continued as Delaware River Master and as adviser to several international water commissions. Luna Leopold succeeded Paulsen as Chief Hydraulic Engineer, with the additional title of Chief of the Division (later Chief Hydrologist). Leopold chose Nace, also strongly research oriented, as his Associate Chief. As Assistant Chief, Leopold selected groundwater specialist Albert G. Fiedler, a 30-year employee who earlier worked for Paulsen and Meinzer. As USGS geohydrologist William B. Bull later recalled, Leopold quickly began asking fundamental questions about the amount and nature of basic research in the Division.[83] Leopold emphasized careful quantitative and qualitative field investigations, supported more active participation in the international scientific community, started process-oriented studies in geomorphology, increased cooperation with the Geologic Division and, like the agency's best managers since 1879, set high standards for hiring and operations.

Leopold's Division aimed some of its research during fiscal year 1956–57 toward explaining the principles governing the movement of water and entrained sediment through river channels to gain a better understanding of the long-term effects of reservoir impoundments, channel modifications, and climatic variations on channel erosion and sedimentation. To aid these studies, members of the Topographic Division completed and tested a photogrammetric system to replace hand measurement of water-flow effects for compiling contoured "maps" of sand configurations in the Water Resources Division's hydraulic test flumes. Water shortages in the West continued to highlight the need for additional research on the effects of runoff after the proposed removal of upland vegetation and of methods for suppressing evaporation from lakes and reservoirs. Division specialists studied records of storage in reservoirs to determine the amounts of water available for present development and to devise methods for defining optimum yield from reservoir regulation. They began analyses of the relative influence of climate and vegetation on measured sediment yields. Division scientists also studied advances or recessions of glaciers in relation to long-term fluctuations in water supplies. Continued increases in flood damage intensified the need for accurate methods of estimating potential floods in areas where streams remained ungaged and for developing hydrologic principles applicable in zoning urban lands subject to floods. On August 7, 1956, a new law provided "insurance against flood damage."[84] The Division demonstrated how its hydrologic data and analyses could aid appraisals of the flood potential and risks inherent in building on flood plains. Progress in the Division's theoretical and field studies of the mechanics of groundwater recharge advanced the understanding of the artificial recharge of depleted groundwater reservoirs. Robert W. Stallman developed numerical methods for analyzing regional water-level networks to define aquifer parameters and recharge-discharge characteristics.[85] Division engineers tested ultrasonic instruments to obtain initial continuous measurements of water velocities in locations unrecorded by present methods. Division members began a comprehensive study of the hydrology and evaluation of the water resources of the Delaware River Basin that they hoped would be completed during fiscal 1958–59. In eastern Pennsylvania, Division and other USGS scientists again served as consultants in a program designed to conserve anthracite-coal resources through mine drainage. Division personnel also continued to prepare comprehensive reports on the water resources of industrial areas and the requirements of specific industries.

The Surface Water Branch completed its review of the nationwide streamgaging network during fiscal year 1956–57, classifying all streamgaging stations as being either (1) hydrologic network or (2) water management. The Branch's hydrologic network provided basic data for hydrologic studies, and its water-management stations produced information where needed for specific purposes. Branch personnel obtained surface-water records at 6,900 sites, 100 more than in 1955–56, in the conterminous United States, Alaska, Hawaii, and Guam. The Branch's compilation of all streamflow records for 1888–1950 reached 77 percent, and the unit published the volume for the Snake River Basin; the basin summary included records that were previously scattered through some 50 annual volumes in the series of Water-Supply Papers. Branch hydrographers, using funds transferred from the Soil Conservation Service, made rainfall-runoff analyses of maximum annual floods for more than 820 gaging stations in the United States, including all those that recorded runoff from drainage areas of less than 400 square miles. They completed flood-frequency analyses for Florida, North Dakota, and South Dakota and advanced similar regional analyses for the Colorado River Basin as part of the nationwide effort. The Branch also continued investigations of the quantity, movement, and sources of waterborne sediments and their effects on reservoir storage, navigable waterways, diversion works, irrigation canals, and water-supply systems.

Investigations in 44 States, Hawaii, and Guam by the Ground Water Branch during fiscal year 1956–57 ranged from research on the principles of the occurrence and movement of water in varied geologic and hydrologic environments,



In the 1950s, USGS geohydrologists studying groundwater obtained data and samples from this test hole and others drilled by rotary rigs owned by small companies under contract to the agency. These wells did not compete, as Layne-Western and smaller industrial firms complained to Congress, with commercial wells drilled to supply agricultural, industrial, rural, and urban users. Although the USGS convinced Congress that the agency's wells were drilled only to enable scientific observations, the legislators required that such specialized surveys be done only when administrators determined them to be in the public interest. (Photograph from Ferguson and others, 1990, p. 256.)

through studies of areas, to systematic continuing inventories of draft and observation of water-level fluctuations. Branch members concentrated on areal investigations and reports on the geology and groundwater resources of geographic or hydrologic units, commonly of counties or groundwater basins, to contribute to the nationwide coverage. They focused on the use and expansion of natural underground-storage facilities, which could be made to complement surface reservoirs in water management. Studies of artificial recharge near Amarillo, Texas, showed that at least 10,000 acre-feet of water could be stored in the Ogallala Formation (Miocene–Pliocene) beneath a square mile of land that contained the municipal McDonald well field. Investigations in California's San Joaquin Valley indicated that a groundwater storage capacity of some 90 million acre-feet existed in the interval between 10 and 200 feet below the land surface in an area of 10,000 square miles. In 1955, the 9 million acre-feet of groundwater pumped for irrigation in that area represented about two-thirds of all groundwater withdrawn for irrigation throughout California and at least one-fourth of U.S. total use.

The Quality of Water Branch increased its staff to 300 in fiscal year 1956–57, a gain of 240 persons since 1947. Branch members analyzed more than 60,000 samples from 500 sites during the year, compared to 17,500 a decade earlier. Most of the stream samples, including 75 from west of the Mississippi River, were collected to determine trends in dissolved mineral content to aid irrigation projects. Some 7,500 of the samples represented groundwater nationwide. Branch specialists improved their studies of water quality in streams by developing criteria for station-network operation to satisfy minimum national needs. They also continued, and made more intensive, the chemical-quality investigations in the selected river basins. Cooperative studies included those for governments in 16 States and 7 Federal organizations—the AEC, the USBR, the DoD, the Federal Housing Administration, the Public Health Service, the Tennessee Valley Authority (TVA), and the Veterans Administration. The Branch issued chemical-quality reports on the West's surface waters for 1953, as part of the continuing series, and on the Fort Belvoir area for 1954–55 by Charles N. Dufor. Branch members prepared reports on water salinity in the Delaware River estuary and the surface-water chemistry of Arkansas, New York, North Carolina, Texas, and Virginia and began studies of radium and uranium in groundwater in parts of the West.

This view shows the C.G. Glasscock Drilling Company's mobile platform "Mr. Gus II" being installed on a U.S. Government lease—Outer Continental Shelf (OCS) 134—in block 48, Grand Isle area, off Louisiana, on August 6, 1957. Six wells could be completed from the platform without changing its position. Heightened exploration, new discoveries, and greater production by oil companies in the Gulf of Mexico significantly increased both the supervisory responsibilities of the Conservation Division's Oil and Gas Leasing Division on that part of the OCS and the rents, royalties, and other payments made to the Federal Government. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., pef00010, https://www.sciencebase.gov/catalog/item/51dda096e4b0f72b4471dda5; published in Yochelson and Nelson, C.M., 1979, p. 47.)

In fiscal year 1956–57, Harold Duncan's Conservation Division continued to receive more than 97 percent of its funds from its SIR appropriation of about $1,940,000, or nearly 153,000 more than during the previous year. Other Federal agencies and nonfederal sources supplied $46,000, a $6,000 loss, for a total of nearly $1,987,000. During the year, the Division's supervisory work helped to return $132 million to the Federal Government. Public-land income remained divided. The Federal Treasury received 10 percent; 37.5 percent went to the States, for schools and roads; and the Bureau of Reclamation received 52.5 percent, for general use in the Western States. In Alaska, 90 percent went to the Territory and 10 percent to the Federal Treasury. Receipts from supervised operations on the Outer Continental Shelf and on military and naval lands went to the U.S. Treasury. Income from restricted Indian lands was received for the benefit of the tribes or allottees. To the Division's reactivated post of Assistant Chief, Duncan appointed his long-time assistant Robert Spratt.

As part of the Conservation Division's operations during fiscal year 1956–57, members of the Mineral Classification Branch processed a total of some 32,900 cases, some 4,000 more than in 1955–56. Now led by John C. Miller, who had replaced David Cerkel in 1956, Branch members also completed a mineral map of New Mexico and maps and reports on eight coal, gas, or oil fields and structures in Colorado, North Dakota, and Wyoming. Personnel of the Water and Power Branch prepared six reports as part of their systematic review of land withdrawn for waterpower reserves that resulted in recommendations for restorations to the public domain of 75,000 acres of recommended and previously withdrawn lands. Branch members added nearly 29,000 acres and eliminated about 29,000 acres, leaving some 7,128,500 acres of power-site reserves in 23 States and Alaska. They also surveyed 350 miles of stream channels and 15 dam sites and published maps of 110 miles of channels and 6 sites. The Mining Branch supervised nearly 3,300 properties in 32 States and Alaska, whose production of mineral commodities, worth some $143.7 million, generated more than $7 million in royalties. On October 31, 1956, a Survey order, signed by Acting Director Robert Lyddan and approved by Secretary Seaton on November 6, authorized the Regional Oil and Gas Supervisors to act on applications for suspension of operations or production, or both.[86] Members of the Oil and Gas Leasing Branch supervised production on nearly 106,300 properties, covering more than 77 million acres, on the public lands in 24 States and Alaska, 4,490 acquired-land leases, and 11,265 leaseholds on Indian lands; royalties from these wells totaled $108.2 million. Production from military lands and Naval Petroleum Reserve No. 2 (NPR–2) added another $3.5 million. On the OCS, Branch members supervised 533 leases, of which 298 were originally issued by Louisiana and Texas but then passed to Federal jurisdiction under section 6 of the Outer Continental Shelf Lands Act; the remaining 235 were issued under section 8 of the Act. Of the 322 wells spudded during the year, 177 produced oil and gas. Although gas production from the OCS in 1956–57 fell by 4 percent from production in the previous year, petroleum production rose by 58 percent, and total revenues from both resources reached $13.3 million. During the year, 182,700 acres were eliminated from the Katalla-Yakataga development contract on lands in southeastern Alaska.

Foreign-policy issues dominated the Presidential campaign in 1956, beginning with another crisis in the Middle East. Members of the Arab League, hoping to reverse the outcome of their unsuccessful war against Israel in 1948–49, blockaded Israel by land, exchanged fire with Israeli forces, and campaigned against the Jewish State in the United Nations (U.N.). On June 13, 1956, the last British forces withdrew from the Suez Canal, leaving its operations and defense to Egypt, whose voters elected Nasser their President on June 23. Secretary Dulles announced on July 18 that the United States would not fulfill its promise to fund the proposed

High Dam on the Nile at Aswan. Eight days later, Nasser nationalized the Canal, through which passed daily almost 1.5 million barrels of oil, and decided to use the Canal's revenues and increased Soviet aid to build the Aswan Dam. On October 5, the Soviet Union vetoed a French resolution in the U.N. Security Council to restore partial international control of the Canal. To avoid appeasement, to humble Nasser, and to recover the Canal, the British, French, and Israelis secretly planned and agreed, on October 24, to launch joint, supportive, and nearly simultaneous attacks on Egypt. American U–2 photographs disclosed their preparations. Israeli forces attacked Egyptian units in the Sinai Peninsula on October 29, drove them west toward the Canal, and planned to take all of the Sinai. The British and French demanded that Egypt return the waterway to their control.

When Nasser rejected the Anglo-French ultimatum, their air and naval forces struck Egyptian bases on October 31. Nasser closed the Suez Canal and ordered it blocked by scuttling ships. Three days later, Arab extremists severed Iraq Petroleum's pipeline that delivered 445,000 barrels of oil each day to the terminal on the Mediterranean. The twin stoppages removed more than 2 million barrels a day from the West's petroleum sources, or nearly two-thirds of its daily requirement of 3.25 million barrels. On November 2, only the Egyptians heeded the U.N.'s call for a cease-fire. The British, French, and Israelis rejected similar requests from the Soviet Union and the United States after Eisenhower telephoned Eden on the new trans-Atlantic line to express his displeasure.[87] The Israelis captured the remainder of the Sinai, and Anglo-French airborne and amphibious forces took Port Said and other key points in the Suez Canal Zone during November 5–6. They then agreed, under increasing diplomatic and related pressure from the two superpowers, to a cease-fire. A U.N. Emergency Force began occupying the Zone on November 15. In December, Anglo-French troops left the Zone, and U.S. Army Engineers and international specialists began to clear the waterway.

During the Suez Crisis, Hungarians, encouraged by the Eisenhower administration's earlier expressed intent to aid the liberation of Eastern Europe, rose against Soviet rule.[88] During the Communist Party's 20th Congress in February 1956, Khrushchev damned Stalin's personality cult and its effects. Khrushchev then renewed Beria's earlier efforts toward liberalizing the Warsaw Pact countries, but Khrushchev promptly ended the reforms when the Hungarians revolted. On October 23, police in Budapest fired on demonstrators who demanded that their government form a democracy and free the country from Soviet domination. After a week of turmoil, the Soviets promised the Hungarians free elections and a policy of neutrality and began withdrawing from Budapest. With the West's attention increasingly focused on Egypt, Soviet forces returned to Budapest. Soviet tanks and troops crushed all opposition in the country during November 1–4; some 25,000 Hungarians died, and another 100,000 fled the country.

The Suez Crisis and its resolution temporarily shattered the unity of the Western allies. The Eisenhower administration threatened to sell British bonds to adversely affect its currency and refused to replace the oil withheld from Britain and France by the Middle East's producing countries until the Anglo-French forces left Egypt. Oil production in the United States, as Daniel Yergin later recorded, proved sufficient to meet all of Europe's needs during the 1956–57 boycott.[89] The Interior Department reported a domestic oil surplus and estimated that some 300 billion barrels and a corresponding volume of natural gas would be discovered and recovered by new technological innovations. On August 1, 1956, Secretary Seaton, at the request of the ODM's Director Arthur Flemming, decided that the Middle East emergency required preparing the response plan authorized under the Voluntary Agreement Relating to Foreign Petroleum Supply as amended on May 8, to deal with expected shortages. The Foreign Petroleum Supply Committee, after meeting on August 7, promptly sent a plan to Seaton, who passed it to Flemming.

After consulting with representatives of the ODM, the Justice Department, and Interior, Seaton announced the plan on August 10. With some reservations, 16 oil companies became members of and participated in the Middle East Emergency Committee and its subcommittees on Information, Pipeline Transportation, Production, Refining, Statistical, Supply and Distribution, and Tankers. The Committee met regularly during December 1956–April 1957 to alleviate the shortages and avoid economic disruptions by establishing scheduled activities. Their work, and related efforts at home and abroad, used reserve production to supply an extra 3 million barrels per day, or about 90 percent of the normal requirements of the affected areas. In March 1957, the National Petroleum Council's report on "World Petroleum Tanker Construction" suggested to Seaton that future disruptions could be avoided, or minimized at least in large measure, by constructing more and larger oil-carrying supertankers in the next decade.

The two major U.S. political parties held their national conventions in August 1956. The Democrats met in Chicago on August 13, as violence grew on Israel's borders with Egypt and Jordan. The Party's delegates again chose Adlai Stevenson for President, rather than Governor Averell Harriman of New York (who was endorsed by Truman) or Senator Estes Kefauver of Tennessee. John F. Kennedy, Joseph Kennedy, Sr.'s second son and now the junior Senator from Massachusetts, placed Stevenson's name in nomination. After the first ballot, Kefauver withdrew his name and released his delegates to Stevenson, who left to the convention the selection of his running mate. Kennedy, who voted not to condemn McCarthy in December 1954, led Kefauver on the second ballot. When Kennedy lost on the third tally, he asked the convention delegates to make their choice unanimous. Stevenson and Kefauver campaigned for equal opportunities in education, public development of water power, fixed rates for parity payments to farmers, and, as Britain successfully tested a hydrogen bomb in May, an end to such future tests. Stevenson also proposed ending the draft and favored a worldwide halt to all nuclear testing. Republicans convened in San Francisco on August 20 and renominated Eisenhower and Nixon. Eisenhower claimed responsibility for the country's peace and prosperity. He and Nixon promoted gradual elimination of segregation, private and government development of water power, maintaining flexible parity rates, and continued testing of advanced nuclear weapons.

In October 1956, Soviet Premier Bulganin wrote to Eisenhower and endorsed Stevenson's proposal to halt testing of nuclear weapons. When the administration made the letter public on October 20, a little more than 2 weeks before Election Day, some U.S. officials accused Bulganin of interference. That charge paled into insignificance compared to events in Hungary that began only a day later. On October 23 representatives of 70 countries at a U.N. conference approved a statute that would lead to the establishment of the International Atomic Energy Agency (IAEA) on July 29, 1957. The U.S. Congress agreed and President Eisenhower signed a bill that provided for U.S. representation and participation in the IAEA. The events of October 1956 in Hungary and the Middle East created a sense of emergency, but they did not seem to affect the U.S. Presidential election. On November 6, Eisenhower defeated Stevenson by margins larger than those in 1952. Eisenhower won by almost 9.6 million popular votes and received 457 of 531 electoral votes. Again, the President's victory proved only a personal one; in elections for the 85th Congress, the Democrats increased their majority in the House to 33 seats and raised their slender margin in the Senate to 2.[90] The Soviet Union declared on November 16 that it would accept a modified form of the "Open Skies" policy proposed by Eisenhower in 1955 but later withdrew its pledge. On December 6, as the Soviets reorganized Hungary, Eisenhower ordered the DoD to set up emergency transportation to bring to the United States some 15,000 Hungarian refugees.

January 1957 proved an exceptionally busy month for President Eisenhower. On the 1st, he hosted a bipartisan executive-congressional conference on foreign policy, mutual security, and national defense. Four days later, Eisenhower addressed a special message to the new 85th Congress about the continuing critical situation in the Middle East, which, he emphasized, held two-thirds of the world's known oil deposits. Suggesting that U.S. armed forces might have to be deployed in the region to counter any Communist threats to its and U.S. security, he asked Congress for the authority to do so but pledged to use it only "at the desire of the nation attacked."[91] In addition to continuing the economic and military aid under the Mutual Security Act, Eisenhower added that he would request $200 million in discretionary funds in each of fiscal years 1957–58 and 1958–59. Anthony Eden resigned as Britain's Prime Minister on January 9. On the next day, Eisenhower congratulated Harold Macmillian (with whom he served in North Africa during World War II) as Eden's successor, and the President also reported on the State of the Union to a joint session of Congress. Eisenhower cited his continuing concerns for human liberty, welfare, and progress and for world peace, goals that guided his administration's legislative program. He repeated his request "for Congressional authorization to help counter this threat" of Soviet aggression in the Middle East, a matter "of vital and immediate importance to the Nation's and the free world's security and peace."[92] The President closed by renewing his offers of open-skies surveillance by unarmed sentinels, armament reductions, and new agreements to ensure world peace. He urged Congress to authorize U.S. membership in the proposed organization for trade cooperation and full participation in the IAEA. On January 16, three B–52s took off from their base in California on the initial round-the-world nonstop flight by jet aircraft and returned there 45 hours and 19 minutes later. They demonstrated that the U.S. Air Force could drop nuclear bombs anywhere. Yet to be shown was the same ability for rapid intervention by U.S. ground forces in the Middle East or elsewhere worldwide.

On the day the U.S. bombers began their flight, Eisenhower delivered his budget message for fiscal year 1957–58.[93] The President reemphasized his continued twin goals of balanced budgets and tax reductions. The estimates for 1957–58, he promised, would ensure receipts of $73.6 billion and expenditures of $71.8 billion, leaving a surplus of $1.8 billion, the third consecutive year that excess funds would be available to reduce the national debt. The President also noted the degree to which the Federal workforce had been reduced by 240,000 persons since 1953. To improve public service, Eisenhower continued to approve amendments to the Government Employees' Incentive Awards Act[94] and established the seven-member President's Committee on Government Employment Policy. He promised that vacant Federal jobs would not be filled by new hires unless those posts could not be abolished or filled by transfers. Any and all proposals to increase Federal payrolls, Eisenhower added, would be carefully and critically examined and evaluated. Eisenhower was reinaugurated as President on January 21, 1957, and videotaped coverage was shown on national television the next day. Reiterating a desire for peace, he hoped the United States would "pursue the right—without self-righteousness," "know unity—without conformity,"[95] "grow in strength—without pride in self," and "ever speak truth and serve justice"[96] in dealing with the world's peoples.

Eisenhower personally welcomed King Saud at Washington National Airport on January 30 for talks aimed at improving relations with Saudi Arabia and exploring how the two nations might cooperate within the U.N. Charter to resolve the continuing crisis and restore peace in the Middle East. The King already had agreed to a 5-year, unified military command with Egypt and Yemen, but he firmly opposed Soviet influence in the region. He now wished to renew Saudi-American relations "on the basis of amity and mutual interest," hoping that divine-given "wisdom and sagacity" would serve as guides "towards universal peace and good will."[97]

On February 6, during Saud's visit, Eisenhower accepted Flemming's resignation as ODM Director. Saud departed 2 days later, after agreeing to renew for a second 5 years the U.S. lease on the airbase at Dhahran in return for continued U.S. military equipment, services, and training. Meanwhile, Israel maintained some of its military forces outside two of the armistice lines agreed upon in 1956, in defiance of the U.N.'s call of November 2, 1956, and Eisenhower's personal request 6 days later to Premier David Ben-Gurion. On February 17, 1957, Eisenhower referred to the U.N.'s renewed resolution on February 2 and again asked Ben-Gurion to withdraw the forces still in the Gulf of Aqaba area and the Gaza Strip. The U.S. Army Engineers and the international specialists, under the protection of the U.N. Emergency Force, had nearly cleared the Canal, the President reported to the Nation on the 20th. Under increasing international pressure, Israel withdrew its remaining forces from the armistice lines by March 2. "To promote peace and stability in the Middle East,"[98] Congress approved on March 9 the "Eisenhower Doctrine" by authorizing the President to extend economic and military aid to any nation in the region that requested it. The new law provided $200 million in Mutual Security Act funds. Eisenhower appointed a special ambassador to the Middle East and met with Macmillan in Bermuda during March 20–24.

Secretary Seaton made his initial appearances in January and March 1957 before the appropriations subcommittees of the 85th Congress to justify Interior's portion of the budget for fiscal year 1957–58. The Department now required support for salaries for and operations by nearly 50,000 full-time or part-time employees, of whom about 7,330 were in the USGS. By the time Seaton testified, Interior's upper management had changed again. In addition to new Under Secretary Chilson, Ross L. Leffler of Pennsylvania became the Assistant Secretary for Fish and Wildlife, the fourth such topical post in the DoI, to oversee the new Fish and Wildlife Service, both established by the same statute on August 8, 1956, as part of a new "sound and comprehensive national policy * * * to strengthen the fish and wildlife segments of the national economy."[99]

On January 22, Seaton testified at the House subcommittee hearing. Michael Kirwan welcomed Seaton by assuring him that he was "going to make a good Secretary" and "do what is proper and right, not only for Interior but for the interests of the country."[100] Seaton urged the subcommittee to approve the requested increases in funding for the USGS for the topographic and geologic mapping required to implement the administration's national polices for minerals and water resources. The Secretary requested additional sums for purchasing certain strategic minerals during the adjustment interval after reaching the stockpile requirements for those minerals. Kirwan specifically mentioned the Nation's need for more water. He deplored past thefts and waste of this resource, the results of which he reminded Seaton, "You saw * * * on the trip with the President." Kirwan expressed his pleasure that Seaton was "making every effort to ask for increases in the budget." "You said," Kirwan emphasized, "we must continue to find the minerals, the best uses of water and timber—this is the department which develops and protects the wealth of the United States Government."[101] Kirwan, seconded by his Democratic colleague William Norrell, praised Seaton's written statement; Kirwan called it "one of the best" he had seen during his 14 years of service on the subcommittee. Kirwan hoped that Seaton would "accomplish many things which should have been accomplished many years ago."[102] On January 24, Seaton left for 10 days in Alaska, where Interior then stationed about 2,500 employees, including some 40 from the USGS.

The budget Seaton proposed for the USGS increased its SIR funds by nearly $7.2 million to $38,775,000, but deducting the costs of Civil-Service retirement would reduce the gain to $5.8 million. The USGS also asked to hold over and expend the $415,000 from the 1956–57 appropriation not yet used for work connected with special-purpose buildings, which required an additional $940,000 in 1957–58. The GSAd's Public Buildings Service estimated the total of $1,355,000 would enable a third building of 81,000 square feet to be constructed, in a single step, for the Pacific Coast Center at Menlo Park. Approving the USGS budget would raise the total of the agency's 7,595 employees—6,961 permanent and 634 other full-time-equivalent (FTE)—authorized for fiscal year 1956–57 to 8,127—7,487 and 640—during fiscal 1957–58.

Director Nolan explained these numbers and other parts of the budget request when he and Assistant Secretary Wormser appeared before Kirwan's subcommittee on January 15. During the next fiscal year, Nolan estimated, the USGS would incur $39,190,000 in direct obligations and $19,650,000 more in those indirect. He asked for an increase in base of $1,365,000 to cover retirement funds. The additional $1,145,000 for topographic surveys and mapping, and the $1,375,000 expected from the States, would enable the USGS to complete standard maps for some 155,000 square miles during fiscal year 1957–58, compared to 131,000 and 121,000 square miles, respectively, in fiscal 1956–57 and 1955–56. The new work would help the agency fulfill the recommendation by the Presidential Advisory Committee on Water Resources Policy to complete mapping the country topographically within 15 years. Nolan asked for $1.3 million more for geologic and mineral-resource surveys and mapping, noting that "recent events involving the Suez Canal have shown the wisdom of the program to increase our capacity to supply our own mineral resource needs in this country."[103] Responses to his recent invited talk at the World Mining Congress in Los Angeles during the fall of 1956, Nolan reported, indicated a much wider interest, beyond that of the mining companies, in USGS methods in photogeology and geochemical prospecting. The agency asked for an additional $490,000, under general-service geology, to provide more mapping support required for the national water-resources policy.

The largest single increase in the USGS budget for fiscal year 1957–58 was $2,525,000 (requested to raise the 1958 base from $8,885,000 to $11,410,000) in SIR funds to add to estimates of $6.2 million in State cooperative funds and another $4 million in transfers from other Federal agencies. These funds would support USGS hydrologic activities, including the principal Federal program of basic research. During the years of continuously funded investigations of water resources by the USGS since 1894, Nolan pointed out to Kirwan's subcommittee, most of the effort "has of necessity gone into what might be called a measurement or data collecting program." "There is emerging now," he continued, "a need for a new kind of work, based on but differing from the measurement program—that is a need for interpretative studies that draw out from existing records the information that is most significant and place it in its most useful form." Nolan gave as examples "the adaptation of flood-frequency data for use in problems of zoning and flood insurance, and the investigation of the utilization of water in certain industries." Nolan proposed to continue these measurement activities, because upon them depended the coeval "sound interpretative work," but the USGS planned to "capitalize more fully on the data we have and to expand our knowledge of some of the fundamental phases of water and its disposition and movement in the hydrologic cycle." "A considerable part of the increase" requested for water-resources investigations, Nolan promised, would be used in meeting the need "for 'interpretive studies on an effective scale,'"[104] as stressed by the President's advisers on water-resources policy. When Kirwan asked for examples of recent results of this research, Nolan described the use of thin films, one molecule thick, on the surface of reservoirs to reduce losses by evaporation and the extension of phreatophytic studies to scrub juniper and salt cedar. Nolan expected the new electronic computers—the Burroughs Datatron, now on line, and other computers, now being tested—to improve economy and efficiency in the automatic processing of streamflow records and speed publication. Nolan also reported that 200 of the 340 new staff recently authorized by statute went to the Water Resources Division; Kirwan agreed that decision would prove more effective in solving the present drought than the "President flying over the country and saying 'Yes, we are in a heck of a mess for water.'"[105]

Nolan hoped that the House subcommittee would approve the full request of the USGS for SIR funds for fiscal year 1957–58. He reported that the agency would be required to locate its new building in the Washington area on Federal land in the District of Columbia. Few sites of appropriate size remained in the District. The USGS still wanted to be close to the other agencies with which it worked daily and also to avoid having to move some 2,000 of its employees across the city's normal traffic flow during the workweek. Near the hearing's end, Kirwan and Ben Jensen, also with 14 years of service on the subcommittee, agreed that they had "never doubted your requests and the need for what you requested. When we granted it we knew it would be a job well done for this country."[106] Jensen also urged a direct appropriation for the new building in the Capital. When Nolan suggested the USGS might make that request next year, Kirwan promised "a sympathetic ear."[107] The House subcommittee and its Committee on Appropriations approved $36 million in SIR funds for 1957–58, $2,775,000 less than requested, but $4,398,000 more than in 1956–57. As the USGS encountered difficulties in recruiting qualified personnel, the Representatives decided the new sum they provided represented the maximum effective expansion in fiscal 1957–58.

Representatives of Interior and the USGS presented their justifications to the Senate subcommittee on the DoI, still chaired by Carl Hayden, in mid-March 1957. Democratic Senators Dennis Chavez and Warren Magnuson and the five Republicans continued to serve on Hayden's subcommittee, but Democrats Richard B. Russell of Georgia and Lyndon B. Johnson (LBJ)[108] of Texas replaced Senators Clements and Holland. LBJ, supported by Russell and Sam Rayburn, rose rapidly in the Democratic leadership after his election to the Senate, from party whip in 1951, through minority leader in 1953, to majority leader in 1955. LBJ also grew increasingly conservative. He opposed expanded civil rights and Federal ownership of the offshore oil lands, and supported the Taft-Hartley Act against the labor unions, but he worked to pass through the Senate the 1957 Civil Rights Act[109] for Eisenhower, despite a day-long filibuster by South Carolina's Strom Thurmond. On September 9, the new law established a Commission on Civil Rights, created a Civil Rights Division within the Justice Department, and enabled the Attorney General to seek district-court injunctions to restore improperly deprived rights to vote; meanwhile, it also repealed the President's authorization, from 1866, to use Federal troops for enforcement. Although the U.S. Supreme Court declared school segregation unconstitutional in 1954, Arkansas' Governor Orville E. Faubus called out his State's National Guard on September 3, 1957, essentially to prevent African-American students from entering Little Rock's Central High School for the fall term. Faubus, failing to fulfill an agreement he reached with Eisenhower on September 14, refused to withdraw the Guard and did not do so until forced by a district-court injunction. Riots followed the Guard's departure on the 23d. The next day, Eisenhower federalized the Guard and authorized the deployment to Little Rock of 1,000 members of the 101st Airborne Division to restore order. After the African-American students began classes on September 25, Eisenhower gradually withdrew the paratroopers.[110] The crisis was resolved, but discrimination against minorities continued in the South and elsewhere in the Nation.

On March 13, Seaton asked Carl Hayden's Senate subcommittee to restore the $60.1 million, not including funds for the USBR and the four power administrations, cut by the House from Interior's budget, which included a reduction of $2,775,000 in the estimate for the USGS. Two days later, Wormser and Nolan reinforced Seaton's request for the USGS. Nolan told the subcommittee that appropriating less than the full estimate would pose problems for the agency. The USGS would not be able to begin several new projects as responses to recommendations by the Cabinet committees for mineral and water-resources policies or keep trained personnel for the existing programs just expanded in response to those recommendations. Especially "in regard to geologists," he emphasized, "the sharp reduction [of another $1,339,000] in our Atomic Energy Commission program will make it difficult to maintain the present staff."[111] Part of the House's perception in making its cut, Nolan suggested, involved difficulties due to how the USGS was required to report part-time personnel. Many of the vacancies seen by the House's subcommittee as representing the agency's "inability to hire personnel," the Director explained, represented what he termed "normal vacancies." These gaps were caused by the continuing seasonal employment of university and college students and their teachers, the usual turnover in personnel, and the required planning for "rates of hiring in anticipation of program changes."[112] Nolan hoped the justifications for increased funding for topographic and geologic mapping, and for water-resources investigations, and all responses to recommendations by the Cabinet committees for raising the rate of mapping and undertaking additional fundamental research, including the hydromechanics of flowing water, would convince the Senators "that our ability to find personnel is not greatly out of line with our current needs or with the needs anticipated in 1958."[113] The additional reduction of more than $1 million in AEC funds, Nolan assured Hayden, would free nearly 110 employees for assignment elsewhere in the USGS or, if necessary, separation from the agency. Applications for the examination for GS–5 through GS–13 positions rose steadily in recent years, Nolan reported, increasing significantly the agency's eligibility lists in those grades. Qualified people, he emphasized, could be recruited to carry out the proposed programs if they were fully funded. Senator Henry Dworshak, who entered the chamber at this point, repeated the House subcommittee's concern that the needed technical personnel were not available and that AEC transfers actually funded all USGS work for the AEC.

Hayden then presented for the record the sources of the $59,582,000 the USGS expected to receive in fiscal year 1957–58. That total included $39,190,000 in SIR appropriations; $12,545,000 from other Federal agencies; $7,490,000 in reimbursements and direct payments from States, counties, and municipalities; and $357,000 from miscellaneous nonfederal sources. Nolan, queried by Dworshak, agreed that the requested budget increase of about $7 million would fund 526 new employees for the expanded programs. When the questions passed to facilities, Nolan reported plans to transfer some 250 employees from Sacramento to the new third building, out of four planned, at Menlo Park, but he said that a significant number of people would remain at Sacramento "to provide liaison with the State."[114] Building 2, encompassing 32,455 square feet, was completed and occupied, mostly by geologists, early in 1957 and acquired by the Government in 1960. To provide a combined national-regional center in Washington that met Federal requirements and recommendations by the USGS Science Advisory Committee, the agency planned, with the GSAd's approval, to occupy and build on the National Bureau of Standard's site on Van Ness Street, N.W., after the NBS moved to a location in Maryland. Nolan expected that arrangement would save a significant part of the estimated cost of $22 million. Dworshak agreed that USGS operations needed to be consolidated in Washington, but, as fears of inflation and the administration's mandate now held the lease-purchase program in abeyance, he objected to funding the building's construction by direct appropriation. No construction funds, or even those for planning, could be requested until at least fiscal 1958–59, Nolan assured the Senators, but the USGS must comply with the House's request to report possible alternatives. Dworshak then asked if any of the USGS employees in the Capital area could work more efficiently in the field. Nolan replied that lack of room in Washington already had accomplished a certain amount of dispersal, but some work, like terrain intelligence for the Army Engineers, required the facilities for, the skills of, and close coordination by the agency's personnel in the District.

The Senate subcommittee and its Committee on Appropriations did not restore any part of the $2,775,000 the House cut from the USGS budget estimate. On July 1, 1957, Eisenhower signed Interior's appropriations bill for fiscal year 1957–58. The new law provided the USGS with $36 million in SIR appropriations for the coming year,[115] $4,398,000 more than in 1956–57 but $1,860,000 less than the amount the agency requested. Of the SIR total, $5.8 million was limited to investigations of water resources in cooperation with the States, counties, and municipalities. As of June 30, the USGS rolls held 7,606 employees, of whom 456 worked part time or seasonally. The agency's workforce included 101 people in the Director's Office, 228 in the Publications Office, 338 in the Administrative Division, 2,423 in the Water Resources Division, 2,400 in the Topographic Division, 1,817 in the Geologic Division, and 299 in the Conservation Division. Another 511 individuals were on furlough for military service, on unpaid leave, or on related nonpaid status.

As the new Federal fiscal year began on July 1, 1957, so did the International Geophysical Year, and a conference of experts from several nations met in Geneva through August 1 to discuss monitoring a proposed nuclear-test-ban treaty. On June 30, Eisenhower welcomed the IGY's opening and the "valuable scientific knowledge" expected to be obtained between then and the formal end of the IGY on December 31, 1958. The President believed that the IGY's "most important result" would demonstrate "the ability of peoples of all nations to work together harmoniously for the common good." He hoped that "this can become a common practice in other fields of endeavor."[116] During the IGY, scientists from 66 other nations, but not including the two Chinas, planned to participate in studies of the Earth's atmosphere and its electrical-conducting ionosphere, glaciers, lands, and oceans, and the Sun, concentrating on rapid changes in these entities. The IGY organization also sponsored work in gravity, magnetism, seismology, and topography to increase knowledge about the Earth and its interior. These investigations would involve at least 40,000 persons, in 13 research specialties, working at 4,000 primary and 4,000 subsidiary stations. IGY studies would focus on the Arctic and the Antarctic, as agreed in 1955. Personnel from 12 nations, operating from 60 stations, would have unrestricted access within the southernmost continent. The NSF received an additional $2 million for U.S. IGY activities during 1957–58 to raise its total to $39 million, of which $1.9 million supported U.S. work on Antarctica during that year.

During September 30–October 5, the U.S. Committee on the IGY hosted at the National Academy of Sciences a meeting, recommended by the CSAGI in June, to discuss the status of the IGY's rocket and satellite program. During this week, Eisenhower addressed the IAEA's initial meeting, and he accepted the resignation of Secretary of Defense Wilson. Delegates from the national IGY committees of seven countries—Australia, Britain, Canada, France, Japan, the Soviet Union and the United States—that were planning to orbit satellites were joined by representatives from many other nations that intended to receive scientific data from the satellites. The U.S. and Soviet attendees displayed designs for their satellites and their scientific instruments and plans for launching and observing the satellites, receiving their data, and modifying their orbits. The Soviets' *Radio* magazine for July asked amateur operators to be alert for signals from a satellite. They announced the successful launch of an intercontinental ballistic missile (ICBM) on August 11 but gave no date for orbiting their initial IGY satellite. The stations in the Satellite Tracking and Data Acquisition Network, being established worldwide to receive data on the agreed standard frequency from the IGY satellites, remained incomplete.

During the evening of October 4, the Soviet delegates at the IGY conference hosted a reception for their colleagues at the Soviet Embassy. Lloyd Berkner, Sydney Chapman, other delegates, and journalist Walter Sullivan were among the attendees. James Van Allen, who designed the scientific-instruments package for the Vanguard satellite to be launched in November, was in Navy icebreaker *Glacier* en route to Antarctica. In the midst of the soiree, Sullivan later recalled,[117] he learned from his newspaper's Washington office that Radio Moscow had just announced the successful orbiting of Sputnik, a 184-pound, polished aluminum-alloy sphere nearly 2 feet in diameter. Sullivan quickly informed Chapman and Berkner; they announced it to the attendees, who responded with applause. Professional and amateur radio operators around the world quickly picked up the "beep-beep" signal rapidly repeated by the satellite's only instrument, a battery-powered radio transmitter. Sputnik, in a nonpolar elliptical orbit that reached an apogee of 584 miles, circled the Earth every 96 minutes. The U.S. National Broadcasting Company's stations promptly put the satellite's signal on their airwaves, spreading wider the news of the Soviet Union's breakthrough achievement in space.

Daniel J. Boorstin, in his "The Americans—The Democratic Experience," recalled in 1973 the amazing influence of Sputnik on world opinion 16 years earlier. Sputnik, tiny and inert, except for its radio transmitter, caused an unprecedented furor worldwide.[118] The unexpected feat encouraged the Soviet people and their allies, and correspondingly depressed many persons in the Western Alliance. The Soviet Union, long presumed by many experts to be technologically less advanced than the West, had won what many people considered a race to place the first artificial satellite in Earth orbit. Confusion in the United States quickly turned to anger and then to fear. Did Sputnik represent just a loss of prestige or was it really a Pearl Harbor in space? To Lyndon Johnson, the Senate's Majority Leader, Richard Russell, Chairman of the Senate's Armed Services Committee, and other Members of Congress, the satellite represented a future military danger far more significant than the effects of lessened prestige or psychological disadvantage. Those and other legislators quickly called for congressional hearings.

Even President Eisenhower could not allay those concerns as inaccurate and ephemeral, when, at his news conference on October 9, members of the press corps asked what he was going to do about Sputnik. Eisenhower, although pleased that the Soviet satellite ended his concerns for open skies, or at least open space, denied a U.S.-Soviet race in space and summarized the intentions of and progress made toward orbiting the first of the U.S. scientific satellites planned for the IGY. "Now, so far as the satellite itself is concerned," he asserted, "that does not raise my apprehension, not one iota."[119] The Soviet satellite, the President continued, "involves no new discovery to science."[120] The United States intended to loft small test satellites in December and launch in March 1958 the Naval Research Laboratory's Vanguard, whose Viking-derived slender rocket would boost the 21.5-pound and instrumented satellite into orbit. Vanguard would transmit scientific data via the IGY's agreed standard of 108 megahertz. Sputnik used a different frequency, as Chapman reminded the Soviet delegates in his comments at the close of the IGY's Washington meeting on October 5. The Soviet rocket was an entirely different matter. Although the President confidently asserted that the Soviets would not soon orbit spy satellites or weapons platforms in space, they claimed the ballistic missile used to orbit Sputnik also could accurately deliver nuclear warheads on targets worldwide. How had the Soviets gained this technological advantage and to what degree was it a surprise and a threat?

Historians Walter A. McDougall, William E. Burrows, Thomas A. Heppenheimer, Roger D. Launius, and James E. Oberg analyzed the origin and development of robotic and manned ventures into space.[121] Soviet rocketry, like the American and German efforts, traced its beginnings to a time before World War I.

The tempo of rocket development increased in the next 2 decades and during World War II. As that conflict ended in Europe, the Soviet Union acquired some of Wernher von Braun's V–2 personnel, but the Soviets claimed they contributed only a little to an already well developed effort before being repatriated early in the 1950s. As the U.S. Air Force, Army, and Navy each sought greater control of the Nation's ballistic and cruise missiles, the Soviets informed the West in 1955 that they planned, like the United States, to orbit a scientific satellite within 2 years as part of the IGY's program. First Secretary Nikita Khrushchev announced, via Moscow radio on August 26, 1957, the 4,000-mile flight of a Soviet ballistic missile that had been launched 5 days earlier. The missile was designed, produced, and launched (after three failures) by a team led by Sergei P. Korolev (Korolyov), who was the Soviet counterpart of von Braun. Khrushchev warned the West that the new missile enabled his country's rocket forces to deliver thermonuclear and other warheads globally.[122]

The CIA's high-altitude U–2 aircraft began flights over the Soviet Union on July 4, 1956, principally to assess Soviet bomber strength. These overflights revealed no "bomber gap," and American superiority in these piloted aircraft continued to grow, as did Soviet rage when their interceptors failed to shoot down any of the U–2s. Subsequent U–2 missions passing over Leninsk (Tyuratam), east of the Aral Sea in the central part of the Kazak Soviet Socialist Republic (Kazakhstan), photographed the Baikonur rocket facility, northeast of Tyuratam. By late summer in 1957, Eisenhower and his advisers knew about but dared not publicize the preparations at Baikonur. On October 4, Korolev's team launched Sputnik before any of the much larger scientific satellites they designed for the IGY. The importance of this achievement was indeed, as Eisenhower emphasized, not the satellite but its launch vehicle, which the CIA had estimated could not be operational before 1969. The Soviet Semyorka R–7, a two-stage rocket, with its core engine and four outer boosters, produced 900,000 pounds of thrust and could carry a warhead weighing up to 5 tons.

The U.S. Defense Department continued its work in high-altitude rocketry in 1957. On March 25, Naval Research Laboratory (NRL) personnel in California launched an Aerobee, a balloon-carried rocket, or "rockoon," that James Van Allen helped to design, to study the effect of solar radiation on communications. This continuing investigation also formed part of U.S. scientific activities during the IGY, which Congress and the President supported by supplying $39 million to the National Science Foundation. By the time the Soviets orbited Sputnik, the Air Force Office of Scientific Research failed at Enewetak Atoll to launch successfully four of Project Farside's Harvie multistage rockoons. Late in October, the USAF lofted two Harvie rockoons to about three-quarters of the design altitude of 4,000 miles, but no data were received from the onboard scientific instruments.

Major General John Medaris and Wernher von Braun received news of Sputnik[123] on October 4 at Medaris' Army Ballistic Missile Agency's facility in Huntsville, Alabama, while hosting a predinner cocktail party for a visiting delegation led by Neil H. McElroy, president of Procter and Gamble and now also the newly designated Secretary of Defense. McElroy's group at Huntsville included lawyer and Secretary of the Army Wilber M. Brucker; General Maxwell Taylor, who succeeded General Matthew Ridgway as Army Chief of Staff in 1955; and Lt. General James M. Gavin, the Chief of Army Research and Development. Medaris and von Braun urged McElroy to authorize them to resume work on the Army's own well-tested rocket and its satellite. They promised, with hardware at hand, to launch within 90 days their multistage Jupiter-C, an improved Redstone, with its Orbiter-Project instrumented satellite as the fourth stage. McElroy took office on October 9, as Eisenhower faced the press, and von Braun's team, with Medaris' approval, began to ready a reserve Jupiter-C.

On November 3, as the U.S. Army and Navy prepared their own rockets and satellites, the Soviets orbited the 1,120-pound Sputnik 2, carrying the mixed-breed dog "Laika," to mark the coming 40th anniversary of the Bolshevik Revolution. The next day, McElroy officially told Medaris and von Braun to ready the Jupiter-C. Eisenhower again responded calmly when, via television and radio on the evening of November 7, he spoke about science and national security. The President emphasized the nature and power of U.S. retaliatory forces that could "bring near annihilation to the war-making capabilities of any other country."[124] He repeated his earlier claim that only the propulsion abilities of Soviet rockets, not their satellites, were militarily significant. Eisenhower remained confident that existing U.S. bombers and missiles were a force sufficient to deter the Soviets while America's industry and armed forces developed and deployed new weapons systems.

The President also called for higher priorities for scientific education and basic research.[125] Eisenhower reported that he had just appointed James Killian, Jr., as his Special Adviser for Science and Technology.[126] In a second address on November 13, Eisenhower distinguished between the funds for and priorities of the U.S. satellite programs and again requested action to improve education in science. On November 22, Eisenhower added the word "President's" to the Science Advisory Committee's name and transferred the Committee from the Office of Defense Mobilization to the Executive Office of the President. Eisenhower appointed Killian a member of the President's Science Advisory Committee (PSAC) and then the group's chairman. Early in 1958, Killian's PSAC included 17 other members: Robert Bacher; William O. Baker, vice president for research at Bell Labs; Rear Admiral Lloyd Berkner; Hans Bethe; Detlev Bronk, NAS president since 1950; Lt. General James Doolittle; James B. Fisk, Bell's executive vice president; Caryl P. Haskins, president of the Carnegie Institution of Washington; George Kistiakowsky; Edwin Land; Edward M. Purcell, professor of physics at Harvard; Isidor Rabi; Howard P. Robertson, professor of physics at Caltech; Paul A. Weiss, head of developmental biology at the Rockefeller Institute of Medicine; Jerome Wiesner; Herbert F. York, professor of physics at Berkeley and Director of the AEC's Livermore Laboratory; and Jerrold R. Zacharias, professor of physics at the Massachusetts Institute of Technology (MIT). Consultants to the PSAC included Hugh L. Dryden, Director of the National Advisory Committee for Aeronautics since 1947; Emanuel T. Piore, IBM's director of research; Herbert Scoville, Jr., the CIA's Assistant Director; and Alan Waterman, the NSF's Director.[127] Eisenhower asked the PSAC to provide perspective and advice on science and technology, especially as they related to national defense, nuclear weapons, nuclear-test detection, and arms control. He also requested Killian's group to recommend the best administrative responsibility for the IGY, related satellites, and the rest of the space program, and to facilitate more rational decisions on developing and using technological advances and improving education.

U.S. prestige, scientific hopes, and more than $110 million rode with the 3-pound, 6-inch-diameter Vanguard satellite when the countdown for the live-televised launch began at Cape Canaveral, Florida, on December 6, 1957. The rocket's first-stage liquid engine, expected to deliver 27,000 pounds of thrust, ignited successfully. The slender TV–3 rocket rose slowly off its pad, reached a height of nearly 4 feet, then sank back, and exploded in a spectacular fireball. This public failure of Vanguard, nicknamed "Flopnik," "Kaputnik," and worse, also generated additional gallows humor about the abilities of America's German rocket scientists.[128] More importantly, commentators questioned the quantity and quality of the products of the U.S. educational system in engineering and science. In quantity alone, the United States trailed the Soviets; in 1956, the Soviets graduated 70,000 engineers and the United States produced only 30,000. To address these deficiencies, the administration continued to evaluate actions recommended in the second interim report of Howard L. Bevis' Presidential Committee on Scientists and

Engineers that Eisenhower received on November 26. Although Vanguard failed on its first attempt, other U.S. ballistic missiles worked, and the Strategic Air Command's (SAC's) 1st Missile Division became operational on January 1, 1958. The next generation of U.S. ICBMs and IRBMs would use solid rather than liquid fuel. In February, General Bernard Schriever convinced McElroy to authorize Aerojet General to proceed with the development, for deployment early in the 1960s, of the Minuteman ICBM, a three-stage, solid fuel (Thiokol) rocket that would deliver a 1-megaton thermonuclear warhead on targets up to 8,000 miles distant.

Lyndon Johnson's Subcommittee on Preparedness, of Richard Russell's Senate Committee on Armed Services, began hearings on the U.S. space program in November 1957 and resumed them in January 1958 soon after the 85th Congress reconvened for its second session. Johnson's subcommittee heard testimony from Vannevar Bush, Edward Teller, Wernher von Braun, and other scientists and engineers, and then from Generals Gavin and LeMay, Rear Admiral Rickover (promoted to Vice Admiral later in 1958), and other members of the armed forces. The subcommittee's report had 17 recommendations, including the development of a rocket motor with 1 million pounds of thrust. On February 6, the Senate established a Special Committee on Space and Astronautics, with LBJ as Chairman; on July 24, the Senate founded the standing Committee on Aeronautical and Space Sciences.

In January and February 1958, as the Senate hearings continued, Eisenhower reported to Congress on the state of the Nation's defense and its economy. The President emphasized the Nation's two main tasks—building "strengths that keep the peace" and ensuring "governmental and fiscal soundness."[129] To reach these goals, Eisenhower would reorganize the defense establishment, accelerate its efforts, especially in areas affected by the new advances in science and technology, strengthen mutual-security aid and mutual trade, increase scientific cooperation with U.S. allies, and build intellectual capital by stimulating and improving education and research. He requested a supplemental defense appropriation of $1.3 billion for fiscal year 1957–58; an increase of $2.5 billion for missiles, nuclear-powered ships, and other defense projects in 1958–59; and an additional $1 billion spread over 4 years for topically balanced programs in the Department of Health, Education, and Welfare and the NSF. The NSF's "Basic Research—A National Resource," issued on October 15, 1957, influenced the content of Eisenhower's addresses in November on "Science in Our National Security" and "Our Future Security," in which he emphasized the importance of increasing Federal and other support for research. Many persons in the U.S. scientific community and in the NSF remained convinced that "the Federal Government must not exercise control over science."[130] Eisenhower's additional request for fiscal 1957–58 meant a fivefold increase in the NSF's funds for science education and a twofold gain in its monies to support basic research. The NSF also received an additional $3.7 million on March 28 for salaries and expenses, but not additional employees, in 1957–58. The President promised to curtail spending on older and some newer weapons systems and to restrain selected civilian programs, although he established on March 4 a five-member Career Executive Board, to report to him through the Civil Service Commission, "to assure the retention and effective use"[131] of top-rank career officers and executives in the Federal civil service. These changes would raise estimated expenditures in 1958–59 to $73.9 billion but still leave an after-receipts surplus of $0.5 billion.

During these months, the United States successfully launched a scientific satellite and began a program to send robotic spies into space. On January 31, 1958, the Army's Medaris-von Braun team at Cape Canaveral used a Jupiter-C/Juno rocket to place Explorer 1, the fourth stage, in an orbit whose apogee reached some 1,500 miles into space. The U.S. scientific satellite weighed just 31 pounds, but it contained a Geiger counter and other instruments designed and prepared by James Van Allen's group at the University of Iowa and William H. Pickering's Jet Propulsion

Laboratory (JPL) in Pasadena, California. Photographers recorded Pickering, Van Allen, and von Braun holding aloft a mockup of the vertical-striped, cylindrical-bodied satellite.[132] J. Wallace Joyce, who led the NSF's IGY Office, reported the success to the President. Early in February, Eisenhower authorized the implementation of Project Corona,[133] an Air Force-CIA operation directed by Richard Bissell and designed, with the aid of the USGS and other Federal agencies, to supplement the U–2 flights by gathering intelligence and mapping information on photographs taken from cameras in a series of Keyhole spy satellites[134] that bore the cover name Discoverer. Modified IRBMs and ICBMs, launched from Vandenberg Air Force Base, on the California coast north of Lompoc, would place these new satellites in polar orbits where they would eject photo-filled and parachute-equipped capsules that aircraft would retrieve in mid-air. Work also continued on Project Samos, the second reconnaissance effort by the USAF–CIA team, whose satellites would electronically scan their camera's photos and return them via signals as they passed over ground stations. On February 7, Secretary McElroy established an Air Force Advanced Research Projects Agency (ARPA, later DARPA), appointed Roy W. Johnson, General Electric's executive vice president, to lead ARPA, and transferred to it all U.S. space ventures. In March, Herbert York became ARPA's chief scientist.

Other U.S. satellites successfully orbited in 1958 provided data about the Earth's shape and information about its surrounding radiation belts. On March 16, Eisenhower again emphasized the civilian connection by saying that Waterman had just informed him that the Navy-NRL Vanguard 1 was in Earth orbit. The geodetic instrument in the 3.5-pound satellite returned data demonstrating that the Earth was slightly pear shaped. The Army's Explorer 3 succeeded on March 26, the day the President made public the new "Introduction to Outer Space," prepared by Killian's PSAC. The report recommended taking the fullest advantage of the military and scientific potential of space. Explorer 4, launched on July 26, also reached orbit. Instruments on these and later U.S. satellites detected inner and outer belts of radiation, trapped by the Earth's magnetic field. The belts, named for Van Allen, comprised a doughnut-shaped zone of electrons and protons some 150 to 31,000 miles above the Earth and helped to define the planet's magnetosphere. The President approved and the White House announced on March 27, new projects for the preparation and launching by ARPA of additional small scientific satellites for Earth orbits and initial lunar probes.

Some Members of Congress, encouraged by these U.S. successes in space, proposed establishing a department to unify Federal science and technology agencies, increasing funding to bolster Federal science and technology, and providing the ways and means to train additional scientists and engineers, especially those for work on defense projects. Members of the 84th and the 85th Congresses knew well the shortages of these specialists, and they introduced but did not pass alleviating measures. During those efforts, a combination of factors, including operations by 1955's Critical Skills Reserve Program, a smaller required number of draftees, and a greater number of graduates began to produce more than the expected pool of engineers and scientists. In both sessions of the 85th Congress, several Members introduced bills to try to remedy the remaining deficiencies. Senator Hubert H. Humphrey, Jr. (D–MN), sponsored a comprehensive measure in July 1957 and reintroduced it in 1958. Humphrey's bill proposed establishing a Cabinet-level Department of Science and Technology, standing Committees on Science and Technology in Congress, and national institutes of scientific research. His measure also contained authorization for a program of Federal loans and loan insurance for college and university education in the physical or biological sciences, mathematics, or engineering and the establishment of scientific programs abroad. During May 2–June 26, 1958, a subcommittee of the Senate's Committee on Government Operations held hearings on the bill. Killian, the NSF, and many NAS members opposed the bill and its centralization of Federal efforts in science and technology. After

Eisenhower founded the Federal Council for Science and Technology[135] (FCST) on March 13, 1959, opponents of Humphrey's bill claimed it was no longer necessary; the measure was tabled later that year.

The FCST, as recommended in 1958 by Killian's PSAC, was intended to improve the coordination and effectiveness of the research and development programs being conducted by Federal agencies. The FCST's members included Killian; representatives of the Departments of Interior, Agriculture, Commerce, Defense, and HEW; the NSF's Director; the AEC's Chairman; the State Department's Science Adviser; and the Bureau of the Budget's Assistant Director.[136] USGS Director Thomas Nolan represented Interior's Under Secretary on the FCST, which began a standing Committee on Oceanography, also chaired by Nolan, and asked it to review a report by the NAS–NRC Committee on Oceanography. William R. Thurston, with the USGS during 1942–51 and the Executive Secretary of the NAS–NRC's Division of Earth Sciences since 1955, served as the Secretary and Executive Officer of its Committee on Oceanography. Thurston also was an observer on the Interagency Committee on Oceanography that developed from the Navy's Subcommittee on Oceanography.

Congress, the Eisenhower administration, and the NAS also moved to improve U.S. efforts in aeronautics and space, separate their civilian and military components, and support the former more effectively but still give the highest priority to the military programs. Eisenhower, after consulting with Nixon, Bronk, Dryden, Killian, and Waterman, accepted the idea of using the existing National Advisory Committee for Aeronautics as the nucleus of the new Federal civilian agency for all nonmilitary aeronautical and space programs and projects. The new agency would make its information available to the world. Eisenhower, in his special message to Congress on April 2, 1958, agreed to support the bills introduced in Congress to establish the new Federal agency for aeronautics and space. The President also recommended founding a National Aeronautics and Space Board, with members appointed by him who would include eminent citizen-specialists, representatives of the Federal agencies most concerned, and at least one member of the DoD. He asked Congress to give the new agency the authority "to conduct research projects in its own facilities or by contract with other qualified organizations"[137] and promised to request a supplemental appropriation for the agency's operations in its initial year of operations.

These efforts received another boost when Korolev's Soviet team placed Sputnik 3 in Earth orbit on May 15. The satellite and its 2,925-pound scientific payload, designed, built, and originally scheduled to be the first Sputnik launched, again demonstrated the huge lifting capacity of the Soviet R–7 rocket. Sputnik 3 gathered significant data for the IGY about cosmic rays, ion concentrations, the magnetic field, micrometeors, and solar radiation. As one response, the U.S. National Committee for the IGY urged Bronk to appoint a Space Science Board (SSB). Bronk gave the new SSB, established in the late spring of 1958 and led by Berkner, two principal tasks. Bronk asked the SSB to advise the ARPA, the NSF, and the U.S. National Committee for the IGY about rocket-satellite programs, and he also requested it to look further ahead by examining the space program's "scientific problems, opportunities, and implications."[138] The SSB also served as U.S. liaison to the Committee for Space Research (COSPAR) founded in November by the International Council of Scientific Unions. COSPAR cooperated with three of the ICSU's new committees—the Special Committee on Antarctic Research (SCAR), founded in February 1958; the Special Committee on Oceanic Research (SCOR), established in August 1957; and the International Geophysics Committee. These groups collaborated with the NAS–NRC's existing equivalent bodies—the Committee on Polar Research, established in February 1958; the Committee on Oceanography, founded in July 1957; the Committee on Meteorology (1955), renamed the "Committee on Atmospheric Sciences" in 1958; and the Geophysics

Research Board (GRB), appointed by Bronk in 1960. The GRB's members included the persons chairing the four NAS–NRC committees and its two boards; the chairs and one other member of each of the four national committees for the international unions for astronomy, geodesy and geophysics, physics, and scientific radio; and several persons chosen at large.

In November 1957, Killian's PSAC evaluated the recommendations by a Presidential committee, founded earlier and led by H. Rowan Gaither, Director of the Ford Foundation, to find ways to decrease U.S. vulnerability to Soviet attacks. Gaither's panel recommended, but Eisenhower rejected, a 5-year program, costing some $44 billion, to increase the development and production of U.S. missiles, deploy them in dispersed but hardened sites, and construct a national system of fallout shelters. The President, seeking alternatives, asked Killian on April 8, 1958, to convene the long-delayed conference of experts to study the verification requirements needed for an effective agreement to ban nuclear tests. Killian appointed a PSAC Panel on Seismic Improvement, chaired by Lloyd Berkner and better known as the Berkner Panel. Among its 12 other members were Hugo Benioff; Hans Bethe; Maurice Ewing; David Griggs; Jack H. Hamilton, Geotechnical Corporation's vice president for research and engineering; Walter Munk, Scripps Institution of Oceanography (SIO); Jack E. Oliver, Lamont Geological Observatory; Frank Press, Director of Caltech's Seismological Laboratory and a NAS member in 1958; and Carl F. Romney, Air Force Office for Atomic Energy. The Berkner Panel reviewed existing and potential ways and means of verification, including the possibility of establishing a standardized global seismic network.[139]

On May 8, 1958, Eisenhower proposed having international technical advisers assess the possibilities of a nuclear-test-ban agreement based on a workable and effective monitoring system. Khrushchev accepted the offer on the following day. U.S. confidence came in part from the results of the AEC's Rainier underground nuclear test on September 19, 1957, at the Nevada Test Site (NTS). Charles Bates, Thomas F. Gaskell, and Robert B. Rice later noted in their "Geophysics in the Affairs of Man" that the Rainier test exploded a 1.7-kiloton warhead to determine the depth required to fully contain the released radioactivity,[140] observe the surface-ground motion created by the test, and identify any harmful effects on the site's groundwater. Radioactivity was well contained, and surface motion did not extend beyond 3 miles. Seismic waves from the shot, equivalent to an event of 4.6 magnitude on the Richter scale, were recorded by 46 stations, one as far away as the U.S. Coast and Geodetic Survey's facility at College, Alaska. At shorter distances from the NTS, six stations registered a significant compressional (or outward) initial signal rather than the lower amplitude P (primary or compressional) wave that preceded the arrival of the higher amplitude S (secondary or shear) wave generated by earthquakes. Critics pointed out that the two compressional waves might be confused. Successful monitoring required a new and enhanced worldwide standard seismographic network linked by electronic computers, a combination then being referred to as the "new seismology."[141]

On May 15, Eisenhower suggested that a group of experts and representatives from Britain, Canada, Czechoslovakia, France, Poland, Romania, the Soviet Union, and the United States convene in Geneva, on July 1, the Conference on the Discontinuance of Nuclear Weapons Tests. John Cockcroft, who led the British Scientific and Technical Mission in Washington during World War II and earned a Nobel Prize in physics in 1951, headed the British delegation in Geneva. Edward C. Bullard, of Cambridge University, served as one of Cockcroft's seismological advisers. Eisenhower objected to AEC Chairman Lewis Strauss' selection of Edward Teller to lead the U.S. team, and so Ernest Lawrence went instead, but James Fisk led the U.S. delegation and Robert Bacher filled its third seat. Advisers to the U.S. group included Hans Bethe; Harold Brown, Teller's Associate Director at the Lawrence

Radiation Laboratory; Berkeley's Perry Byerly; Jack Oliver; Frank Press; and Carl Romney. Evgeny K. Fedorov, Director of the Academy of Sciences' Institute of Applied Geophysics, led the Soviet delegation, which also included seismologists and nuclear-weapons experts. British, Soviet, and U.S. experts at Geneva remained concerned about distinguishing earthquakes from underground nuclear tests. They estimated (and the PSAC reported) that twice the number of natural earthquakes occurred whose released energy equaled that produced by underground tests of specific yields.[142] On August 21, after 30 formal sessions, the experts agreed on the technical feasibility of a control system to detect any violations of a worldwide suspension of nuclear tests.

On August 22, 1958, the U.S. and British Governments proposed, provided the Soviet Union halted its tests, a 1-year ban on such testing, effective October 31. Eisenhower's and Harold Macmillan's announcements extended a test race before the new deadline. Britain conducted 4 tests at Christmas Island between August 22 and September 23, 1958. The United States tested 37 devices in its Hardtack II series at the NTS between September 12 and October 30. Two of the tests in tunnels on October 16 and 30—the 5-kiloton Logan (4.4 magnitude) and the 22-kiloton Blanca (4.6 magnitude)—produced larger numbers of smaller and downward, or natural-looking, compressional waves than expected and led to recalculations that lowered Rainier's magnitude by 0.5. Those levels led U.S. experts to increase by a factor of 10 the whole number of seismic events not identified as natural or fabricated that released energy equivalent to 5-kiloton explosions.[143] Khrushchev agreed to consider the ban on August 29, but the United States detected and announced the resumption of Soviet tests before Khrushchev made them public on October 2. Negotiations aimed at banning underground nuclear tests resumed at Geneva among the United States, Britain, and the Soviet Union on October 31. The United States' revised estimates of the personnel needed for verification, claimed the Soviet delegation, would require unacceptable numbers of inspection groups and provide greater opportunities for spying. Eisenhower extended the U.S. test ban in 1959.[144] The Geneva talks ended on June 27, 1960, without reaching an agreement, but the United States and the Soviet Union ceased nuclear tests in the atmosphere and did not resume them until September 1961.

Bates, Gaskell, and Rice recorded how the Berkner Panel on Seismic Improvement analyzed the data from the Hardtack tests, improved the Geneva system for detecting and distinguishing between earthquakes and artificial explosions, and recommended a program of basic and applied research intended to secure better methods of seismological detection. The Panel drew on the work of the Air Force's ongoing seismic-research group, chaired by Roland Beers (Sr.). Beers' group included John N. Adkins, the Director of the Office of Naval Research's (ONR's) Earth Sciences Division; Hugo Benioff; Perry Byerly; Dean S. Carder, the U.S. Coast and Geodetic Survey's chief scientist; Maurice Ewing; Beno Gutenberg; Norman A. Haskell, USAF Cambridge Research Center; James B. Macelwane, St. Louis University; Frank Neumann, who shifted from the U.S. Coast and Geodetic Survey (USCGS) to the University of Washington in 1953; Caltech's Charles F. Richter; and Louis Slichter.

The Berkner Panel issued its report, "The Need for Fundamental Research in Seismology," as a State Department document on March 16, 1959. Since 1948, the report noted, the Air Force's panel sent some $8 million to academic, government, and industry laboratories for investigations aimed at improving the detection of nuclear explosions. By comparison, the NSF was spending only about $300,000 a year on similar studies. More than $52 million, the panelists suggested, would be required to fund a 2-year research program that would monitor new conventional and nuclear explosions, at a cost of $24 million; use $12 million to develop better detection systems, conduct additional basic and applied studies, and establish large seismic arrays; and use $16 million to modernize selected stations. On April 23, Killian, Deputy Secretary of Defense Donald A. Quarles (an engineer who served earlier as Assistant Secretary of Defense for Research and Development and then as Secretary of the Air Force), and the AEC's new Chairman John A. McCone (who advised Secretary Forrestal and then served as Under Secretary of the Air Force) decided that the DoD would fund the Berkner Panel's recommendations, provided the AEC paid for and conducted the required tests at the NTS. Responsibility for funding passed to Herbert York, now the DoD's Director of Defense Research and Engineering, and accountability for operations, to the hitherto mostly missile-conscious ARPA. Two members of York's new Advisory Group on Seismology, Hugo Benioff and Norman Haskell, also served on the Berkner Panel. York's advisers, chaired by Frank Press, also included F. Gilman Blake, who led the Geophysical Research Division of Socal's California Research Corporation; John M. Gerrard of Texas Instruments; Walter Munk; Jack Oliver; and James T. Wilson, who chaired the University of Michigan's Department of Geology.

Eisenhower, meanwhile, made two changes in his Cabinet and appointed a new Chairman at the AEC. On October 23, 1957, Eisenhower accepted the resignation of Herbert Brownell, Jr., who earlier wished to leave as Attorney General. In November, Eisenhower replaced Brownell with William P. Rogers, a lawyer who served as one of Vice President Nixon's advisers and traveled with the candidate during the 1952 campaign. As Attorney General, Rogers established a Civil Rights Division in the Justice Department. On June 30, 1958, Lewis Strauss ended his second tour with the AEC. John McCone succeeded Strauss as chairman, and Strauss became Eisenhower's special assistant in the Atoms for Peace program. Arthur Flemming returned to the Eisenhower administration, on August 1, 1958, as Secretary of HEW, replacing Marion B. Folsom, who had served since Oveta Hobby resigned in 1955.

Commerce Secretary Sinclair Weeks began a comprehensive review of his department. Beginning in January 1958, the review by Weeks and his office staff of all his agencies concentrated on those with a science component. When Weeks resigned later in 1958, Eisenhower nominated Lewis Strauss as Weeks' successor. When the Senate refused to confirm Strauss in 1959, Eisenhower selected and the Senate approved Frederick H. Mueller as Secretary of Commerce. As part of the reorganization that followed the internal review of the Commerce Department, the Bureau of Public Roads, the Coast and Geodetic Survey, the Maritime Administration, the National Bureau of Standards, the Office of Technical Services, the Patent Office, and the Weather Bureau began reporting to a new Assistant Secretary for Science and Technology on March 2, 1960.

On July 3, 1958, Eisenhower, after twice in 2 years vetoing omnibus-appropriations bills for constructing, repairing, and preserving public works on rivers and harbors for navigation, flood control, irrigation, or multiple-purpose projects, signed an acceptable measure for these purposes. The new statute's first two titles covered rivers and harbors and flood control. Only the closest cooperation and partnership among municipalities, counties, States, and the Federal Government, the President emphasized earlier, would make the best use of each drop of water. So the new law's Title III, the Water Supply Act, declared Congress' policy of recognizing

> **the primary responsibilities of the States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes.[145]**

The law also required "that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects."[146] Senator Robert S. Kerr (D–OK), the chairman of the board of Kerr-McGee Oil Industries, Inc., was one of the measure's chief sponsors; he would chair the Select Committee on Natural Water Resources in the 86th Congress during 1959–61. In 1971, former Representative Frank Smith, then on the TVA's Board of Directors, would say that the 1958 act "established water supply as a firm purpose in the construction of federal water projects."[147]

Secretary Seaton, again calling for sound use of the Nation's natural resources, noted that the Census Bureau's projections suggested the country's population would reach 220 million as early as 1975. A large share of that increase would occur west of the Mississippi River, where survival depended on wisely using water resources. Sound use, he emphasized, required new and improved knowledge, especially of the effect of radioactive waste on U.S. water resources; research on this effect was one of the USGS' postwar responsibilities. Seaton also called for more efficient recovery and use of the Nation's helium resources. The four plants in Kansas, New Mexico, and Texas extracted 340 million cubic feet of helium in 1956–57 but also lost some 3 billion cubic feet when helium-bearing natural gas was used as fuel in the absence of extraction facilities. The administration planned to request funds to build 12 new helium-processing plants, if incentives would not encourage private industry to do so, and authority for a program to reserve by 1985 some 32 billion cubic feet of helium produced from these plants by storing it in the federally owned Cliffside Field just northwest of Amarillo.

The USGS, while continuing to evaluate the Nation's water and helium resources, and fulfilling its other responsibilities in science, mapping, and regulation, also hoped to participate in the growing U.S. effort in space. To meet these and other challenges, the agency strove to increase its funding at a time when the Nation's economic slowdown led the Eisenhower administration and Congress to favor fiscal retrenchment. On January 13, 1958, Interior Secretary Seaton appeared before the House appropriations subcommittee to defend the Department's budget for fiscal year 1958–59. Nevada's Royce A. Hardy, Jr., Felix Wormser's successor as Assistant Secretary for Mineral Resources, accompanied Seaton's group. As the Public Works subcommittee considered the sum Interior sought for the Bureau of Reclamation and the four power agencies, Seaton's request for the Interior Department and its remaining bureaus represented a decrease of almost $38.9 million compared to the equivalent estimate for 1957–58. Seaton assured Chairman Kirwan and the subcommittee's other members that he was "happy to report" that the DoI's programs could be continued "in a manner adequate to serve those needs of our country * * * with a reduction in the appropriations." In preparing the budget for 1958–59, Seaton continued, he again emphasized improving economy and efficiency by "curtailing or eliminating work of less importance in order to meet the additional requirements constantly placed upon the Department."[148] Most of Interior's agencies would lose some of their requested funds, including nearly $2 million for the USGS. The only overall gain for USGS programs would be $447,000—the sum of $197,000 from SIR appropriations and $250,000 from the States, counties, and municipalities—to increase cooperative water-resources investigations. Although nearly $1.8 million would "cover geologic and minerals resource surveys and mapping previously financed by the [U.S.] Atomic Energy Commission,"[149] the Geologic Division actually would lose more than $900,000 from its total funds available during the year.

Assistant Secretary Royce Hardy and USGS Director Thomas Nolan met with Michael Kirwan's subcommittee on January 16. Hardy continued as Interior's liaison to the Committee on Government Activities Affecting Prices and Costs and as its representative on the Council on Foreign Economic Policy. He also advised the Director of the Office of Civil and Defense Mobilization about the administration of the Federal strategic-stockpiling program and chaired the Oil Input

Appeals Board. "The responsibilities of the Geological Survey," Hardy emphasized, "include a group of functions that are becoming increasingly important with the growth of the country." "In view of our greater need for, and utilization of, our natural resources," he continued, "never in its history has this country so urgently needed the services performed by the Survey."[150] "The funds requested," Hardy concluded, "are the minimum necessary for continuing its activities with the effectiveness to meet present requirements."[151] "Recent events," Nolan then noted, "have emphasized the importance of anticipating the need for the kinds of basic data and fundamental research provided by the Survey, and have confirmed the wisdom of the committee in supporting these activities in the past." The space age, he continued, "has added to, rather than diminished the need for accurate geographic and topographic information."[152] New research and exploration programs, as demonstrated during and since World War II, took 10 to 20 years to significantly increase the availability of raw materials. Echoing Directors Mendenhall and Wrather, Nolan cautioned that

> **it is both dangerous and poor economy to wait until an emergency is upon us before developing new methods, new concepts, and new applications of the geologic sciences.[153]**

The Soviet Union demonstrated that it likewise considered this work an investment in its future growth and security, Nolan emphasized, by investing "heavily in geologic mapping and research." The Russian Federation, the largest part of the Soviet Union, operated "eight main geological research organizations, exclusive of the educational institutions and the Ministry of Geology," which alone employed 14,000 geologists, and the other Soviet Republics also financed their own geological institutes. Nolan pointed out the Water Resources Division's growing emphasis on analysis and interpretation to meet "an increasing demand for the solution of exceedingly complex water problems."[154] Members of the Conservation Division, he added, continued to face an ever-increasing workload. Nolan then reminded the subcommittee that a "solution of the Survey's housing needs in the Washington area continues to be one of our most critical problems"; solving it should meet "the physical requirements of the Survey's operations" and provide "a means of attracting and retaining skilled employees."[155]

Kirwan summarized the estimate for the USGS for fiscal year 1958–59. Congress and the President appropriated $36 million in funds for SIR operations by the agency for 1957–58 but they held $430,000 in reserve so the amount presently available was $35,570,000, to which transfer and repay funds added more than $21 million. The 1958–59 SIR amount included two gains—$1,178,000 to cover activities now funded by the AEC and $447,000 for water-resources investigations. The request also delineated two losses—$940,000 due to a nonrecurring item in the building program and $107,000 for topographic surveys. Kirwan termed the total SIR estimate of $36,750,000 for 1958–59 an increase of $1,180,000. Why, he then asked, could the USGS not locate a building site in the District of Columbia? The Old Soldiers Home was one of the sites considered, Nolan responded, but the General Services Administration made other arrangements for its use. The GSAd's General Counsel decided that the Lease-Purchase Act's expiration ended the authorization for a USGS building, and the agency would "have to start from scratch again"[156] if it still wanted one. In reply, Kirwan and Ivor Fenton both voiced their concern and frustration before asking about how the USGS used the $3 million increase, not including retirement costs, authorized for 1957–58.

The major portion of the $3 million increase, Nolan replied, went toward the estimated $1,355,000 required for the special-purpose structure (Building 3) to be constructed at Menlo Park to house the Western Mapping Center when it moved from Sacramento. Final plans and specifications were due from the contract architect before May 1, after which bids would be requested and the 9-month construction contract let by June. Most of the additional $280,000 for topographic work funded new efforts in quadrangle mapping that supported the mineral- and water-policy programs. The Geologic Division devoted a large part of its $600,000 gain to mapping for the latter program four areas selected by the Water Resources Division—the Delaware River Valley, locales near Del Rio in Texas, those east of Colorado's Front Range, and lands near Carrizo and Corduroy in Arizona. Like the topographers, the geologists also concentrated on developing "new instruments and new principles." "One is a spectrometer," Nolan continued, for determining trace amounts of metals in small-grained ore minerals; "another is a small portable seismometer."[157] Geologic and geophysical work funded by the AEC was shifting in part from its Raw Materials Division to its Military Applications Divisions and its other units, including the studies, involving two conventional-explosives tests, begun in July 1956 and completed for the Rainier underground nuclear test in September 1957. The USGS helped to select the test site, a tunnel 2,000 feet long and built 820 feet below the surface in bedded rhyolitic tuffs of the Oak Spring Formation (Tertiary).[158] The agency also responded to concerns that the nuclear explosion might create fractures that would (but did not) vent radioactive gas to the atmosphere, cause an earthquake, or contaminate local groundwater. In related investigations, the USGS also aided determinations of safe and efficient disposal of radioactive waste from AEC plants. Of the Water Resources Division's nearly $1 million increase, about one-half matched larger cooperative offerings from non-federal sources, including those for a comprehensive survey of Puerto Rico's water resources and amelioration-oriented studies of the flood plains of Pennsylvania's rivers.

On January 16, 1958, Kirwan passed to a more troubling issue, the failure of the USGS to improve its accounting methods in 1956 after the Comptroller General reported deficiencies to the subcommittee in 1955. On January 10, 1957, the Comptroller General's Office issued its report on USGS accounting practices and sent it to Interior. Administrative Assistant Secretary Beasley forwarded Interior's comments to the GAO on July 30, noting that the Department planned to issue soon its new draft manual that established procedures and adequate control over cashflow. When Kirwan specifically asked if the accounts of the Surface Water Branch at Columbus, Ohio, were now corrected, Nolan admitted the he was "not familiar with that particular case." The USGS would keep single accounts for individual cooperative projects; then it would divide costs into two parts at year's end and bill cooperators for half the total cost. The new system would replace the one that billed cooperators "for a series of individual items that represent one-half of the cost."[159] Kirwan agreed that this might be a problem for some States and their systems but, he added, "we still must have a proper accounting of all funds, including charges to the proper accounts."[160] Kirwan then placed into the record, the GAO report's 10 principal findings and the reasons for the refutations or modifications by the DoI and (or) the USGS. Recommended changes included discontinuing regional disbursing officers, except in Hawaii; a study and trial of consolidated cooperative accounts; the distribution of indirect charges by electronic computers; new instructions for depositing monies from the sales of Government Printing Office (GPO) publications; drafting a purchasing guide and another for using and maintaining property stock levels and records. The USGS refused, as it did several times earlier in the decade, to delegate complete authority for Division operations to Division representatives at Denver. The agency also decided to avoid expensive and unnecessary administrative work by continuing map sales on credit.

Kirwan then assessed the sums requested for specific activities. Nolan's statement noted that the USGS had adequately mapped, for most users, about 42 percent of the country by July 1, 1957. Even with a loss of $107,000, Nolan asserted, the Topographic Division would still meet the Nation's needs for new and revised maps. While the cost per person-year for producing these maps increased from $4,500 to $6,300 between 1947 and 1957, improved instruments and methods reduced the per-square-mile cost from $171 to $124. Allowing for price-index increases during the same interval, Nolan noted, "the equivalent price is $88 per square mile, approximately half of the cost of 10 years ago, although our salary costs have increased over 50 percent in that period."[161] USGS map printers now earned three times their salaries of 1945, while the average reproduction cost per map edition fell from $325 in 1945 to $295 in 1957. "Industry and business have not been able to accomplish this," Kirwan enthused, "I know that the committee is thankful and grateful for it. They will find it much easier to appropriate the funds that you are requesting."[162]

When the discussion moved to geological and mineral-resource surveys and mapping, Kirwan and Nolan returned to the AEC funds and a seeming overlap between the base of $1.54 million for the AEC activity under the Long-Range Minerals Program and the $3 million under the mineral-deposits investigations. The change, Nolan summarized, reflected the shift from rapidly discovering and blocking out new ore bodies to the geologic, geochemical, and geophysical studies required for finding additional deposits that could be developed to extend the AEC's present 10-year supply of uranium. The AEC decided in fall 1957, Nolan continued, that these longer range and more traditional USGS investigations would best be done by a transfer of base. When Kirwan read into the record a statement the day before by AEC Commissioner Willard Libby that uranium reserves were adequate for the next 2 or 3 decades, Nolan countered, as Kirwan intended, by citing the opinion of Jesse Johnson, Director of the AEC's Raw Materials Division. At the Budget Bureau's hearing, Johnson "emphasized the need for the longer-range geologic exploration by the Survey; not the physical exploration by the companies."[163] Nolan, encouraged by Kirwan, asked Johnson for a clarification and added to the record his confirmation of the 10-year reserve and his view that the USGS should continue its work of the past 12 years to maintain the "present satisfactory uranium-reserve position."[164]

Ben Jensen and Ivor Fenton then joined to query the USGS work funded by transfers from other Federal agencies, particularly topographic mapping for the Bureau of Reclamation. Nolan verified for Jensen the $21 million the USGS gained in fiscal year 1957–58 from sources other than its SIR appropriation. Nolan anticipated the USGS would receive transfers and repayments of some $17.2 million, of which about $7.6 million would be from States, counties, and municipalities to match an equal amount in USGS funds for cooperative work in topography and water resources. "Under present circumstances," Jensen, ever the self-described friend of the USGS but also of government economy, hoped the agency and the subcommittee "might be justified in making a saving below last year in your activities wherever it is possible to do so and where it does not interfere with our security program."[165] The equally friendly Fenton remained concerned about USGS priorities in meeting Federal needs for topographic maps and the total amount of the USBR's transfers—$18.3 million between fiscal 1945–46 and 1956–57, with another $2.2 million expected between 1957–58 and 1958–59. Nolan reminded him that Congress decided not to appropriate those funds directly to the USGS and that appropriations for all Interior agencies performing as-required work for the USBR were now in the DoI's other bill before the public-works subcommittee.

The increase of $447,000 for water-resources investigations, Nolan explained, would advance the program's three principal objectives—maintaining the nationwide network of observation stations, using the data collected to prepare descriptive and interpretative reports intended to aid the solution of "developmental and operational problems," and continuing "research on hydrologic principles, to increase our scientific ability to solve practical problems and add to the sum of scientific knowledge about water."[166] Continuing to strengthen research, analysis, and interpretation, he emphasized, would "achieve better balance in the program, thereby increasing its usefulness in [solving] the increasingly complex water problems of the modern age."[167] When Kirwan asked which of the five subactivities was the most essential, Nolan distinguished between two groups of investigations—operations (surface-water, groundwater, sediment, and chemical quality) and planning (recommendations for water-resources policy).

Fenton recalled his flight in November over platforms with producing wells in part of the Outer Continental Shelf in the Gulf of Mexico. He asked for, and later received, the status of leases in Louisiana and Texas, and the amount of Federal revenue from them. Harold Duncan responded that about $300 million (later verified as $285 million) in bonuses, rentals, and royalties went to the Federal Treasury between August 1953 and June 1957, representing production of 27 million barrels of oil, 2.9 million barrels of condensate, and 293.4 billion cubic feet of natural gas. Duncan estimated that $14 million more would be added during 1957–58 by the daily production of 45,000 barrels of oil, 2,800 barrels of condensate, and 250 million cubic feet of gas. The subcommittee's questions ended with that exchange. "We are glad to have had you with us," said Kirwan in closing the hearing, "Continue to do the job you are doing and I think we will be satisfied."[168] The House Committee on Appropriations voted to hold the line on the SIR appropriation for fiscal year 1958–59, reducing geologic and mineral resources surveys and mapping by $750,000 and leaving the agency's total at $36 million, the same amount it received in 1957–58.

On March 25, Secretary Seaton asked Carl Hayden's Senate appropriations subcommittee to restore the cut, made in response to the shift of base from the AEC, and not slow down USGS work on mineral resources. Hayden agreed, adding, as before, that did not make "much difference which agency of the Government pays, just as long as we continue our efforts."[169] He also noted that the impasse in securing for the USGS a building in Washington meant that it would "be necessary to authorize the construction."[170] Three days later, Assistant Secretary Hardy and Director Nolan made the same plea to Hayden's subcommittee. In February, Eisenhower's Executive order revised the sequence, set by Truman in 1950, of Interior's administrators authorized to act as Secretary in Seaton's absence; Hardy now would so serve after the Under Secretary and the earlier appointed Assistant Secretaries but before Interior's Solicitor.[171] On March 19, Willard Libby wrote to Seaton to express his "hope that the Survey will be in a position to continue basic geologic studies related to uranium as part of its regular minerals investigation program. We consider such studies of great importance in assuring an adequate long-range uranium resource position." Libby also hoped to continue "close cooperation with the Survey on the other programs of the Commission" and to "expect to be able to enlist their aid on additional programs as the need arises."[172] Nolan reported Libby's increasing interest in and USGS work for the AEC on Project Plowshare, a national effort that planned to use nuclear explosions to mine oil shale and other sources of energy, fracture rock at and for construction sites, and excavate artificial canals and harbors.[173]

Hayden recalled his participation in passing 1925's Temple Act that authorized within 20 years, but did not fund, the completion of national topographic mapping and the Federal-State cooperation required for it. He asked about the decrease of $107,000 below the amount appropriated for topographic surveys and mapping during fiscal year 1957–58. "Will this result in a further deferment of our long-sought goal of adequate maps of the entire country?"[174] At the USGS' present rate of mapping 3 percent of the Nation each year, and assuming no raise in the proportions of funds for the increasingly important revisions, Nolan responded, "we look forward to a complete map in about 20 years—19 to 20 years."[175] That estimate, he continued, represented a reduction from the 30-year interval the USGS projected would be required 10 years earlier.

In reviewing these and other USGS programs, Hayden noted that the USGS expected to receive total funds of $54 million in fiscal year 1958–59. "Will this reduction of $3 million," Hayden queried, "result in the Survey having to separate experienced professional and technical personnel?"[176] "Yes it will," Nolan replied, "about 200 plus in the Geologic Division in the field of mineral studies," and "[i]f the House figure is sustained * * * about another 100."[177] The House, they noted, had twice reduced the original SIR request of $39.4 million to $36 million, not including the $2.8 million provided in 1957–58 by the AEC's Raw Materials Division. Agreements between the members of the House-Senate conference committee produced SIR appropriations for the USGS of $36,915,000,[178] of which $6,950,000 was limited to cooperation with the States, counties, and municipalities in water-resources investigations. On June 4, 1958, Eisenhower approved Interior's appropriations for fiscal 1958–59. Supplemental appropriations enacted on August 27 added $1.5 million more in SIR funds.[179] A second supplement, dated May 20, 1959, and also spurred by post-Sputnik developments, supplied another $3,073,200[180] that brought the year's total for the USGS to nearly $41.5 million or $2 million more than the original budget request.

As the USGS learned in June 1958 what SIR funds it could definitely count on for fiscal year 1958–59, the 1957–58 operating year drew near its close. The USGS reported total receipts of slightly more than $59,496,000 during 1957–58, or almost $6,420,000 more than in 1956–57. The SIR appropriation for 1957–58 of about $37,510,000 represented 63 percent of the year's total, an increase of $6,330,000. SIR funds for investigations in soil and moisture conservation rose by $36,000 to $165,500. Other Federal agencies transferred nearly $13,612,000, or a loss of $880,000. Nonfederal agencies provided some $8,374,000 in reimbursements and direct payments, or nearly $978,000 more than in 1956–57, but representing the same 14 percent of total funds received. The USGS received an additional $1,140,000 in special-purpose-buildings funds for its Pacific Coast Center, where the agency hoped eventually to raise its total floor space to 138,000 square feet. The USGS also received about $1,208,000 for general administration, not counting the $529,500 from other Federal agencies reported under the Divisions' substantive-activity totals. After Congress and the President approved on March 28 the transfer of $1.35 million[181] from any of Interior's other appropriations for 1957–58 to cover typhoon damage in the Trust Territory of the Pacific Islands, the USGS provided $150,000 as its share.[182]

During fiscal year 1957–58, Nolan made several administrative changes aimed at improving USGS management, staffing, and operations. Douglas R. Woodward succeeded Russell Wayland as Staff Engineer in the Director's Office. On February 13, 1958, a Survey order established an Exhibits Committee to improve the quality of USGS internal and external public displays of "the results of its scientific and engineering work."[183] The new advisory Exhibits Committee included members from each of the operating Divisions (designated by their Chiefs), the Publications Office's Exhibits Construction Officer, and the USGS Information Officer (Chairman). The Committee reported to the Director through the Executive Committee. On April 8, another Survey order abolished, as of April 1, two publishing groups—the Office of Geologic Reports' Section of Geologic Cartography and the Office of Illustrations—and transferred their functions, funds, personnel, and equipment to the Office of Publications' new Branch of Technical Illustrations. Arthur Baker, as Acting Director, asked the new Branch to aid in planning manuscript illustrations from the operating Divisions, turn the draft versions into final copy for publication, and arrange for securing "specialized base map materials." The order continued to make the Topographic Division responsible for preparing "final copy for quadrangle maps of the topographic map series and base or special maps."[184] A third Survey order on May 13 established the USGS Board of U.S. Civil Service Examiners, composed of at least one representative from each USGS Division and a

USGS geologist Eugene Merle ("Gene") Shoemaker (1928–97) trained at the California Institute of Technology (Caltech) and Princeton. After joining the USGS in 1948, he mapped and studied geology and uranium deposits on the Colorado Plateau. To this work, he added investigations of impact and volcanic craters and those resulting from nuclear and conventional explosions and laboratory projectiles. Sputnik confirmed Shoemaker's decision to try to go to the Moon. He began a USGS program in space geology in 1960 and cooperated with the National Aeronautics and Space Administration (NASA). Shoemaker, using images from telescopes and spacecraft, established a lunar chronostratigraphic scale. Addison's disease, diagnosed in 1962, kept Shoemaker out of the astronaut corps. As Chief of the USGS Astrogeologic Studies Group (later Astrogeology Branch), he helped to establish NASA's program of robotic and human exploration and sampling on the Moon. Shoemaker also led NASA's Manned Space Sciences Division (1962–66). He participated in the Ranger, Lunar Orbiter, Surveyor, Apollo (11–13), Voyager, and Clementine Programs. In 1962, Shoemaker began teaching part time at Caltech and chaired its Division of Geological and Planetary Sciences during 1969–72. Shoemaker and his wife Carolyn began mapping asteroids and comets at Palomar Observatory in 1982, and then collaborated with Canadian astronomer David H. Levy. An ounce of Shoemaker's ashes reached the Moon in 1998 in NASA's Lunar Prospector. (Photograph, 1965, from the USGS Denver Library Photographic Collection, Portraits, in "Shoemaker, Eugene M.," folder; see also Levy, 2000.)

This photograph looks northwest across Meteor (Barringer) Crater, a feature about 0.74 mile in diameter and located south of Winslow in northeastern Arizona. Eugene Shoemaker's investigation of the stratigraphy, structure, and mechanics of Meteor Crater in the late 1950s supported an origin by meteorite impact, rather than volcanism. Meteorite and nuclear-explosion craters both contained overturned strata on their outside rims and fused sedimentary particles. USGS geologist Edward Chao confirmed the impact origin when he and Shoemaker discovered natural coesite (pressure-shocked quartz) at Meteor Crater. Shoemaker and Chao's subsequent studies of similar structures in and outside the United States, Shoemaker's experiments with projectile and explosion-produced craters, and his studies of lunar craters confirmed that impacts commonly occurred on and off planet and were significant events in Earth-Moon history. (Photograph by USGS geologist David J. Roddy; from the USGS Denver Library Photographic Collection as Project Apollo (1960–73) pap00001, https://www.sciencebase.gov/catalog/item/51dda464e4b0f72b4471e1f5; published in Schaber, 2005, fig. 1.)

Director-named Chairman, all nominated by the Director and approved by the Civil Service Commission. Nolan asked the new Board to handle the work of recruiting, scheduling, examining, registering, and certifying qualified individuals in science, engineering, and technical positions. Nolan also requested the Board to advise him regarding USGS "policy in these and related functional areas."[185]

The Geologic Division received $15,396,000 for salaries and operations during fiscal year 1957–58, a modest gain of $384,000. SIR appropriations rose by almost $1,237,000, to a total of $8,013,000, and enabled the Division, at long last, to control more than half (52 percent) of its program. States, counties, and municipalities added $302,000, a loss of just over $9,000 from the previous year. Although the AEC again reduced its transfer, by nearly $924,000, its total of $3,972,000 kept it as the largest Federal contributor. The Army and its Engineers shifted $1,224,000, or about $128,000 more than the previous year's transfer; the ICA's contribution rose by $92,000 to $867,000; and the DMEA increased its transfer by $36,000 to a total of $504,000. The Navy contribution continued to fall, but the Air Force raised its transfer to nearly $139,000. Chief Geologist Bill Bradley chose Montis Klepper to succeed Dwight Lemmon as Assistant Chief Geologist (ACG) for Operations. Harold Bannerman (Program) and Lincoln Page (Trace Elements) continued to serve as the other ACGs. Raymond Becker replaced Robert Lindvall as Central Region Geologist in Denver. After John Rabbitt died suddenly on June 10, 1957, Mary Rabbitt transferred from her post as Assistant Chief of the Geophysics Branch to succeed her husband as the Division's Staff Assistant for Publications.

The growing U.S. effort in space led Nolan and Bradley, prompted by Eugene ("Gene") Shoemaker and other younger members of the USGS, to consider ways of mapping the Moon from Earth-based observations. In "To a Rocky Moon—A Geologist's History of Lunar Exploration," USGS program participant Don E. Wilhelms later (in 1993) analyzed the origins and subsequent development of the agency's mapping and other contributions to robotic and manned exploration and increased scientific understanding of the composition, structure, and history of the Earth's only natural satellite. G.K. Gilbert's studies of Arizona's Coon Butte area in 1891 led him to interpret that feature, later and better known as Meteor (Barringer) Crater,[186] as the result of explosive volcanism. After Gilbert studied the Moon through the Naval Observatory's reflecting telescope during 18 nights in August 1892, he decided in his next year's publication, "The Moon's Face—A Study of the Origin of Its Surface Features," that meteorite impacts had formed some of the lunar craters.[187] In the postwar years, astrophysicist Robert B. Baldwin and geologists Reginald Daly and Robert S. Dietz supported an impact origin for lunar craters.[188] Dietz joined the Navy Electronics Laboratory (NEL) in San Diego in 1946 and served as an oceanographer during Operation Highjump in 1946–47. In articles published during and after 1946, Dietz described the shatter cones in terrestrial rocks and the circular and radial symmetry, central peaks, and six other properties of lunar craters that reflected their impact origin and distinguished them from volcanic craters on Earth.

Shoemaker completed a master's degree in geology at Caltech in 1948 and promptly joined the USGS Colorado Plateau Project. He spent nearly all of 1948–52 in field mapping and uranium studies for the project in Colorado and Utah, then participated in the Distribution of Elements Project during 1952–55. Shoemaker also led the Investigation of Diatremes Project in 1952–60, while also working full time during 1957–60 on the Investigation of Geologic Processes Project. As part of these investigations, he mapped and studied the diatreme volcanoes of the Hopi Buttes and other areas of the Hopi and Navajo Indian Reservations, the nuclear-explosion craters at the Nevada Test Site, Meteor Crater, and similar features elsewhere that Columbia's Walter Bucher and other geologists interpreted as volcanic. Shoemaker, who also investigated ballistic theory and craters caused by small projectiles and by nuclear and conventional explosives, became convinced that impacts caused many terrestrial and most lunar craters. The natural and nuclear craters shared geologic features and dispersal patterns and they also seemed similar in aspect to some of the lunar craters. Shoemaker read Gilbert's 1893 article, the 1946 articles by Daly and Dietz, and Baldwin's 1949 book, "The Face of the Moon"; he then read widely among subsequent publications, including the U.S. military's photographic atlases based on telescope-derived images that resolved features as small as 1,500 feet across.

Beginning in the 1830s, Edgar Allan Poe, Jules Verne, Konstantin Tsiolkovsky, H.G. Wells, and Hermann Oberth used varied craft and propulsion methods to take their characters and readers on imaginary voyages to the Moon. Von Braun's long-time wish, inspired by Oberth, to send a rocket to the Moon was no secret; it began even before his V–2 years. Von Braun, after relocating to the United States, promoted space travel in articles and interviews in *Colliers* during 1952–54 and in other magazines, on radio, and on television, including an appearance for Walt Disney's theme park "Tomorrowland." Shoemaker, a more recent but no less enthusiastic convert, believed the United States' expanding program in space would include plans for human exploration of the Moon and decided to go there as that venture's initial geologist. Shoemaker suggested to Nolan in 1956 that the USGS begin a four-person program of lunar studies. William Rubey, whose opinion Nolan then sought, did not think it a far-fetched idea, but Shoemaker's proposal progressed no further before the advent of Sputnik 1. "I'm not ready yet,"[189] Shoemaker responded to news of the Soviets' success, but other members of the USGS began maneuvering to participate in the mapping underway or being planned, with military sponsorship, to improve existing lunar atlases by using newer telescopic photography. As 1957 ended, the Air Force also continued to consider Project Red Socks—a proposed mission to the Moon that would use the new, two-stage Thor-Able rocket being developed from the IRBM, a modified Explorer as proposed by JPL's Pickering, and lunar-atlas data. The USAF, General Schriever suggested in June 1958, could develop a system (costing nearly $100 million) to place a man in lunar orbit by April 1960.

Members of the USGS Pick and Hammer Club quickly commented on the agency's attempts to hop on the U.S. space bandwagon. On May 2, 1958, the Club's "Missileaneous Players" presented "Lunar Ticks or How to Solve the Space Problem" as its annual show. In "Fun Demental," sung to the tune of Lester Lee and Zeke Manners' "Pennsylvania Polka," the Andrews Sisters' hit song in 1942, they asked to:

> **Strike up the music, the job has begun—**
> **The Lunar Mapping Program.**
> **Pick out your gimmicks and join in the fun—**
> **The Lunar Mapping Program.**
> **It started with Noolan, now we're on the run.**
> **It's bound to soon involve ya,**
> **Everybody wants to solve the**
> **En-ig-ma of Lunar Mapping Program.**[190]

After "Noolan" said "the Survey's got the dough,"[191] four Chiefs—"Leo Lunarpold," "Clod," "Firpo," and "Begorra"—assembled in the office of "Admiral Speed," a character inspired by John Reed (Sr.), Staff Coordinator in the Director's Office, and a Commander, U.S. Naval Reserve (USNR). To gain the prize, the Chiefs extolled the expertise in stratigraphic and structural geology of their operational units, Water Resources, Paleontology and Stratigraphy, Geophysics, and Geochemistry and Petrology. Crews from Leopold's, Cloud's, Balsley's and Pecora's units, trained and tested, sought "the honor / To be sent to map the moon."[192] "Speed" and the other former field men now on the Director's staff wanted to lead the effort but decided they could not leave their well-padded chairs. As the program's funds came from the Army Engineers, "Speed" picked the previously unheard photogeologists of Frank Whitmore's Military Geology Branch. The new "Missileled Crew" used Johnny Burke and Jimmy Van Heusen's "Road to Morocco," the title tune from the Hollywood film of 1942, sung by Bing Crosby and Bob Hope, to announce that:

> **We're off to the moon in our rocket,**
> **Make way, clear the road, here we come.**
> **Tom Noolan he just told us that the job had to be done,**
> **A ge-o-lo-gic map of green cheese really will be fun.**
> **Our program is certainly sound—**
> **Like Von Braun's can of Millers, we are moonward bound.**[193]

The chosen ones were "quite prepared to tackle any crater big or small" as part of their terrain studies. "With scientific gadgets at our ev'ry beck and call," they promised, "That map will be no trick at all."[194]

As the USGS military geologists began their lunar studies, other members of the Geologic Division and their colleagues outside the agency continued to focus on an objective below the Earth's surface—drilling to and through the Mohorovicic discontinuity to investigate and sample the upper mantle. Better known as the "Moho," the discontinuity was named for the Croatian geophysicist Andrija Mohorovičić, Director of Zagreb's Institute for Meteorology and Geodynamics and professor at that city's university, who based his discovery in 1909 on the sharp increase of 1.2 kilometers per second in seismic-wave velocity across the crust-mantle boundary and on differences in travel patterns. Willard N. Bascom's "A Hole in the Bottom of the Sea," an insider's view through 1960 of the origins of Project Mohole, traced its beginning to a decision by Gordon Lill and Carl O. Alexis, of the Office of Naval Research, in Washington during the summer of 1952 to establish an informal organization that could deal more effectively with the wide-ranging proposals for research submitted to the ONR's Geophysics Branch. The meetings of the newly formed coeval organization, named the American Miscellaneous Society (AMSOC), became casual venues for more interdisciplinary evaluations of ideas not yet ready for formal presentations for funding. Lill and the other members of AMSOC eschewed both constitution and bylaws, operated without officers, and gave fanciful names to their informal divisions. When Maurice Ewing, who still directed Columbia's Lamont Geological Observatory (LGO) and continued to promote securing deeper cores from Atlantic Ocean sediments, encountered a deep-drilling discussion by members of AMSOC meeting at the Cosmos Club in 1956, they asked him to join them. That October, Frank B. Estabrook, a physicist at the Army Office of Ordnance Research, published a letter in *Science* describing the major geological and geophysical problems—those involving composition, density, gravity, isostasy, magnetism, radioactivity, seismicity, and temperature and pressure—that could be investigated by downhole sensing in and cores from a "research shaft"[195] to the Moho.

AMSOC's horizons expanded significantly on March 23, 1957, when Charles Behre, Hugo Benioff, Princeton's Harry Hess, King Hubbert, Walter Munk, and William Pecora, all members of the NSF's Advisory Committee for Earth Sciences in 1957–58, met with William Benson to evaluate a number of research proposals submitted to Benson's Earth Sciences Program at the NSF. The reviewers found all the proposals worthy, but they thought that none of those projects would likely yield a major increase of knowledge. The mantle-sampling project, Munk suggested, would produce a major advance.[196] Selecting a site on an oceanic island, like those already drilled in the Pacific by Harry Ladd's team, or a better site below the ocean itself, would reduce the depth of the Moho to less than 3 miles, and fewer heat-generating radioactive minerals would be encountered in drilling in the thinner basaltic crust. Hess and Munk considered the project as the consummate opposite of a mission in outer space,[197] one that could generate favorable publicity for the earth sciences as well as draw in oil-company expertise and support. On April 20, when AMSOC met again at Munk's house in La Jolla, its members capped additional discussion by naming Lill to chair a project-evaluation committee. Hess, Ladd, Munk, Roger Revelle, and Joshua Tracey formed the rest of Lill's Committee on Deep Drilling. A week later, the new Committee met at the Cosmos Club, where Lill added William Rubey and Maurice Ewing. Oceanographer Arthur E. Maxwell, who served at the SIO and measured heat flow in the Pacific with Revelle before transferring in 1952 to the ONR's Geophysics Branch, joined Lill's Committee later in 1957.

On July 15, 1957, AMSOC requested funds from the NSF for a feasibility study, but, lacking a link to a formal organization, did not get them and sought support elsewhere. Hess and Revelle promoted a resolution in September at the meeting of the International Union of Geodesy and Geophysics (IUGG) in Toronto. There, they were seconded by British Petroleum's geophysicist Thomas Gaskell, who conducted seismic-refraction surveys to locate bedrock depths on Funafuti and Nukufetau in 1951 during the cruise of HMS *Challenger*, the Royal Navy's second survey ship of that name. The IUGG's resolution, approved on September 14, called determining the composition of the mantle a vital goal for geophysicists.[198] The document urged nations with deep-drilling experience (like the United States) to estimate the possibility and cost of drilling into the mantle at a site where the crust was thinnest.[199] During the discussion, a Soviet scientist informed attendees that his country already possessed the equipment for a Mohole and now was just looking for the best site, one presumably on land.

To this Sputnik-like challenge from the Soviets, independent oilman John W. Mecom of Houston responded positively at AMSOC's next meeting on December 6 at Rubey's home. Mecom's company held the world's depth record for oil wells, the one drilled in 1956 from the barge *Keystone* to a salt dome's flank 22,570 feet below a Louisiana bayou southwest of New Orleans. Mecom and the AMSOC members suggested a multiphase program that would drill three holes—one on land, to 35,000 feet, and then two at sea to penetrate first the sedimentary section and then through the crust to the mantle. Two days later, Hess, who chaired the NAS–NRC's Earth Sciences Division, asked the NAS–NRC to absorb AMSOC's project into the Earth Sciences Division and to seek up to $50,000 from the NSF to enable AMSOC to study the project's feasibility. Ewing (elected in 1948), Hess (1952), Munk (1956), Revelle (1957), and Rubey (1945) were members of the NAS. Munk and Revelle also sailed together on the SIO's Capricorn Expedition in the Pacific in 1952–53, with Maxwell and two other members of the SIO's staff—marine geologist and oceanographer H. William Menard and geophysicist Russell Raitt, Jr. Menard, a former Lt. Commander, USNR, earned a Ph.D. at Harvard in 1949, and Dietz promptly hired him for the Navy Electronics Laboratory. Menard joined Dietz and Revelle in the NEL–SIO Mid-Pacific Expedition in 1950 and in other cooperative research until he shifted to the SIO in 1955.[200] Columbia's Isidor Rabi, NAS member, Nobel laureate, and one of the participants in the discussions, was glad to focus on a topic other than space.[201] Geologist Willard Bascom, a NAS staff member fresh from installing instruments to measure Pacific Ocean waves during the IGY, became an enthusiastic convert to the drilling project. While at the SIO during 1951–54, Bascom, also participated in nuclear tests in the Pacific. Bascom, as Executive Secretary of the Meteorological Society in 1957, represented the United States at the IGY's Conference on Oceanography in Sweden; he became Executive Secretary of the NRC's Maritime Research Committee in 1958.

On April 26, 1958, an array of U.S. geophysicists met in the NAS' headquarters in Washington, at the invitation of William Thurston, to assess the Mohole project and the possibilities for funding it. Harry Hess, who continued to serve with James Balsley, Charles Behre, William Heroy (Sr.), and Harold Urey on the NSF's Advisory Panel for Earth Sciences for 1957–58, chaired the session. Gordon Lill presented the plan, and Hess and Roger Revelle effectively responded, both historically and scientifically, to some attendees' objections about the project's cost and utility. Union Oil's A.J. Field then demonstrated its practicality. He showed movies of a well being drilled in 200 feet of water off California by use of the 98-foot-tall derrick amidships in *CUSS I*, a 3,000-ton, 260-foot-long, former Navy freight barge modified and operated by a consortium of four oil companies—*C*ontinental, *U*nion, *S*hell, and *S*uperior. Attendees voted unanimously to approve the project, and the NAS–NRC lauded its prospect of increasing basic knowledge of the Earth and providing "new insight into theories of continental drift."[202] The NSF provided for 1958–59 a preliminary grant to Thurston of $15,000, as a down-payment on the now specifically requested $30,000 for a 2-year feasibility study.[203] In September, as Gaskell published a project prospectus in *Nature* and the newly formed Global Marine Exploration Company bought *CUSS I*, Phillips Petroleum extended a well in western Texas' Pecos County to a depth of 25,000 feet at a cost of less than one-third the nearly $50 per foot then required for drilling in the Gulf of Mexico. In an expanded study, fueled by an additional $80,500 from the NSF to the NAS–NRC in fiscal year 1959–60, researchers led by John Adkins examined site surveys by the LGO and the Woods Hole Oceanographic Institution (WHOI), looked at *CUSS I* and Humble's *SM 1*, considered other drill ships worldwide, and sorted scientific objectives. Then, during April–July 1959, Bascom, Hess, Lill, and Maxwell combined to publish four additional prospectuses in the *American Geophysical Union Transactions* (reprinted in *American Scientist* in 1960), *Nature*, *Science*, and *Scientific American*.[204] They presented Project Mohole as a two-phase and multiple-drilling effort, in competition with the Soviet Union's as yet unverified program, at a cost of $5 million, or about equal to the price of a single satellite launch. "When going ahead in space, it is also important to go back in time," AMSOC's proverb proclaimed, "The ocean's bottom is at least as important to us as the moon's behind!"[205]

By then, Lill's Committee on Deep Drilling actively operated three advisory panels—Scientific Objectives and Measurements, Drilling Techniques, and Site Selection. Ladd led the Panel on Scientific Objectives and Measurements, with Balsley as his deputy. The panel's 10 other members were Harvard geophysicist Francis Birch, elected to the NAS in 1950; Lt. Colonel George Colchagoff, Air Force Office of Scientific Research; geophysicist Henri-Georges Doll, Schlumberger Well Survey Corporation's former research director and board chairman; LGO geologist David B. Ericson; marine geologist George H. Keller, Naval Oceanographic Office; John Lyman, who left the Navy Hydrographic Office in 1959 to serve as Assistant Director of the NSF's Oceanography Program; Arthur Maxwell; William Menard; William Pecora; and Hatten S. Yoder, Jr., a research petrologist at the Carnegie Institution of Washington's Geophysical Laboratory[206] and a newly elected member of the NAS. One representative each from Humble, Pan American, Phillips, Socal, Socony Mobil, and Texaco formed William Heroy's Panel on Drilling Techniques. Hess' Panel on Site Selection included geophysicist and oceanographer John B. Hersey, WHOI; John E. Nafe, LGO; Russell Raitt, SIO; and marine seismologist George G. Shor, SIO. Bascom's NAS–AMSOC staff, whose salaries were paid by the NSF, comprised a secretary, a scientist, 10 engineers, and 2 naval architects. They were aided by five consultants—a lawyer, a third naval architect, and three other engineers.

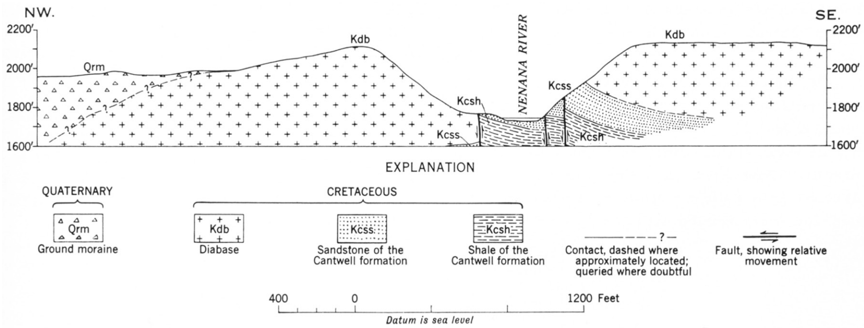
Geologists in Andy Anderson's Mineral Deposits Branch continued during 1957–58 to concentrate on longer term studies intended to increase knowledge of identified mineral deposits and their origins and histories as the keys to developing new and improved exploration techniques. The Branch directed 126 projects, of which the AEC supported 27 and 20 others involved cooperative work with the States. Members of these projects mapped in the Little Dragoon Mountains of Arizona, the Grants and Laguna areas in New Mexico, the Holy Cross quadrangle in the Colorado Mineral Belt, and the Boulder Batholith west of Butte in Montana. Branch scientists expected their investigations of the water included in minerals to provide additional clues to the nature of ore deposition. Studies for the DMEA led to the discovery of significant amounts of lead ore in the Viburnum area of southeastern Missouri and the prospect of the deposit being developed as the largest in the district, as the overall study of lead-zinc areas in the Upper Mississippi Valley neared completion. Branch personnel continued to appraise boron resources and their mode of occurrence in response to the increasing use of that commodity in fuels. Branch geochemists participated in five exploration projects in 1957–58. They developed new methods for rapid analyses, in field and laboratory, to determine concentrations of mercury and tin in soils and rocks. They also perfected a new and more accurate technique for determining lead and zinc, when those occurrences were masked by interfering elements, and significantly improved the field spectroscope's accuracy and precision.

Members of the Trace Elements Planning and Coordination Office, led by Vincent McKelvey, completed more than 20,000 analyses during fiscal year 1957–58, but changes in U.S. requirements for uranium and thorium resulted in additional modifications to Anderson's Branch. By 1955, some 800 mines were producing uranium ore from the 12 large and high-grade deposits located on the Colorado Plateau since 1948. Sites near New Mexico's Ambrosia Lake yielded in 1956 additional large deposits, studied by Harry Granger, and other discoveries were made in Wyoming. The AEC began cutting back its guaranteed purchase program in 1956, the Colorado Plateau Project's peak year, when it employed 125 persons. Uranium and thorium were now being produced at more than five times the rate in 1952 and yielded stockpile reserves by 1957 of some 15,000 tons, even though the price for uranium ore remained fixed by the AEC at $31 per ton. In 1957, the AEC froze uranium-ore purchases by refusing to begin new contracts, a decision which led to harder times for miners that did not change significantly until uranium went on the free market in 1966. On May 13, 1958, Nolan and Bradley again revised a Survey order to modify the Mineral Deposits Branch,[207] reflecting the continuing decline of funding by the AEC's Raw Materials Division for the Branch's Colorado Plateau Project and related projects. The changes, effective June 30, ended the Colorado Plateau Project by abolishing the posts of Staff Assistant for Uranium and District Supervisor. By this order, the other District Supervisors became Area Supervisors at the offices at Beltsville in Maryland, Denver, and Menlo Park. Work continued only for the DMEA. By the late 1950s, Alfred Bush noted in his history of the Colorado Plateau Project, studies of uranium-bearing sandstones "in the Black Hills, in the Tertiary basins of Wyoming, and in the Texas Gulf Coastal area showed, as in the Colorado Plateau region, that the deposits lacked a consistent pattern of geologic relations and geologic history, such as might be expected if the deposits had a common hydrothermal origin."[208] Ideas on their genesis now favored a groundwater origin, as proposed for foreign deposits. Lorin Stieff and Thomas Stern's radiometric determinations of their age, originally thought to be Late Cretaceous-early Tertiary, indicated that they were older and that they had formed nearer the time when their sandstone hosts were deposited.

Work in two Branches—William Pecora's Geochemistry and Petrology and James Balsley's Geophysics—supported efforts in mineral-deposits investigations as well as advancing their specific responsibilities in their own programs and operations in fiscal year 1957–58. Members of Pecora's Branch completed nearly 22,000 analyses and determinations by chemical, mineralogical, radiometric, spectrographic, and X-ray methods and prepared some 16,000 thin sections. Lead-alpha radiometry provided new geologic ages for granites in New England and batholiths in Western States and in Alaska. Brian J. Skinner, who shifted from the University of Adelaide to the USGS in 1958, developed a technique that linked a precision-controlled furnace with an X-ray diffractometer to determine the behavior of minerals at temperatures as high as 1,000 degrees centigrade to yield clues to their formation. In related laboratory and field studies, scientists continued to seek an improved understanding of the origins of deposits of boron, iron, phosphate, uranium, vanadium, and zinc ores. The 15 projects underway in Balsley's Geophysics Branch involved continuing aerial and ground magnetic and radioactivity surveys. These efforts included a 1:24,000 aeromagnetic survey over the Grace Mine, near Morgantown in Berks County, Pennsylvania, by Bill Bromery and his team, and aeromagnetic and ground surveys of two areas in New Mexico that showed potential for mineral fuels. Induced-polarization measurements indicated that the grades of some copper ores could be determined at mine faces. During the year, the Geophysics Branch published 27 aeromagnetic maps based on its surveys.

In 1957, James Gilluly left the General Geology Branch to succeed Ralph Miller as Chief of the Fuels Branch. Miller, who led the Branch from 1951, also chaired the Interdivision Committee on Photogrammetric Techniques for Geology during 1955–56. In November 1957, Miller began a year's detail to the Foreign Geology Branch to help the ICA prepare petroleum legislation for Afghanistan. At home, the United States had been a net importer of oil since 1953, and searches for new domestic sources continued nationwide. To support this effort, Branch geologists mapped and made stratigraphic studies in 29 States that were producing oil or that had significant potential for future production; six of the studies were conducted in cooperation with State agencies. They correlated Devonian shales in New York to aid exploration for oil and gas in the northern Appalachians. In Wyoming, Branch members determined that some overthrust remnants in Wyoming's Wind River Basin were old landslides and showed that Upper Cretaceous black sands marked shorelines, whose deposits commonly held petroleum. They began a stratigraphic study of areas in the southern Appalachians and an evaluation of petroleum possibilities on the Atlantic Coastal Plain and the adjacent Continental Shelf. The Branch's coal specialists investigated areas in 13 States, 5 of which also received assessments of total resources. Branch geologists supported the Interior Department's Long-Range Minerals Program, originally submitted to Congress in June 1957, revised and resubmitted in April 1958, and then approved by the legislators and the President. Interior designed the program to accelerate research and development by the USGS and the USBM as part of an effort to increase the production of copper, lead, zinc, and other commodities hampered by falling prices during the past year and also to provide stabilization payments to distressed producers in the mineral industry to encourage exploration. Using field and photogeologic techniques, Branch geologists completed or began the mapping at 1:24,000 of 16 quadrangles in Arizona, Colorado, Delaware, Idaho, and Texas to aid the USGS National Water Resources Policy Program.

During fiscal year 1957–58, members of Edwin B. Eckel's Engineering Geology Branch continued cooperative mapping in Connecticut, Massachusetts, and Rhode Island, investigations in nine metropolitan areas, and related work in eight more rural locales in Colorado, Montana, and Nebraska. Their research centered on landslides, classified by David Varnes on the basis of material contained and type of movement,[209] and also mudflows and the causes and rates of cliff erosion. For the Federal Housing Administration, Branch members studied several construction sites and conducted a 2-week course in geology for FHA engineers. After the Eisenhower administration began shifting in September 1957 from aboveground to underground nuclear testing at the Nevada Test Site, also the home of the Nuclear Rocket Development Station since 1956, Branch members continued to investigate preshot and postshot geologic conditions.

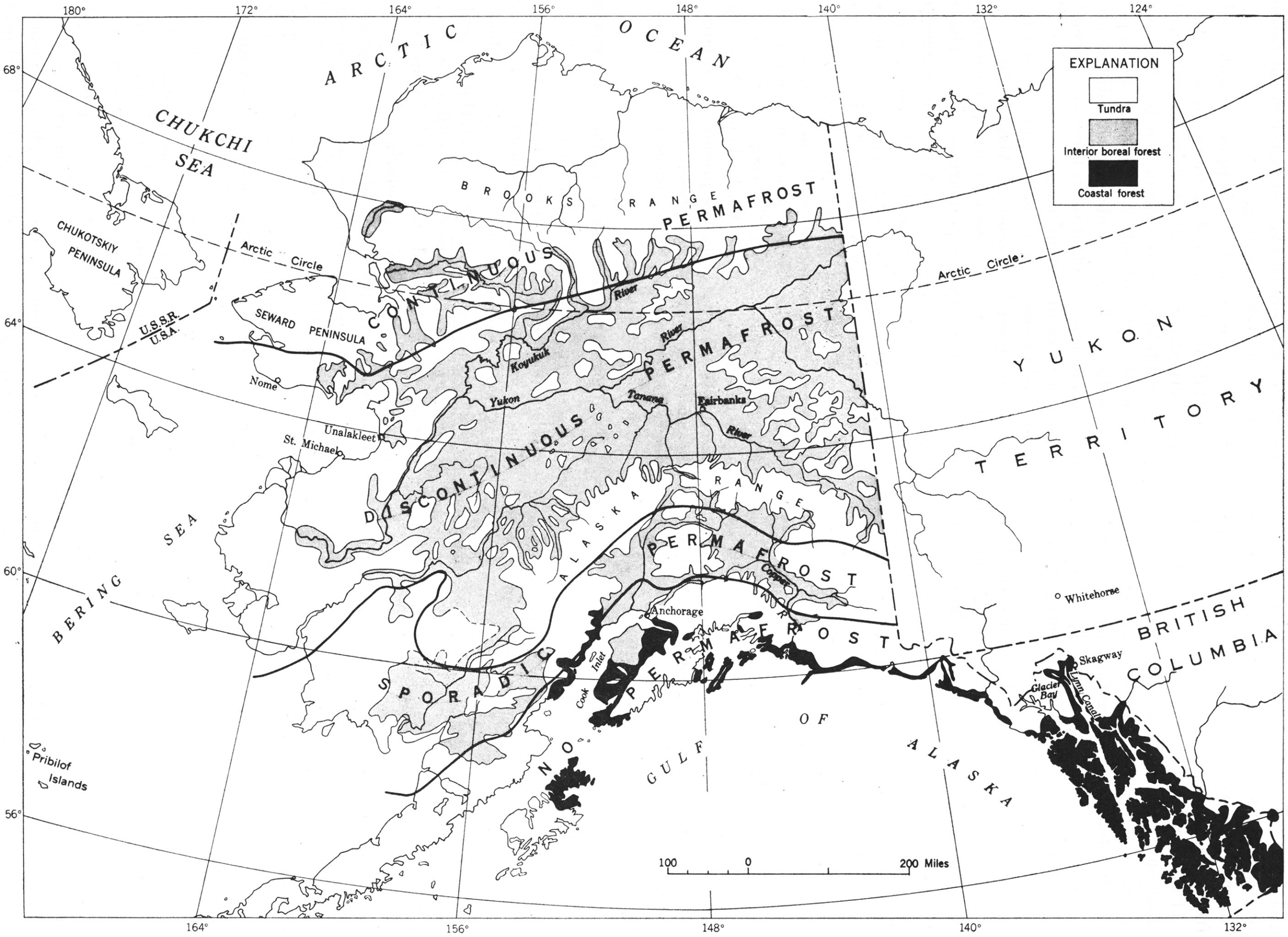


This geologic section (originally at 1 inch = 800 feet) shows a potential site for a dam across the Nenana River at mile 342.0 on the Alaska Railroad, south of Moody, as determined by USGS geologists Clyde Wahrhaftig and Robert Black during field studies in 1947–52; results were published in 1958. Building at this site, in a narrow and fault-controlled gorge of diabase and sandstone, would have required a “dam 200 feet high and 1,000 feet long at its crest” (and realigning 1–1.5 miles of track) that would pond a reservoir having an area of “about 2.5 square miles and a storage capacity of about 80,000 acre feet.” The two geologists also mapped geology and studied landslides, icings, and frost heaving and settling and their effects on the maintenance of the track bed as part of engineering investigations between miles 322 and 385 of the Alaska Railroad. The railroad linked Anchorage and Fairbanks and also served adjacent coal fields, gold fields, and Mt. McKinley (now Denali) National Park. The railroad had been damaged and traffic delayed by landslides following the central Alaska earthquake on October 16, 1947. The geologists’ work formed a part of USGS studies of the Quaternary and engineering geology of the central Alaska Range, particularly the Nenana River Valley and adjacent areas. (Geologic section and quotations from Wahrhaftig and Black, 1958, fig. 58, and p. 114; see also Wahrhaftig, 1958.)

Managerial changes also occurred in two other Branches in the Geologic Division during fiscal year 1957–58. J. Fred Smith, Jr., a veteran of studies of strategic minerals and of military and regional geology with the USGS since 1942, replaced James Gilluly as Chief of the General Geology Branch in December 1957. Preston Cloud, Jr., returned to the USGS on July 14, 1957, after taking 1,200 hours of leave without pay for non-USGS work in Europe, and resumed his former post as Chief of the Paleontology and Stratigraphy Branch (PSB). Charles W. Merriam, the Acting Chief during Cloud’s absence, returned to full-time research. In addition to the PSB members’ regular work of examining and reporting on collections referred from other units in the USGS, their research included X-ray studies of magnesium in foraminifer tests as a check on their biological affinities.

In Alaska during 1957, a discovery well along the Kenai Peninsula’s Swanson River began producing 900 barrels of oil per day. Secretary Seaton then opened to leasing 20 million acres of public land in the Territory. In 1958, more than 5,000 leases were filed on 28 million acres of public lands in Alaska, especially around Cook Inlet. The Kenai discovery increased ongoing efforts by members of George Gates’ Alaskan Geology Branch to assess potential petroleum resources in the Territory, especially in the Iniskin-Tuxedni, Koyukuk, and Nelchina areas, and in the Gulf of Alaska Tertiary Province, whose mollusks and other megafossils Stearns MacNeil continued to study while completing his analysis of those in Cenozoic deposits on the North Slope. Also in fiscal year 1957–58, Branch members continued studies of the Tofty-Eureka gold-tin district and applied field geochemical tests for commodities proved elsewhere to searches in Alaska. They also completed mapping tungsten deposits north of Nome and nearby tin deposits in the western Seward Peninsula. In work for the DMEA, Branch geologists almost finished mapping the deposit that produced uranium and thorium at Bokan Mountain at the south end of Prince of Wales Island. Branch members also conducted geologic and geophysical studies at Cape Thompson for the AEC’s Project Plowshare. The Branch’s engineering-geology investigations included mapping 100 square miles of surficial deposits near Fairbanks and some 80 square miles along the Alaska Railroad, surveying sites to aid the planning for dams proposed by the USBR for Devil Canyon and Denali, and mapping bridge sites along the highway from Nenana to Mt. McKinley (Denali) National Park for the Bureau of Public Roads. Geologists in the Alaskan Geology and Mineral Deposits Branches, joined by some of their colleagues elsewhere in the Geologic Division, mapped 2,200 square miles in 20 areas in the Territory and in Colorado, Montana, and other States for the Long-Range Minerals Program. The Division aimed this work at developing regional patterns of mineralization as guides to future exploration for mineral commodities in short supply but essential to national security. The Juneau (B–3) sheet by Fred Barker was issued in 1957 as GQ–100; it began the published 1:63,360 coverage of Alaska in the Geologic Quadrangle (GQ) Map series.

During fiscal year 1957–58, members of Frank Whitmore’s Military Geology Branch continued or completed work, principally for the Army Engineers,



USGS botanist Robert S. Sigafoos compiled this map (originally at about 1 inch = 180 miles) of Alaska and part of Canada to show the distribution of areas of no permafrost; sporadic, discontinuous, or continuous permafrost; and coastal forest, interior boreal forest, and tundra. "Treeless areas [shown] are predominantly tundra but also include exposed bedrock, glaciers, sand dunes, and grasslands." USGS geologist David Hopkins and 10 geologists and geobotanists in the agency studied how the effects of groundwater and permafrost on each other influenced their distribution in Alaska. They found that "local differences in topography, lithology, and drainage result[ed] in sharp local differences in the character and distribution of permafrost that tend[ed] to obscure the regional zonation." Permafrost's distribution pattern, based on interpretations of aerial photographs and checked by ground observations, they concluded, was "not exclusively the product of present-day climates." The "poor relationship between surface manifestations and underlying permafrost" prevented them from constructing reliable keys for photointerpreting permafrost." (Map and quotations from Hopkins and others, 1955, fig. 11 and caption, and p. 113.)

in Alaska Territory and in California, Georgia, New York, and other States. Roy C. Kepferle, who joined the Fuels Branch in 1950 and transferred to the MGB in 1956, applied punch-card computer techniques to retrieving literature from the MGB's library. Other MGB members completed and sent to the Army Engineers a terrain study of Alaska's Big Delta area. They also cooperated with permafrost specialists from the USAF's Cambridge Research Center and the IGY's glaciological program in studies by Charles Lewis along the Arctic Coast near Barter Island, east of Camden Bay, and adjacent land areas south of the Beaufort Sea.[210] Simeon Muller reported on permafrost conditions and related problems at Ladd Field and elsewhere in the Fairbanks area, Galena on the Yukon River, Kotzebue, and Point Barrow, while Arthur Lachenbruch described three-dimensional heat conduction in permafrost beneath buildings in several areas and developed a probe for measuring in place the thermal conductivity of permafrost.[211] Lachenbruch and Max C. Brewer, who joined the USGS full time in 1950 and began directing research at the Naval Arctic Research Laboratory in 1956, studied the dissipation of the thermal effect in drilling wells in Arctic Alaska. Oscar J. Ferrians and Henry Coulter finished a 1:5,000,000 slope map of Alaska and northwestern Canada, with larger scale insets for Forts Greely and Churchill, as MGB Miscellaneous Paper 137.

Whitmore's military geologists also completed several Engineer Intelligence Studies (EIS) during 1957–58. For EIS 274, they analyzed the geology, terrain, construction materials, mineral and water resources, permafrost, soils, underground structures, and related aspects of the Yukon Flats district, Alaska. MGB members, in cooperation with their colleagues from the Army Engineers' Beach

Erosion Board and Engineer Detachment (Terrain) 517 in Washington, completed, as EIS 141, a "Terrain Study of Monterey-Estero Bays Area" in central California, with maps at 1:50,000. EIS 141 summarized information about possible airborne operations, existing airfields and potential sites, bridges, climate, coast and landing beaches, drainage, electric power, fuels, landforms, natural construction materials, railroads, roads, stream bank and bottom materials, surface-water and groundwater resources, terrain, trafficability, and urban areas; it was illustrated by ground photographs, maps at 1:50,000 and 1:250,000, and other graphics. For EIS 180, geologists analyzed the terrain in the 6th Army's area in the Western States. EIS 210 depicted, at 1:25,000, the military geology of the area in New York around West Point. EIS 211, "Military Geology of the Fort Benning, Ga. Area," printed by the Army Map Service in June 1959, depicted the area at 1:25,000 on 10 topographic quadrangles (Series V 845) that included those for Forts Benning and Mitchell. That report also contained a general index map at 1:100,000, Fort Benning and seven of the other 1:25,000 topographic quadrangles in shaded relief, terrain at 1:100,000, general geology and engineering geology at 1:100,000, geology with engineering data at 1:25,000 for Fort Benning and seven other quadrangles, water resources at 1:100,000, and surficial soils at 1:100,000 and 1:25,000.

Abroad, MGB members continued to aid the work of the Army Engineers and the Air Force in Greenland, Latin America, Germany, Africa, Asia, and the Pacific. Their worldwide summary, at 1:60,000,000, reported generalized conditions for cross-country movement by tanks. William Davies, Stanley Needleman, and Donald W. Klick examined and mapped, at 1:165,000, ice-free areas near Greenland's Polaris Promontory tested as landing sites in the 1958 continuation of the Air Force's Operation Groundhog. Mario Conti and Jules D. Friedman completed a geomorphic map of Brazil at 1:5,000,000. Botanist Raymond Fosberg spent March and April 1958 in a study of terrain and vegetation in Colombia. George Rozanski finished a hydrologic map of Honduras at 1:1,000,000 and, at the same scale, a similar map of Ethiopia-Somalia. Frederick Betz's team in Europe compiled geologic data about airfields and oil-shale deposits in Germany. Three reports included maps at 1:5,000,000 or 1:5,500,000 of the Middle East and summarized the region's water resources (EIS 183), cross-country movement (EIS 208), and the suitability of areas for airborne operations and airfield construction (EIS 231). EIS 214 contained the results of terrain studies of Afghanistan. Jack Rachlin studied cross-country movement in and the construction materials and water resources of the area around Lampang in Thailand that contained significant deposits of copper, iron, and lead. George S. Corchary completed a wide-ranging geological reconnaissance of South Korea. Gilbert Corwin discussed intelligence methods used in the Pacific Geologic Mapping Program, EIS 257 summarized the MGB's knowledge of vegetation in Micronesia (with a map at 1:20,000,000), and a Special Report described seismic activity in the Mariana Islands.[212]

Geologists in William Johnston's Branch of Foreign Geology during 1957–58 participated, with local colleagues and with ICA aid, in economic-mineral and other investigations, and in education programs, in Afghanistan, Brazil, Chile, the Republic of China, Ghana, India (where oil was discovered in 1 of its 26 sedimentary basins), Indonesia, Iran, the Republic of Korea, Libya, Mexico, Pakistan, Peru, the Philippines, Saudi Arabia, Thailand, and Turkey. More than 70 participants, from 24 countries and sponsored by the AEC, the ICA, and the U.N.'s Eisenhower Fellowship Program, were trained in photogeologic and other field and laboratory techniques in the USGS domestic programs and also at U.S. universities. Three principal field projects continued in Brazil. John Dorr 2d, aided by Joel Pomerene, Arthur Rynearson, Norman Herz, Charles H. Maxwell, Samuel Moore, Robert G.L. Reeves, and George C. Simmons, investigated Minas Gerais iron deposits. Donald D. Haynes, who served with the Colorado Plateau Project during 1952–56, John J. ("Rod") Matzko, who earlier participated in USGS radioactivity investigations in

Alaska, Charles Pierson, and Max White studied the uranium occurrences in Brazil. Alfred J. Bodenlos, Robert Johnson, who previously worked in Peru, and Jacques F. Robertson studied base metals in Brazil. Harold Bannerman spent April–June 1958 advancing the education of Brazil's student geologists. George Ericksen, assisted by William D. Carter, Russell Gibson, Samuel Moore, and Kenneth Segerstrom, continued mineral-resources investigations in Chile. Frank Simons and John Straczek summarized in 1958 the results of USGS investigations of Cuba's manganese deposits during November 1940–September 1945.

In the Eastern Hemisphere, Gus Goudarzi and James L. Gualtieri advanced the USGS geologic mapping of Libya. Glen Brown and geologists and topographers in the USGS and Aramco, with the continuing sponsorship of the U.S. State Department and Saudi Arabia's Ministry of Petroleum and Mineral Resources, continued compiling the bilingual 1:500,000 geographic and geologic quadrangles as aids in planning any future Kingdom-wide program of exploration and development. Brown also continued providing advice about water resources to the Saudi Ministry of Agriculture and Water. From October 1957 through June 1960, John Albers contributed to institutional development in India, while Paul W. Richards studied mineral deposits and also advised the director of the national geological survey. Walter Danilchik, who served with the Fuels Branch during 1951–57, spent January–June 1958 aiding institutional development in Pakistan, while Richard Bogue continued mineral investigations there during April–June. David Andrews continued to lead mineral-resource studies in Indonesia, assisted by Raymond Becker, Robert Johnson, and Howard Weeks. Darwin Rossman and James F. Harrington investigated selected mineral deposits in the Philippines, while David Cerkel, Jr., continued to look for evidence there that might lead to new oil deposits.

South Korea's President Rhee avidly sought to base a steel industry on his country's domestic deposits of iron ore, but those known were too small and too low in grade. David Gallagher returned to South Korea during July–December 1957, and William Johnston also sent there geophysicist Robert B. Hall, who earlier operated a tripod-mounted Askania magnetometer in Harold James' Michigan Iron Project and served on one flight with James Balsley's airborne-magnetometer team. Aero Service Corporation personnel flew an aeromagnetic survey over a large portion of South Korea, and Gallagher interpreted the data. Hall's ground-magnetic traverses checked the more promising anomalies on Aero Service's map in the northeast corner of the country near the demilitarized zone. He found there, in granite gneiss, local concentrations of magnetite grains whose iron grade did not exceed 15 percent in the richest zones, too low to be considered economic. South Korea later imported ore from Australia and the Philippines to make steel at a plant near the port of Ulsan. The MGB also completed relief-map coverage of South Korea at 1:150,000 in 1957.

In 1958, the NSF received two supplemental appropriations for the IGY—$2 million on March 28 and $2.5 million on August 27—both of which would be available until June 30, 1960. The NSF provided $1.9 million for U.S. IGY Antarctic programs during 1957–58. During the austral summer, the Navy deployed three of its icebreakers, *Atka, Glacier* (flag), and *Staten Island*; the Coast Guard's *Westwind*; and seven other ships in Operation Deep Freeze III to support IGY and other activities on and off Antarctica. As in 1956–57, Rear Admiral George Dufek led the operation as commander of the Naval Support Force Antarctica and the Antarctic Projects Officer; Gerald L. Ketchum directed Task Force 43, accompanied by geologist Laurence Gould, who continued to chair the U.S. IGY Committee's Antarctic group.[213] Albert Crary led U.S. IGY activities on the continent. Two members of the USGS returned for a second year's service in Antarctica. John Behrendt's geophysical survey covered the Filchner and Ronne Ice Shelves and the Dufek Massif in the Pensacola Mountains.[214] Walter Boyd, Jr., operating from Little America V, ran a glaciological and seismic traverse across Marie Byrd Land and the Ross Ice

Shelf. The Geologic Division's Troy Péwé and Norman R. Rivard examined the geology around Lake Fryxell, named for Péwé's professor at Augustana, in the McMurdo Dry Valleys. On the Filchner Ice Shelf, between Berkner Island and the Luitpold Coast, and in the Pensacola Mountains, inland from the Ronne Ice Shelf, William H. Chapman tested the Topographic Division's new electronic equipment and methods for establishing map-control points.[215] From the Ellsworth Station, personnel in two ski-equipped C–47s tested another new electronic-positioning system by surveying a large area out to a radius of some 400 miles. U.S. aircraft stopped dropping claim markers on October 23, 1957, 8 days after the initial commercial flight from Christchurch in New Zealand landed at McMurdo.

Representatives of Argentina, Australia, Belgium, Britain, France, Japan, Norway, the Soviet Union, and the United States attended the first meeting of the ICSU's SCAR, held during February 3–5, 1958, at The Hague in the Netherlands. During the austral summer, a British IGY party collected rock specimens for paleomagnetic studies from 60 sites on Powell Island and adjacent islands in the South Orkneys, and a Soviet tractor-borne group operating from the Mirnyy Station reached the Pole of Inaccessibility. On March 2, British explorers Vivian Fuchs and Edmund Hillary, and their multinational team, completed a 99-day, trans-Antarctic passage on tracked vehicles via the Amundsen-Scott Station at the South Pole. To try to reach a more important goal for Antarctica, on May 2, the U.S. State Department invited representatives from Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, and the United Kingdom to participate in a Conference on Antarctica, to be held in Washington in June, to begin discussions aimed at securing a multinational treaty.

During fiscal year 1957–58, the Topographic Division received $18,318,000, which was $1.25 million more than in 1956–57. That monetary gain came principally from a SIR appropriation of more than $14,242,000, or 78 percent of the Division's total funds and an increase of nearly $1,370,000 from the amount available in 1956–57. Other Federal agencies transferred to the Division about $2,106,000, about $351,000 less than in the previous year. The USBR provided $1,169,000, a $98,000 increase, but the Air Force and the Army shifted only $798,900, or a loss of $399,000. Nonfederal sources reimbursed or directly paid the USGS more than $1,969,000, of which $1,765,000, a gain of almost $211,000, came from the States and their political subdivisions. Technological improvements enabled the Division to decrease by $107,000 its expenditures on the mapping of all standard topographic quadrangles. As Nolan told Kirwan, the per-person-year cost of topographic mapping increased by $1,800 during 1947–57. In the same interval, the per-square-mile cost of mapping decreased by $47 to $124 or $88 after allowing for price-index increases. Salaries rose by more than 50 percent in those 10 years, but average reproduction costs per edition fell.

Gerald FitzGerald retired as Chief Topographic Engineer on September 30, 1957. On the following day, George Whitmore, the Deputy CTE and "Supervisory Cartographer," became the CTE and the Chief of the Topographic Division. When the Civil Service Commission approved the position-classification standards for the Cartographer series on November 25, George Whitmore began changing the Division to an engineer-technician unit. Trying to ensure continuing high standards in hiring and operations, the Division developed a training program for engineering students and a career-development program for graduate engineers. By May 21, 1958, Nolan and Whitmore completed the reorganization of Topographic Division headquarters begun in 1957, and it went into effect in fiscal year 1958–59. No one immediately succeeded Whitmore as Deputy CTE, but the position would later be renamed "Associate Chief," and Earle Fennell would fill it in 1961. Until then, Assistant CTE Fennell led Program Development and supervised two Branches—John Davidson's Program Planning and Franklin Mann's Program

USGS topographic engineer and photogrammetrist George Dewey Whitmore (1898–1981) worked for R.H. Randall and Company (1917–32) and the Planning Commission of Toledo, Ohio (1932–33), before joining the Tennessee Valley Authority. In the TVA, Whitmore rose to lead the Maps and Surveys Division's Surveys Section; from 1943, he also served as the Division's Assistant Chief, responsible for all war-related activities. Whitmore transferred to the USGS in 1946 as Chief of the Topographic Branch's Research and Technical Control Division. After a year as Deputy Chief Topographic Engineer, he succeeded Gerald FitzGerald as Chief of the Topographic Division in 1957. Whitmore continued to promote the Orthophotoscope and other photogrammetric improvements that he hoped would help USGS topographers to complete two programs—the national topographic coverage, due before 1976, and, resurveys at 1:24,000 of all of the included 1:62,500 maps, except for Alaska, due by 1980. Whitmore also guided the Division's reconnaissance-scale mapping in Antarctica and its contributions to satellite imagery. Whitmore retired in 1967. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Whitmore, George D.," folder as Public Inquiries Office 75–75 [1a]; see also Thompson, 1983.)

Control and Analysis—and Jerome Kilmartin's Map Information Office. Assistant CTE Roland Moore led Research and Technical Standards and supervised four Branches—Russell Bean's Research and Design; Charles H. Buckley's Field Surveys; Photogrammetry, where Harold J. McMillen succeeded Bean; and a renamed Cartography, temporarily vacant after Charles Fuechsel's transfer. Whitmore's office also included an Assistant to the Chief Topographic Engineer and Division Officers for Administration and for Training. The Branch of Special Maps, now under M. Kerwin Linck after Davidson's shift, continued to report to Whitmore, who, with Fennell, Linck, and others, began to reevaluate the Branch's functions and organization as it neared the end of compiling aeronautical charts for the Air Force. Division members continued a 3-year study, begun by Robert O. Maxson's Map Use Research Section, of how the Division's maps were used by government agencies and the public, as well as by internal groups.

The Topographic Division's reorganization retained its four geographical field areas, each under a Region Engineer: Fuechsel's Atlantic, at Arlington; Daniel Kennedy's Central, at Rolla; James Lawson's Rocky Mountain, at Denver; and Robert O. Davis' Pacific, at Sacramento. Each Region Engineer's headquarters office contained an Assistant Region Engineer and five Sections—Cartography, Field Surveys, Plans and Production, Photogrammetry, and Administrative Services. In addition, an Alaska District Engineer resided at Fairbanks. Engineers directed the Hawaii Project from Honolulu and the Puerto Rico Project, now revising the 1:20,000 coverage, from San Juan.

Nolan and George Whitmore also decided that all future large-scale manuscript maps, except for those for Alaska, would be prepared under 1:24,000-series specifications, although some might be prepared initially at 1:62,500, and then open-filed for immediate use. That choice might enable both series to be produced from the same color-separation materials. Whitmore also continued to chair the U.S. Technical Advisory Committee on Antarctic Mapping. Division specialists also provided information about air-photo coverage and geodetic control to U.S. participants in the IGY. In June 1958, Whitmore's "The Role of Photogrammetry in an 'Open Skies' Program" appeared in *Photogrammetric Engineering* to promote the Division's potential contributions to the Eisenhower administration's continued effort to secure international support for its proposed agreement.[216]

To support mapping operations and products in 1957–58, the Topographic Division let commercial contracts for nearly 106,000 square miles of precision aerial photography and received an additional 14,000 square miles of coverage from the Air Force for defense-related compilations. The Division prepared about 2,900 maps for publication during the year, including new 1:500,000 maps of Colorado, Kentucky, North Carolina, and Utah. The Division completed for printing and distribution some 1,180 new standard topographic quadrangles, nearly 50 others compiled by other agencies, standard maps for 12 urban areas prepared by combining the 1:24,000 coverage in each, 45 special-use maps for other USGS Divisions and 5 other Federal agencies, and the civilian versions of about 360 military maps. The USGS and the Army Engineers agreed to have the USGS, as part of its responsibilities for domestic mapping, maintain the Army Map Service's former 1:250,000 series, and the Map Information Office issued an index to the civilian editions of mapping photography in Alaska by the USAF, the U.S. Navy (USN), and the USGS during 1948–57. The Division also continued cooperative mapping programs with 32 States, of whom Arkansas, Kansas, Minnesota, and Ohio significantly increased their monetary contributions, and new work began in Florida, Oregon, and Texas. The year's new mapping at 1:24,000 in the States depicted almost 60 square miles; another 90 square miles were mapped at 1:62,500.

Division members continued or began to test newly developed equipment for field surveys and compiling topographic maps. These devices included improved elevation meters, more precise leveling rods, enhanced alidades and stadia rods, ground panels, 35-millimeter photographs taken from small aircraft to improve the identification of control points, and electronic digital computers to convert geodetic control to plane coordinates on a production basis. Efforts were made to program analytical aerotriangulation by the direct geodetic restraint method. Testing continued on a new automatic-dodging contact printer that used infrared light to quench ultraviolet; a contract was let to test this technique on projection printers. James Buckmaster, Atherton H. Mears, and others improved instrumentation for altimetry. The Orthophotoscope was redesigned again, and orthophotographic mosaics were checked in the field. In cooperation with the Lincoln Laboratory at the Massachusetts Institute of Technology (MIT), Division specialists tested the Lincoln Raydist system's accuracy in determining the spacing of air-photo images. Division members also developed plans for the unit's initial analytical plotter.

The Division's Map Information Office published new editions of index maps showing the status of topographic mapping, aerial photography and aerial mosaics in the conterminous United States; all three were in the format for the ongoing U.S. national atlas. The Office continued to serve as the central repository for maps produced by this second program designed to produce a new and comprehensive atlas. In 1952, the American Geographical Society, with financial support from the American Council of Learned Societies and guidance from Samuel W. Boggs, the State Department's Geographer, completed a prototype atlas. Ten major publishers agreed not to print the volume and referred the responsibility for the compilation and production of a final version to the Federal Government. At the recommendation of the Association of American Geographers, the NAS–NRC established late in 1954 an interagency Committee on the National Atlas of the United States, chaired by Carleton S. Barnes, the Agriculture Department's Geographer. The new Committee included representatives from the USGS and 11 other Federal mapping agencies. The NAS–NRC asked its interagency Committee "to draft basic specifications and to coordinate the cartographic work of those agencies so that maps they normally made for other purposes could be accumulated as a looseleaf collection that would eventually become the national atlas."[217] As part of the second pilot program, the cooperating agencies began producing thematic sheets, using the standards specified by the Committee, and sent them to the USGS Map Information Office. During 1957–58, Federal agencies deposited 42 additional sheets for the atlas.

While continuing to provide technical assistance abroad, members of the Topographic Division extensively trained three civil engineers from Iceland and conducted briefer courses for cartographers from Brazil and the Sudan and a photogrammetrist from Thailand. Representatives of the Division traveled to a meeting in Tehran in October 1957 to promote Topographic Mapping for Economic Development. Other Division personnel compiled a report on U.S. cartographic activities between fiscal years 1954–55 and 1956–57 for presentation at the 8th Pan American Consultation on Cartography held in Havana in February 1958, the same month that the 1st Symposium on Natural Resources in Cuba convened in that city.

During fiscal year 1957–58, Luna Leopold's Water Resources Division accrued \$20,902,000, nearly \$3 million more than the total it received in 1956–57. The Division's SIR funds rose by \$2 million to \$10,516,000, or 51 percent of the total, but \$5.8 million of that sum could be used only for cooperative investigations with States, counties, and municipalities. The States and their political subdivisions reimbursed or directly paid \$5,830,000 to the Division, a gain of nearly \$697,000 and a total to which California, Texas, New York, Florida, and New Mexico, in that order, were the principal contributors. Other Federal agencies transferred more than \$4,289,000, an increase of \$198,000 and including nearly \$1,528,000 from the Army and its Engineers and about \$362,000 from the Agriculture Department. Funds from the USBR, the ICA, and the AEC fell by a total of almost \$75,000.

Luna Leopold developed this braided channel (above) in sand beds in three flume-river runs at a Caltech laboratory during 22 hours on February 19, 1954, as part of a multiyear study with M. Gordon Wolman (Abel Wolman's son) of braided, meandering, and straight rivers and creeks in the American West. The surface pattern and cross sections proved similar to those in Horse Creek (at right) near Daniel in Sublette County, Wyoming. A run in March 1954 duplicated dunes in fine sediments. These experiments showed "that at a given grain size, shear velocity is not the sole determinant of bed transport." Wolman joined Johns Hopkins University's faculty in 1958, but he continued part time with the USGS. (Quotation from Leopold and Wolman, 1957, fig. 52 caption. Braided-channel photograph (at left) from the USGS Denver Library Photographic Collection as Leopold, L.B., llb00081, https://www.sciencebase.gov/catalog/item/51dd795ae4b0f72b4471adb3; published in Leopold and Wolman, 1957, fig. 35. Horse Creek photograph (at right), ibid., fig. 30; see also Wolman and Leopold, 1957.)

The Division's monies for studies of soil and moisture conservation increased by $36,000 to a total of more than $165,000.

Chief Hydrologist Leopold continued to combine management with research and publication. In Leopold's only major administrative change in the Division during fiscal year 1957–58, Philip LaMoreaux, District Geologist of Alabama since 1945, succeeded Henry Beckman as Mid-Continent Regional Hydrologist in March 1958. LaMoreaux moved the regional office from Rolla to Tuscaloosa. Leopold established a career-development program for the Division while investigating major issues. In 1956, Leopold and civil engineer James P. Miller, Director of the University of Pittsburgh's Water Resource Engineering Program, published their analysis of hydraulic factors of ephemeral streams and their relation to the drainage net. Two related publications by Leopold appeared in 1957—one on the braided, meandering, and straight patterns of river channels, and the other about the formation of flood plains—both coauthored by M. Gordon ("Reds") Wolman, Abel Wolman's son, who joined the USGS in 1951. Gordon Wolman also began chairing Johns Hopkins' Department of Geography in 1958, the year Leopold briefly discussed water's role in the conservation movement. Stanley A. Schumm completed a longer analysis of the relations between the shapes of alluvial channels and their transported sediment, and he advanced his study of how different types of sediment influenced erosion and deposition in ephemeral-stream channels. In May, the U.S. Inter-Agency Committee on Water Resources' Subcommittee on Evaluation Standards began revising its report on proposed practices for economic analysis of river-basin projects; the subcommittee's recommendations appeared in 1959.

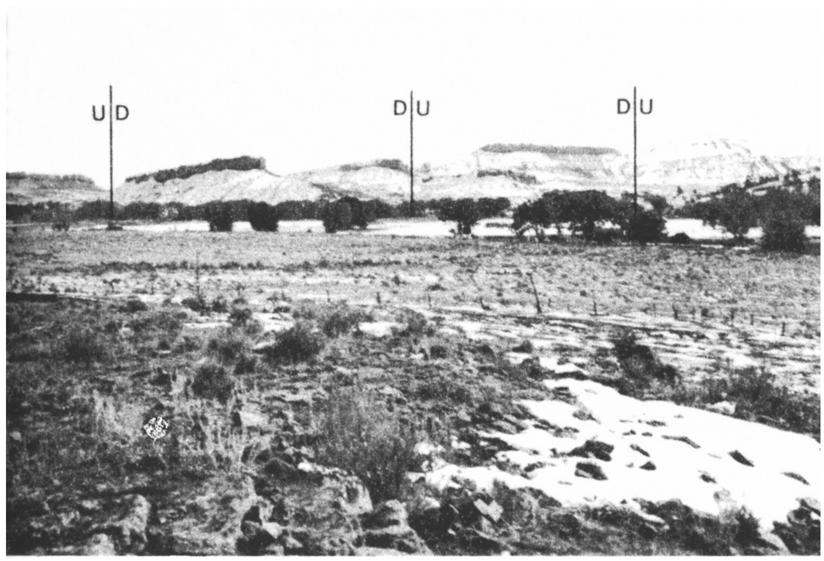
Members of Joseph Wells' Surface Water Branch during fiscal year 1957–58 operated some 7,000 gaging stations in the 48 States, Alaska, Hawaii, Guam, and Puerto Rico, in cooperation with 205 State, municipal, and Federal agencies that also included the FPC, the State Department, and the TVA. Branch members, aided by Walter Langbein and others, began appraising the national network to improve the comprehensive and systematic collection of streamflow data. As the compilation of records for 1888–1950 reached 89 percent of completion, the Branch published reports for Alaska and for the Ohio River Basin and the Missouri River Basin. Work continued on the nationwide study of regional flood frequency, and State reports were open-filed as they were completed, but reports on major floods continued to appear as Water-Supply Papers. For the Soil Conservation Service, Branch members conducted rainfall-runoff investigations of maximum annual floods in 49 larger drainage basins and runoff studies of such floods in 630 smaller basins, those having areas of 400 square miles or less.

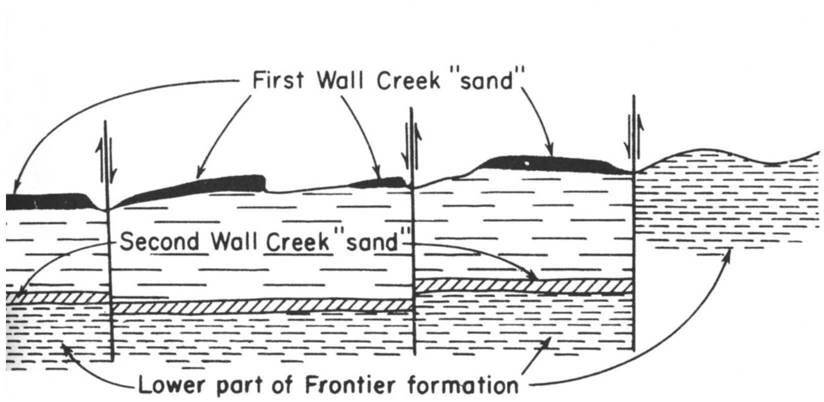
Members of Nelson Sayre's Ground Water Branch pursued some 600 investigations during fiscal year 1957–58, four-fifths of which were in cooperation with State and local agencies in 44 States, Alaska, Hawaii, Guam, Puerto Rico, and the U.S. Virgin Islands. Branch members continued to concentrate on developing a better understanding of the occurrence and movement of groundwater in various geohydrologic environments, including those of the Nevada Test Site. In November 1957, about 2 months after the Rainier test, Alfred Clebsch, Jr., began a 3-month study of the 1,400 square miles in the NTS and surrounding areas aimed at formulating a plan to determine the possibility of groundwater contamination from the Logan and Blanca tests scheduled for 1958 and others in the future. A committee of six USGS geologists and hydrologists—Edwin B. Eckel, Stanley Lohman, Arthur Piper (who advised the AEC during the NTS' atmospheric tests), Charles Read, Charles Theis, and Harold Thomas—approved Clebsch's plan. Operations based in Las Vegas began early in 1958, and geohydrologist Isaac J. ("Ike") Winograd joined Clebsch and geochemist Francis B. Barker that July. Data from water samples, including those from AEC tunnels, extended existing and subsequent information from geologic mapping, effects of the explosions on the containing rock, studies of heat flow and geochemistry, and gravity and seismic surveys. Clebsch, Barker, and Winograd initially reported their data and interpretations to the AEC as trace-element investigations in the USGS series of Open-File Reports. Other specific studies by Branch members included inventories of drawdowns of water supplies and areal fluctuations of water levels as read in observation wells. Thomas Robinson published a comprehensive catalog of phreatophytes and estimates of the amounts of water consumed by these plants.

During fiscal year 1957–58, members of Kenneth Love's Quality of Water Branch collected data on the chemical quality of water at some 550 stations nationwide. Branch members also gathered information about the sources, quantity, and movement of waterborne sediment at about 220 locations, and they made continuous, daily, weekly, or monthly observations of water temperature at more than 600 sites. Branch members continued to establish criteria for a national network of water-quality stations. They also began a worldwide study of major contributions of dissolved solids carried from the lands to the oceans, including the potential use of tritium as a tracer and age determiner. Publications by Branch specialists included a study of uranium and radium in groundwater on the Llano Estacado of New Mexico and Texas; the chemical character of public water supplies in Alaska, Hawaii, and Puerto Rico; the chemistry of iron in natural waters; a primer on the study and interpretation of water analyses; and hydrologic and tracer studies of New York's Mohawk River at the Knolls Atomic Power Laboratory.

Among special investigations conducted during fiscal year 1957–58, members of Charles McDonald's General Hydrology Branch and some of their colleagues from the Division's other Branches began a study of the hydrology of the Colorado River above Lees Ferry, Arizona, that involved the occurrence, use, availability, and chemical quality of surface water and groundwater and the relations between them. This project mirrored the ongoing investigation, in cooperation with the

Army Engineers, of the Delaware River Basin. Other studies were finished on the copper and petroleum industries' water requirements, and one was begun on the steel industry. Summary studies initiated for urban water resources included those for Los Angeles; Springfield, Massachusetts; and Syracuse, New York. Those for States involved Arizona, Georgia, Oklahoma, Oregon, and Rhode Island. Reports were published for North Carolina's Neuse and Yadkin-Pee Dee River Basins. Branch hydrologists G. Earl Harbeck, Jr., and Gordon E. Koberg; Max A. Kohler, the U.S. Weather Service's Chief Hydrologist since 1952; and their colleagues in the USBR and the Navy's Bureau of Ships and its Electronic Laboratory published their investigation of water loss by evaporation from Lake Mead during March 1952–September 1953. Using measuring techniques developed at Oklahoma's Lake Hefner, and published in 1954, they reported a water loss during the 1953 water year of 875,000 acre-feet. Continuing and wide-ranging investigations of water in its natural solid state by the USGS ended with the death of François Matthes in 1948. To resume that work, the Division placed Mark Meier on full-time status to continue his earlier part-time studies of the mechanics and hydraulics of glaciers, especially those in the northern Cascades, ice melting and runoff precipitation, and the responses of glaciers to climate change, all aimed at understanding how they affected water supply. As part of ongoing work on soil and moisture conservation, Division members also investigated the water supplies of grazing areas in California, Idaho, Nevada, and Utah. They also studied runoff and sediment yields for public-land reservoirs in Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming, and the effects of water spreading on water yield and sediment movement in the Cheyenne River Basin.





This photograph (above), taken from the road between Kaycee and Barnum in southern Johnson County, Wyoming, looks southeast toward the bluffs beyond the Powder River. The upper Wall Creek Sandstone Member (the first Wall Creek "sand" of water-well drillers) of the Frontier Formation (Cretaceous) forms the dark-colored ledges on the skyline. The formation's lower shales form the snow-covered rocks in the foreground. The three normal faults depicted in the photograph and in the geologic section (below) display vertical displacements of 300 to 500 feet; D (down) and U (up) represent relative motion along the fault planes. As part of the Interior Department's program for developing the Missouri River Basin, the U.S. Bureau of Reclamation proposed building a dam about 12 miles west of Kaycee (scene of the Johnson County "war" of 1892) and extending the Sahara Canal to irrigate 10,000 additional acres principally for use by the area's cattle industry. During July–October 1950, USGS geohydrologists Francis A. Kohout and Francis A. Koopman mapped (at 1:24,000) the surficial geology of 320 square miles in the area of the Powder River's Middle and North Forks and sampled water from 88 springs and wells in the region. USGS hydrologist Donald A. Warner concluded "that an adequate supply of water could not be obtained from the [three] Wall Creek 'sands.'" Water from these sands also "would require considerable treatment to make it satisfactory for domestic use." (Quotations of Warner's conclusions, photograph, and geologic section from Kohout, 1957, p. 346 and fig. 49; see also Hembree and others, 1952.)

Under Leopold's leadership, the Water Resources Division expanded its activities in research and development in fiscal year 1957–58. Division members investigated the nature of water movement through sand and other porous and permeable material, the mechanism and extent of saltwater encroachment and contamination in areas where excessive pumping or related factors upset the land-ocean hydrologic balance, water flow near river mouths where tides reversed flow direction, water-sediment relations in laboratory flumes to improve mathematically based descriptions of flow conditions, the chemical source and form of dissolved iron, the downstream effects of land conservation on water quality and quantity, and the effectiveness of using hexadecanol and other thin-surface-film chemicals to suppress evaporation in reservoirs.

The Division also continued providing technical assistance to studies of surface-water and groundwater resources abroad, with some personnel on detail to the ICA, and training local colleagues there or in the United States. During fiscal year 1957–58, Division members participated in investigations and training as part of long-term projects in Afghanistan, Chile, India, Iran, Libya, Pakistan, Peru, and the Philippines. Division hydrologists also spent 3-month intervals in British Guiana, Cambodia, and Turkey. Robert W. Devaul joined Robert Dingman's studies of groundwater in Chile. Chase Tibbitts and Robert C. Vorhis, aided by James R. Jones, assessed groundwater resources in Libya. John A. Baumgartner conducted similar investigations in Iran, as did Edward Bradley and P. Eldon Dennis in Iraq. F.D. Bertleson, Robert L. Cushman, Raymond Kiser, and George LaRocque, Jr., assisted personnel from the Army Engineers' Far East District in groundwater studies in Pakistan. Richard Murray and Leonard Snell continued similar work in the Philippines. In the United States, other members of the Division trained visiting specialists from Afghanistan, Chile, the Republic of China, Colombia, Greece, India, Pakistan, the Philippines, Tanganyika (Tanzania), Turkey, and Yugoslavia.

Harold Duncan's Conservation Division received almost $2,367,000 during fiscal year 1957–58, a gain of almost $380,000 over the previous year's total. The $2,225,000 in SIR funds represented an increase of nearly $285,000, while funds from other Federal agencies rose by more than $94,000, to about $139,000. On February 12, 1958, Eisenhower's Executive order transferred to Secretary Seaton responsibility for enforcing the requirements of the Connally "Hot Oil" Act of 1935.[218] Two days later, a Secretarial order shifted to the Conservation Division, effective February 21, four functions from Interior's Office of Oil and Gas in the Administrative Assistant Secretary's Office.[219] The order made the Division responsible for assisting administration, cooperating with States in preventing waste in oil and gas production, adapting uniform oil and gas conservation laws, keeping informed of facts required to exercise responsibilities, and supervising the operations of the Federal Petroleum Board (FPB) in enforcing the requirements of the Connally Act. The FPB, composed of a chairman, a member, and an alternate member, operated from offices in Kilgore, Texas, principally in field-inspection operations in Louisiana, New Mexico, and Texas, and, to lesser degrees, in Arkansas, Kansas, Mississippi, and Oklahoma. During the year, the FPB received monthly reports from about 9,600 producers, 464 pipeline managers, and 71 processors and refiners. Oil-field-operation reports increased by 278 fields, and producing-well summaries rose by 2,437. The FPB's staff monitored 2,826 leases (and visited 1,606 of them) and 5 pipelines, traveled to 483 oil fields, and conducted 1,184 interviews. Fifteen cases of alleged violations were before the FPB at the beginning of 1957–58, and five more began during the year. Court action closed eight cases in 1957–58, yielding fines of nearly $121,000.

In fiscal year 1957–58, members of John Miller's Mineral Classification Branch completed maps and reports on oil and gas fields and areas in Colorado, Utah, and Wyoming; phosphate in the three-corners area of northeastern Nevada, northwestern Utah, and southern Idaho; power sites in Montana and Oregon; classifications of sedimentary basins in Alaska; and oil and gas occurrences in Arizona. Although Branch members processed nearly 1,450 fewer cases than in 1956–57, for a total of about 31,450 in 1957–58, the increased work in New Mexico required opening offices in Carlsbad and in Farmington. They also geologically appraised 263 unit plans and participating-area proposals and reported the geologic significance of 200 new discoveries of oil and gas on Federal leaseholds.

Work by the members of Arthur Johnson's Water and Power Branch during fiscal year 1957–58 involved them in surveys and related determinations of the waterpower and water-storage possibilities of locales in Alaska, California, Idaho, Montana, Oregon, and Washington that covered 250 miles of stream channels and 35 dam sites. They also completed 10 reports on land withdrawn for waterpower; these reports resulted in the return to the public domain of 60,000 acres of reserves. Their classifications added nearly 160,000 acres to the waterpower-site reserves and eliminated 82,500 acres, leaving a total of about 7.2 million acres, a gain of some 77,000 acres, in 23 States and Alaska. They also reduced reservoir-site reserves by 920 acres to about 193,000 acres. Fred F. Lawrence, Carl E. Nordeen, and Harold L. Pumphrey completed a history of land classification as it related to waterpower and water storage.

On August 13, 1957, a new law amended the Mineral Leasing Act of 1920 by repealing the maximum limit of 5,120 acres placed by some States on phosphate leases held by an individual, a corporation, or an association.[220] The national limit of 10,240 acres now applied to all States and added to the work of Joe Turner's Mining Branch. At the end of fiscal year 1957–58, the Branch remained responsible for slightly more than 4,000 mining properties in 32 States and Alaska, of which more than one-half were located on public lands. The production of 20.3 million tons of mineral commodities from these properties during the year yielded revenues of $142.5 million and royalties of $6.75 million, which represented a decrease of some $0.35 million compared to royalties in 1956–57.

When Harold Barton retired in 1957, Johnson Mitchell took over as Chief of the Oil and Gas Leasing Branch. Mitchell's staff managed more than 119,000 properties on 93.1 million acres of public lands in 23 States and Alaska during fiscal year 1957–58. The 27,223 wells on these properties produced 132.6 million barrels of oil, 439.5 billion cubic feet of natural gas, and 224.2 million gallons of gasoline and butane worth a total of $440.6 million and yielded royalties of $53.8 million. Oil and gas from wells on acquired, Indian, and military lands and from NPR–2, worth nearly $104.9 million, added $56.9 million more in royalties. By now, nearly 1.6 million acres of the Outer Continental Shelf were leased to industry by the Federal Government and the States of Louisiana and Texas. The 224 producing wells drilled on the OCS during the year raised the total to 681, which represented increases of 45 percent for oil and 7 percent for gas. Production of these OCS fuels yielded revenues of nearly $70.9 million and royalties of more than $15.8 million, the latter a gain of $2.5 million over the previous year's sum. During the year, Branch members approved 73 new unit plans and terminated 35 others on the onshore public lands, leaving a total of 335 approved plans covering 6.1 million acres. On the OCS, the approval of 1 plan and the end of 2 others left 13 plans in operation that covered 333,900 acres.

Fiscal year 1957–58 ended on June 30 without a resolution of the struggle between the civilian and military agencies in the Federal Government for control of the organization proposed to direct and enhance the Nation's efforts in outer space as a long-term response to the Soviet Sputniks. The dispute reflected earlier contests over funds and programs among the Interior and War Departments' science and mapping agencies in the West in the 1870s, the War Department's Office of the Chief Signal Officer and the Smithsonian Institution in the 1880s, the Treasury

Department's U.S. Coast and Geodetic Survey and the Naval Hydrographic Office in the 1880s and 1890s, and the Revenue Cutter Service, the Life Saving Service, and related organizations in the 1910s. Those controversies produced three new U.S. agencies—the Geological Survey in the Interior Department in 1879, the Weather Bureau in the Agriculture Department[221] in 1890, and the U.S. Coast Guard in the Treasury Department[222] in 1915. Would the new space agency be under civilian or military control and would it include a basic science component?

Chapter 10.
A New Cycle, 1958–1961

> **A transition from an exploration of a geographical frontier to an intellectual one characterized the early work of the Geological Survey. In recent months, some of our more inquisitive younger members have proposed various studies of the geography of the individual components of "outer space." Perhaps we are about to see the beginning of a new cycle in the history of the Geological Survey in the public service.[1]**
>
> **—Thomas B. Nolan**

On July 29, 1958, President Eisenhower, working closely with Senator Lyndon Johnson, secured the passage of and signed the National Aeronautics and Space Act to separate partially civilian and military activities. The new law established the National Aeronautics and Space Administration (NASA) to promote civilian research and development, as part of larger efforts to "provide for research into problems of flight within and outside the earth's atmosphere"[2] and to expand

> **human knowledge of phenomena in the atmosphere and space.[3]**

"It is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind," Congress declared, but the legislators also claimed that "the general welfare and security of the United States" required an "adequate provision * * * for aeronautical and space activities."[4] The new organization's work and its results would promote "close cooperation among all interested agencies of the United States" and "cooperation by the United States with other nations and groups of nations."[5] The statute provided the Eisenhower administration with authority to "engage in a program of international cooperation * * * pursuant to agreements made by the President with the advice and consent of the Senate."[6] The law established the National Aeronautics and Space Council, over which the President would preside and by which he would be advised on policies and programs. The Council's eight members included the Secretaries of State and Defense; NASA's Administrator, who received the responsibilities of the discontinued National Advisory Committee for Aeronautics (NACA); the Chairman of the U.S. Atomic Energy Commission (AEC); and four other persons appointed by the President—one from a Federal department or agency and three from private life. Military activities in space remained the responsibility of the Department of Defense (DoD), but NASA would have a Civilian-Military Liaison Commission with a Chairman, appointed by the President; one or more members each from the DoD, the Air Force, the Army, and the Navy, as assigned by the Secretary of Defense; and NASA representatives, assigned by the Administrator and equal in number to those from Defense.

Additional sections of the act covered NASA's rules and regulations for employment, property acquisition, gifts or donations of service, contracts, cooperation with other agencies with their approval, advisory committees, and regular reports through the President to Congress. Eisenhower nominated T. Keith Glennan, Case Institute of Technology's president and a member of the National Science Foundation's (NSF's) National Science Board, as NASA's Administrator.

Hugh Dryden became Glennan's Deputy Administrator. Congress and the President provided direct and supplemental appropriations of $47.8 million on August 14 and $80 million more 13 days later; these monies[7] funded NASA's salaries and expenses, research and development, and construction and equipment during fiscal year 1958–59.

NASA absorbed existing civilian and military units and their funding, personnel, and facilities. To NASA, when it began operations on October 1, 1958, came some of the Advanced Research Projects Agency's (ARPA's) satellite projects and its lunar probes, the Naval Research Laboratory's (NRL's) Vanguard Project, and five NACA research centers—Langley in Hampton and Wallops at Temperanceville in Virginia, Ames at Moffett Field and Dryden at Edwards Air Force Base in California, and Lewis at Cleveland in Ohio. In December 1958 and January 1959, the Army, under protest, began transferring to NASA administrative responsibility for the Jet Propulsion Laboratory (JPL) in California and elements of General John Medaris' Ballistic Missile Agency in Alabama. The JPL continued under Caltech's management. Medaris retired, but Wernher von Braun stayed on and the facility at Huntsville later became the George C. Marshall Manned Space Flight Center. On January 1, 1959 (effective on January 15), NASA established the Beltsville Space Center in Maryland; the agency renamed it the Goddard Space Flight Center on May 1. Von Braun's facility, along with Saturn, the huge booster rocket under development but now not needed by the Defense Department, officially passed to NASA by agreement with the DoD on October 21, 1959, the President on November 2, 1960, and Congress on March 15, 1961, when the legislators approved the administration's reorganization-transfer plan. NASA, as later organized administratively, comprised four program offices—Manned Space Flight, Space Science and Applications, Advanced Research and Technology, and Tracking and Data Acquisition. NASA asked Lloyd Berkner's Space Science Board to form a committee to report on the potential for orbital stations, probes to Mars and Venus, and detecting extraterrestrial life.

As NASA began operations, the United States continued to log successes and failures in its ongoing contest with the Soviet Union in space. Both countries tested launch vehicles, placed additional scientific satellites in Earth orbit, sent other robotic spacecraft to the Moon and beyond, and selected the initial persons for travel into space. The Soviets reported only their successes and so broadcast no space news during the remainder of 1958, as three of their lunar probes failed during September–December before the fourth succeeded. During a flight of 34 hours, instruments on Soviet Lunik (Luna) 1 discovered the solar wind before the spacecraft hurtled past the Moon at a distance of 3,700 miles on January 4, 1959. Three U.S. Vanguards and one of two Explorers failed during May–September 1958. The Air Force's Thor-Able rocket successfully carried Pioneer 1 into space on October 11, but the probe, intended for lunar orbit, did not escape the Earth's gravity and burned up when it reentered the atmosphere. Pioneer 3, launched on December 6, failed to reach the Moon, but the probe did return new data on the outer Van Allen belt. On February 17, 1959, Vanguard 2 carried meteorological equipment and a camera that took pictures of the Earth's cloud cover. On February 28, an Air Force Thor-Agena sent up Discoverer 1, the first of Project Corona's military reconnaissance satellites. The satellite failed to assume a polar orbit.

On April 9, 1959, in a blaze of publicity broadcast live nationwide, NASA announced the selection of its seven Mercury astronauts. All of the selectees were military test pilots with college or university degrees and more than 1,500 hours of flying time. Three of the new astronauts—L. Gordon ("Gordo") Cooper, Jr.; Virgil I. ("Gus") Grissom; and Donald K. ("Deke") Slayton—were Air Force captains. Lieutenant M. Scott Carpenter, Lt. Commander Walter M. Schirra, Jr., and Lt. Commander Alan B. Shepard, Jr., represented the Navy. Lt. Colonel John H.

Glenn, Jr., was the only Marine.[8] The Mercury astronauts persuaded von Braun's team to turn its newly designed and McDonnell-produced capsules into spacecraft by adding viewports and flight controls for Mercury's missions planned to begin in 1961. Until then, the U.S. Air Force (USAF) and NASA would launch nonhuman passengers. In May 28, 1959, monkeys Able and Baker reached an altitude of 300 miles in the nose cone of a Jupiter intermediate-range ballistic missile (IRBM), returned, and were recovered alive. Four mice in Discoverer 3, launched on June 3, died when the satellite failed to reach orbit and crashed.

U.S. efforts to develop viable monitoring methods to enable successful verification under a treaty to ban nuclear tests continued along with the Nation's efforts in space and those toward extending the rule of law above and beneath the Earth's surface. The freedom of the seas, as defined by Hugo Grotius and his successors since the early 17th century, now was imperiled by the claims of the United States and other nations to the water and seabed resources of areas well beyond the 3- or 12-mile limits earlier agreed upon. The United Nations' (U.N.'s) initial Conference on the Law of the Sea[9] (UNCLOS [I]) was held in Geneva in 1956 to propose laws for national and international waters. Four UNCLOS treaties emerged in 1958—(1) Convention on the Territorial Sea and Contiguous Zone, (2) Convention on the Continental Shelf, (3) Convention on the High Seas, and (4) Convention on Fishing and Conservation of Living Resources of the High Seas—and they were ratified and became effective during September 1962–March 1966 but without the United States as a signatory. The original definition of the Continental Shelf, the adjacent coastline outside the territorial sea to a depth of 200 meters, or beyond to depths where natural resources could be exploitable, continued to prove troublesome, and UNCLOS II held in 1960 failed to refine the limits of territorial seas. The U.N. extended its concerns to the legalities and the uses of outer space by establishing, on November 24, 1958, an ad hoc Committee on the Peaceful Uses of Outer Space.[10] The continuance of nuclear-weapon tests also remained an international concern. President Eisenhower and British Prime Minister Harold Macmillan, in a joint statement on March 29, 1959, asked the Soviet Union's Premier Nikita Khrushchev to agree to a moratorium on such tests below magnitude 4.5, because of the difficulty of detecting them, and to authorize tripartite research on improving control methods for these lesser magnitude tests. Members of the Soviet delegation at the test-ban talks in Geneva refused on May 11 to cooperate in this new venture because they still considered as adequate the seismic-system upgrade agreed upon in December 1958. Eisenhower also announced, early in May 1959, that Project Vela, the U.S. effort to detect nuclear explosions more effectively, was underway. Vela contained three principal monitoring components—Hotel, for high-altitude aircraft and orbiting satellites; Sierra, for surface detectors; and Uniform, for tests underground and underwater.[11]

New and continuing crises in the Middle East, the Far East, and Berlin in 1958–59 again demanded attention from members of the Eisenhower administration while they continued to work toward arms control and related efforts for peaceful international relations. On July 14, 1958, leftist nationals, encouraged by Egypt's Gamal Nasser, killed Iraq's King Faisal (ibn Ghazi) II and Crown Prince Abdullah and overthrew their West-affiliated government, placing that country, formerly Lebanon's protector, under Ba'athist control. Since February 1, Nasser also led the new and pro-Soviet United Arab Republic (UAR) that linked Egypt and Syria. In Lebanon, President Camille Chamoun led a Christian-Muslim coalition government since 1952. Chamoun sought reelection, which required a constitutional change, but he faced an incipient pro-Muslim and anti-Western insurgency allegedly encouraged by Nasser. On July 14, after Faisal's death, Chamoun asked

Eisenhower for U.S. military support. Eisenhower promptly told Congress that Lebanon, deemed vital to U.S. interests in the region, faced indirect external aggression. Eisenhower, applying his own doctrine, ordered 6,000 U.S. Marines into Lebanon in Operation Bluebat, to safeguard American lives, protect oil pipelines, and assure Lebanon's independence and territorial integrity.[12] They were joined by an Air Force strike group and some 8,500 U.S. paratroopers flown in from West Germany. Two months earlier, the Army reactivated XVIII Airborne Corps as the principal element in the new Strategic Army Command, a rapid-reaction force deployable worldwide under the new policy of gradual response and limited war as an alternative to massive retaliation and all-out conflict. The Lebanese held orderly elections on July 31 that made General Fuad Chehab the new president. On August 21, a U.N. resolution sponsored by Arab countries provided the circumstances for the withdrawal of U.S. and British forces from Lebanon and Jordan. The last U.S. troops left Lebanon on October 25, as Eisenhower pledged when the United Nations assumed responsibility for that country.

By then, renewed aggression by the People's Republic of China (PRC), encouraged by the Soviet Union, drew heightened responses from other U.S. forces. On August 23, Chinese Communist artillery again bombarded the offshore islands of Quemoy and Matsu, both still occupied by armed forces of the Republic of China. A deployment of U.S. air and naval forces from bases in Japan and the Philippines again helped to defuse the crisis. After Eisenhower suggested a cease-fire on October 1, PRC forces began brief halts during that month, but they did not stop shelling the islands until December. A month earlier, on November 10, Khrushchev again insisted that NATO forces leave West Berlin and threatened to transfer Soviet authority in East Berlin to the Democratic Republic of Germany. American-Soviet exchanges of diplomatic messages and emissaries during December 1958–August 1959 resolved this situation without additional military posturing and led to an agreement enabling Khrushchev to come to the United States and Eisenhower to visit the Soviet Union.

While the crises in Lebanon and the Taiwan Strait abated, others in the Caribbean and the Middle East took their places. On January 1, 1959, as Commandante Fidel Castro's forces captured Santiago and Santa Clara, President Fulgencio Batista resigned and fled Cuba, capping the 3-year struggle by Castro and his insurgents to topple the dictator.[13] Havana fell to the rebels on the next day, and the United States recognized the new Cuban Government. Castro, and the older political leaders in Cuba who supported him, failed to restore the 1940 constitution and then hold national elections. During April 15–17, Castro, premier since February, visited New York City and claimed that his revolution was humanistic rather than communistic. His government then tried and executed 600 so-called war criminals, passed agrarian reforms designed to nationalize U.S. companies' lands, and sought economic and military support from Khrushchev in return for Cuban sugar and minerals. Castro also began efforts to export a version of his revolution in the Caribbean, especially to the Dominican Republic, Haiti, Nicaragua, and Panama. When the Organization of American States' 21 foreign ministers next met, during August 12–18, the U.S. representative denounced these Cuban activities and requested a regional investigation of them. While the ministers' group condemned dictators, it also opposed efforts to overthrow them.

Additional troubling events occurred in Tibet and Iraq, and Eisenhower's Secretary of State resigned. At the Baghdad Pact's meeting during January 17–30, 1959, John Foster Dulles promised its members military support under the Eisenhower Doctrine. On March 5, the United States signed bilateral defense agreements with Iran, Pakistan, and Turkey. The Dalai Lama left Tibet for India and exile on March 17, after a failed revolt by his supporters against the PRC's nearly decade-long occupation. A week later, Iraq withdrew from the Baghdad Pact, after Gamal Nasser denounced the alliance that 5 months later became the Central Treaty Organization

(CENTO), headquartered at Ankara.[14] Dulles, in increasing ill health, resigned as Secretary of State on April 15. A week later, Republican Governor Christian A. Herter of Massachusetts replaced Dulles, who died on May 24.

In the midst of these larger and lesser traumas, the 85th Congress and the President enacted additional reforms to improve national defense and education. On August 6, 1958, a new law reorganized the Department of Defense to increase efficiency, economy, and civilian control, improve activities and operations by the Joint Chiefs of Staff, and perhaps end interservice disputes "to promote the national defense."[15] Congress released on March 30, 1959, testimony by Admiral Arleigh A. Burke, who, as the Chief of Naval Operations since 1955, pushed the development and production of the Polaris IRBM and supported an increased U.S. capacity for fighting limited wars, or so-called small wars. General Maxwell Taylor, his tour as Army Chief of Staff nearing its end, and now designated as the next commander of NATO's forces, also repeated his recommendation for developing this flexible-response option to massive retaliation and did so again in 1960 in his book "The Uncertain Trumpet."

While plans and actions progressed for improving national defense, some persons continued to comment on Congress' lack of interest in passing measures introduced in its 84th sessions to alleviate the Nation's shortage of engineers and scientists. In March 1958, Howard Meyerhoff, from his bully pulpit in *Geotimes*, wondered how and where all the new scientists and engineers would be educated, placed, and used. Meyerhoff, as a member of the Federal Scientific Manpower Commission (SMC) in Washington since 1953, hoped the success of Explorer would "return us to sanity and give us better perspective on the job to be done." The effect of that satellite and its successors, Meyerhoff continued, might "assist us [the SMC] in injecting some sound thinking into Federal policies affecting scientific and engineering manpower."[16] Congress responded to these and similar suggestions by passing a bill that became the National Defense Education Act[17] when Eisenhower signed it on September 2. The new statute provided for strengthening the national defense through a fund of $295 million to provide $1,000 loans, at 3-percent interest over 10 years, to college students; the loans could be repaid at 50 cents on the dollar if the student-borrowers thereafter taught in an elementary or high school for 5 years. The law also authorized grants of $280 million to State schools, with matching grants from the States, for improved facilities for teaching modern foreign languages and science; $28 million for language study in colleges and universities; $18 million for increased use of visual media in education; and 5,500 fellowships for graduate students in training to become college or university teachers. The act directed the National Science Foundation to establish a Science Information Service to be advised by a Science Information Council composed of Federal librarians and other citizens appointed by the NSF's Director.

In other sectors of the administration's domestic front in 1958, the Republicans gained voters in a new State but lost seats in the midterm congressional elections. Bills for statehood for Alaska were introduced beginning in 1916. On March 19, 1955, the Territory's legislature passed an act authorizing a constitutional convention, Alaska's voters approved the convention's draft on April 24, 1956, and the Territorial Government sent it to the U.S. Congress for ratification. Congress and the President agreed, on September 7, 1957, "To grant to the Territory of Alaska title to certain lands beneath the Territory's tidal waters," including the "oil, gas, and all other minerals" but not their "marine animal and plant life, waterpower, or the use of water for the production of power." In gaining the authority of the Submerged Lands Act of 1953, Alaska received "all the right, title, and interest of the United States"[18] in and to the lands between high mean tide and the pierhead line, a boundary that the Army Engineers fixed as parallel to low mean tide. The new law excepted those lands on which were located U.S. facilities, reservations, or holdings for native tribes and the oil and gas deposits in the intertidal zone off the coast of

Naval Petroleum Reserve No. 4 (NPR–4). The Federal Government retained the rights of first refusal for purchasing, in wartime or for national defense, the oil and gas elsewhere in this zone and free navigation through its waters. The statute authorized Alaska's legislature to manage and dispose of any tract of these lands, and the revenue from them, but only after the Secretary of the Interior and the Territorial Governor approved the Engineers' map showing its established pierhead line. A year later, on July 7, 1958, Eisenhower signed the enabling act for statehood.[19] Eisenhower's proclamation on January 3, 1959, admitted Alaska as the Nation's 49th State.[20] The Federal Government, which held title to more than 99 percent of Alaska's lands, granted the new State authority to select within 25 years as much as 400,000 acres from vacant, unappropriated, and unreserved lands in national forests in the State and up to another 102,550,000 acres from its public lands. Alaska chose 6.5 million acres during its first year as a State. Five percent, less Federal costs, of the proceeds of all land sales by Alaska would go to support its public schools.

On the day Alaska became a State, the two houses of the 86th Congress convened their first sessions. Two months earlier, in the mid-term elections on November 4, 1958, the Democrats raised their margin in the House to 284–153 and that in the Senate to 65–35.[21] These results reflected the voters' reaction to a yearlong economic recession, brought on by industrial overexpansion and reduced exports, which Eisenhower's personal popularity did not overcome. By the previous March, nearly 5.2 million Americans were unemployed, and the antirecession legislation that Congress passed in the fall did not help to revive sufficiently the Nation's economy. Charges of corruption in the White House also hurt the Republicans' cause. On September 22, Sherman Adams, Assistant to the President (who functioned as Eisenhower's chief of staff), resigned after the disclosure of gifts he received from a Boston industrialist in return for access to and influence with Federal regulatory agencies. New Hampshire's Adams, a former Representative during 1945–47 and Governor during 1949–53, served as Eisenhower's floor leader at the 1952 Republican convention. Now, Eisenhower said that he continued to need Adams' aid, but Adams generated no bipartisan support in Congress and so he departed. The Republicans did somewhat better in the gubernatorial races; among the winners was Nelson Rockefeller in New York.

The U.S. Geological Survey (USGS) received from all sources in fiscal year 1958–59 a total of just over $63,650,000 for salaries and operations by the agency. Of that sum, more than $41,178,000, or 65 percent, represented surveys, investigations, and research (SIR) appropriations; nearly $12,846,000, or 20 percent, came from other Federal sources; and the States and other nonfederal sources provided almost $9,120,000, or 15 percent. SIR appropriations grew by more than $3,668,000, and Federal transfers declined by nearly $766,000, continuing the trend that slowly made the USGS less dependent on its Federal cooperators. At year's end, the agency's staff totaled 6,638 permanent employees, 62 fewer than the official ceiling of 6,700. Of the permanent employees, 27 were in the Director's Office, 15 in the Public Inquiries Office, 22 in the Texts Office, 318 in the Administrative Division, 332 in the Publications Office, 324 in the Conservation Division, 1,441 in the Geologic Division, 1,958 in the Topographic Division, and 2,201 in the Water Resources Division. The USGS also employed an additional 1,074 seasonal personnel during the year, for a total of 7,712. Director Nolan reorganized the Administrative Division to try to improve its performance. On March 9, 1959, a Survey order modified the Administrative Division to include in Washington, D.C., the Office of the Executive Officer and five Branches—Budget and Finance, Computation, Organization and Management, Personnel, and Service and Supply.[22] The headquarters offices for the Division's four field areas—Atlantic Coast, Mid-Continent, Rocky Mountain, and Pacific Coast—continued to operate, respectively, at Arlington, Rolla, Denver, and Menlo Park.

The total receipts of nearly $17,105,000 for fiscal year 1958–59 in Wilmot ("Bill") Bradley's Geologic Division represented a gain of $1.7 million over the previous year. Of that sum, the SIR appropriation of nearly $11,346,000 was almost $3,333,000 more than in 1957–58. These amounts reflected the change of base in AEC funds that followed its Raw Materials Division's recent request for the USGS to emphasize its more traditional and longer term geological, geochemical, and geophysical investigations, and the agency's newer studies for some of the AEC's other Divisions. The AEC still supplied nearly $2,217,000, the largest transfer by any Federal agency, but the loss of about $1,755,000 represented by that new sum was covered by the gain in SIR monies. The Army and its Engineers increased their support by $75,000 to a total of nearly $1,299,000; the International Cooperation Administration's (ICA's) contribution rose by about $239,000 to reach $1,106,000,[23] and the Interior Department's Office of Minerals Exploration provided nearly $291,000. Bradley made only one significant administrative change in his office's staff during the fiscal year. On July 1, 1958, Andrew Brown replaced Lincoln Page as Assistant Chief Geologist for Trace Elements. Bradley also formalized Vincent McKelvey's appointment as head of the Trace Elements Planning and Coordination Office (TEPCO).

Also on July 1, 1958, Warren Hobbs succeeded Charles ("Andy") Anderson as Chief of the Mineral Deposits Branch. Anderson, elected to the National Academy of Sciences (NAS) in 1957, and his colleague S. Cyrus ("Cy") Creasey, an economic geologist who began serving with the USGS in 1941, published in 1958 their analysis of the geology and the copper and other ore deposits of Arizona's Jerome area. Creasey continued to study that State's copper deposit at San Manuel as structural investigations in the Pima District by other geologists suggested that major copper bodies might be extended along faults. Donald A. Brobst summarized the barite resources in the United States. Other members of Hobbs' Branch continued for Interior projects begun for the Defense Minerals Exploration Administration on manganese deposits in Montana's Phillipsburg area, Idaho's Coeur d'Alene mining district, and the regional relations of North Carolina's pegmatite districts. Their investigations of Nevada's Ely district aimed to extend the area of known porphyry-copper deposits. The studies directed at extending the uranium occurrences at New Mexico's Ambrosia Lake, then containing the Nation's largest known reserves, were planned to determine the physico-chemical controls on deposition. Branch geologists also began to study the newly discovered but low-grade bauxite deposits on Kauai in Hawaii Territory. Geophysicists George V. Keller of the USGS and Pasquale H. Licastro of HRB-Singer published for the USGS their measurements of the dielectric constant and electrical resistivity in 27 cores from the Morrison Formation (Jurassic) on the Colorado Plateau.[24] Their analysis indicated that these properties were potential exploration tools, as high resistivities were associated with low water content, and high dielectric constants, with high water content. Henry Faul and three of his colleagues published a primer on scintillation counters for wider geologic use. Robert Garrels and Esper Larsen 3d finished their compilation of geochemical and mineralogical studies of Colorado Plateau uranium; a separate and nationwide study neared completion for a map (at 1:5,000,000) of uranium in U.S. sedimentary rocks. Vincent McKelvey published a comprehensive treatment of the Phosphoria, Park City, and Shedhorn Formations in the western phosphate field; the publication included sections by Thomas M. Cheney, Earle Cressman, Richard Sheldon, Roger Swanson, and James Williams.[25]

Members of James Gilluly's Fuels Branch mapped and studied stratigraphic sequences during fiscal year 1958–59 in 24 States that produced or might produce petroleum; agencies in 6 of the 24 States cooperated in advancing this work. For the Office of Civil and Defense Mobilization, Branch members, with their colleagues in Interior's Office of Oil and Gas and in the U.S. Bureau of Mines, combined their expertise to project the overall potential of the Nation's petroleum industry in 1975. Branch geologists investigated coal-bearing areas in 10 States, continued appraising reserves in 5 States, and began revising the evaluation of Washington's coal resources. They also finished recasting the U.S. coal map and started redoing the USGS Circular on U.S. coal resources. Gilluly's memorandum to Branch members, dated August 6, 1958, offered constructive criticism that helped to improve these and subsequent project reports.[26]

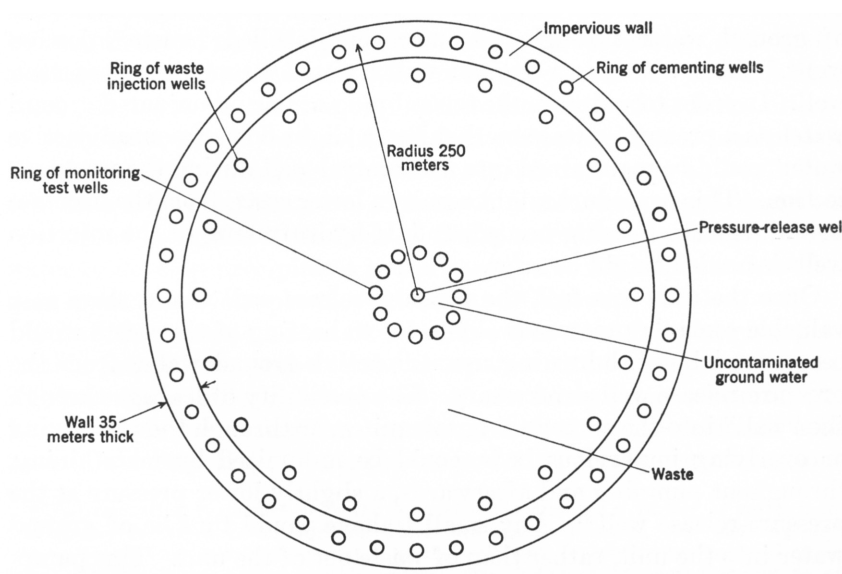
Scientists in Fred Smith's General Geology Branch in fiscal year 1958–59 continued to map quadrangles at 1:24,000 and other scales for the ongoing Geologic Quadrangle (GQ) map series. Members of a committee, chaired by George Cohee and composed of representatives of the USGS and the American Association of Petroleum Geologists, began compiling a new tectonic map of the United States, exclusive of Alaska and Hawaii, on two sheets at 1:2,500,000, and hoped to complete it by 1961. Clyde Ross and Richard Rezak, drawing on their own fieldwork and earlier efforts by USGS geologists since 1901, published a report on the rocks and fossils of Glacier National Park aimed at reaching an audience beyond the usual readers of the agency's Professional Paper series. In October 1958, as the Hawaiian Volcano Observatory (HVO) occupied a second wing, behind and north of the first building, Kiguma ("Jack") Murata replaced Director Jerry Eaton and was designated Scientist in Charge, and the HVO was transferred from the General Geology Branch to the Geochemistry and Petrology Branch. Eaton, while leading the HVO, installed a network of telemetered short-period seismographs[27] that improved earthquake prediction tenfold; he also developed a precise water-tube leveling system for the long-base tiltmeter site to improve the tracking of bulging at Kilauea.[28] Geologic, geochemical, and geophysical studies at the HVO continued to be applied toward increasing its scientists' ability to predict the timing and location of eruptions and to improve their understanding of volcanic processes and the formation of ore-bearing rocks. Scientists returning to or newly assigned to the HVO continued to find it difficult to locate housing closer than 35 miles away at Hilo.

Members of Edwin B. Eckel's Engineering Geology Branch in fiscal year 1958–59 studied urban areas around Denver, Knoxville, Los Angeles, Omaha, Portland in Oregon, San Francisco, and Seattle. Branch members published formal maps of parts of the Knoxville and San Francisco areas and a preliminary map of landslides in Los Angeles' Pacific Palisades locales. They also released an open-file version of a preliminary geologic map of New Jersey's Atlantic City area and its beaches. Cooperative mapping programs continued in Connecticut, Massachusetts, Rhode Island, and Puerto Rico; in the last effort, scientists, aided by the Commonwealth's Economic Development Administration, extended the work beyond the San Juan metropolitan area.

Investigators in William Pecora's Geochemistry and Petrology Branch in fiscal year 1958–59 concentrated on the geochemistry of seawater, especially the concentrations of its major elements, to increase understanding of the processes of depositing marine sedimentary minerals. Accurate equilibrium measurements of radioactive protactinium and thorium successfully dated layered ocean-bottom sediments. Branch members studied the ratios of light isotopes in mineral deposits as clues to ore genesis and aids to exploration for new occurrences. Areal studies continued on the geochemistry and geology of iron and other elements in submarginal sedimentary deposits and massive sulfide veins in the Southeastern United States. In the West's Basin and Range Province, analyses of geochemical halos in valley fill suggested that sampling groundwater and basal alluvial conglomerates might disclose deposits of copper, lead, and zinc. Variations in oxygen-carbon isotope ratios different from the original ratios in central Colorado's carbonate rocks led to the recognition of hydrothermal-dolomite halos related to sulfide ores at Gilman; researchers hoped that these observations might guide future exploration. Branch scientists also investigated the geology and geochemistry of rare-earth deposits, including the beryllium occurrences near Colorado's Lake George that remained one of the principal domestic sources of that commodity. Their studies based on heavy minerals helped to locate a new tungsten deposit in western Colorado.

Other studies by members of Pecora's Branch led to the discovery of an assemblage of rare borate minerals in sodium-carbonate deposits in the Green River Formation (Eocene) of Colorado and Wyoming. The identification in southwestern Idaho of erionite, a fibrous zeolite used to separate gases and oil in purifying water, led to the discovery of a commercial-sized deposit by the mineral industry. Branch scientists continued developing more accurate and faster field and laboratory methods of identifying and determining concentrations of beryllium, fluorine, niobium, rhenium, tantalum, and other and rarer elements. A new electron-probe analyzer, fabricated by Isidore Adler, enabled elements in minute grains of minerals and rocks to be identified by X-ray analyses without destroying the samples. Branch members also prepared and analyzed, or provided to the Division's other geologists, some 13,000 thin and polished sections, while analyzing nearly 14,000 samples by chemical, polarizing-microscopic, spectrographic, X-ray, and other methods. Among the research results published during the year was Edwin Roedder's experimental analysis of the radioactive waste generated in processing nuclear fuel and possible solutions for disposing of it in the deep, brine-saturated, and glass-sand beds known as salaquifers; the work was done for the AEC's Division of Reactor Development. Roedder, now widely considered an expert on fluid inclusions as guides to ore formation at Creede in Colorado and elsewhere, served as Chief of the Branch's Solid State Group since joining the USGS in 1955. Esper Larsen, Jr., and three of his colleagues published their compilation of lead-alpha radiometric ages for Mesozoic batholiths in Western North America and continued to assess the distribution of uranium in these intrusions. Clifford Frondel, a veteran of the Office of Scientific Research and Development (OSRD) and Larsen's colleague at Harvard, extended his X-ray and related analyses of uranium and thorium in a comprehensive publication on their systematic mineralogy.

In fiscal year 1958–59, members of the Airborne Surveys Section in James Balsley's Geophysics Branch flew magnetic and radioactivity surveys that totaled 80,000 traverse miles over 11 sites; they also continued to complete aeromagnetic maps of quadrangles, areas, and counties in States nationwide. The preliminary results of aeromagnetic surveys flown over southwestern Pennsylvania correlated well with the geologic data and disclosed several new magnetic anomalies similar to those generated by known magnetite deposits. Ground-based geophysicists tested



USGS geologist Edwin Roedder suggested that enclosing wells with an impervious cement wall (as shown in this cross section) before injecting high-level radioactive solutions of acidic aluminum nitrate would increase safety in storing these solutions in deep and brine-saturated permeable beds (salaquifers) well below any potable water. Prior large-scale exploration and tests of potential sites would be required to determine the nature of chemical reactions between the injected radioactive wastes (radwastes) and the surrounding earth materials. Removing highly dangerous and heat-producing long-lived isotopes, aging to remove short-lived heat-producing isotopes, and chemically pretreating the radwastes or the salaquifers, Roedder added, would yield safer storage. USGS geologists and hydrologists continued in the 1950s to investigate methods of safely disposing of radioactive waste from nuclear-reactor fuels. (From Roedder, 1959, fig. 6.)

in field and laboratory electrical-prospecting methods in northern Maine's sulfide-ore districts and in copper and iron occurrences around Lake Superior. Variable-frequency electromagnetic techniques applied in northern Wisconsin's Gogebic Iron Range yielded estimates of magnetic susceptibility and content of taconites as aids to tracing covered deposits of these low-grade iron ores. A mobile magnetometer located small masses of subsurface serpentine rocks in California. Geophysics Branch scientists, cooperating with geologists and geochemists from other Branches in the Geologic Division continued studies of valley-fill deposits in the Basin and Range Province aimed at discovering new ore deposits in the two-thirds of the region covered by Cenozoic alluvial deposits. As part of this program, they began work in the porphyry-copper district around Arizona's Twin Buttes, already known for major deposits under the alluvium. Branch members advanced their investigations of the physical properties of rocks with a view to increasing their understanding of the environments in which igneous and metamorphic rocks, and their associated ore minerals, were formed and modified. With engineering geologists, they applied the results of their experiments on the solubilities and formation of minerals in water and steam under high pressures and temperatures in studying the results of underground nuclear tests. In investigations of products from industrial nuclear processes, they cooperatively searched for minerals containing radioactive isotopes of cesium and strontium for future utilization without endangering groundwater supplies. After determining clay capacities for absorption, they experimented on crandallite and vermiculite as absorbers of radioactive isotopes.

As part of these studies, Balsley, advised by his former Assistant Branch Chief Mary Rabbitt, established a Rock-Magnetics Project in the Geophysics Branch at Menlo Park in 1959. Balsley asked Allan V. Cox and Richard R. Doell, the new project's scientists, to concentrate on determining whether rocks with anomalous magnetism represented field reversals or self-reversals. Geologist and historian William Glen emphasized the USGS-Berkeley connection in his "Road to Jaramillo"; Cox and Doell were former geophysics students of John Verhoogen (still working part time with the USGS), and their years at Berkeley overlapped in the early and mid-1950s. Cox spent three summers in Alaska with USGS field teams that included Henry Coulter, David Hopkins, Troy Péwé, and Clyde Wahrhaftig, who, with Robert Black completed engineering geology studies along the Alaska Railroad. Cox became a full-time employee with the agency in 1957 and earned a Ph.D. at Berkeley in 1959. Cox, who worked on Cenozoic volcanic sequences and their paleomagnetism in Oregon, with Parke D. Snavely, Jr., and basalts in Idaho, with Howard Powers and Harold E. Malde, met the Berkeley-trained Rabbitt and Balsley through Wahrhaftig. Doell earned his doctorate at Berkeley in 1955. He taught for a year at the University of Toronto, where he worked with J. Tuzo Wilson; he went to Ellesmere Island with a Canadian team during the summer of 1956 to prepare for the International Geophysical Year (IGY). Doell then taught at the Massachusetts Institute of Technology (MIT) during 1956–59. The NSF granted Doell $16,600 in 1956–57 for a 3-year study of magnetism in sedimentary rocks, and he renewed his acquaintance with Balsley in Balsley's seminar at MIT. By the summer of 1958, as Glen related, Cox and Doell prepared for a multiyear collaboration at Menlo Park, and Cox described it to Balsley that September.[29] The duo intended to find a better explanation for and chronology of rock magnetism, goals whose origin Balsley and other USGS geophysicists could trace to George F. Becker's comments at a session on the present problems of geology and geophysics held at the International Congress of Arts and Sciences in St. Louis in 1904. There, on September 21, Becker challenged his colleagues by calling for additional basic research on the phenomenon, reported 3 years earlier in France by Jean Brunhes, "that lavas and strata indurated by lavas retain the polarity characteristic of the locality in which they cooled. The time may come," Becker added,

when this will lead to determinations of the relative age of lavas, the duration of periods of eruption and possibly even the absolute determinations of date.[30]

Victor Vacquier joined the Scripps Institution of Oceanography (SIO) in 1957 and received in 1958–59 a grant of $68,000 from the NSF for an investigation of anomalies in electrical conductivity. Balsley later recalled that Vacquier borrowed and modified a USGS fluxgate magnetometer and deployed it successfully from some of the SIO's ships. The USGS later lent another magnetometer to the Lamont Geological Observatory for towing behind its ships. The tendency of fluxgate magnetometers to drift in aircraft, Balsley remembered, could be dealt with "by circling back to cross the traverses and correct them from a common magnetic base." To overcome ship speed, Vacquier "developed a drift-free proton-precession magnetometer." He towed it behind the U.S. Coast and Geodetic Survey's *Pioneer* off California's coast, located magnetic anomalies, and produced a map showing the black-and-white lines of negative and positive linear anomalies that he compared with the traces of the faults delineated by the SIO's William Menard during the same ship's earlier bathymetric survey of that area. The faults, to Balsley's surprise, "lined up with obvious shifts in the linear magnetic anomalies."[31] In their flights across the United States, Balsley remembered, his teams recorded many linear anomalies on the continent but never any like those off California.

Cox, like other geologists before him, viewed volcanoes and volcanic rocks as "magnetic tape recorders."[32] He and Doell now proposed collecting rock samples with magnetic minerals from as many well-documented locales as possible worldwide and accurately determining their magnetic orientations and radiometric ages. Doell joined Cox in Menlo Park in March 1959. With aid from Balsley (who still hoped to return to research), Louis Pakiser's Ground Surveys Section, the Administrative Division's Chief Glendon Mowitt, and the General Services Administration (GSAd), Cox and Doell began operations in June in a tarpaper shack near the one that housed Arthur Lachenbruch. To help Cox and Doell "build a first-class magnetic laboratory,"[33] Balsley, who still favored self-reversals, detailed to them instrument technician Major Lillard, who built Balsley's spinner magnetometer. Geochronologist Ronald W. Kistler, who began working part time for the USGS in 1953 and continued that affiliation while earning a doctorate at Berkeley in 1960, provided initial potassium-argon (K-Ar) isotope dates. Kistler established the potassium-argon-dating facility at Menlo Park in 1959 and determined radiometric dates for western rocks, including the granites collected by Paul C. Bateman. Kistler and John D. O'Bradovich, also trained at Berkeley, joined Menlo Park's part of Samuel Goldich's Isotope Geology Branch in December 1961, 2 years after Goldich returned to the USGS. Cox and Doell found it increasingly difficult to get age determinations from Kistler, O'Bradovich, and other members of the Isotope Geology Branch, who were dating rocks for the economic geologists. Cox and Doell decided, if funds permitted, to invite to the team their own K-Ar specialist. At Berkeley, geologists Garniss H. Curtis and Jack F. Evernden,[34] whom the NSF granted $55,800 in 1958–59 for 2-years' work in K-Ar dating, and physicist John Reynolds, who began the K-Ar program at Berkeley in 1955, introduced G. Brent Dalrymple and several other students to that rock-dating technique. Curtis, Evernden, and Dalrymple worked principally on Cenozoic volcanic rocks. Dalrymple met Cox and Doell in the White Mountains in 1961 and hoped to join them after completing his doctorate.

On July 9, 1958, a major earthquake, generated along a portion of the Fairweather fault, heavily shook the northeastern coast of the Gulf of Alaska and especially Lituya Bay, a high-walled inlet, 2 miles wide and 7 miles long, just southeast of Cape Fairweather. The quake, measured at a Richter magnitude of 7.9 was assigned a modified Mercalli intensity of XI. At the epicenter, just southeast of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◀ These photographs look northeast across Lituya Bay, just southeast of Cape Fairweather in southeastern Alaska, before (above, in 1954) and after (below, in August 1958) the magnitude 7.9 earthquake and subsequent tsunami of July 9, 1958. In these photographs, Mt. Carillon, at an elevation of 12,726 feet, is on the skyline at right. Earlier giant waves devastated the shoreline areas of Lituya Bay in 1853 or 1854 (at k) and in 1936 (g). Lateral moraines (m) indicate a recent advance of ice. The 1958 earthquake generated a rockslide (r) that plunged into Gilbert Inlet, sheared off part of Lituya Glacier, and surged up the opposite slope to an elevation of more than 1,700 feet (d). Runups extended as much as 3,600 feet inland at Fish Lake (F) and deforested an area of 4 square miles. Two persons died when the tsunami, in passing seaward, sank their fishing boat, which was under way near the entrance of the bay. Two anchored boats (at b and e) survived. USGS geologist Don Miller, then nearby at Glacier Bay while studying the Gulf of Alaska Tertiary Province, assessed the tsunami's results by gathering data on the ground and from the air. (Photographs from Miller, D.J., 1960, pl. 3*A*, *B*.)

Lituya Bay, displacement along the right-lateral, strike-slip fault reached 3.5 feet vertically and 21.5 feet horizontally. At bay's head, a rockslide displaced some 40 million cubic yards of material. The debris flow crossed the Gilbert Inlet, sheared off the front of the Lituya Glacier, and drove water far up the opposite shore to topple trees at elevations as high as 1,720 feet. The wave surge completely deforested an area of 4 square miles. The tsunami also passed, at about 100 miles per hour, west down the bay and into the gulf, sinking a fishing boat and killing its two-man crew. Don Miller, then on the USGS power barge *Stephen R. Capps*, just 40 miles to the east in Glacier Bay, flew over the devastated site on July 10. His subsequent studies on the ground, combined with survivors' accounts of this and earlier and similar tsunamis in the area, recorded the effects of four lesser runup events between the 1850s and 1936 and indicated that they might occur again.[35]

Elsewhere in Alaska during the rest of fiscal year 1958–59, geologists in George Gates' Alaskan Geology Branch mapped some 850 square miles in detail and another 34,000 square miles at reconnaissance scales. Aeromagnetic and gravity surveys by members of the Geophysics Branch aided ongoing investigations of actual and potential petroleum areas in Alaska. In addition to continuing to map and assess Alaska's coal fields, Alaskan Geology Branch members completed four commodity maps that showed the occurrence and distribution of 13 elements. Other members of the Branch worked in engineering geology and combined their investigations of permafrost with those by the Military Geology Branch. This work involved mapping surficial deposits near Fairbanks, examining construction sites at military installations, and preparing a reconnaissance map of potential routes for a Fairbanks-Nome highway to be built under the direction of the U.S. Bureau of Public Roads.

In fiscal year 1958–59, members of Frank Whitmore's Military Geology Branch (MGB), in cooperation with the Air Force's Cambridge Research Center and the IGY's glaciological program, examined areas along the Arctic Coast and adjacent inland locales. Other MGB staffers completed investigations for the Army Engineers of terrain and permafrost conditions on Alaska's Arctic Slope, along the Copper River and Kuskokwim River, and on the Seward Peninsula. Their colleagues in the Branch continued or began investigations of the effects of nuclear explosions on rocks, soils, and vegetation.

With transfer funds from the Army Engineers, and later those from NASA, USGS geologists started compiling a photogeologic map of the Moon and expanded that effort to related lunar studies. The MGB's Robert J. Hackman, Arnold Mason, and Maxim Elias, aided by geologists William Fischer and Annabel B. Olson, compiled terrain and geologic data for the Lunar Mapping Program by using Fischer's modern stereoplotters to study recent telescopic images of the Moon's nearside, the nearly 60 percent of the lunar surface visible from the Earth. In 1959, Elias completed a 6-page preliminary study of the Moon's terrain as MGB Miscellaneous Paper 222; it included ideas about the feasibility of gathering additional information on the surface's physical characteristics and engineering properties. A 170-page lunar bibliography followed in 1960.

Hackman, in compiling a lunar geologic map for the Army Engineers, drew on his years of experience as a USGS geophotogrammetrist. He interpreted air photos and field data in preparing geologic maps for the Navy Oil Unit in NPR–4 before photogeologically mapping 70 quadrangles for the Colorado Plateau Project between 1952 and 1959. During this interval, Hackman invented "several photogrammetric instruments, including the Stereo-Slope Comparator, the Isopachometer, an adjustable profile plotter for the Kelsh and Multiplex plotters, a circular trigonometric computer for geologic instruments, several models of photo holders for use with a stereoscope, and various types of stereoscopes."[36] Beginning in 1959, he applied some of those photogrammetric and other technological developments in evaluating photographs taken through telescopes at five observatories—Lick

(California), McDonald (Texas), Mount Wilson (California), Pic du Midi (France), and Yerkes (Wisconsin).

Some of these photographs were published in the two lunar atlases[37] compiled by astronomer Gerard P. Kuiper, who directed the combined McDonald and Yerkes Observatories, and then by Kuiper and four collaborating astronomers. In 1954, Kuiper, then at the University of Chicago, published an analysis of lunar surface features[38] in which he ascribed maria (the large, dark, plainlike areas) to the almost complete melting of the Moon by its radioactive heat during its first billion years. Kuiper proposed three intervals—premelting, maximum-melting, and postmelting—in the development of the surface features by both impact and volcanic events. Harold Urey, also at Chicago, thought the Moon would prove to be the solar system's Rosetta Stone; he favored an accreting and cold Moon, believing that volcanism, not internal heating, formed the maria. Kuiper decided to compile a lunar atlas detailed enough to help settle the acrimonious dispute with Urey. The NSF supplied initial funds in April 1957, but the USAF's Cambridge Research Center provided the bulk of the necessary monies that fall for the initial atlas. Kuiper established a Lunar and Planetary Laboratory at Tucson, and his British colleagues joined him there for additional work in the fall of 1958, as Urey retired from the University of Chicago and moved to the University of California at San Diego. As Hackman and his colleagues continued to compile their lunar maps, the Army Map Service tried but failed in November 1958 to generate its own stereophotogrammetric lunar atlas. The AMS was thwarted, as Don Wilhelms later noted, by deficient data and old stereoplotters.

Late in 1958, as Wilhelms later recalled, Eugene ("Gene") Shoemaker, by then at Menlo Park and encouraged by NASA's founding and by two colloquiums on lunar and planetary exploration, renewed his offer to begin a lunar-studies program within the USGS. Shoemaker intended, as Wilhelms remembered,

> **to assemble an overall picture of the Moon's structure and history by examining it first through the telescope and later in photographs taken by spacecraft[39]**

as a prelude to recommending

> **where on the lunar surface the field work should be conducted, and samples collected.[40]**

This time, Shoemaker discussed the proposal with Assistant Chief Geologist Montis Klepper in Washington and again when Klepper visited Menlo Park. Their talks, like those in 1956, yielded no decision, but new events at NASA influenced Shoemaker's determination to continue preparing for a future lunar program. NASA established at Langley a Space Task Group, and Homer E. Newell, a Naval Research Laboratory mathematician, came aboard as Deputy Director in the Office of Space Flight Development, led by Abe Silverstein, a mechanical engineer and NACA veteran since 1929. In NASA's Office of Space Flight Development, Project Mercury received its name late in November 1958 just before Pioneer 3 was launched in early December. Newell hired physicist Robert Jastrow, an NRL consultant who earlier taught at Berkeley and Yale, to lead Goddard's Theoretical Division and appointed him in January 1959 to chair an ad hoc Working Group on Lunar Exploration at the JPL that included Frank Press, Harold Urey, and a number of other NASA advisers and employees. Jastrow's Working Group planned by early in 1960 a four-part spacecraft program, including hard landings in Project Ranger, within 12–18 months; rough landings, by using rockets as brakes; satellites in lunar orbits; and soft landings and returns to Earth in Project Apollo, within 3–4 years. On March 23, NASA gave the lunar program a priority second only to Project Mercury.

During 1958–59, members of William Johnston's Foreign Geology Branch continued to cooperatively appraise mineral resources abroad, improve the national surveys and educational institutions of other countries, and share knowledge in the earth sciences by disseminating their own publications or publishing bilingual reports with their colleagues. More than 50 members of the Branch and other units in the Geologic Division participated in the cooperative program during the year. They conducted fieldwork in Brazil, Chile, the Republic of China, India, Indonesia, Libya, Mexico, Pakistan, Peru, the Philippines, and Thailand. They also provided advice to the governments of Afghanistan, Burma, Ghana, Iran, Japan, Jordan, the Republic of Korea, Nepal, the Netherlands Antilles, Paraguay, Saudi Arabia, and Turkey. In the United States, nearly 90 participants from 24 countries, sponsored by the AEC, the ICA, and the United Nations, were trained in parts of USGS domestic programs and in the graduate schools of cooperating academic institutions. Twenty-four young geologists from 15 countries enrolled in a seminar in Washington, D.C., and received 7 months of field and office training in photogeological techniques from members of the Geologic and Topographic Divisions. The staff of the USGS Library, an administrative unit of the Geologic Division since its transfer during fiscal year 1947–48, expanded its efforts to make, or obtain from other Federal sources, translations from the Russian of useful earth-science articles and books published in the Soviet Union.

The composition of the Foreign Geology Branch's teams in several countries changed during 1958–59 as geologists completed existing tours of service or began new tours. Ralph Miller, who returned to research in the Fuels Branch after his work for the ICA, again was detailed to the Foreign Geology Branch to serve 29 months as the Chief of Party in Mexico. Joel Pomerene and Arthur Rynerson completed their tours with John Dorr's iron project in Brazil; Robert Morris and Mackenzie Gordon, Jr., arrived there, respectively, in September and January to advance geological education. Thor H. Kiilsgaard, who joined the USGS and Defense Minerals Exploration Administration (DMEA) work in 1951, began studies of ore deposits in southern Peru; he was on detail from his regular assignment as Staff Assistant to Albert Weissenborn, who managed the Mineral Deposits Branch's efforts for the DMEA. The USGS issued a 1:1,000,000 geologic map of Paraguay, by Edwin B. Eckel, using a topographic base compiled by Gladys H. Benedict from a Paraguayan map of the same scale and U.S. Army Air Forces (USAAF) trimetrogon photography taken during 1943–45. Eckel's bilingual map

The manganese-bearing arkose forming the hill in this photograph's background is part of the Misiones Sandstone (Triassic) and crops out just southwest of Yaguarón in eastern Paraguay. To the left of and beyond the central palm tree, the joints and other fractures in this feldspar-rich sandstone are filled with manganese veinlets, but samples of these veinlets proved to contain less than 10 percent manganese dioxide. USGS support for the Truman administration's Point Four Program in Latin America included reconnaissance studies and mapping of the geology and mineral resources of Paraguay completed by Edwin B. Eckel, in cooperation with some of its Government's geologists, during 6 months in 1952. Eckel judged the manganese deposit as noncommercial in size, but he directed future searches for other mineral occurrences to several areas of Precambrian rocks. Eckel also published a geologic map of Paraguay at 1:1,000,000 and a soils map of the country at about 1 inch = 30 miles. (Photograph from Eckel, 1959, fig. 54.)

of 1958 accompanied his 1959 report on his 6-months' reconnaissance in 1952 of Paraguay's geology and mineral resources that was conducted under the auspices of the Point Four Program and the Institute of Inter-American Affairs, and with cooperation from the Ministerio de Obras Públicas y Communicaciones' Departmento de Geología. R.C. Douglas and William W. Doyel served with George Ericksen's mineral-resources team in Chile during the first half of 1959. Gus Goudarzi started compiling, from the Army Map Service's 1:250,000 series, and other U.S. and British sources, a 1:2,000,000 bilingual topographic map of Libya; his work received support from the U.S. State Department and the Kingdom of Libya's Ministries of National Economy and of Petroleum Affairs and Industry. Goudarzi and Louis Conant intended to use Goudarzi's base to compile a geologic map of Libya. Vincent McKelvey, sponsored by the ICA, spent 2 months during the fall of 1958 in Jordan advising its Government about the country's phosphate and related commodity resources. James F. Seitz joined the Branch's mineral investigations in India in July 1958. J.F. Gude began serving with the minerals team in Pakistan in January 1959, and Joel Pomerene began work with the minerals team in the Philippines.

The USGS, on August 23, 1958, and through Interior Secretary Seaton, received statutory authority to operate officially in two additional areas outside the national domain and to use therein its direct appropriations for the first time. The new law extended

> **the authority vested in the Secretary of the Interior, to perform surveys, investigations, and research in geology, biology, minerals, and water resources, and mapping * * * to include Antarctica and the Trust Territory of the Pacific Islands.[41]**

To work officially in most other foreign locales, including Saudi Arabia, USGS personnel remained dependent on detail to and funding by other Federal departments or agencies. General authority for USGS work in all areas outside the national domain, if determined by the Interior Secretary "to be in the national interest,"[42] did not become law until September 5, 1962. On August 28, 1958, a second new statute officially authorized "details and transfers of Federal employees for service with international organizations." The new law allowed "The head of any Federal agency * * * to detail for a period not exceeding three years any employee of his department or agency to an international organization requesting services."[43] That statute also provided measures for retaining the allowances, compensation, privileges, rights, seniority, and other benefits due detailed or transferred personnel, whether or not the international organization(s) reimbursed the United States. The act of August 23, 1958, also authorized the compilation of "maps of Antarctica from materials already available and from such additional material as may result from the several expeditions in support of the International Geophysical Year."[44] The Topographic Division began long-range planning for mapping all of Antarctica at 1:250,000.

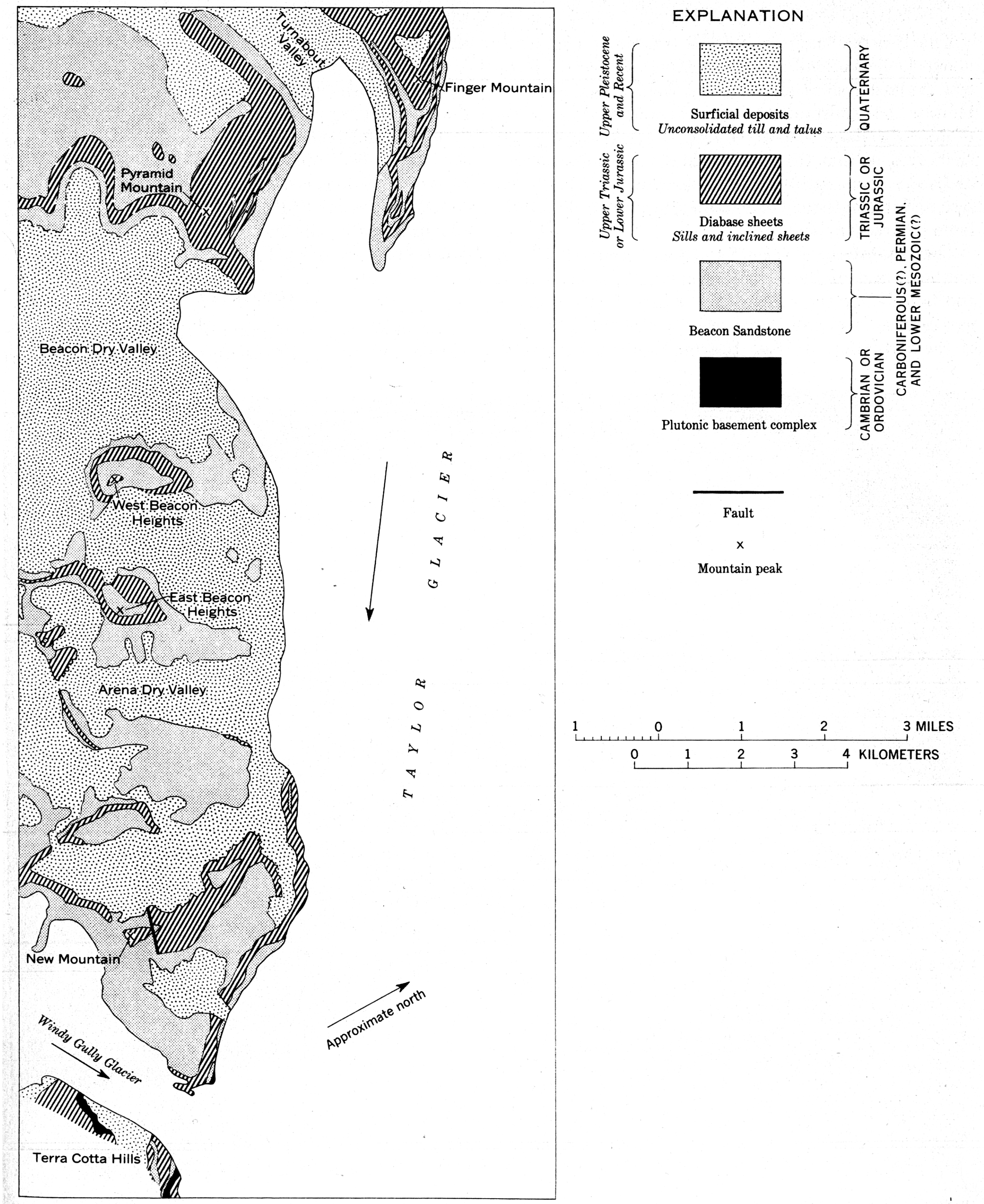
During the austral summer of 1958–59, the IGY's international activities in Antarctica continued, as agreed after the Comité Spécial de l'Anneé Géophysique Internationale (CSAGI) met in Moscow in July and August 1958. The International Geophysical Cooperation agreement in 1959 extended the IGY for a year beyond its scheduled end on December 31, 1958. On that day, the NAS transferred to the NSF responsibility for the administration, coordination, and funding of all subsequent U.S. research activities on the continent. The NSF established a U.S. Antarctic Research Program in March 1959 and chose to direct it chemist Thomas O. Jones, who left his post as acting head of the NSF's Office of Scientific Information. John Reed (Sr.) joined the 20-member Interdepartmental Committee on Antarctic Research. The IGY's 11 archives of its World Data Center A included a repository for geomagnetism, gravity, and seismology established in Washington, D.C., as part of the U.S. Coast and Geodetic Survey's Geophysics Division.

This photograph, taken in November 1958, looks southwest from the Taylor Glacier toward the west wall of the Beacon Dry Valley in Victoria Land, eastern Antarctica. The three major units of the Beacon Sandstone are present—the sandstone of New Mountain underlies talus slopes, the sandstone of Pyramid Mountain forms the conspicuous light-colored cliffs, and the sandstone of Finger Mountain forms the highest slopes and capping ledges. The thick dark layers are diabase sills. Pyramid Mountain is on the skyline at right. (Photograph by USGS geologist Philip Hayes; from the USGS Denver Library Photographic Collection as Hamilton, W.B., hwb00387, https://www.sciencebase.gov/catalog/item/51dc7c67e4b097e4d3838c23; cropped versions were published in Hamilton and Hayes, 1963, fig. 7, and in Yochelson and Nelson, C.M., 1979, p. 39.)

Rear Admiral George Dufek's Naval Support Force Antarctica intended to evacuate all U.S. stations at the end of 1958, but it received a new mission to provide logistical support for U.S. research in Antarctica for as long as necessary. In Operation Deep Freeze IV, Dufek continued as the Navy's Antarctic Projects Officer, and Edwin A. McDonald commanded Task Force (TF) 43; its nine ships included icebreakers *Edisto*, *Glacier*, *Northwind*, and *Staten Island*.[45] During the austral summer, USGS geologists surveyed the volcanic peaks of the Executive Committee Range in Marie Byrd Land and other areas of Antarctica. Warren B. Hamilton and Philip T. Hayes studied the geology of the McMurdo Dry Valleys; Hamilton joined the USGS in 1952 and investigated the Sierra Nevada and Idaho batholiths and the tectonics of the Blue Ridge and Great Smoky Mountains. Charles Johnson sailed in *Glacier* to geologize on Beaufort Island in the Ross Sea and at nearby Cape Bird on Ross Island. John Behrendt, now on the University of Wisconsin's faculty, examined areas in Coats Land, west of Queen Maud Land, and parts of the Filchner Ice Shelf. USGS topographic engineer William Chapman, held over from Deep Freeze III, spent a total of 18 months at the Byrd Station accompanying round-trip traverse parties to the Horlick Mountains and to other areas to fix the location of peaks and other landmarks intended to be used for mapping control.[46] Operations ended at Little America V on January 18, 1959. Later, the United States transferred its Ellsworth Station to Argentina and its Wilkes Station to Australia.

George Whitmore's Topographic Division received more than $19,158,000 during fiscal year 1958–59, a gain of about $840,000 compared to the total received in the previous year. The Division's SIR appropriations rose by $431,000 to $14,674,000. Increases by the Army, its Engineers, and other Federal agencies more than made good the loss of nearly $365,000 in funds from the Bureau of Reclamation as the total of such transfers climbed by $166,000 to $2,272,000. States, counties, and municipalities provided direct and repay funds of about $2,013,000, a nearly $248,000 increase, as the Division's nonfederal monies rose to a total of $2,212,000.

On July 10, 1958, a Secretarial order transferred to the USGS the domestic-names functions of Interior's Office of Geography "that relate to domestic geographic names (names of locations within the United States, its territories and



Turnabout Valley
Finger Mountain
Pyramid Mountain
Beacon Dry Valley
West Beacon Heights
East Beacon Heights
Arena Dry Valley
TAYLOR GLACIER
New Mountain
Approximate north
Windy Gully Glacier
Terra Cotta Hills
EXPLANATION
Upper Pleistocene and Recent
Surficial deposits
Unconsolidated till and talus
QUATERNARY
Upper Triassic or Lower Jurassic
Diabase sheets
Sills and inclined sheets
TRIASSIC OR JURASSIC
Beacon Sandstone
CARBONIFEROUS(?), PERMIAN, AND LOWER MESOZOIC(?)
Plutonic basement complex
CAMBRIAN OR ORDOVICIAN
Fault
x
Mountain peak
1 0 1 2 3 MILES
0 1 2 3 4 KILOMETERS

◀ This geologic map (originally at 1 inch = 1.7 miles) shows the type area of the Beacon Sandstone in the Beacon Heights area, west of McMurdo Sound, in eastern Antarctica. USGS geologists Warren Hamilton and Philip Hayes used published information, aerial and ground photographs, and their ground observations in mapping the composite type section of 8,000 feet in and near Beacon Heights. Their four map units included the plutonic basement complex (Cambrian or Ordovician), the Beacon Sandstone (Carboniferous[?], Permian, and lower Mesozoic[?]), diabase sills and sheets (Triassic or Jurassic), and till and talus (Quaternary). Two of the three arrows show direction of ice flow. The Beacon Sandstone contained the *Glossopteris* flora; the wide distribution of these fossils in the Southern Hemisphere remains one of the principal supports for continental drift. Hamilton and Hayes examined the Beacon Sandstone type section in November 1958 during the International Geophysical Year (IGY). During the IGY (July 1957 through December 1958), scientists from 67 nations participated in astrophysical, geodetic, geophysical, glaciologic, gravimetric, magnetic, meteorologic, oceanographic, seismologic, solar, and topographic studies using data from ground-based observations and those made by balloon- and rocket-borne instruments. Personnel from 12 nations, operating from nearly 60 stations, received unrestricted access within Antarctica. That cooperation helped leaders to formulate and enact the Antarctic Treaty, which was signed December 1, 1959, and became effective in 1961. (Map from Hamilton and Hayes, 1963, fig. 3.)

the Commonwealth of Puerto Rico, and adjacent waters)." This order reserved authority for "final approval of the Board on Geographic Names [BGN]" to "the Secretary, the Under Secretary, or an Assistant Secretary." Also transferred from the Office of Geography to the USGS were "[a]ll records, files, books, periodicals, maps and other materials that relate to domestic geographic names."[47] The order directed the USGS to determine when investigations should be made; provide the BGN's meeting place, an Executive Secretary, and other staff aid; and promulgate the BGN's decisions. The order, as amended on August 8, delayed the transfer until October 1. In the Division's only major internal administrative change during the fiscal year, Charles Davey retired as Atlantic Region Engineer in November 1958 and was succeeded by Charles Fuechsel.

In fiscal year 1958–59, Topographic Division personnel mapped in 40 States, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. Florida, Ohio, and Tennessee significantly increased their financial support for cooperative mapping. Field parties mapped more than 38,000 square miles at 1:24,000 and another 54,000 square miles at 1:62,500 (in the conterminous United States) and at 1:63,360 (in Alaska). Mapping in California and Texas depicted 7,000 square miles at those scales. Division members established more than 350 permanently marked triangulation stations to provide control for areas totaling some 30,700 square miles. They also ran about 6,840 linear miles of transit traverses, another 3,100 miles by electronic traverses, and 15,400 miles of leveling. The Division let contracts with industry for some 73,300 square miles of precision aerial photography to support its domestic mapping program, and the Air Force provided air-photo coverage of an additional 5,555 square miles to use in compiling topographic maps for the Defense Department. Nearly 2,440 maps were sent to the Publications Office for printing and distribution; of these, almost 1,340 represented new USGS standard topographic quadrangles; the remainder were new maps for other agencies, revisions, reprints, State index maps, civil editions of DoD maps, and special-format maps. The Division raised its total of published topographic maps to more than 21,000. A new 1:500,000 topographic map of Tennessee appeared during the year, as work continued on equivalent sheets for nine other States. The urban-mapping program[48] issued composite maps for four areas—Denver, Honolulu, Norfolk-Portsmouth-Newport in Virginia, and Philadelphia. The Division also mapped for other USGS Divisions, and provided cartographic aid to the Army Map Service's 1:1,000,000 coverage of North America, the Bureau of the Budget's photomosaic, the Interstate Commerce Commission's special compilation, the Office of Civil and Defense Mobilization's special coded overlays, the Post Office Department's rural routes, and a new edition of the U.S. Water Resource Development map.

The Topographic Division also introduced new instruments and methods to improve its geodetic surveys. A new signal lamp's two-transistor circuit produced flashes at constant intervals to provide the means to avoid past problems created by observations under difficult daytime conditions. Additional new electronic equipment for measuring distances yielded improved accuracy at reduced cost. Division personnel tested the direct geodetic restraint method, the fully analytical system of aerotriangulation that verified the geometrical approach and the accuracy of the electronic-computer program. They also used provisional analog equipment from the Jerie-International Training Center, at Delft in The Netherlands, to test aerotriangulation's horizontal and vertical block adjustments and yield corrections of discrepancies in measurements of position and elevation. Division members cooperated with colleagues in the Army Engineers' Research and Development Laboratories in testing the accuracy of the Decca system used to determine accurately aircraft positions when making a series of photo-exposure stations.

The Topographic Division also concentrated during 1958–59 on improving the precision of its photogrammetric equipment to speed the completion of the topographic map coverage of the Nation at the now standard large scales.

Division members completed a long-range plan to replace the Multiplex system and continued to modify the Twinplex instrumentation and its calibration to increase accuracy. Developing an orthophotomap, however, proved difficult. As most of the requests for orthophotographs continued to come from geologists within and outside the Geologic Division,[49] who wished to use them as bases for compilation, the Topographic Division envisioned many potential applications but by this time actually made few practical uses of orthophotoproducts. In July 1958, the Topographic Division formed an Orthophotography Use Study Group, composed of one representative from each Branch in Roland Moore's Office of Research and Technical Standards, except for the Branch of Cartography. The new group met to determine the best uses of orthophotogrammetry in new mapping or in revising the Division's standard topographic-quadrangle series.

Topographic Division personnel began reengineering the initial Universal Orthophotoscope to further automate the application of electronic readouts to accommodate the existing dichromatic projectors. They also designed a simpler and less expensive model, using only ellipsoidal reflector-55 (ER–55) projectors, to yield orthophotographs under most terrain and photographic conditions. Division designers planned to have their orthophotoscopes make possible the production of three principal photo-image products—orthophotographs for fieldwork; orthophotomaps, with contours and extensive color-enhanced cartographic treatment, in the standard 1:24,000 quadrangle format and with relative horizontal and vertical reference systems; and orthophotoquads, monochromatic maps in standard quadrangle format, without contours, and with little or no cartographic treatment.[50] Progress toward generating actual orthophotomaps depended on overcoming the Division's limited production and reproduction capabilities. The Branch of Special Map's prototype Orthophotoscope remained the only one in the Division, reproduction of continuous-tone photography still depended on the half-tone process, and the high-altitude photographs from the Army Map Service and photographs obtained for stereocompilation remained inadequate sources for good orthophotomosaics. In 1959, the Division began planning and then operations to shift from analog to digital photogrammetry.

Members of the Topographic Division provided continuing technical aid and training at home and abroad to foreign colleagues in fiscal year 1958–59. Division personnel also prepared and issued an experimental 1:1,000,000 map of the Knox Coast, along eastern Wilkes Land, and gathered in Washington a collection of geodetic-control data, maps, photographs, and other cartographic materials to support the planned comprehensive mapping of Antarctica.

Luna Leopold's Water Resources Division received funds from all sources in fiscal year 1958–59 that totaled about $22,764,000, or $1,862,000 more than in 1957–58. Of the SIR appropriation of nearly $11,278,000 (an increase of nearly $762,000), $6,950,000 was limited to cooperative work with the States and their political subdivisions. They supplied the USGS with almost $6,796,000 in direct and repay funds, representing a gain of nearly $967,000. California's $705,000 and lesser amounts from Texas, New York, Florida, New Mexico, Arizona, Pennsylvania, and Utah provided the major portion of these cooperative funds. Other Federal agencies supplied about $4,418,000, an increase of almost $129,000. The Army and its Engineers raised their total transfers by $232,000 to nearly $1,760,000, and the ICA and the AEC also increased their contributions by a total of almost $214,000. Transfers by the Bureau of Reclamation, the Agriculture and State Departments, and the Tennessee Valley Authority (TVA) fell by about $466,000. Federal and State cooperative funds now represented about 60 percent of the total monies received by the Division, by far the largest such dependency within the USGS. The Interagency Committee on Water Resources' Subcommittee on Hydrology completed a report, published by the Government Printing Office (GPO) in 1959, on Federal programs for collection of data on water use.

Leopold's reorganization of his Division drew an inevitable comment from the Pick and Hammer Club. The "Wonderments" introduction to the Club's show in April 1959 closed with a verse that observed:

> **Our Water Resources laddies felt that they should change their ways.**
> **To be more like geologists could bring them naught but praise,**
> **The brand-new brass soon learned to play the old reshuffling game,**
> **But just as in Geology the outcome was the same—**
> **They're swapping jobs each month so all can share the blame.[51]**

As part of the Division's technical-assistance outreach, water-resources projects supported by the ICA's $498,000 continued in Afghanistan, Chile, Iran, Libya, Pakistan, Peru, the Philippines, and Saudi Arabia. William Doyel completed during September 1958 his tour in Libya with Chase Tibbitts' team, who gained the services of Thomas G. Newport in April 1959. Eldon Dennis and Edward Bradley finished their service in Iraq in September 1958 and returned to the United States, but Bradley left again for 3 months' work in Jordan during April–June 1959. In Iran, John Baumgartner completed his work in March 1959 and was succeeded by Alvin F. Pendleton, Jr. Nelson Sayre spent more than 2 months with Division hydrologists in Pakistan late in 1958. Regular turnover of personnel continued in Pakistan, as elsewhere, when Robert Cushman left in December 1958 and George LaRocque departed in June 1959. Meanwhile, John B. Cooper completed a 6-month tour in Pakistan during March 1959, an interval that overlapped the assignment there in January of David W. Greenman. Their colleagues on similar assignments in British Guiana, Cambodia, Tunisia, and Turkey also aided the modernization or expansion of investigations of those countries' surface water and groundwater. Division personnel provided in-country training to more than 100 colleagues in the cooperating nations. This experience was needed, especially in view of continuing problems with water quality abroad; on August 25, 1958, 25 people died in New Delhi after drinking contaminated water. Division members also helped to train in the United States personnel from Afghanistan, Brazil, British Guiana, Chile, the Republic of China, Guatemala, India, Pakistan, the Philippines, Tanganyika, and Turkey.

During 1958–59, the Surface Water Branch operated and maintained a national streamgaging network of 7,100 stations in 49 States, Hawaii, Guam, and Puerto Rico. Branch members continued streamflow measurements for the 19 interstate compacts and investigations of U.S.-Canadian boundary waters for the International Joint Commission. Research on surface water included continuing studies in field and laboratory of flow in open and constricted channels and in different climate and land conditions. Branch members continued to experiment with electronic computers, but they did not succeed in using vacuum-tube models to read gage heights from automatically recorded data on strip charts, compute the discharges, and record the results on punch cards. During the year, the Branch published streamflow reports for basins nationwide, including the South Atlantic Slope (James River to Savannah River), the St. Lawrence River, the Great Basin, and some on the Pacific Slope. The special summary of streamflow records for 1888–1950 now was more than 98 percent complete. Reports also nearly finished included those for California's Central Valley, the Upper Missouri River Basin, and the Upper Mississippi River Valley. Work continued for those on the Gulf of Mexico basins, the North Atlantic Slope, the Upper Colorado River Basin, other basins in California, and those in Hawaii. Similar studies began for the Columbia River Basin. As part of ongoing countrywide analyses of regional flood frequency, Branch members finished those for New England and the Lower Colorado River Basin and issued one for the Delaware River Basin. They also released open-file preliminary and cooperative reports on Florida, North Dakota, Ohio, and South Dakota and published reports of specific floods in the United States in 1952, Illinois in 1954, and Indiana in 1954 and 1957. For the Soil Conservation Service (SCS), Branch specialists studied runoff from maximum annual floods in 1,426 drainage areas of less than 400 square miles and provided hydraulic data for 38 drainage-structure sites to the highway departments of 11 States. They also began a manual of hydrology, to describe the standard surface-water techniques used in the Branch, and they issued separately its first six chapters.

On January 14, 1959, Luna Leopold's memorandum named Philip LaMoreaux, then Mid-Continent Regional Hydrologist at Tuscaloosa, as Nelson Sayre's successor as Chief of the Ground Water Branch. Sayre, Branch Chief since December 1946, returned to research as a Staff Scientist in Leopold's office. Charles McDonald took over temporarily as Mid-Continent Regional Hydrologist at Rolla. Branch members conducted during fiscal year 1958–59 some 640 investigations in the 49 States, Hawaii, and Puerto Rico. Work in areal hydrology and geology comprised three principal efforts. One of the major cooperative "Regional" studies involved continuing work in parts of nine States in the 900,000-square-mile area of the Mississippi Embayment. "System" studies included those of Idaho's Spokane River Basin and Arizona's Verde Valley. "Type" investigations, the least inclusive of the three kinds of areal hydrology and geology studies, encompassed work on the hydrology of volcanic and limestone terranes, specifically geohydrologic conditions in basalt terranes, to locate and develop groundwater supplies in the Pacific Northwest and apply the results to similar areas. Branch members researching the occurrence and movement of groundwater strove to develop analytical methods for hydrologic systems and regions, investigate saturated flow to understand better the dynamics of groundwater and surface-water relations, study the mechanics and properties of groundwater reservoirs and porous media, and examine the relation of regional flow and geologic environment to the distribution of constituent minerals. Gerth E. Hendrickson summarized, on a map at 1:750,000, the occurrences of groundwater in Kentucky. As part of investigations of saltwater encroachment in coastal areas, work continued in eight Southeast States, seven Northeast States, and Hawaii. Hilton Cooper, Jr.'s generic analysis[52] of the dynamic balance of freshwater and saltwater in a coastal aquifer in 1959 generated a study of the Biscayne aquifer near Miami, Florida. One Branch team programmed two analog computers to process geologic and hydrologic data on the responses of water-bearing formations to withdrawing or injecting water as an aid to investigating hydrologic systems.

The Branch of Water Quality supplemented its nationwide investigations of water chemistry and radioactivity, concentrating on uranium and radium, with detailed studies of surface-water and groundwater conditions in the basins of the Colorado, Columbia, Connecticut, Missouri, Pecos, and Yadkin-Pee Dee Rivers and in several river basins in Alaska. John D. Hem's study and interpretation of natural water's chemical characteristics, published in 1959, emphasized the inorganic aspects of water chemistry; his discussion of the significance of properties and constituents in natural waters became a standard reference.[53] Branch members completed reports on the chemical quality of South Dakota's surface waters that emphasized the concentrations of boron, fluorine, and selenium; the analytical methods for determining strontium; and the nationwide distribution of uranium and radium in groundwater. They began measuring the level of synthetic detergents in groundwater in the United States and also continued studies of worldwide runoff of solids from lands to oceans. Selected closed lacustrine basins in California and Nevada became their natural laboratories for studies of dissolved minerals and the distribution and behavior of minor elements. Other specialists in the Branch measured in detail and analyzed stream-sediment loads in the Colorado, Middle Rio Grande, and Missouri River Basins. In related studies, they investigated how the shape and unevenness of stream channels influenced sediment transport and the bedload discharge of sediment. They also developed automated equipment to measure sediment discharge from streams and improved techniques and standards for interpreting sediment data and records. For the Bureau of Reclamation and the Soil Conservation Service, Branch members studied stream sediments in the Colorado and Rio Grande River Basins and in Nebraska's Medicine Creek watershed. For the SCS, they also continued to examine the sediment yields and trap efficiency of small-watershed reservoirs. They also completed a study of the Delaware River Basin's geology, groundwater, and sediments; the report, documented by a hydrologic atlas and text, passed to the Army Engineers to become part of the Engineers' comprehensive plan for basin development.

Harold Duncan's Conservation Division drew on total funds of more than $2,696,000 during fiscal year 1958–59, nearly $333,000 more than in the preceding year. The Division's SIR appropriation represented all but $262,000 of the new sum. Eisenhower signed a law on August 14, 1958, that reamended 1877's Desert Land Act "to permit entries on disconnected tracts of lands, which, in the case of one entryman, form a compact unit and do not exceed in the aggregate three hundred and twenty acres." Persons who made valid desert-land entries, before June 16, 1955, on lands subject to the 1910 and 1914 acts "may, if otherwise qualified, make one additional entry, as a personal privilege, not assignable, upon one or more tracts"[54] subject to 1934's Taylor Grazing Act, as subsequently amended. On August 19, 1958, a new statute amended the Atomic Energy Act of 1954 by releasing to claimants the reserved public and acquired lands, set aside by Executive order or statute during 1945–47, of "radioactive mineral substances, fissionable materials, or source material, together with the right to enter upon the land and prospect for, mine, and remove the same."[55] Two days later, the Minerals Exploration Act,[56] intended to restimulate exploration for and discovery of mineral reserves, except organic fuels, in the United States, its Territories, and possessions, provided additional support for programs run by Interior's DMEA. The DMEA transferred its responsibilities and staff to its successor, the Office of Minerals Exploration (OME)[57] established on September 11 by a Secretarial order to implement the statute of August 21. Interior's Office of Minerals Mobilization, established in 1955 and also reporting to the Office of Defense Mobilization, shifted from aiding the DMEA's work to helping the OME's efforts. To each contract, the OME could contribute 50 percent, or up to $250,000, toward the costs of exploring for strategic and critical commodities, including antimony, asbestos, bauxite, beryl, cadmium, chromite, cobalt, columbium, copper, corundum, industrial diamonds, fluorspar, graphite, kyanite, lead, manganese, mercury, mica, molybdenum, monazite, nickel, platinum, piezoelectric quartz crystals, rare earths, rutile-brookite, selenium, talc, tantalum, thorium, tin, uranium, and zinc.

Members of the Mineral Classification Branch completed during fiscal year 1958–59 geologic reports on foundation conditions at 18 potential dam sites in Alaska and 13 others in Oregon. They also finished geologic and (or) structure-contour maps of 10 specific coal and oil fields and areas in Colorado, Montana, and Wyoming, including Teapot Dome and West Sussex in Wyoming. Branch members processed more than 33,600 cases involving the disposal of Federal lands, some 8,200 of which dealt with the reservation or release of minerals and the remainder with Federal leasing of the mineral rights. They completed or revised 66 definitions of producing oil and gas fields on Federal lands, geologic appraisals of proposals for 315 unit plans and participating areas, reports on the geologic significance on 194 new discoveries of oil and gas on or affecting Federal-land leaseholds, reviews of 55 appeals from the Bureau of Land Management's decisions about Federal-land disposals, and some 330 reports for other Federal agencies on the mineral potential of specific public lands.

The Water and Power Branch's staff during fiscal year 1958–59 surveyed 370 miles of steam channels and 20 potential sites for dams on 22 rivers and lakes in Alaska, California, Colorado, Idaho, New Mexico, Oregon, and Washington. They also published maps for 96 miles of streams and 12 dam sites. Their reviews recommended the restoration of 190,000 acres of public lands, 113,000 proposed and 77,000 previously withdrawn. Classifications by Branch members added some 85,000 acres to the power-site reserves and eliminated nearly 68,400 acres, leaving reserves of more than 7.2 million acres in 24 States. They also prepared more than 8,650 reports for the Bureau of Land Management (BLM) and the Federal Power Commission (FPC).

By the end of fiscal year 1958–59, members of the Mining Branch supervised more than 4,000 lease, permit, and license properties on public, acquired, and Indian lands in 34 States. The production of coal and mineral commodities from these lands totaled more than 26,159,000 tons, representing a year's gain of about 5,841,000 tons; their value of nearly $170,028,000 (about $27,513,000 more than in 1957–58) yielded royalties of almost $7,832,000, an increase of nearly $1,077,000. The production of phosphate rock and shale produced during 1958–59 fell by about 7,300 tons, a loss helping to validate the need for the projected future increases under the hoped-for stimulation of the Phosphate Mining Act, but the value of these commodities, reflecting market realities, also declined by $202,000 and royalties decreased by nearly $34,000. On May 20, 1959, Branch members attended an interagency meeting in Washington that the Public Health Service sponsored to foster cooperation in devising measures to protect miners from the effects of radon gas, silica dust, and other dangers to health in uranium mines.

Members of the Oil and Gas Leasing Branch again increased their operations during fiscal year 1958–59. They supervised more than 130,600 properties on 107.4 million acres of public lands, a gain of 14.3 million acres from 1957–58. Private companies completed about 1,660 wells, of which some 1,070 produced oil and gas, 173 fewer than in 1957–58, to raise the total of producing wells to about 16,850, or 110 more. The production from these wells rose to some 145 million barrels of oil, an increase of 12.4 million; almost 443 billion cubic feet of natural gas, a gain of 3.4 billion; and nearly 310 million gallons of gasoline and butane, a

This 1960 photograph shows USGS mining engineer J. Paul Storrs observing coal-stripping operations on the Edna Company's lease near Oak Creek in Routt County, northwestern Colorado. USGS supervision of mining operations on the public lands grew in the 1950s as old mines increased their production and new mines began operations. These activities increased the royalties, rents, and other payments made by coal firms through the USGS to the U.S. Treasury. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., pef00703, https://www.sciencebase.gov/catalog/item/51dda0a9e4b0f72b4471ddbb.)

rise of 84.7 million. The total value of these fuel resources rose by $20 million to $406.7 million and returned to the U.S. Treasury royalties of more than $57 million, a gain of $3.4 million. On the Outer Continental Shelf (OCS), nearly 900 wells on more than 200 leases, with 12 unit plans, produced 64 percent more oil and 95 percent more natural gas than in 1957–58, raising their total value to nearly $126.8 million and yielding royalties and rentals of $24.8 million. Branch members approved 80 new unit plans for onshore fields and terminated 42 others, leaving 373 in operation for a gain of 38, but OCS unit plans decreased by 1 to a total of 12.

Interior's Office of Oil and Gas transferred nearly $212,500 to the USGS for the Federal Petroleum Board's administration of the Connally "Hot Oil" Act during 1958–59. The FPB processed about 10,300 monthly producers' reports, some 460 monthly pipeline reports, and 65 processor-refiner reports. The number of reporting oil fields rose by 153 during the year to a new total of 3,853. FPB monitors visited 783 oil fields and conducted 1,479 interviews. By year's end, 17 cases of alleged violations of the Connally Act remained on the docket, and 8 were still under investigation by the Attorney General. The FPB, while preparing a report on an additional case, continued to study 8 others. Court action closed 3 other cases and the fines paid totaled about $58,000.

Some 3 months earlier, on January 27, 1959, Chairman Michael Kirwan began his House subcommittee's evaluation of Interior's budget estimates for fiscal year 1959–60. He welcomed to the subcommittee's deliberations two new members, elected in 1954—Winfield K. Denton (D–IN) and E. Keith Thomson (R–WY), who succeeded Hamer Budge. Kirwan then recognized Seaton, saying that he "has made a good Secretary."[58] Seaton thanked Kirwan, assuring him "that, from personal experience, kind words are at times at a premium at the Department of the Interior because of the very nature of the job."[59] The Secretary brought along Under Secretary Elmer F. Bennett, the former Solicitor, who replaced Hatfield Chilson in 1958.

Seaton, in reiterating the President's hope to avoid bigger deficits and higher taxes, proposed a budget for Interior in fiscal year 1959–60 of $364.1 million, excluding reclamation and waterpower funds. That sum had been reduced by the Budget Bureau from the original request of $404.8 million that included pay increases. The Department, Seaton confirmed for Kirwan, could live with the reduced amount in 1959–60 and still meet its obligations to the Nation. The cuts, intended to help the Eisenhower administration reach its goal of a balanced Federal budget of $77.3 billion, fell most heavily on the Bureau of Indian Affairs, the National Park Service, and the Fish and Wildlife Service. To meet the Nation's increasing needs for minerals and water, Seaton proposed to continue in 1959–60 the U.S. Bureau of Mines (USBM) and the USGS programs at the expanded 1958–59 level. The $42,517,600, including $217,600 to enforce the Connally Act, proposed for the USGS represented an increase of $650,000. Of that sum, $500,000 would go to meet larger offerings by the States for the agency's cooperative water-resources investigations and $150,000 to fund the increased work of supervising oil and gas mining leases on public lands. Interior also estimated the number of USGS employees, permanent and the part-time and seasonal full-time equivalents, would rise from the 7,445 authorized for 1958–59 to 7,510 during 1959–60.

Kirwan's subcommittee considered the USGS budget request on the afternoon of January 28. To save time, Nolan inserted into the record a long statement of justifications for the $42.5 million for salaries and operations requested for fiscal year 1959–60. In his prepared remarks, Nolan reported "substantial progress in reversing the trend, which developed during and after the war, of dependence upon substantial transfers of funds, or repay accounts, from other agencies," one that especially represented a "significant shift in the Geologic Division's financing."[60] Two changes in the SIR language authorized expenditures for the Federal

Petroleum Board's enforcement of the Connally Act and for USGS work in Antarctica and the Trust Territory of the Pacific Islands as authorized by the 1958 statute. Nolan projected total funds from all sources, including those covering pay raises, in 1959–60 would reach about $63,819,600, a gain of $152,000 compared to the sum available in 1958–59.

Kirwan's subcommittee, as before, reviewed all the USGS justifications for its activities for the coming fiscal year. Nolan displayed additional statistics showing that costs declined from $171 to $120 per square mile, or $77 if calculated for cost-of-living adjustments, for topographic mapping and surveys between fiscal 1946–47 and 1957–58, while typical hourly wages increased from $1.31 to $3.64 and the cost per new map edition fell from $324 to $290. During 1959–60, work would continue on 4,300 quadrangles at 1:24,000, 1:62,500, and 1:63,360 and begin on 900 sheets at 1:24,000 and 240 sheets at 1:62,500. Nolan later assured Thomson that the National Geographic Society was almost wholly dependent on the USGS when compiling its maps. The completion of national coverage on adequate maps, Nolan added, now stood at 43 percent, reflecting the increased demand for 1:24,000 mapping, but Kirwan did not press him to name a completion year or a projected cost of finishing the remaining maps.

Nolan, while justifying geologic and mineral-resource surveys and mapping, reported the discovery of several new ore deposits in the West, including a cobalt body in Idaho worth an estimated $30 million. The new "rocket-generated demand for solid fuel propellants and heat- and pressure-resistant alloys,"[61] Nolan emphasized, "has been superimposed upon the long existent, but ever-increasing need for conventional raw materials."[62] "These demands," he continued, "spotlight the need for basic geologic research to determine their mode of occurrence and to develop new exploratory methods and tools for use in the search for commercial sources of supply."[63] Part of the $1.5 million supplemental appropriation for fiscal year 1958–59, Nolan explained, was "being used to make modest starts on several high-priority studies of the type recommended by the National Science Foundation Advisory Committee on Minerals Research,"[64] including new work in Arizona's Bradshaw Mountains, at Ely in Nevada and Phillipsburg in Montana, in Washington's Hunters quadrangle, and in the iron-ore areas of the Southeastern United States. New work for the AEC, funded by an additional $1.5 million, involved pre-test efforts in Nevada, Alaska, and New Mexico for the Division of Military Applications, aerial measurements of background radiation and changes suggested by tests on reactors in Georgia and New York for the Division of Biology and Medicine, and other studies for the Division of Research. Nolan pointed out that the work for the Project Plowshare studies "provide[s] unusually fine opportunities for research on these factors [of ore-deposit formation] under physical conditions that would be impossible to duplicate in the laboratory."[65] In reviewing USGS work in Alaska and the Arctic, Nolan noted that the agency's geophysicists assigned to IGY and related activities on Ice Island T–3 used their instruments to determine ice thickness and suitability for landing aircraft. John Reed (Sr.) continued to oversee these operations by USGS personnel as part of his responsibilities as Chairman of the Arctic Committee of the National Academy of Sciences and National Research Council's (NAS–NRC's) U.S. National Committee on the IGY.

What was the USGS doing, Kirwan then asked, "to reduce the amount of time it takes to complete projects"? In the Geologic Division, he noted, "84 of the present projects were started over 10 years ago; 6 projects are over 25 years old."[66] That problem, Nolan replied, involved two linked parts—the time required for field or laboratory work and the interval needed to write a report. Both considerations were affected by the line-itemized appropriations required before 1950 and the backlog created when researchers completed reports delayed by their contributions to the war effort. "The situation became acute about 2 years ago," Nolan continued, so "we made the first of a series of reorganizations designed to cut down and eventually eliminate this delay."[67] Nolan and Bradley transferred all the Geologic Division's illustrators to the Director's Office unit and then moved the combined unit to the Office of Publications. Nolan explained that the delays in processing reports reflected the differences in three principal types of projects, especially those involving repay or transfer funds: (1) continuing and long-term observations or compilations, like those at the HVO or for *Geophysical Abstracts*; (2) part-time efforts by managers, staff, and when-actually-employed academics, rather than full-time line personnel; and (3) personnel reassignments and resignations, or funding fluctuations. Changes already were in place, Nolan continued, to provide flexible periodic reviews of projects in their planned and time-limited successive stages. New procedures also governed the preparation of final reports (as compared to interim ones) to reduce the number of persons reviewing each report and the time required to get them to the printer; these changes would increase the speed of completion and publication "without sacrificing our technical standards."[68] Kirwan summarized by asking, "Do you think we will do better from here on?"[69] "I think," Nolan replied, "I can guarantee it."[70]

The subcommittee then focused on the two significant increases in the USGS request for fiscal year 1959–60: $500,000 for water-resources investigations, to match larger offerings from States and municipal agencies, and $150,000 for the ever-expanding workload in mineral-lease supervision. Half of the additional funds requested for the water-resources cooperative program would go to surface-water studies, $175,000 to groundwater investigations, and the remaining $75,000 to sediment and water-quality investigations. Nolan cited a recent study that expected water use in the United States to treble by 1980. Kirwan again raised the issue of the delay in reporting, citing that 25 of the 58 annual reports of streamflow data in 1957 and 1958 took 2 to 2.5 years to complete. Nolan responded by emphasizing that each district office made the weekly or bimonthly reports of raw data immediately available to cooperating government agencies and to industry. These records were used mostly by engineers in planning construction projects and were not needed for day-to-day operations. Nolan agreed that the USGS should make every effort to get out immediately the needed information. In subsequent discussions, Nolan assured Denton that USGS cooperative work on water resources with the Army Engineers and the Public Health Service did not conflict with their operations. When Denton asked about funding for studies of the States' areas not in the public domain, Nolan repeated his request for a water appropriation not restricted to the cooperative program, but no change was authorized. All but $25,000 of the $150,000 asked for mineral-lease supervision, Nolan continued, would support staffing at newly active areas, closer monitoring of the OCS leases in the Gulf of Mexico and off California, and greater capacity for royalty accounting. The 16 new personnel would be responsible for the 10,000 new oil and gas properties and wells expected to provide an additional $65 million in production and $8 million in royalties. Three additional people would help handle the work involving the estimated additional $25 million in minerals production and $1.8 million in royalties.

Kirwan closed his review with a query, later renewed by Thomson, about the intra-agency transfers and lack of uniformity in the assessment financing of USGS Division and Branch headquarters. Subcommittee investigators reported a shift of $100,000 for the Office of Public Inquiries from administration to program funds, after the subcommittee disallowed $90,000 for this purpose in the supplemental appropriation for fiscal year 1958–59. The USGS used none of the $1.5 million so received, Nolan responded, for that purpose. Kirwan then asked what was "being done to set up a more effective audit program,"[71] as recommended by the General Accounting Office's report for 1955 and required by the Budget and Accounting Act of 1921.[72] Marion E. Young, the USGS Chief Inspector since 1955, Nolan advised, continued to perform internal audits of agency officers, "under the cognizance of the staff coordinator [John Reed, Sr.], who has been designated the chief inspecting officer of the Survey. The Chief of each of the Divisions * * * has been designated as a deputy inspection officer for his Division."[73] Young, Nolan noted, was auditing the remaining 50 of the 200 USGS national, regional, and district offices. Nolan intended to ask each of the Division Chiefs to designate a person to assist Young's audits. Nolan already had changed USGS administrative procedures in response to Young's discovery of the continued charging of expenses to accounts on funds available rather than work performed and other questionable practices in approving travel vouchers, inventorying property, and utilizing excess property.

The House approved a $517,600 reduction in the USGS budget. Even with that loss, the agency's proposed appropriation increased by $3,585,000, including about $3,217,000 for costs required by the Federal Employees Salary Increase Act of 1955 and $150,000 for mineral-leasing supervision, compared to the total for fiscal year 1958–59. The House Committee on Appropriations decided to fund the cooperative water-resources investigations at slightly less than $7 million, the same level as in 1958–59.

The appropriations review then passed to Carl Hayden's Senate subcommittee, which also included new members. Four of them were Democrats—Alan H. Bible (NV), Robert C. Byrd (WV), Estes Kefauver (TN), and John McClellan (AR)—appointed after Spessard Holland and Warren Magnuson received other congressional assignments. Bible won a special election in November 1954 to fill the seat vacated by the death of Patrick McCarran; Bible defeated Ernest S. Brown, who had been appointed to the seat temporarily. Byrd served in the House during 1953–59 and in the Senate during 1959–2010. McClellan, who represented Arkansas in the House during 1935–39, before being elected to the Senate in 1942, now also chaired the latter's Committee on Government Operations. In the only change in the subcommittee's Republican membership, Thomas H. Kuchel (CA) won a special election in November 1954 to fill the seat vacated when Richard Nixon resigned to become Vice President. Kuchel, although the Minority Whip, attended the Senate subcommittee's hearings more frequently than Majority Leader Lyndon Johnson, the Chairman of the standing Committee on Aeronautical and Space Sciences, or Richard Russell, the Chairman of the Committee on Armed Services.

Seaton asked Hayden's Senate subcommittee on May 11, 1959, to restore the House's cuts of nearly $19.7 million from Interior's budget request for fiscal year 1959–60, including the reductions of $400,000 for the Office of Minerals Exploration and the elimination of the $500,000 increase requested for USGS cooperative investigations of water resources. Nolan addressed Hayden and six other members of the Senate subcommittee on May 18, but only Hayden queried Nolan. Hayden quickly reviewed the major activities, focusing on the request for water-resources investigations and especially on those in the Lower Colorado River Basin. The States, Nolan agreed, would be able to meet the larger figure requested by the USGS. They continued to require the "additional basic information on the availability and nature of water resources" and "to determine the significance of these basic data in relation to proposed developments."[74] Hayden, as before, thought it "imperative that we provide a matching dollar for every dollar that the States make available."[75] Hayden, for the legislators' better understanding, linked the need for streamflow records for planning water-storage projects to the USGS cooperative program with the States. In addition to the completed revisions of the 1:24,000 topographic maps of Kentucky's 40,400 square miles, Nolan reported map revisions underway in Connecticut, Massachusetts, and Rhode Island. Ohio, he added, proposed a 3-year cooperative program to complete the topographic mapping of that State that would provide up to $1 million to the USGS, and the agency quickly approved the agreement. If any part of the additional $500,000 requested for cooperative water-resources investigations was not matched by the States, Nolan assured Hayden that the remaining sum would not be expended for other purposes without

Congress' approval. Nor would the USGS, Nolan added, decrease its ongoing program in the Colorado River Basin. Two months earlier, Nolan also promised the Administrator of the Arizona Power Authority that the USGS would not deemphasize the collection of basic water data to concentrate on interpreting it. The Senate Appropriations Committee voted to restore the $500,000.

On June 23, 1959, Eisenhower signed Interior's appropriations bill for fiscal year 1959–60. The total monies included $42,350,000 in SIR funds for the USGS, of which $7,450,000 was available only for cooperative water-resources investigations with the States and their political subdivisions.[76] At the fiscal year's end, the USGS reported total obligations of slightly more than $65,328,000, of which about $42,037,000, or 64 percent (1 percent more than in 1958–59), represented SIR appropriations. The USGS also recorded an average total of 7,248 employees; 6,578 of them were permanent (the ceiling was 6,840) and 670, seasonal. Of the permanent employees, 2,122 were paid from reimbursable funds, as were 222 of the seasonal appointees. Of this total, 276 were support personnel employed outside the four program Divisions—256 in general administration and 20 in the soil- and moisture-conservation program. Other Federal agencies supplied about $12,363,000, or 19 percent, a loss of nearly $483,000. Nonfederal sources contributed almost $10,928,000, or 17 percent, a gain of about $1,302,000; all but almost $500,000 of this sum came from reimbursements and direct payments from States, counties, and municipalities.

During fiscal year 1959–60, Nolan acted to fulfill his promise to Kirwan to reform the USGS publication process, the agency dedicated its third building at Menlo Park, California, and it received from Interior additional support for consolidating USGS operations in the Washington metropolitan area in the long-sought new headquarters building. A Survey order, dated July 17, 1959 (effective July 1), established the Publications Division as the agency's sixth Division.[77] Publications Officer Robert Moravetz became the Chief of the new Division, which received the funds, personnel, and equipment of the Office of Publications and the Office of Texts from the Director's Office. These units joined three others—the Branch of Technical Illustrations, the Branch of Map Reproduction, and the Branch of Distribution—already shifted from the Topographic Division to the Director's Office. On November 24, 1959, Seaton, Nolan, Donald McLaughlin, other members of the USGS, representatives of the Federal, State, and local governments, and private citizens participated in the dedication of Building 3, the Western Mapping Center, at Menlo Park. The two-story building, encompassing 71,500 square feet and designed specifically by Robert O. Davis, the Pacific Region Engineer, and his staff for topographic-mapping operations, was constructed on Federal land and with Federal funds for $12 per square foot. Buildings 1 and 2 on the Menlo Park campus passed to the General Services Administration in 1960, as later did Building 3. The USGS also hoped to arrange for additional new buildings at Menlo Park that would house only the library or be shared by members of the Administrative, Geologic, Publications, and Water Resources Divisions.

To try to reach a higher priority goal, the USGS resumed its quest for a new national center. Under the 1949 statute, as amended in 1954 and 1956, the GSAd delegated to the Secretary of the Interior the authority to contract for studies of new facilities sought by the Department before the act lapsed in 1957. The Public Buildings Act[78] of September 9, 1959, gave the authority for all construction, alteration, or acquisition of Federal buildings to the GSAd's Administrator. On January 22, 1960, Seaton's Secretarial order redelegated a part of this authority to the USGS Director. Nolan could now "negotiate a contract for personal or professional services"[79] for a study of the USGS offices in some 20 buildings scattered throughout the Washington area between Arlington, Virginia, and Beltsville, Maryland. The contract study would gather the preliminary information required to design the proposed new centralized facility, whose floor space would be no less than 600,000 square feet.

For fiscal year 1959–60, the Geologic Division received total funds of $16,620,000, nearly $485,000 less than the previous year's total, for the salaries of and operations by its 1,600 employees, 110 fewer than in 1958–59. Of the Division's 1,490 permanent employees, 386 depended on reimbursable funds, as did 32 of the 110 seasonal employees. The Division's SIR appropriation of about $11,417,000 represented a gain of about $72,000, and monies from nonfederal sources, for investigations in 18 States and Puerto Rico, rose by more than $33,000 to $363,000. Funds from other Federal agencies fell by about $590,000 to about $4,839,000. The AEC transferred $1,746,000, a $470,000 decrease; the Army and its Engineers supplied about $1,290,000, or only $8,000 less; the ICA increased its funding by more than $38,000 to almost $1,145,000; and the NSF provided nearly $58,000, as William Rubey rejoined the National Science Board.

On July 1, 1959, Andy Anderson succeeded Bill Bradley as Chief Geologist (CG), after Nolan agreed to give Anderson 1 month each year to continue his field studies, the same arrangement Nolan secured from several Secretaries of the Interior. Bradley, after 15 years as CG, returned to research and the completion of his 1:250,000 geologic map of part of southwestern Wyoming and adjacent States; the *American Journal of Science* honored Bradley with a festschrift volume in 1960. Preston Cloud, Jr., James Gilluly, and Frank Whitmore, the Chiefs of 3 of the Division's 10 program Branches, also ended their tours on the same day that Anderson took over as Chief Geologist. Anderson and Nolan quickly began planning the first major reorganization of the Geologic Division since the reforms instituted after Bradley succeeded Gerald Loughlin as CG in 1944. John Reed (Sr.), the Chairman of the Arctic Committee, left Anderson's staff in 1960 to serve as Executive Director of the Arctic Institute of North America in Montreal; Reed also became an Honorary Lecturer at McGill University. Anderson brought George Gryc east from Menlo Park to replace Reed as staff geologist.

During fiscal year 1959–60, the USGS principal participants in Project Mohole—James Balsley, Harry Ladd, William Pecora,[80] William Rubey, and Joshua Tracey—drew the expected attention of the agency's Pick and Hammer Club. On April 29, 1960, the Club's annual show in Washington[81] presented the "d'Oily Cards" in "Last Weeks of the Association for the Advancement of Politics in Geology, or Mo-ho-ho and a Barrel of Funds." The players lampooned the American Association of Petroleum Geologists, black-box geophysicists (yet again), several USGS managers and their units, polar wandering and continental drift, and "oil in Araby."[82] The show closed with "No Moho, No Less,"[83] sung to the tune of 1933's "Flying Down to Rio," from the Fred Astaire-Ginger Rogers film of the same name, to urge a U.S. victory in this latest scientific-technological race with the Soviets. The players serenaded "Glibbly S. Bunkum, Chief of the Branch of Intolerable Phenomena,"[84] who led the show's deep-drilling project, with:

> **Yo-ho-ho, drilling to the Moho**
> **Drilling to the Moho through the muck and the slime**
> **Hey, Buster, let's get through the crust there**
> **Got to reach the Moho and we've got to make time**
> **We'll make it, for our rig can take it,**
> **Searching for the Moho 'way down under the ground.**
> **Send a Schlumberger to Moho 'neath the sea-oh**
> **For a gamma count to tell us what's**
> **The story there,**
> **We'll get there—**
> **So Moho, everything will soon show**
> **Un-con-form-i-ty that will be**
> **So profound.**[85]

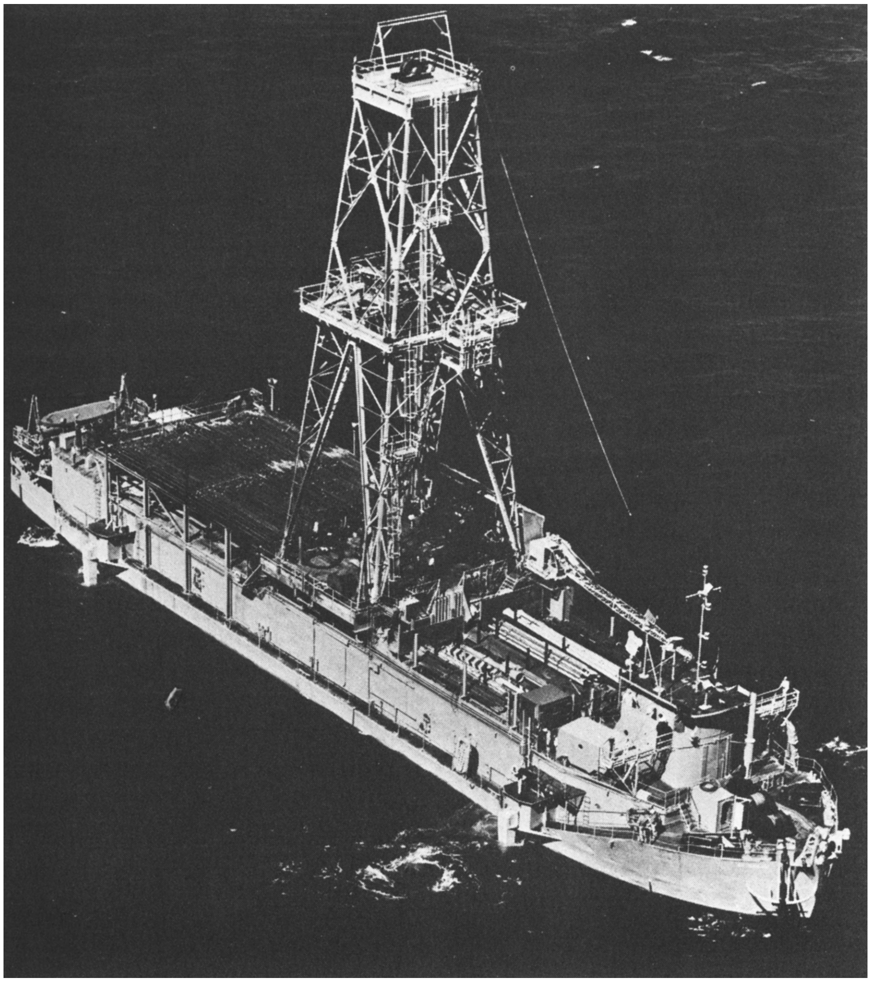
At last, in "Endothermic Research," set to college football's "Buckle down, Winsocky," the players pleaded that only Bunkum again could save them after they reached the Moho:

> **For the oil will flow**
> **And the gas will blow**
> **We will roll in dough**
> **If you will only plug the hole![86]**

By July 1960, in addition to Gordon Lill and Willard Bascom, the American Miscellaneous Society's (AMSOC's) Technical Director since 1959, the NAS–AMSOC group included William Heroy (Sr.), Harry Hess, Harry Ladd, Arthur Maxwell, Walter Munk, Roger Revelle, William Rubey, and Joshua Tracey. They were aided by two military liaisons, Lt. Colonel George Colchagoff and geographer Leonard S. Wilson, who led the Army Office of Research and Development's Environmental Sciences Division. Maurice Ewing resigned from AMSOC in April, once it became clear that the drilling tests would be done in the Pacific rather than in the Atlantic. On July 7, AMSOC added William Bates of Shell Oil, geophysicist-oceanographer John Hersey, and Captain Harold E. Saunders, a retired Navy hydrographer who served as a technical adviser to the Bureau of Ships and also chaired the U.S. Advisory Committee on Antarctic Names.

The NSF provided the NAS–NRC and John Adkins with $172,550 in fiscal year 1959–60 to support a year of experimental drilling in deep water and added to it $130,665 for 1960–61. The NSF sent an additional $8,700 to the USGS to fund the latter's cooperation during 1960–61 in the "Experimental Drilling Program (Project Mohole)."[87] The 14-member NAS–AMSOC now requested $1.25 million, a sum later increased to $1.8 million, from the NSF for Phase 1 of Project Mohole and received $1,364,000 during 1960–61, in addition to the funds provided to Adkins, now the Office of Naval Research's Assistant Chief Scientist. On December 23, 1960, the NSF awarded Global Marine Exploration Company nearly $736,000 for the modification in February 1961 of *CUSS I* at San Diego for drilling in March five preliminary holes to penetrate sediments more than 3,000 feet below the waters off La Jolla. To hold *CUSS I* on station, Bascom devised a new dynamic-positioning system that used four 200-horsepower outboard motors positioned in opposite pairs near the bow and stern, an array of radar and sonar buoys, and Sperry gyrocompasses. Bascom and some of AMSOC's staff planned to leave for San Diego on January 1. *CUSS I*, after refitting, would be towed late in March to the deeper well site, surveyed initially by William Menard and Russell Raitt, and then in more detail by Bascom. The site was in international waters about 220 miles southwest of San Diego and between Guadalupe Island and the west coast of Mexico's Baja California. There, the barge's drillers would attempt, while operating through about 11,700 feet of water, to penetrate and sample the sediments and the uppermost portion of the underlying crust.[88] If they succeeded, AMSOC members would have to decide whether to recommend modifying *CUSS I* or another existing barge for additional sediment-sampling holes elsewhere (to determine the oceans' age) and the Mohole (to identify compositional or crystal-structure changes at the interface) or to propose funds for building a new ship specially designed for those purposes.

Investigations by geologists in Warren Hobbs' Mineral Deposits Branch during fiscal year 1959–60 led to new discoveries of sedimentary iron ore in Arizona's Christmas area (in Gila County south of Globe) and a 200-foot-thick iron-bearing formation, north of Iron Mountain, in northwestern Michigan's Dickinson and Iron Counties. Branch members also recognized additional geologic guides to future exploration for lead, silver, and zinc in the Coeur d'Alene district in Idaho, metal deposits in the Butte area of Montana, and copper in Arizona's Pima district



A consortium of four oil companies—*C*ontinental, *U*nion, *S*hell, and *S*uperior—modified this U.S. Navy freight barge as a ocean drilling ship, renamed *CUSS I*, and used it in Project Mohole. USGS and other scientists helped to plan and establish Project Mohole, an American Miscellaneous Society effort supported by the National Academy of Sciences and funded by the National Science Foundation, to drill through the Earth's oceanic crust past the Mohorovicic discontinuity and investigate and sample the upper mantle. After preliminary drilling off La Jolla, California, in 1960, *CUSS I* was deployed and began operations early in 1961 at a site east of Mexico's Guadalupe Island and about 220 miles southwest of San Diego. There, at about 11,700 feet beneath the waves, the ship's drill rig returned cores from two holes from 100 to 600 feet below the ocean floor. Federal funding for Project Mohole ended in August 1966 before the crust-mantle interface was reached, but the technology used by the Project's participants and the results they obtained later made possible newer purpose-built ships like *Glomar Explorer* and *JOIDES Resolution* and worldwide sediment sampling by an academic consortium's Deep Sea Drilling Program and its successor, the Ocean Drilling Program. (National Science Foundation photograph, from Cochrane, 1978, figure on p. 561; also published on cover 1 of *Geotimes*, v. 5, no. 8, May–June 1961. For a portside view of the ship, taken from water level, see Bascom, 1961, pl. 6.)

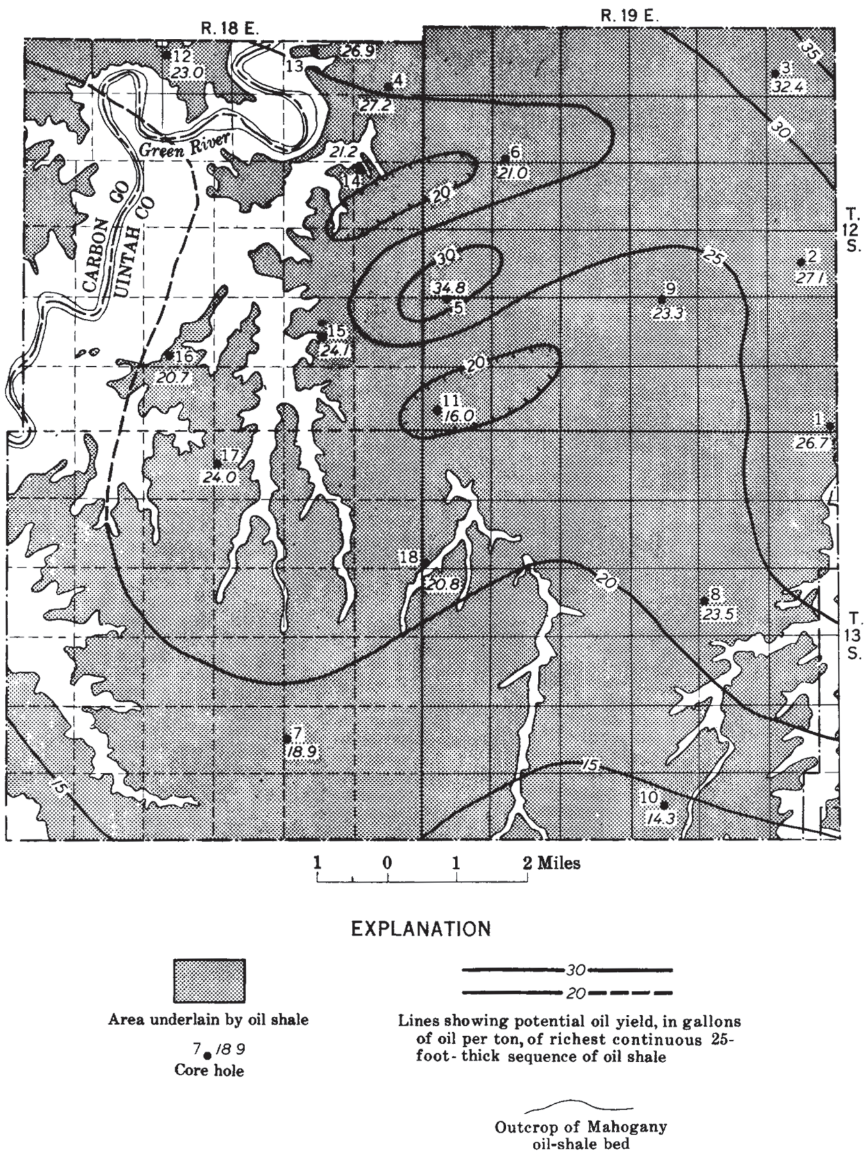
and in Michigan's Upper Peninsula. Their colleagues studied new mineral associations of beryllium-bearing minerals—bertrandite, beryl, and phenacite, all rather similar in physical appearance to feldspar and quartz—in association with fluorite and scheelite along vertical quartz veins in Nevada's Mount Wheeler Mine. They also identified beryllium in beryl and phenacite in bedrock samples from the Lost River Mine and the Cape Mountain and Ear Mountain areas in the tin district of Alaska's Seward Peninsula. Studies of clay beds in Maryland indicated that some of those deposits could be used as fire clays and others, called "bloating clays," in manufacturing lightweight concrete aggregate. Flint-clay deposits were mapped and investigated in northeastern Kentucky. Detailed investigations of uranium deposits in Arizona's Gila County, New Mexico's Ambrosia Lake, South Dakota's southern Black Hills, several basins in Wyoming, and Texas' Palagana salt dome produced data on local conditions during ore deposition and defined new targets for exploration. Uranium studies also concentrated on coals in northwestern South Dakota's Cave Hills area. This and related work on other coals in Idaho, Montana, New Mexico, North Dakota, and Wyoming better defined these uranium bearers as low-rank, high-ash, volcanic-material-laden coals, whose uranium content increased toward fractures, permeable layers, or other groundwater conduits. The concept that circulating groundwater leached uranium from the volcanic materials and deposited it in the coals led to discovering several uranium-bearing lignites and determining additional new areas for exploration. Richard Fischer discussed the vanadium-uranium deposits, mapped at 1:31,680, of the Rifle Creek area in

Colorado, and Richard Sheldon recorded the geochemistry of uranium in the Phosphoria Formation's phosphorites and black shales. Some of their colleagues completed a survey of strategic graphite.

Thomas Hendricks succeeded James Gilluly as Chief of the Fuels Branch on July 1, 1959. During fiscal year 1959–60, George Gryc, Don Miller, and Thomas Payne completed the delineation (at 1:2,500,000) of 22 possible petroleum provinces in Alaska—6 in the southern part of the new State, 3 pre-Cenozoic and 10 Cenozoic provinces in the State's central portion, and 3 in the northern part of the State.[89] A USGS team led by William B. Cashion published the results[90] of their geologic mapping, stratigraphic studies, and drill-core analyses (done in 1953–54) of Naval Oil Shale Reserve No. 2 (NOSR–2), an area of 140 square miles on the southern flank of the Uinta Basin in northeastern Utah. This work extended evaluations made during 1913–49 of the three NOSRs, including No. 1 and No. 3 in Colorado. Cashion reported two oil-shale zones in the Green River Formation that reached their maximum thickness in NOSR–2's northeastern portion; the larger of them, covering more than 110 square miles, averaged an estimated 15 gallons of oil per ton and held a total estimated reserve of 3.8 billion barrels. Physicist Gerald W. Johnson, who ended his tour as the head of the Lawrence Radiation Laboratory's Test Division in 1959 to become that Lab's Associate Director for Tests and Peaceful Applications, suggested that nuclear devices be detonated to extract the oil shales in the NOSRs. In an overview of U.S. black shales, Vernon E. Swanson assessed their oil yield and uranium content. At the end of the fiscal year, some parts of the petroleum industry remained concerned about an oil surplus. Editorials published in the *Oil and Gas Journal* and other industry periodicals suggested ways and means to end oversupply, especially by restraining flush production, coordinating supply and demand, and enacting modern conservation legislation. Paul Averitt and his colleagues finished their latest estimate of U.S. coal reserves; they concluded that some 1,660 billion tons remained in the ground, of which about half seemed recoverable. They also prepared studies of coal fields and areas in Kenai in Alaska, Mesa Verde and Trinidad in Colorado, Square Buttes in western North Dakota, southern Knob Terrace in Utah, and southwestern Washington.

By fiscal year 1959–60, members of William Pecora's Geochemistry and Petrology Branch regularly determined by rapid analytical methods the trace amounts of more than 20 diagnostic elements.[91] They also demonstrated their improved ability to help to predict and assess volcanic eruptions. These scientists developed new techniques for using resin collectors to determine the molybdenum and other ionic contents of natural waters. They also perfected methods and instruments to analyze the trace amounts of antimony, arsenic, and mercury in vegetation and a fluorometric procedure to identify concentrations of 1 to 10 parts per million of beryllium in rocks. Helen Cannon recorded the development

The oil shales shown in this 1916 photograph of strata in the Green River Formation (Eocene) occupy the north side of Argyle Canyon in Carbon County in northeastern Utah. The richer oil shales form the dark horizontal band in the middle of the canyon's side and are separated by lighter colored shales from a second oil-shale sequence about 1,000 feet below. In 1913–25, geologist Dean E. Winchester and his USGS colleagues originally mapped (at 1:250,000) Naval Oil Shale Reserve No. 2 (NOSR–2) and areas in the surrounding Uinta Basin that contained oil shales as future sources of fuel. The strata shown here occupy an area about 30 miles west of NOSR–2, which was just east of the Green River. USGS geologists remapped NOSR–2 at a larger scale during 1949–54. In 2000–2001, the U.S. Department of Energy returned the undeveloped NOSR–2 to the Northern Ute Indian Tribe. (Photograph from Winchester, 1919, pl. VIIA; also available as three separate images in the USGS Denver Library Photographic Collection as Winchester, D.E., winc0434, winc0435, and winc0436, https://www.sciencebase.gov/catalog/item/51ddd366e4b0f72b44721fa8, https://www.sciencebase.gov/catalog/item/51ddd368e4b0f72b44721faa, and https://www.sciencebase.gov/catalog/item/51ddd369e4b0f72b44721fac.)



This map (originally at 1 inch = 1.8 miles) portrays the potential oil yield for the richest continuous 25-foot-thick sequence of oil shale in Naval Oil Shale Reserve No. 2 (NOSR–2) in northeastern Utah. Partly to support the U.S. Bureau of Mines' work on synthetic fuels, USGS geologists returned after World War II to field studies of oil shales in the Green River Formation (Eocene) of western Colorado and adjacent Utah. USGS geologist William Cashion and his colleagues extended work completed by Dean Winchester and other USGS geologists during 1913–25 in the Uinta Basin that included the 140 squares miles of NOSR–2. During 1949–54, the USGS team mapped in detail the geology of NOSR–2 and assessed samples from 18 diamond-drill cores. They delineated principal oil-shale sequences 15 and 25 feet thick with estimated yields of 15–30 gallons of oil per ton. (From Cashion, 1959, fig. 39.)

of botanical methods for uranium prospecting on the Colorado Plateau. In field studies, scientists continued to gather data on plant ecology and geomorphology that showed systematic relationships among plant type, soil composition, topographic form, and water availability. Investigations in the Potomac Basin indicated that its present landscape was formed by lengthy erosion under conditions similar to present ones rather than through erosion-cycles that generate peneplains. Studies of beta-spodumene showed that the lithium-silicate mineral shrank when heated and swelled when cooled; adding it to ceramic materials facilitated molding precise forms that retained their exact sizes after firing. Studies of deuterium aided investigations of mineral formation and ocean currents. Analyses of liquids from minute bubbles in fluorite deposits in Illinois showed that early-formed minerals contained fluids similar to waters normally present at that locality but later-formed minerals held fluids containing progressively less deuterium. Samples of water originating in Antarctica were found to contain 1 percent less deuterium than those from other oceans. Investigations in Pecora's and other Branches were aided by the acquisition or development of an electron microprobe X-ray analyzer (to identify minerals), a heating stage for the X-ray diffractometer, and a cooling cell for microscopically studying temperature effects in fluid inclusions in minerals.

Earle Cressman, of the USGS, and Martin C. Noger, of the Kentucky Geological Survey (KGS), later described how in 1959 Kentucky's Government and its agencies began planning with the Geologic Division and General Geology Branch to cooperate in geologically mapping the Bluegrass State, using as bases the topographic maps of 707 quadrangles recently completed at 1:24,000 by the Topographic Division.[92] The Kentucky Society of Professional Engineers' resolution of February 21, 1959, urging this new cooperative mapping was well received by Kentucky's Governor Albert B. ("Happy") Chandler and the State's Legislative Research Commission, its Department of Economic Development, its Chamber of Commerce, and its Geological Survey. In March, Wallace W. Hagan, the State Geologist and Director of the KGS since 1958, and now also Governor Chandler's representative to the Interstate Oil Compact Commission, suggested this additional cooperative effort to USGS Director Nolan. Hagan, at Nolan's request, tested USGS interest in conversations with Associate Director Baker and Chief Geologist Bradley in April. Hagan then gained formal approval from his advisory board, the State Government, the University of Kentucky, the Chamber of Commerce, and several State geological societies, railroads, and mineral-industry companies. In Washington, during July 10–17, 1959, Hagan, Nolan, and other members of the USGS worked up a preliminary agreement. They would seek funds for a 10-year effort, costing an estimated $12 million, to begin in fiscal year 1960–61. The State and Federal Governments each hoped to supply $300,000 to fund that year's operations and to provide an additional $600,000 each during fiscal 1961–62.

Other members of the General Geology Branch continued to map and investigate areas and ore deposits nationwide during fiscal year 1959–60. This effort included the Leesburg area in Idaho, the Merced Peak area in California, and the uranium-mineralization area in Wyoming's Shirley Basin. Additional studies continued, in cooperation with other Division scientists, of batholiths in the Cascade Range, the Sierra Nevada, and the Front Range; the Idaho Batholith; and Montana's Boulder Batholith.

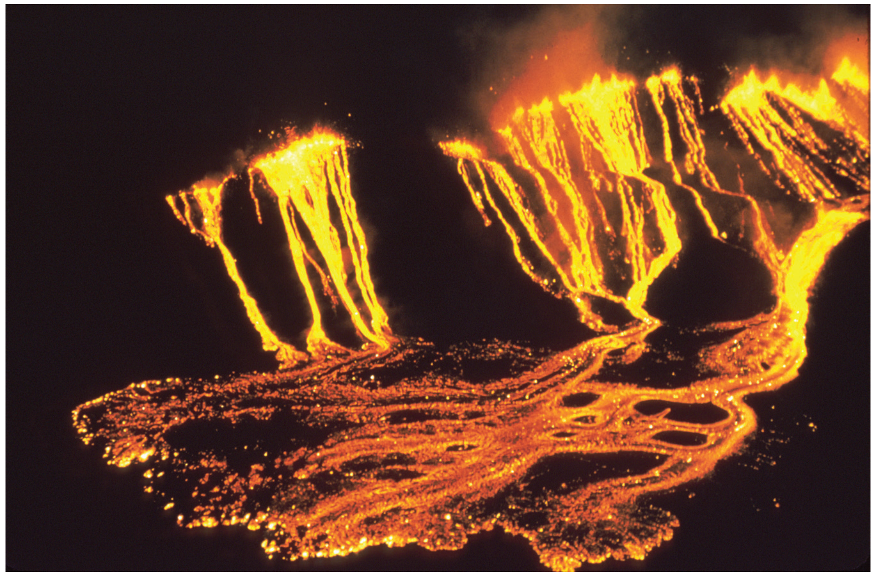
At 11:39 p.m. on August 17, 1959, a magnitude 7.3 earthquake struck the Madison Canyon area west of the Hebgen Dam and Lake area in southwestern Montana, slightly less than 20 miles northwest of West Yellowstone. The shallow-focus quake, measured in Pasadena and the largest yet recorded in Montana, was felt over an area of 600,000 square miles. Structural damage and faulting, respectively, received intensity values of VII and X. The shock reactivated large and small faults, yielding new scarps of up to 20 feet high, tilted the floor of Hebgen Lake and dropped it 22 feet, changed the groundwater regime, and caused landslides, rockfalls, and rock avalanches. The quake moved 37 million cubic yards of material in 1 minute into Madison Canyon to dam its river at a point 6 miles below Hebgen Lake. That debris left 26 persons dead or missing in the area's campgrounds; rockfalls killed 2 others 15 miles west of Hebgen Lake. Debris and subsidence from the main shock and the 1,300 aftershocks, of magnitude 5.75 to 6.5, which occurred at 5-minute intervals thereafter, affected an area of nearly 380 square miles, from which the U.S. Forest Service rescued more than 200 other persons. The quake damaged property valued at $11 million. Hebgen Dam, completed in 1915, was damaged but held. Water topped the quake-caused earthen dam on September 10, but the Army Engineers built a spillway a half-mile long and 200 feet wide to drain the earthquake lake, then 6 miles long and 190 feet deep.

At the time the Hebgen Lake earthquake occurred, two USGS geologic parties were in the area participating in the ongoing program of investigating Cenozoic tectonism in southwestern Montana, western Wyoming, and eastern Idaho. Irving Witkind, Jack B. Epstein, and Epstein's geologist-wife Anita G. Epstein (later Harris), who mapped the complex structures on the east flank of the southern Madison Range, were encamped above Hebgen Lake. Witkind, a stratigrapher and structural geologist with the USGS since 1946, co-compiled the 1955 geologic map

This view looks southwest toward the Madison Canyon landslide and earthquake lake on August 21, 1959, before the latter was drained by the Army Engineers. The magnitude 7.3 Hebgen Lake earthquake that struck the Madison Canyon area in southwestern Montana on August 17 reactivated large and small faults, changed the groundwater regime, and caused landslides, rockfalls, and rock avalanches. The quake moved 37 million cubic yards of material in 1 minute into Madison Canyon to dam its river at a point 6 miles below Hebgen Lake and leave 26 people dead or missing. The results of the main shock and the 1,300 aftershocks affected an area of nearly 380 square miles, from which more 200 other persons were rescued, and where damaged property was valued at $11 million. USGS scientists joined Federal colleagues from the U.S. Forest Service, the National Park Service, and the U.S. Coast and Geodetic Survey in conducting intensive studies, organized by USGS geologist Charles Hunt, of the Hebgen Lake earthquake's geology, hydrology, and seismology. Preliminary reports began appearing on September 16, 1959, and continued into 1962; the combined and comprehensive analysis followed in 1964. (From U.S. Geological Survey, 1964b, frontispiece).

of Montana. The second group, led by Jarvis B. ("Jerry") Hadley, who mapped parts of the Appalachians for the USGS during 1944–50, was quartered about 50 miles to the northwest near Ennis and west of the north end of the Madison Range. Witkind, Hadley, and their Montana teammates were soon joined by George Fraser, Warren Hamilton, Bradley Myers, Frank Swenson, and other USGS geologists, geophysicists, and hydrologists, for a total of 25 such specialists; they began intensive studies, organized by Charles Hunt, of the effects of the Hebgen Lake earthquake and its aftershocks. The USGS scientists, and personnel from the U.S. Coast and Geodetic Survey (USCGS), the U.S. Forest Service (USFS), and the National Park Service (NPS), joined in these and related studies and in planning a comprehensive report on the quake's geology, hydrology, and seismology. Their investigations included epicenters and foci; faults and scarps, landslides, earthflows and rockfalls, and other ground responses; wave motions, regional seismicity, and seismic history; effects on surface waters and groundwaters, especially chemistry, movement, sediments, and springs; and damage to structures. The USCGS issued a preliminary report on September 16; USGS and other initial reports began appearing in print in October and continued into 1962.[93] The USGS published a combined and comprehensive analysis as its Professional Paper 435 in 1964.[94]

During fiscal year 1959–60, maps and charts continued to appear in the USGS series of Coal Investigations (C) Maps and Charts, Geologic Quadrangle (GQ) Maps, Geophysical Investigations (GP) Maps, Hydrologic Investigations Atlases (HA), Mineral Investigations Field Studies (MF) Maps, Mineral Investigations Resource (MR) Maps, Miscellaneous Geologic Investigations (I) Maps, and Oil and Gas Investigations Charts (OC) and Maps (OM). One of the new I-Maps was being compiled by Dallas L. Peck (and published at 1:500,000 in 1961 as I–325) to



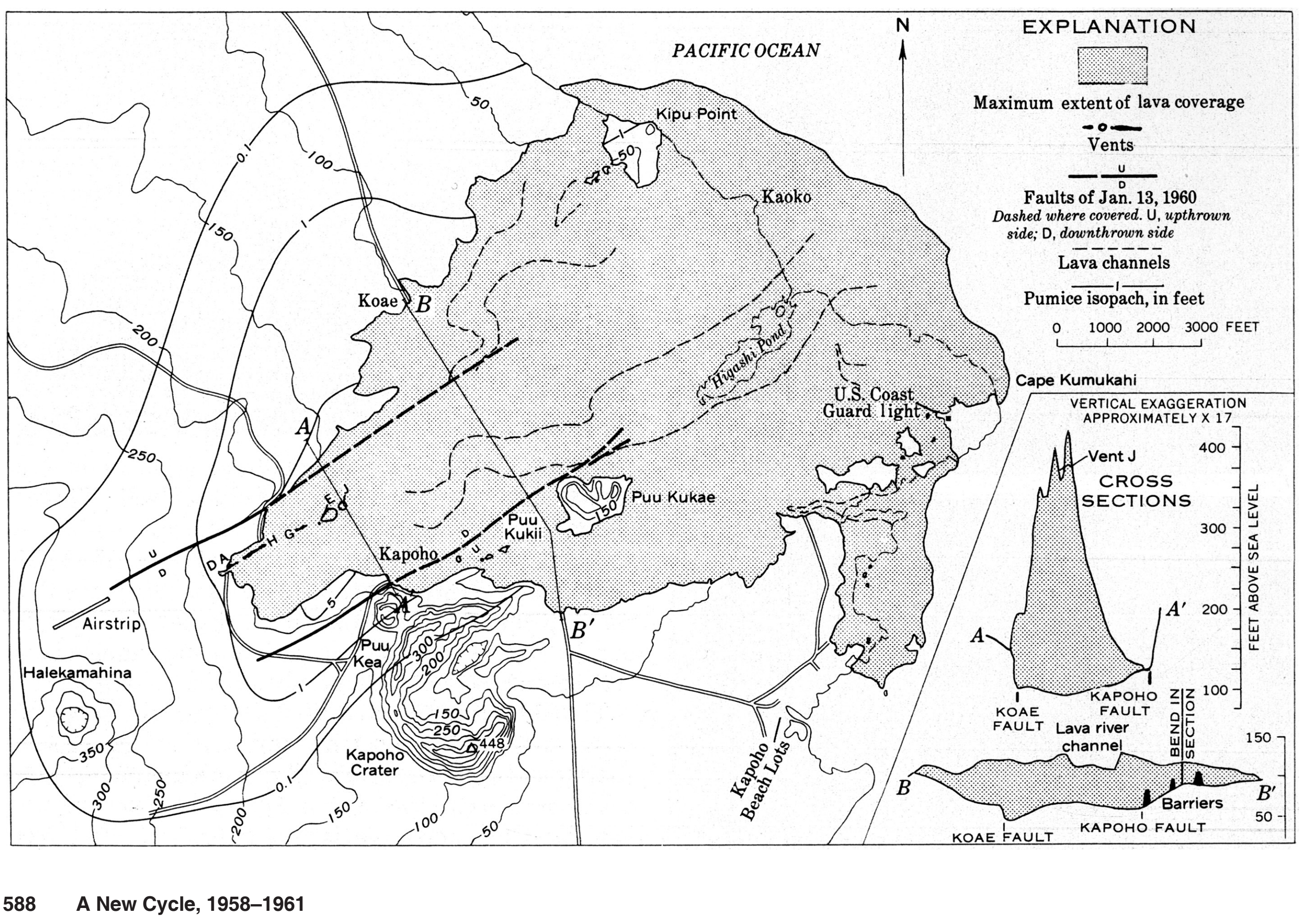
This photograph of fountaining lava, taken from the Byron Ridge overlook, shows the view west toward Kilauea Iki, a collapse (pit) crater on the eastern side of Kilauea Caldera, on the Island of Hawaii. Kilauea Iki began erupting lava during shortly after 8 p.m. (Hawaiian time) on November 14, 1959. Scientists at the USGS Hawaiian Volcano Observatory (HVO), on the opposite side of Kilauea, quickly began taking photographs and making preliminary observations, which were supplemented later by detailed geochemical, petrological, and seismic studies. (Photograph from the USGS Denver Library Photographic Collection as hvo00022, https://www.sciencebase.gov/catalog/item/51dc7973e4b097e4d3838902; published as a black-and-white image in Richter and others, 1970, fig. 5, middle.)

show the geology of Oregon west of the 121st meridian, an area from just east of Bend to the Pacific coast. Peck was trained by Richard Jahns at Caltech; joined the USGS in 1951, while still a graduate student; worked with Paul Bateman, Ogden L. Tweto, and Francis Wells; and earned a Ph.D. with Marland Billings at Harvard in 1960. That year, the last of another series of I-Maps completed the photogeologic coverage at 1:24,000, issued since 1954 as part of the Colorado Plateau Project, of quadrangles in Utah and adjacent parts of Arizona, Colorado, New Mexico, and Wyoming. Robert Detterman, Robert Hackman, William Hemphill, Allan Kover, Robert Morris, Charles L. Pillmore, John S. Pomeroy, John C. Reed, Jr., and their colleagues prepared these maps. No map in any of these topical series, as opposed to those topographic, included areas on the Hawaiian Islands. There, on the main island of Hawaii, Kilauea Iki erupted on November 14, 1959.[95] Scientists at the Hawaiian Volcano Observatory, using data from the new portable tiltmeter system and the seismic array, detected the coming eruption and issued an alert. The fire-fountain eruption continued through February 1960. Although the resulting lava flow devastated a large area near the village of Kapoho, no lives were lost.

Specialists in Edwin B. Eckel's Engineering Geology Branch continued during fiscal year 1959–60 their cooperative work, with members of the General Geology, Geophysics, and other Branches, toward assessing sites for dams, selecting locations for and evaluating the effects of underground nuclear tests, and analyzing the potential hazards and actual results of earthquakes and landslides, especially in urban areas. Eckel discussed in print the opportunities for and responsibilities of earth scientists in those nuclear years. Examinations by Branch members at Devils Canyon, some 125 miles north of Anchorage, led to shifting the dam site 100 feet upstream to avoid a shear zone in the wall rocks and also to relocating the spillway site to reduce construction costs by using a newly found preglacial valley. Louis Currier applied seismic methods in subsurface examinations of sites for highways and building foundations in Massachusetts. William H. Diment and the members of his project at the Nevada Test Site continued to advise the AEC on aspects of the work done before and after the underground nuclear tests. Diment and his team studied the local geology and structure, especially the properties of tuff, and examined the effects of seismic shock and high temperatures and pressures on the rocks. These investigations and their analyses of methods of detecting such tests led to a crustal-refraction study, a seismic-scaling law, and a comparison of the seismic signatures of the tests and the Hebgen aftershocks. Harvard-trained Diment also wrote the proposal sent to ARPA that led to funding for Louis Pakiser's future

Crustal Studies Branch. For the AEC, members of Eckel's and other Branches in the Geologic Division, aided by geohydrologists from the Water Resources Division, continued studies of radioactive-waste disposal.

During fiscal year 1959–60, members of James Balsley's Geophysics Branch continued or began new experimental and related investigations of the physical properties of rocks—deformation, electrical, magnetic, mechanical, optical, thermal, and thermodynamic—to aid explanations of empirical observations. A new map, at about 1:937,500 (with contours at 50 and 250 gammas), by Balsley, Randolph ("Bill") Bromery, and Kenneth Emery, showed the results of their airborne magnetometer reconnaissance off California. Density analyses of more than 2,000 samples from the Los Angeles area helped to integrate surface and subsurface geologic mapping with gravity surveys by facilitating a compartmentalized lithodensity model used to calculate the residual regional gravity gradient that showed the area's crust thickening landward. Recent drilling and seismic surveys in three locations in Indiana confirmed John Henderson, Jr., and Isidore Zietz's predictions in 1958 of the depths to Precambrian basement rocks. Harold James' team published a 1:24,000 map of the geology and layered magnetic rocks in northern Michigan's Iron River-Crystal Falls district. A second aeromagnetic map (coauthored by Bromery) interpreted the data gained during the survey of the 1:24,000 Allentown quadrangle that covered parts of three counties in Pennsylvania. Airborne-radioactivity surveys continued to aid geologic mapping, especially in areas of poor exposures and low surface relief in Maine, Michigan, and Virginia. Small differences in radioactive-mineral content distinguished specific rocks; felsic (acidic) igneous rock and shales were more generally radioactive than mafic (basic) igneous rocks and carbonates. Trials with electrical-resistivity and induced-polarization

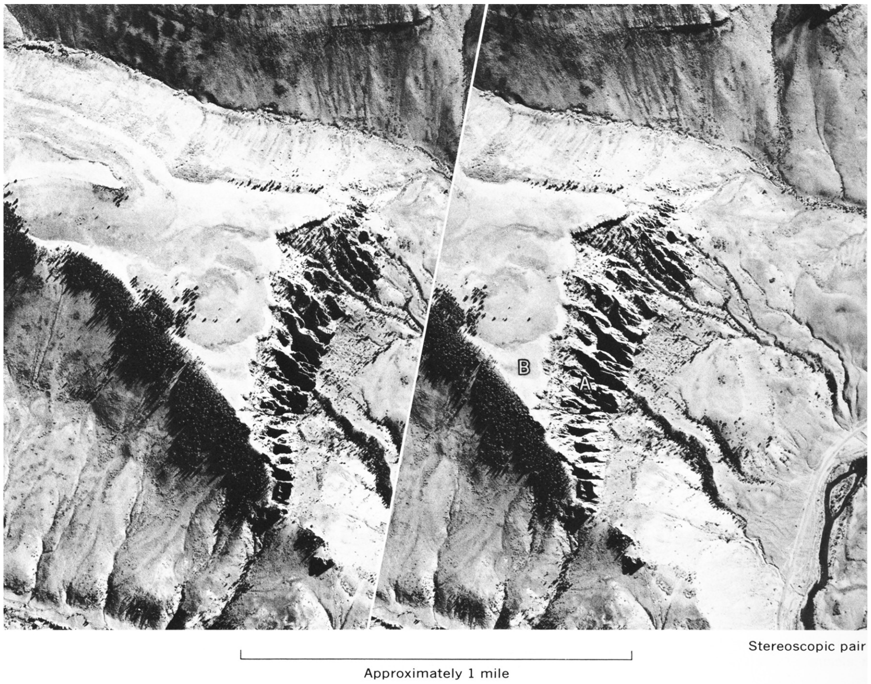


This map (originally at about 1 inch = 3,600 feet) shows the maximum area covered by lava and the thickness of the pumice blanket from the eruption of Kilauea Iki in 1959–60. Lava covered Kilauea Iki's crater, and pumice blanketed an elliptical area that extended more than 2 miles to the southwest when flows ended on December 20, 1959. A flank eruption began to the southeast of Kilauea Iki at the eastern end of the East Rift Zone near the village of Kapoho on January 14, 1960. When activity ended on February 18, lava and pumice covered 2,750 acres of land, two villages, and a U.S. Coast Guard station, but no lives were lost. (Map from Richter and others, 1970, fig. 75.)

This 1960 photograph shows USGS geophysicist Randolph Wilson ("Bill") Bromery (1926–2013) inspecting the magnetic-detector unit (or "bird") of the agency's C–53D aircraft (N19924) on the flight line at Washington National (now Reagan Washington National) Airport. Bromery flew with the Tuskegee Airmen in World War II and joined the USGS in 1948. He rose to lead a field team, then a project, and later planned and supervised the USGS geophysical program in the Eastern United States. During those years he earned degrees at Howard and American Universities and began work on a Ph.D. at Johns Hopkins University. Bromery left the USGS in 1967 for teaching and then administrative posts at the University of Massachusetts at Amherst. (Photograph from the USGS Denver Library Photographic Collection as Patterson, E.F., pef00756, https://www.sciencebase.gov/catalog/item/51dda0bae4b0f72b4471ddcf; published in Yochelson and Nelson, C.M., 1979, p. 35).

methods in Maine, Michigan, and Virginia advanced the geologic mapping of metamorphic rocks buried under alluvial or glacial deposits. Induced-polarization studies helped searches for low-grade metallic ores not concentrated enough to produce other electrical, gravity, or magnetic anomalies; under favorable conditions, measurements aided estimates of grade as well as location. The Branch acquired a new instrument that converted seismic observations into numerical form for more rapid encoding in its electronic computers. Branch scientists, in cooperation with colleagues elsewhere in the Geologic and Water Resources Divisions, continued, with AEC support, to study montmorillonite, vermiculite, and other clay minerals to determine their ability to retain cesium, strontium, or other high-level radioactive wastes by ion exchange, absorption, or other processes. They also investigated deep sedimentary basins that might safely store injected liquid radioactive wastes and determined the natural background radioactivity of many areas proposed for nuclear installations. A joint study with the National Cancer Institute and Maryland's Washington County Health Department determined the distribution of the county's natural radioactivity. Investigations of the magnetic susceptibility of rocks yielded a measurable difference between cancerous and noncancerous tissue from both animals and humans, perhaps due to iron depletion in the former group.

During fiscal year 1959–60, members of George Gates' Alaskan Geology Branch again aided their colleagues in Eckel's Branch while continuing their own mapping and related studies. For William Fischer's Photogrammetry Section, the results of isopach mapping by Irving Witkind, William Hemphill, Charles Pillmore, and Robert Morris that used photogeologic methods in the Monument Valley area of Arizona appeared as the fourth of four parts. The fourth part demonstrated the application of procedures and stereoscopic instruments described in the initial three parts, during 1956–58, by Hemphill, Richard Ray, and Pillmore.[96] Ray also completed a longer discussion of the use of aerial photographs in geologic interpretation and mapping. Samuel Keller and Hillard Reiser described the geology of the Mount Katmai area, and David Hopkins published a preliminary history of the Bering land bridge that alternately was submerged or exposed to link Alaska and Chukotka during the Cenozoic. An interpretation by John Reed (Sr.) of the geology of the Mount McKinley quadrangle (at 1:250,000) was published in 1961.



In this stereopair view (originally at about 1:20,000) of an area of flat-lying igneous rocks in Colorado, a harder and more resistant welded tuff (B) caps a softer and well-dissected pyroclastic unit (A). USGS and petroleum-industry geologists increasingly used stereoscopes, stereometers, and plotters to analyze aerial photographs and explore large areas in less time than the longer intervals required for traditional fieldwork. Successful photogeology required developing skills in recognizing the colors, patterns, shapes, sizes, textures, and tones that indicated sharp or subtle changes in geologic regimes. Whenever possible, initial results were checked by observations on the ground. Many of the maps in the new Geologic Quadrangle (GQ) series, which the USGS began issuing in 1949, were based on photogeologic methods. (From Ray, 1960, fig. 39.)

Edward H. Cobb, who entered the Branch in 1946, completed four Mineral Investigations Resource Maps, MR–8 through MR–11, at 1:2,500,000, that summarized the known occurrences of antimony, bismuth, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, platinum, tin, tungsten, and zinc in Alaska.

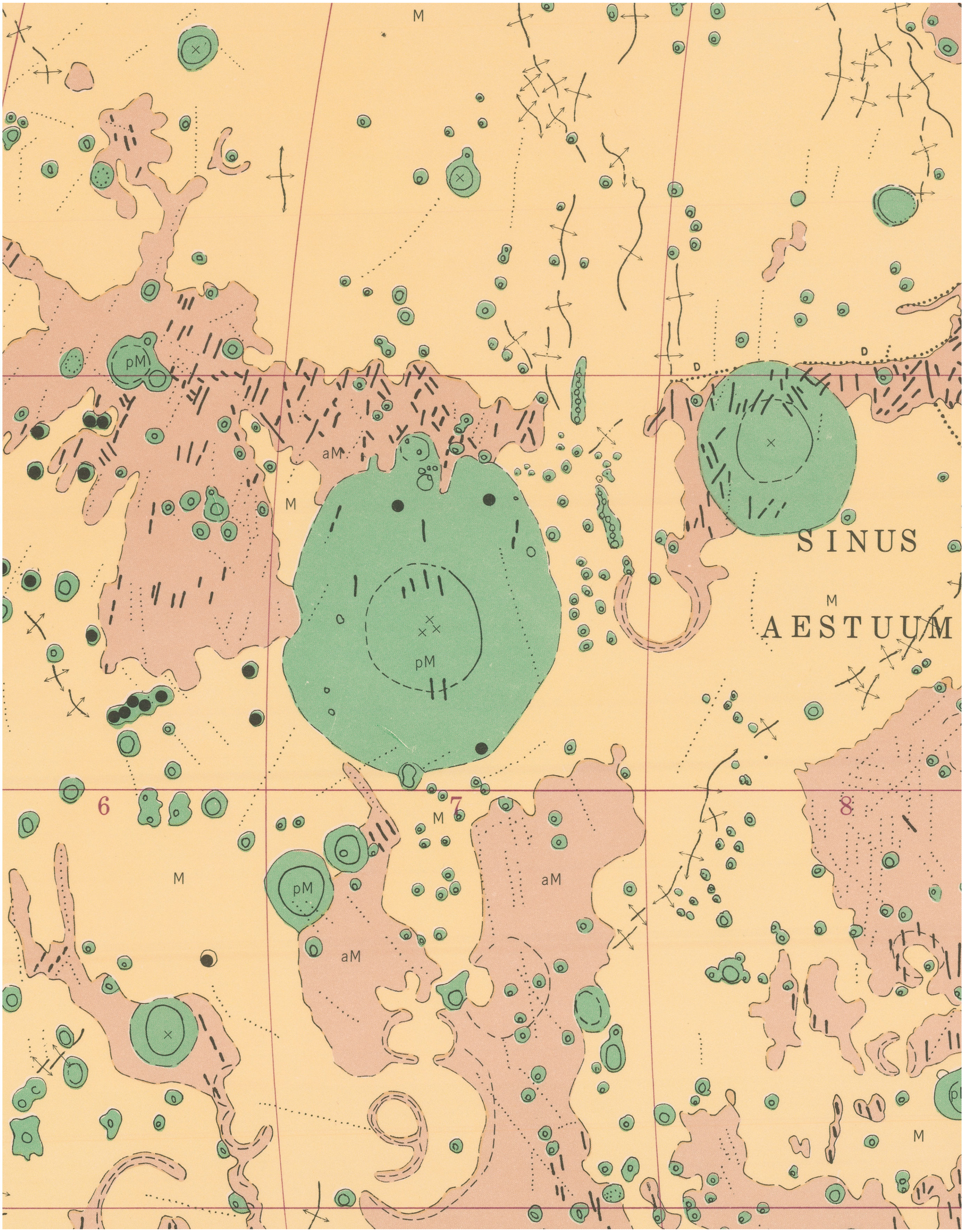
On July 1, 1959, Charles Merriam succeeded Preston Cloud as Chief of the Branch of Paleontology and Stratigraphy as Cloud joined Anderson's staff. There, Cloud promoted marine geology,[97] especially studies of marine carbonates, before leaving to become a professor at the University of Minnesota in 1961. Cloud directed the large increase in the Branch's staff and work; during Cloud's decade as Chief, its staff grew from 15 to 60 people, and the scope of its research and service to other units similarly expanded. Work continued toward completing the paleotectonic atlas of the Permian. The Branch gained a new member when Frank Whitmore ended his 13 years as Chief of the Military Geology Branch[98] on July 1, 1959, and returned to research on Cenozoic vertebrate biostratigraphy, especially that of whales and other marine mammals. Donald Dow succeeded Whitmore as Chief of the MGB, and Roy Kepferle replaced Gilbert Corwin as head of the Branch's Pacific Geologic Mapping Program. Kepferle principally oversaw the preparation of the program's remaining island reports and miscellaneous studies. He served until the program ended and all but one of its remaining reports appeared in 1960; the water-supply supplement to the report on Guam was issued in 1962. Also in 1960, the MGB completed the last of the Ragmanko Project's 149 geologic maps (at 1:250,000), begun in 1955, of Korea, the Kurile Islands, Manchuria, and Sakhalin. That project's second phase produced 17 same-scale maps of the PRC's southern coast, likely with the aid of both existing maps and the U–2 and other new aerial photography.

The preparation of maps to support, directly or indirectly, NASA's lunar program continued during fiscal year 1959–60. The Air Force's Aeronautical Chart and Information Center (ACIC) at St. Louis, led by Robert W. Carder, kept its lunar atlas[99] secret from the Army Map Service, which continued to support USGS efforts by Robert Hackman's group in Donald Dow's Military Geology Branch. The USAF's ACIC published in February 1960 the initial 1:1,000,000 sheet of its lunar astronomical charts, airbrushed by photogrammetrist Patricia M. Bridges, who later joined the USGS. The compilations by Hackman and Arnold Mason also drew on visual interpretations that they and others made by using the telescopes at three observatories— Leander McCormick, at the University of Virginia in Charlottesville; Naval, at Flagstaff, Arizona; and Yerkes at Williams Bay, Wisconsin. Hackman used surface reflectivity and regularity or irregularity of terrain features in compiling their relative ages on the lunar base prepared by the ACIC. The AMS published Hackman's map in July 1960. A revised version, the "Generalized Photo-geologic Map of the Moon," at about 1:3,800,000, appeared in 1961 as sheet 1 of the 4-sheet Engineer Special Study of the Surface of the Moon that was published as USGS Miscellaneous Geologic Investigations Map I–351.[100] Hackman portrayed thereon the lunar "seas" and highlands (uplands) by using three stratigraphic units. From older to younger, they included pre-maria, maria, and post-maria rocks. These units conformed in sequence, but not in origin, to Kuiper's three divisions and emphasized impact origins for craters and volcanic origins for maria. Wilhelms later called Hackman's cartography the "first modern lunar geologic map based on stratigraphic principles."[101] Additional sheets of Map I–351 depicted (2) "Lunar Rays," by Hackman; (3) "Physiographic Divisions of the Moon," by Hackman and Mason; and (4) "Description and Evaluation of the Physiographic Regions," by Mason and Hackman. This work led directly to a 26-page engineer study of the Moon's Kepler quadrangle as MGB Miscellaneous Paper 223 in 1961. Mason, bedeviled by influences both personal and professional, died by his own hand that October.

Gene Shoemaker studied impact craters and their mineral products on Earth, under the influence of earlier published and unpublished work by David Griggs, Edward Teller, Harry Hess, and others. In October 1959, Shoemaker, at the invitation of Kuiper, who was studying Crater Tycho, joined Robert Dietz, Robert Hackman, Arnold Mason, and Annabel Olson at the McDonald Observatory, northwest of Fort Davis, Texas. While there, they also looked at the complex and "cryptovolcanic" Sierra Madera crater, and Dietz found mineral evidence for its impact origin. Shoemaker also encouraged Edward Chao and other colleagues to work on these topics and on tektites, to which some geologists, but not Urey, assigned a lunar origin.

Chao, born in Soochow (Suzhou), some 50 miles west of Shanghai, worked for the Geological Survey of China in Szechuan, came to the United States in 1945, earned a doctorate in geology at Chicago in 1948, joined the USGS in 1949, and was naturalized in 1955. Initially, Chao worked on engineering geology in the MGB, where he prepared 1:250,000 lithologic maps of North Korea and, with William Davies, studied Mammoth Cave's sediments for the National Park Service. Chao shifted to the Branch of Geochemistry and Petrology in 1956, where he studied silicate minerals from the Green River Formation for Charles Milton and contributed estimates of zirconium and other elements in the Earth's crust to studies of geochemistry by Michael Fleischer. In May 1960, Chao began studies of the origin of tektites and "impactites," which led to his discovery of nickel-iron spherules in tektites and of natural coesite. Chao's study by X-rays of minerals in sheared samples of the Coconino Sandstone from Meteor Crater showed patterns that matched those of coesite, a high-pressure and high-density form of silica created artificially in 1953 by chemist Loring Coes, Jr., of the Norton Company. Chao demonstrated that coesite could be produced naturally at the surface by impact-shock metamorphism[102] rather than being formed like diamonds (also newly synthesized) at great depths below the Earth's surface. The Interior Department's Information Service issued a news release on June 17, 1960, touting, especially for NASA and Congress, this USGS discovery in "space geology,"[103] for which Chao and Shoemaker shared in 1965 the Wetherill Medal from Philadelphia's Franklin Institute.

Chao, Shoemaker, and Beth M. Madsen (a geologist trained at Wisconsin, who joined the USGS in 1951) reported the discovery of natural coesite at Meteor Crater in July 1960.[104] That find, with the earlier supportive stratigraphic and related studies, helped to validate the interpretation of the crater as an impact feature.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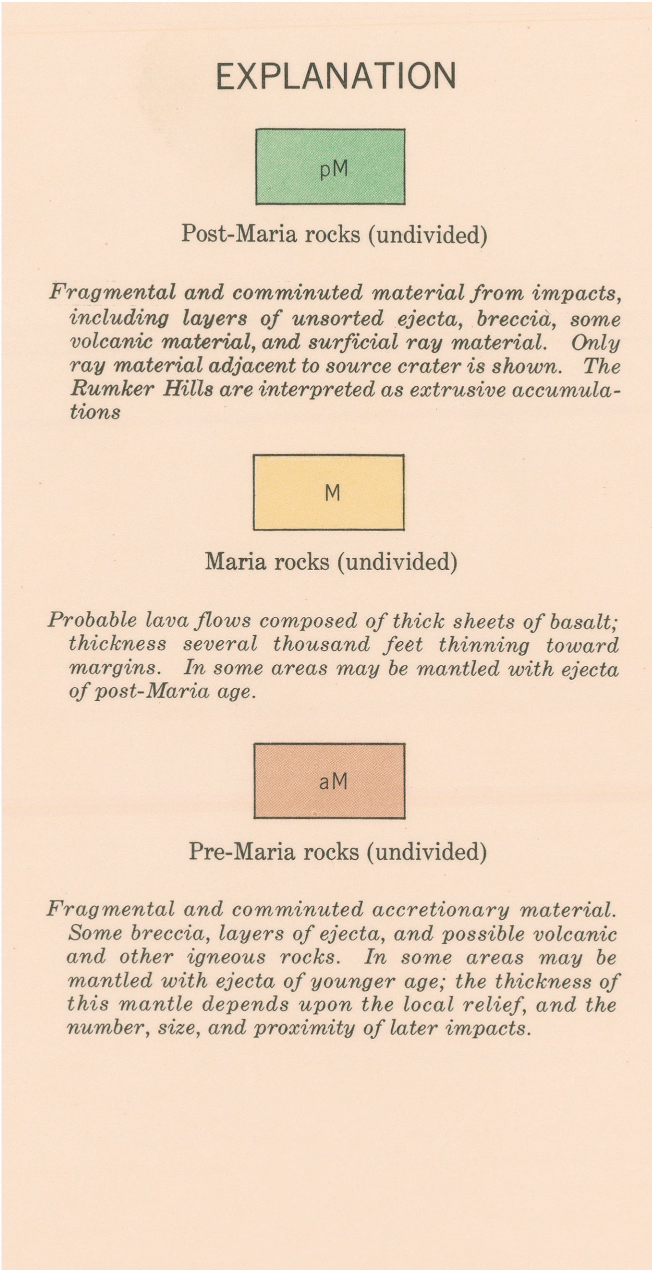
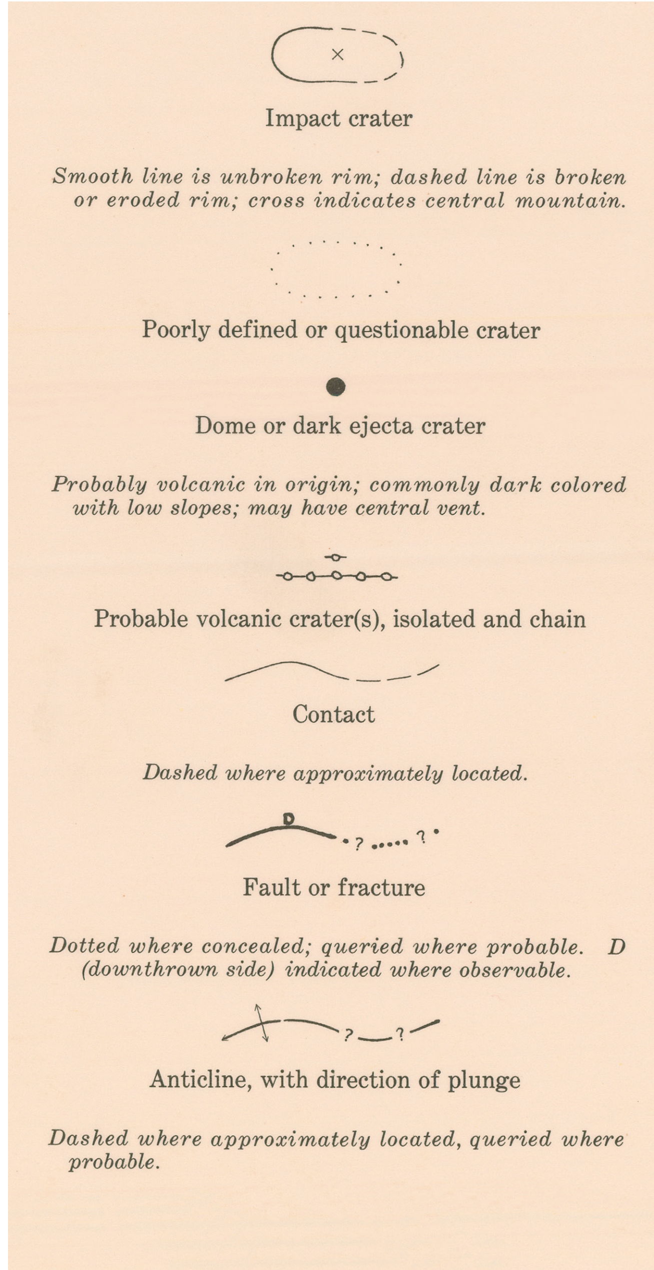


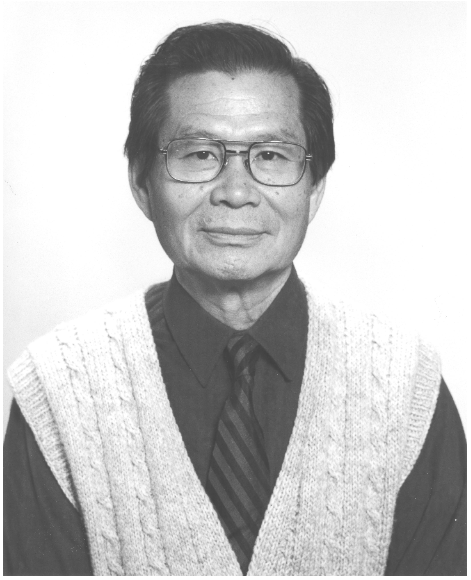


This portion of the generalized photogeologic map (originally at 1:3,800,000) of the nearside of the Earth's Moon shows the 18.6-mile-wide Crater Copernicus (the large crater in grid square J7, directly east of [that is, to the left of] Sinus Aestum), and surrounding features of the Imbrium Serentatis in the northwest quadrant of the nearside. The next largest crater shown in this part of the map is Eratosthenes. The map's grid extends from east to west (numbers 1–18) and north to south (letters A–H, J–N, P–T). The map appeared as sheet 1 of USGS Miscellaneous Geologic Investigations Map I–351 in 1961. The three-unit map portrays pre-maria, maria, and post-maria rocks. USGS photogeologist Robert Hackman compiled this map by interpreting telescopic photographs from four observatories—three in the United States and one in France. Robert Dietz (U.S. Coast and Geodetic Survey); Gerard Kuiper (Director, Lunar and Planetary Laboratory, University of Arizona); Maxim Elias (formerly with the USGS and now a consultant); Chester A. Watts (U.S. Naval Observatory); USGS scientists William Fischer, Annabel Olson, and Eugene Shoemaker; and colleagues from the Army Corps of Engineers aided the compilation. Sheet 2 (by Hackman) of this Army "Engineer Special Study of the Surface of the Moon" depicts lunar rays; sheet 3 (by Hackman and Arnold Mason, project chief in the USGS Military Geology Branch) shows the physiographic divisions (10 major highlands and lowlands, plus lesser bays, hills, mountains, and seas). Sheet 4 (by Mason and Hackman), "Description and Evaluation of the Physiographic Regions," contains text and an interpretative table. Shoemaker, Hackman, and their USGS colleagues subsequently used high-albedo Crater Copernicus to test Shoemaker's crater-count method. They combined the results with analyses of overlapping rays (Copernicus overlapped Craters Aristarchus and Kepler) and interpretations from other superpositional methods to determine relative ages on the lunar surface, work up a time scale, and prepare 1:1,000,000 geologic maps, including those of the Kepler region (I–355) in 1962 and the Copernicus quadrangle (I–515) in 1967. (From Hackman and Mason, 1961; see also Ashworth [1989], Wilhelms [1993], and Whitaker [1999].)

USGS photogeologist Annabel Brown Olson (1922–92) is shown here using paired stereoscopic photographs and a plotter to measure the diameter of nearside craters on the Moon. Her results contributed to the mapping and relative-age determinations of terrain features by the Military Geology Branch's Lunar Mapping Project. Olson, educated at Chicago and Stanford, served with the California Division of Mines and Geology before joining the USGS in 1950. She worked with the MGB in Tokyo, learned photogeologic mapping from William Fischer, applied that technique in the Navy Oil Project and the Colorado Plateau Project, and checked her results by field observations. In 1969, Olson returned to mapping the surface of the Moon and then Mars. During the 1970s and 1980s, she used stereoscopic photographs and color infrared imagery to map geology and coal resources in New Mexico. (Photograph from U.S. Geological Survey, 1961, p. [110].)

Chao's and Shoemaker's coeval work on Bavaria's Ries Basin in West Germany demonstrated a similar origin for that crater. Shoemaker also conducted experiments on the ballistics of ejecta from artificially created craters, both explosive and impact, and large and small, and compared their ejecta patterns to those of Copernicus, its satellite craters, and other lunar craters old and new. He presented his results in March 1960 at the 8th Lunar and Planetary Exploration Colloquium in March, sponsored, as were the seven preceding ones since 1958, by North American Aviation's Missile Division in Downey, California. Shoemaker also described his view of the penetration mechanics of high-velocity meteorites at the 21st International Geological Congress in Copenhagen in August 1960.[105]

In 1960, Shoemaker returned to trying to establish a formal unit in the Geologic Division for lunar studies, while earning a doctorate at Princeton using the results of his studies of Meteor Crater. Early in the year, Shoemaker offered his lunar-studies program to USGS managers for the third time. He now approached Chief Geologist Anderson, who asked the opinion of Loren Stieff, Shoemaker's friend and colleague from the Colorado Plateau Project. Stieff queried colleagues at the JPL and the Smithsonian, who agreed to promote a USGS study of tektites, as Shoemaker readied a second proposal for crater studies and lunar mapping. These investigations would be funded by an initial $200,000 transferred from NASA to the USGS. By May, Shoemaker, Stieff, Chao, and several colleagues were in Menlo Park or Washington as the nucleus of a USGS program of space geology, but Hackman refused Shoemaker's offer to relocate to Menlo Park. The new USGS unit, which Shoemaker named the Astrogeologic Studies Group (ASG), began formal operations there, Wilhelms later recalled,[106] on August 24, 1960, 4 days after NASA began transferring funds to the USGS. By October, Shoemaker added three more geologists to the ASG, renamed the Branch of Astrogeology[107] in 1961.



Edward Ching-Te Chao (1919–2008), born in Suzhou, worked for the Geological Survey of China in Szechuan (1941–45) before relocating to the United States. He earned a doctorate in geology at the University of Chicago in 1948. He served with the USGS Military Geology Branch (1949–56) and the Geochemistry and Petrology Branch (1956–60) before joining Eugene Shoemaker's newly formed Astrogeologic Studies Group (later Astrogeology Branch). Chao, in studying the origin of tektites and impact metamorphism, used X-ray analysis to identify natural coesite in sheared samples of sandstones from Meteor Crater. He extended this work in a cooperative investigation of Ries Crater in southern Germany. Chao aided the National Aeronautics and Space Administration in planning for studies of lunar samples from Project Apollo, helped Shoemaker and others to train astronauts, and served on the teams that investigated the lunar specimens returned by the 11th, 12th, 16th, and 17th missions. In 1977, Chao shifted to the Coal Resources Branch, where his team applied lunar-studies methods to investigations of coal petrology. In 1984, Chao began USGS coordinating activities under the Earth Science Protocol signed by the United States and the People's Republic of China (PRC) and also investigated the PRC's rare-earth-elements deposit at Bayan Obo in Inner Mongolia. He retired from the USGS in 1994. (Photograph by USGS photographer David F. Usher, about 1965.)

They included Richard E. Eggleton, who mapped for the Engineering Geology Branch the "Chantilly" site for the Dulles International Airport in Virginia; Charles H. Marshall, one of the photogeologic mappers in Utah; and Henry J. Moore 2d, Shoemaker's field assistant in the Colorado Plateau Project. Shoemaker and his team kept well informed about NASA's plans for manned missions in space later in the decade, including Project Gemini, following the last of the Mercury missions, to place two-man spacecraft in orbit to photograph the Earth and gather scientific data. On July 28, 1960, NASA announced that its Project Apollo, a name chosen by Abe Silverstein, subsequently would loft three-man capsules into Earth orbit and perhaps later into orbit around the Moon. Shoemaker, now 32, still hoped to be the astronaut-geologist who would accompany the Apollo lunar circumnavigation, or, even better, a subsequent lunar landing. Wilhelms thought that Shoemaker intended to have Stieff lead the ASG, while Shoemaker sought ways and means to qualify as an astronaut, but Stieff left the USGS later in 1960 to become a physical-science administrator at the Air Force Technical Applications Center.

Shoemaker also worked up a more detailed lunar stratigraphic scheme while he waited for Anderson's decision, visited Kuiper in Tucson, and considered offers to shift to the JPL or to the RAND Corporation. Shoemaker combined the results of his own investigation, Patricia Bridges' prototype lunar-atlas sheet of the region around Crater Copernicus, and his colleagues' terrestrial and lunar studies in preparing a preliminary stratigraphic column for the Copernicus area[108] based principally on the superposition of deposits, craters, and other terrain features. Shoemaker grouped materials from crater rims (ejecta blanket), crater sides ("talus"), crater floors ("breccia"), domes, maria, ray material, and regional material in seven "classes" by age. He defined five time-stratigraphic units at "system" level—pre-Imbrian (oldest), Imbrian, Procellarian, Eratosthenian, and Copernican (youngest). Shoemaker later subdivided the Imbrian System into two series—Apenninian (older) and Archimedian (younger)—as he and his colleagues extended the stratigraphic column to other areas on the Moon's nearside. He presented his scheme twice in December 1960—in Leningrad (St. Petersburg) at the 14th Symposium of the International Astronomical Union and, with the Ries Basin study, in New York City at the annual meeting of the Geological Society of America (GSAm). Hackman used the new scheme in his Engineer Study of the Kepler quadrangle, issued in 1961 for the Army Engineers as MGB Miscellaneous Paper 223, and in his 13-unit "Geologic Map and Sections of the Kepler Region of the Moon," at 1:1,000,000 and published in 1962 as USGS Map I–355. That map's text and the three same-scale quadrangles of the Lansberg region that closely followed it, Wilhelms recalled, "were simple statements of mapping principles, stressing the then-novel idea that the surface of the Moon is [geologically] heterogeneous" and produced a workable stratigraphy for the nearside. Hackman's Kepler quadrangle "introduced a major innovation into lunar geologic mapping." Thereafter, Wilhelms continued, geologic-unit descriptions in USGS lunar maps "had two parts: *characteristics*, the objectively observable properties, including coarse topography; and *interpretations*, the speculations on origin and inferred terrain properties."[109]

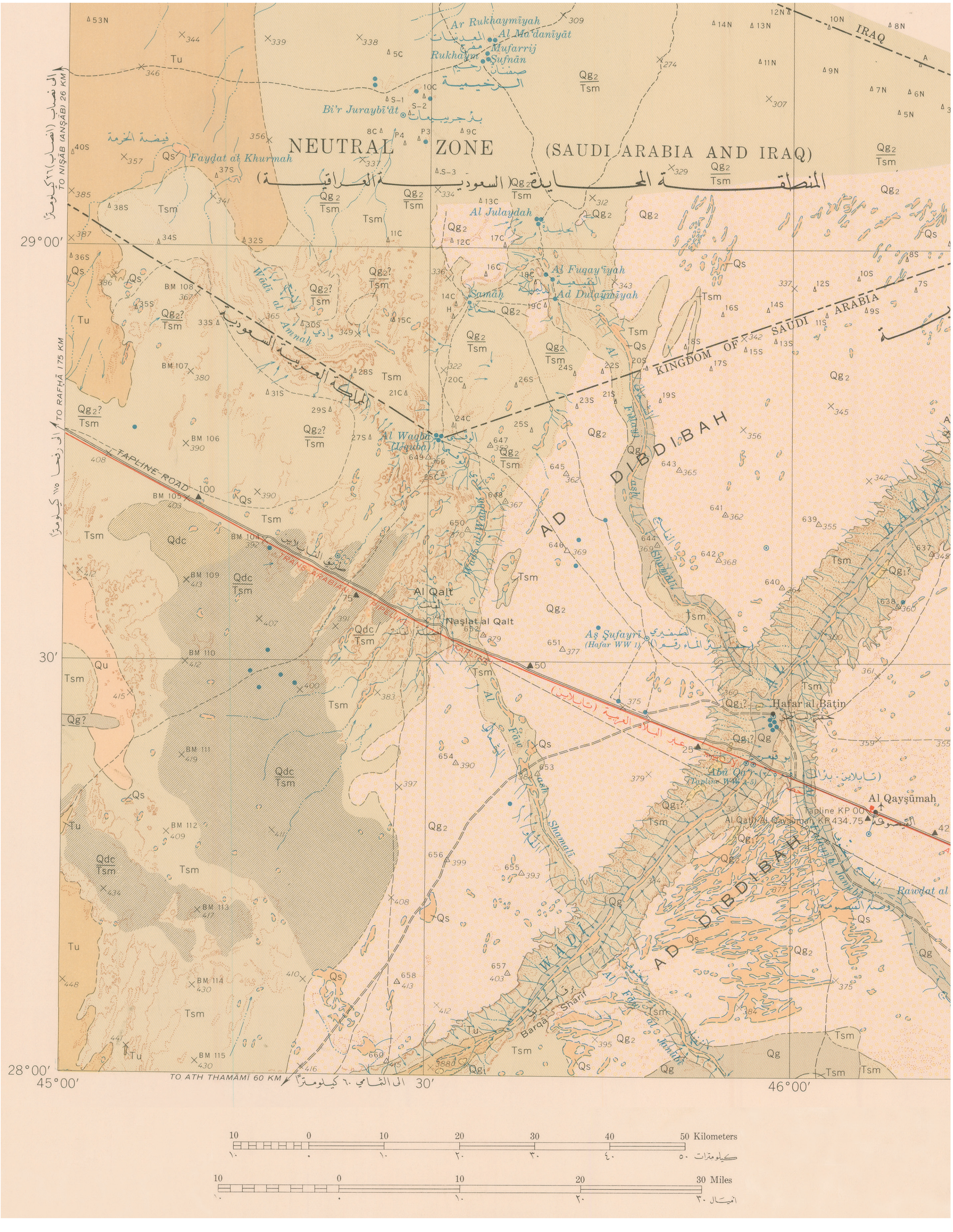
Members of William Johnston's Foreign Geology Branch continued during fiscal year 1959–60, with the ICA's financial aid, to provide technical assistance to mineral-resource and related investigations abroad and to train visitors at home, whose instruction (aided by Topographic Division personnel) included photogeologic techniques. Nearly 50 geologists in the Branch and the Division and at Interior worked with their colleagues in 13 countries and helped to train some 120 scientists and technicians from 30 countries. They continued cooperative geologic mapping and related studies, and (or) advised government agencies, in Bolivia, Brazil, Chile, the Republic of China, India, Indonesia, Libya, Mexico, Pakistan, Peru, the Philippines, Saudi Arabia, and Thailand. Thor Kiilsgaard finished his mineral investigation in southern Peru during September 1959 and then traveled to Bolivia for similar work and to aid the formation of a national geological survey; he returned to the United States in April 1960 and began a 3-year term as the Geologic Division's commodity geologist for lead and zinc. In Brazil, Robert Johnson completed his base-metals assignment in September 1959 and shifted to full-time work in Indonesia on that country's phosphate and bauxite deposits. Robert Reeves ended his service with John Dorr's Minas Gerais iron project in March 1960. In June, Mackenzie Gordon finished his geologic-education work in Brazil, 6 months after Russell Gibson began a similar assignment in January. Samuel Moore's association with George Ericksen in Chile ended in September 1959, and so Moore missed the magnitude 9.5 earthquake off the southern coast of Chile on May 22, 1960; the quake, named for Valdivia, was the strongest ever recorded and caused local tsunamis with wave heights of up to 80 feet that killed more than 500 people. The Valdivia quake also generated a Pacific-wide tsunami whose runups of heights to 35 feet in Hawaii devastated Hilo Bay and killed 60 people there before it reached and damaged areas in Japan and in the Philippines.[110] James Gualtieri finished his service in Libya during September 1959. Quentin Singewald joined the Branch's mineral-deposits studies in Turkey in January 1960. Paul Richards served with the Branch's mineral investigators in India during July 1959–March 1960, as John Albers completed his aid to the institutional development of that country's national geological survey. William Hemphill lent his photogeologic expertise to John Reinemund's project in Pakistan during September–December 1959. Roscoe M. Smith, who left industry to join the USGS in 1951 for DMEA-funded studies, began a multiyear assignment in October 1959 as a technical adviser on minerals to Thailand's Government. In Indonesia, Howard Weeks completed his investigations of mineral resources in September 1959; Howard Waldron arrived there in October for work in engineering geology until year's end.

Glen Brown, Chief of the Foreign Hydrology Section, remained in Washington overseeing the preparation and publication of the bilingual geographic and geologic maps of Saudi Arabia. Between July 1960 and October 1963, he also advised the International Bank for Reconstruction and Development (part of the World Bank Group) while reporting to the ICA's Harold Folk. During this interval, Brown also gave requested information about minerals, water, and maps to the World Bank for its mission to Saudi Arabia. By the end of calendar 1960, 24 of the 1:500,000 Saudi quadrangles were printed as I-Maps—10 geologic, labeled "A" after their three-digit I numbers, and 14 geographic, labeled "B" after those numbers. The maps were prepared by Brown, Richard Bogue, Richard Bramkamp, Gus Goudarzi, Roy Jackson, Leon F. Ramirez, Max Steineke, and their colleagues. Both geographic and geologic maps were now available for nine of these quadrangles. They included Wadi Al Batin in the north, which covered the Neutral Zones that Saudi Arabia shared with Iraq and Kuwait; an interior-to-Persian Gulf strip of six quadrangles between 20 and 28 degrees north latitude and 45 and 54 degrees east longitude, including Dammam, Riyadh, and the eastern coast; and the last two in the coastal southwest, extending coverage to the Kingdom's indefinite border with Yemen. Three other geographic quadrangles provided additional coverage to the northwest and completed that mapping of the entire Red Sea littoral and the areas around Mecca and Medina.

The NSF deployed nearly $6,180,000 of the $154,773,000 appropriated for fiscal year 1959–60 to support Antarctic research.[111] Rear Admiral David M. Tyree replaced George Dufek as the Navy's Antarctic Projects Officer in April 1959 and as commander of the Naval Support Force Antarctica for Operation Deep Freeze 60 during the austral summer of 1959–60. Edwin McDonald continued to lead TF 43, an eight-ship group that included icebreakers *Atka*, *Burton Island*, *Eastwind*, and *Glacier*.[112] The Air Force's logistical support increased when it made new transport aircraft available. On January 23, 1960, a four-turboprop C–130 Hercules landed at McMurdo; this transport, another product of Clarence ("Kelly") Johnson's Skunk Works at Lockheed, could carry up to 21 tons of cargo for as much as 8,500 miles and was modified for polar operations. USGS geologists and topographers again formed teams to conduct mapping and science surveys on the continent. William Chapman and geologist Eugene L. Boudette participated in a round-trip traverse across Marie Byrd Land from the Byrd Station to the Amundsen Sea, via the Executive Committee Range. Preliminary results of investigations on and over Marie Byrd Land suggested that it was a volcanic archipelago. Chapman and Boudette (who served with the Army Engineers before beginning work in economic and regional geology for the USGS in 1953) wintered over at the Byrd Station, where they continued map-control surveys and made stellar and other observations to fix geographic locations. Geologist Harold A. Hubbard and topographer Warren T. Borgeson sailed in *Burton Island* as part of the Navy's Bellingshausen Sea Expedition and fixed a number of geographic positions, including those on the coast of the Thurston "Peninsula," which the expedition decided was an island separated from Ellsworth Land by Peacock Sound. Geologist Alfred R. Taylor and topographer Louis J. Roberts completed a geological and map-control traverse across Victoria Land, during which they discovered the Outback Nunataks. Topographer Walter R. Seelig finished map-control surveys for McMurdo Station aerial photography and also the land-surveying and mapping to be used by the Topographic Division's Future Planning Team.[113] Members of the Topographic Division in Washington continued to prepare three 1:500,000 maps of areas along the Knox Coast, east of ice-free Cape Hordern, began compiling similar maps for the McMurdo Sound area, and added maps and aerial photographs to the Division's Antarctic library.

During November–December 1959, representatives of countries participating in the IGY and those with claims on territories on Antarctica met to assess scientific results and sign a treaty that continued that cooperative effort by determining the future of the continent in the coming decades. Attendees at the Antarctic Symposium, held at Buenos Aires during November 17–25, evaluated the achievements of the 2.5 years of scientific programs conducted under IGY auspices. In Washington, on December 1, following a year of negotiations, representatives of 12 counties—Argentina, Australia, Belgium, Britain, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, and the United States—signed the Antarctic Treaty. The agreement, with equally authentic versions in English, French, Russian, and Spanish, declared that the area south of 60 degrees south latitude "shall continue forever to be used exclusively for peaceful purposes and shall not become the scene of international discord." The treaty required sharing all scientific information, giving free access to all scientific bases, and protecting the continent's living resources. The pact prohibited nuclear explosions, radioactive-waste disposal, and all military installations and activities (except those required to support scientific operations or other peaceful purposes); provided for international inspections and peaceful solutions of disputes; held in abeyance all territorial and sovereign claims south of 60 degrees; allowed no mining or other resource extraction until 2041; and provided for its own renewal. Representatives of the signatory countries would meet in Canberra within 2 months after the treaty became effective on June 23, 1961, "and thereafter at suitable intervals and places."[114]

To promote the Antarctic Treaty's requirements for continued free access to all areas for scientific investigation and the unrestricted exchange of information and personnel, organizations in some of the participating countries established new centers for polar investigations. In the United States, during February 1960, Ohio State University (OSU) founded an Institute for Polar Studies (later the Byrd Polar Research Center). Richard P. Goldthwait, a glaciologist-geomorphologist who joined OSU's faculty in 1946, directed the new center in Columbus. From there, Goldthwait also managed the reduction of the IGY's glaciological data, stored in



NEUTRAL ZONE (SAUDI ARABIA AND IRAQ)
المنطقة المحايدة (السعودية العراقية)
IRAQ
KINGDOM OF SAUDI ARABIA
المملكة العربية السعودية
AD DIBDIBAH
Ar Rukhaymiyah
Al Ma'aniyāt
Mufarrij
Rukhaym
Sufnān
Bi'r Juraybī'āt
Faydat al Khurmah
Al Julaydah
Al Fuqay'iyah
Ad Dulaymiyah
Samāh
Wadi al Amnah
Al Waqba (Uqubā)
Wadi al Waqbā
Al Qalt
Naslat al Qalt
Aş Şufayrī (Hafar WW 1)
Hafar al Bāţin
Abū Qūr (Tapline WW A-5)
Al Qayşūmah
Tapline KP 00
Al Qalt/Al Qayşūmah KP 434.75
Rawdat al
Al Fāw ash Shamāli
Wadi al Bāţin
Barqā' Sharīf
TAPLINE ROAD
TRANS-ARABIAN PIPELINE
TO NIŞĀB (ANŞĀB) 26 KM
TO RAFHĀ 175 KM
TO ATH THAMAMI 60 KM
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10 0 10 20 30 40 50 Kilometers
10 0 10 20 30 Miles

This portion of the geologic map (originally at 1:500,000) of the Wadi al Batin quadrangle in the northeastern part of the Kingdom of Saudi Arabia was prepared by the USGS and the Arabian-American Oil Company (Aramco) and sponsored by the Saudi Government's Ministry of Petroleum and Mineral Resources and the U.S. Department of State. The USGS published the map in English and Arabic in "1960 A. D." (and "1379 A. H." in the Arabic calendar) as USGS Miscellaneous Geologic Investigations Map I–203 A. The map does not show geologic features north of the northern boundary of the Neutral Zone between Saudi Arabia and Iraq. The same-scale geographic (only) map of the Wadi al Batin quadrangle, also in English and Arabic, had appeared as I–203 B in "1959 A. D." ("1379 A. H."). Personnel from the USGS, Aramco, Saudi Arabia, and other countries used aerial photographs (1949–59) as base maps in compiling (1950–63) the Kingdom's geography and geology on 21 quadrangles. Members of this mapping project, directed by Glen Brown, completed the 1:500,000 depiction of the geology and geography of Saudi Arabia with the publication of the 21st quadrangle in 1964. The geologic maps were combined as a single geologic map of the Arabian Peninsula at 1:2,000,000 and published as I–270 A in 1963, the year the USGS began its continuing mission to Saudi Arabia. The geographic composite at 1:2,000,000 initially appeared as I–270 B–1 in 1958; a revised edition was issued as I–270 B–2 in 1963. (From Bramkamp and Ramirez, 1960.)

the World Data Center A's glaciology facility at the American Geographical Society in New York City. Goldthwait also completed a glacial map of Ohio at 1:500,000. Two collaborators aided the compilation—the Ohio Geological Survey's Jane L. Forsyth and George W. White, earlier a professor at OSU and State Geologist of Ohio. Since 1947, White had chaired the Department of Geology at the University of Illinois at Champaign-Urbana, where he continued part-time work with the USGS begun in 1942.

During fiscal year 1959–60, the Topographic Division drew on total funds of nearly $19,811,000, about $652,000 more than it received in 1958–59, for the salaries of and operations by its 2,450 permanent and seasonal employees, or 8 more than in the previous year. More Topographic Division personnel depended on reimbursable funds—523 of 2,135 permanent personnel and 79 of 315 seasonal workers—than did Geologic Division staff. SIR appropriations supplied some $14,715,000 of the new total, representing an increase of about $41,000 compared to the previous year's sum. Nonfederal sources provided nearly $2,904,000, a gain of more than $691,000. Most of the additional funds came from the States, counties, and municipalities, which contributed more than $2,731,000, an increase of more than $718,000. The State-supplied monies included $1 million from Ohio, which, if it continued its yearly and equally shared funding with the USGS, would have its 1:24,000 map coverage completed in 1962. Other Federal agencies provided nearly $2,192,000 in 1959–60, a loss of about $80,000 from the previous year. The USBR increased its transfers by nearly $104,000 to $908,000, but funds from the Army and its Engineers fell by almost $450,000 to about $785,000. The AEC provided $130,000, which was $30,000 less than the sum received from the NSF. In 1960, Chief Topographic Engineer George Whitmore appointed Russell Bean, then Chief of the Branch of Research and Design in Arlington, as Assistant CTE for Research and Technical Standards and Chief of the Office of Research and Technical Standards. William Radlinski became Bean's Deputy Assistant CTE. Radlinski, an Army Engineer officer in Europe during World War II, joined the USGS in 1949; he later served on Bean's photogrammetry staff and helped to develop the ER–55 projector and the Orthophotoscope. Radlinski traveled to Antarctica in 1960 to gain the on-site experience required to advance the Division's plans to map the continent.

During 1959–60, the Topographic Division continued its cooperative mapping in 32 States and Puerto Rico. Division personnel mapped 60,000 square miles at 1:24,000, including 15,100 in Ohio and Texas and 13,195 in Arizona, California, Indiana, and Nevada. They also mapped 18,000 square miles at 1:62,500 and another 18,000 at 1:63,360 in Alaska. Although maps of an additional 6,800 square miles were revised, the area depicted by 1:24,000 maps needing revision neared 250,000 square miles. Using data from the Defense Department and civilian agencies, Division members completed an additional 11,000 square miles of new quadrangle mapping and revised maps showing another 3,000 square miles. The Division published 1:62,500 maps for Oahu and Molokai in Hawaii, a new two-sheet, 1:2,500,000 map of the United States, and a new 1:500,000 map of Utah. Compilations continued for similar maps of Kansas, Maine, Montana, Nebraska, North Dakota, South Dakota, and Washington. Urban-area maps were published for Chattanooga, San Juan in Puerto Rico, and Washington (D.C.), while work continued on those for Albuquerque, Indianapolis, Madison in Wisconsin, and New York City. Following the priorities set by the NPS for the cooperative program, the Division published maps of Maine's Acadia National Park and New Mexico's Bandelier National Monument. Work continued on the prioritized maps requested for other national parks, including Olympic in Washington, Rocky Mountain in Colorado, Wind Cave in South Dakota, and Yellowstone in Wyoming, Montana, and Idaho. Division members also prepared maps to aid the USBM's studies of land subsidence in Arizona, maps of electric-powerplant locations for the Interior Secretary's Office, and base maps for the U.S. Study Commission-Southwest River Basins. They also continued work on the 1:1,000,000 series depicting North America for the Army Map Service.

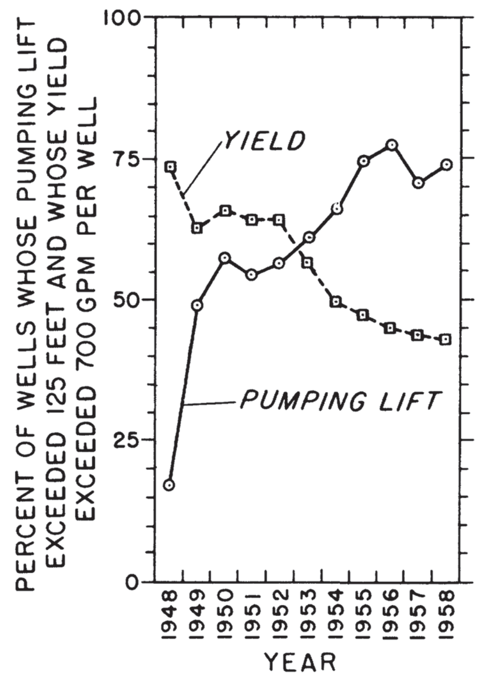
As part of the second pilot program for the comprehensive national atlas of the United States, directed by the NAS–NRC Interagency Committee, the cooperating Federal agencies produced nearly 80 thematic sheets by 1960 and deposited them in the Map Information Office. By then, Carleton Barnes and his Committee decided the project required "a more formal arrangement of the maps, more comprehensive scope of the subject matter, greater uniformity of quality, and centralized distribution of map sheets."[115] They recommended to the NAS' Detlev Bronk that he end their service and give the responsibility for completing the national atlas to a single Federal agency, preferably the USGS, and set a specific time limit. On June 22, 1960, Bronk endorsed that recommendation and sent it to Interior Secretary Seaton. In the fall, Seaton informed Bronk that the Department of the Interior (DoI) would study the project's feasibility. Bronk then again recommended the USGS as the principal agency for the national atlas, whose preparation would be funded by additional monies in its future appropriations or by a separate statute. Before the end of fiscal year 1959–60, the Topographic Division published two U.S. index maps in National Atlas format—the 9th edition of the Status of Topographic Mapping and the 10th edition of the Status of Aerial Photography. Both maps included data for all the States, Puerto Rico, and the Virgin Islands.

The Topographic Division's research and development efforts continued in fiscal year 1959–60 to center on improving the efficiency of mapping instruments and their supporting equipment. Division members began a project to empirically determine and analyze representative horizontal errors in all component phases of the mapping. They reorganized and revised the "Manual of Topographic Instructions" for publication as a sales item of 41 parts. Colleagues developed a lightweight surveying tower to facilitate theodolite observations and electronic-distance measurements over obstructions. Two people could erect the tower in about an hour, and it could be transported by helicopter without disassembly. The 50-foot and 500-pound tower, with welded one-piece horizontal triangular sections, could be modified by adding or omitting some of the 12-foot standard, tubular-aluminum sections. Division personnel installed collimator equipment to more rapidly, accurately, and completely test theodolites and levels. Experiments with a new, polyester-based aerial film proved its increased dimensional stability, but the USGS awaited the advent of commercially available quantities before the film could be used to increase horizontal and vertical accuracy in photogrammetrically compiled maps. Division members completed a study of visual factors in stereoplotting that included the effects of applying refractive correction and varying room illumination. They obtained for testing two new super-wide-angle (120-degree) cameras and devised a system to modify the camera calibrator to accept the wider angle coverage. The Orthophotography Use Study Group continued to aid planning for improving the Division's Universal Orthophotoscope, orthophotomosaics, and 1:24,000 and other orthophotomaps. The group expanded in March 1961 and was renamed the Working Group on Use of Orthophotography.

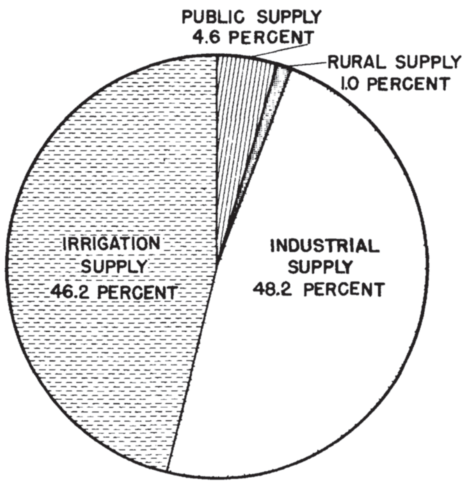
With the ICA's aid, the Topographic Division continued its program of technical assistance at home and abroad to colleagues in ICA-accredited nations. Division members trained in the United States technical personnel from Argentina, Brazil, Ceylon (Sri Lanka), Ethiopia, Nicaragua, and Pakistan. Gus Goudarzi returned to Libya to gain additional information needed for the 1:2,000,000 base map of that country. Other Division personnel spent 6 months training a photographic-laboratory staff and also provided advice to colleagues in Brazil for their national cartographic program and training their technicians in modern cartographic techniques.

In fiscal year 1959–60, the Water Resources Division accumulated total funds of almost $24,133,000, an increase of some $1,368,000 compared to the sum in 1958–59, for the salaries of and operations by its 2,572 employees, or 72 more than in the previous year. The numbers of the Division's permanent personnel—1,141 of 2,335—and seasonal employees—111 of 237—paid by reimbursable funds during the new fiscal year were the largest of the four program Divisions. The SIR appropriation provided more than $11,675,000, a gain of nearly $398,000. The statutory limitation on the use of the SIR funds for cooperative work with the States, counties, and municipalities increased by $500,000 to $7,450,000; although those nonfederal sources did not match this total, they did supply about $7,342,000 in reimbursements and direct payments or about $546,000 more than the Division received in 1958–59. California, the leading contributor, furnished more than $714,000, Texas contributed more than $432,00, Florida supplied nearly $338,000, and 9 other States each provided more than $200,000. Other Federal agencies transferred about $4,812,000, or $394,000 more than the total in 1958–59. The Army and its Engineers increased their transfers by $77,000 to a new total of about $1,837,000, the USBR's funds rose by $103,000 to more than $879,000, those from the AEC increased by nearly $167,000 to total $599,000, and the TVA added nearly $1,200 to raise its transfer to $97,000. Four other Federal organizations reduced their transfers by a total of about $72,000—the ICA supplied nearly $463,000, the Agriculture Department provided $227,000, the Air Force shifted $131,000, and the State Department transferred almost $115,000. In August 1959, Chief Hydraulic Engineer Luna Leopold detailed R. Hal Langford, whose water-quality studies in Great Plains and Rocky Mountain States began in 1949, as John Horton's successor as staff assistant to Assistant Director Robert Lyddan. Leopold's memorandum of July 12, 1960, confirmed the responsibilities for planning and scheduling programs assigned to the Division and those for scheduling and conducting operations, with Division review and approval, now assigned to the Branches. He continued the process of consolidating the Division's operations in each District under a single Chief, who reported to the Regional Hydrologist as well as to the Branch Chief.

In 1959 and 1960, Luna Leopold continued to promote basic research in the Division and to issue general but systematic discussions of water-related issues in the United States. His and Thomas Maddock, Jr.'s analysis of the hydraulic geometry of stream channels earned them the GSAm's Kirk Bryan Award. Leopold published brief contributions about probability analysis applied to water problems, conservation and protection, water management's challenges, conservation views, and the place of water resources in ecological systems. Leopold, with Ralph A. Bagnold, Gordon Wolman, and Lucien M. Brush, Jr., published an analysis of flow resistance in sinuous or irregular stream channels. Equally brief overviews included John A. Baker's on wetlands and water supply; Walter Langbein's on U.S. water yield and reservoir storage; Raymond Nace's on water management, agriculture, and groundwater supplies; Arthur Piper's on present and future concerns about water, and his interpretation of the current status of groundwater rights; and Ralph Bagnold's study of sediment discharge and stream power, and his analysis of river-meander shapes. Bagnold served with the British Army in France and Belgium during World War I, and then in Egypt, England, Hong Kong, and India before retiring in 1935. At the University of London's Imperial College, he conducted wind-tunnel and hydraulic experiments to add to his field observations on windblown desert sand and waterborne sediment. Major Bagnold, recalled to the colors in 1939, created and led the Long-Range Desert Group in daring and disruptive reconnaissance missions behind Italo-German lines in Egypt and Libya before being promoted to Colonel in 1941 and assigned to the staff in Cairo. The Royal Society of London elected Bagnold a member in 1944. In postwar years, he directed Shell's Research Center in Chester and helped to establish the Hydraulics Research Station at Wallingford.[116] Leopold invited Bagnold to spend a month each



This graph depicts the growth of pumping lift and the decline of water yield during 1948–58 in groundwater wells on the High Plains of Texas. Of the 8,356 such wells in 1948, "only 17.5 percent * * * lifted water more than 125 feet and 74 percent yielded more than 700 gallons per minute." As a measure of the subsequent significant drawdown on the aquifer, "[i]n 1958 the number [of wells] had increased to 45,522 and the percentages had changed to 74 and 43 respectively." (Quotation and graph from Nace, 1960, fig. 4 and caption.)



This chart shows the percentage of water supplied to irrigation, industrial, rural, and public users in the United States during 1958. Raymond Nace, in analyzing the use of water in the United States per day during that year, reported an estimated total of 240 billion gallons, not counting "conveyance losses in irrigation" of 32.4 billion gallons per day. That use represented an estimated increase since 1955 of 29.5 billion gallons, exclusive of the additional 3.5 billion gallons lost in conveyance. Nace called for "aggressive intelligent management" of the Nation's total water supplies, based on the results of "further scientific studies." (Quotations and chart from Nace, 1960, fig. 2's caption, p. 11, and fig. 2.)

year in the United States as a consultant to the Water Resources Division, thereby helping to "stir the pool of complaisant tradition with the stick of inquiry,"[117] and offered to publish the results of his water-sediment research in USGS serials.

During fiscal year 1959–60, the Water Resources Division continued to issue parts of its "Manual of Hydrology" in its series of Water-Supply Papers. Walter Langbein and Kathleen T. Iseri's "General Introduction and Hydrologic Definitions" prefaced the sections for "Part I. General Surface-Water Techniques" that included James K. Searcy's "Graphical Correlation of Gaging-Station Records." In the Manual's "Part 2. Low-Flow Techniques," Searcy presented "Flow-Duration Curves." Rolland W. Carter and Richard G. Godfrey's discussion of "Storage and Flood Routing" formed a section in the Manual's "Part 3. Flood-Flow Techniques." Norbert J. Lusczynski's description of the "Filter-Press Method of Extracting Water Samples for Chloride Analysis" and Solomon M. Lang's presentation of "Methods for Determining the Proper Spacing of Wells in Artesian Aquifers" were scheduled to be issued in 1961 as parts, respectively, of "General Ground-Water Techniques" and "Methods of Aquifer Tests."

Leopold announced on December 28, 1959, that Joseph Wells, the Chief of the Surface Water Branch since September 1946, would become the second Assistant Chief Hydrologist. Ernest L. Hendricks succeeded Wells as Branch Chief on March 6, 1960. Hendricks joined the Surface Water Branch in 1935. He worked mostly in Florida before being appointed Chief of the General Hydrology Branch's Research Section in September 1956. Hendricks and Robert Sigafoos subsequently studied the movement of glaciers on Mount Rainier during the past 1,000 years to interpret long-term climatic and water-supply trends.

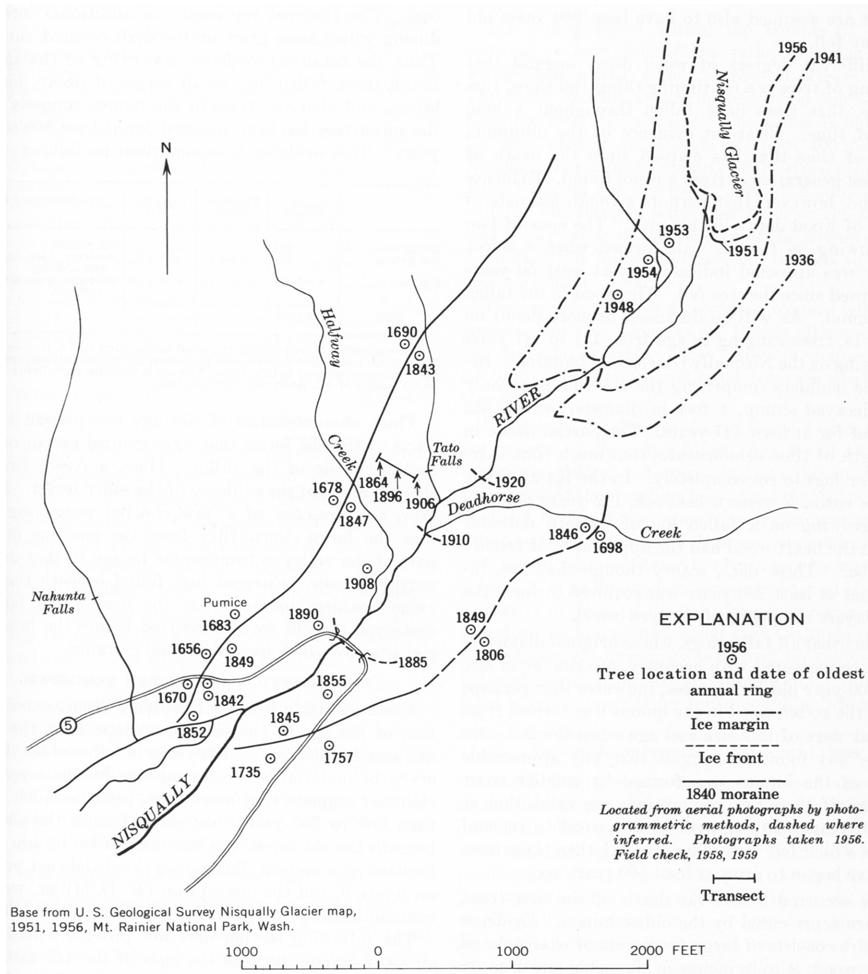
During fiscal year 1959–60, Branch members operated some 7,200 gaging stations in all of the States, Puerto Rico, Guam, and Samoa. They continued to revise and improve the long-range program established 3 years earlier to develop a coordinated streamgaging network consisting of (1) permanent hydrologic-base gaging stations; (2) temporary stations, operated long enough to define basic relations; and (3) permanent and temporary stations, intended to yield data for more efficient water management. The compilation of streamflow records for 1888–1950 reached virtual completion, summarizing nearly 142,500 station-years of records from almost 11,300 measuring stations. Branch members contributed streamflow data to aid the operations of the 19 ongoing interstate water compacts and the International Joint Commission that regulated U.S.-Canadian boundary waters. For the Soil Conservation Service, they also studied the runoff from maximum annual floods for 2,443 drainage areas of less than 400 acres each. Branch personnel published reports for the river basins of the Hudson, the Upper Mississippi, the Upper Missouri, California's Central Valley, and the Pacific Slope. They also published 22 reports on individual metropolitan areas, continued work on 10 others, and began investigations of 2 additional cities. The nationwide flood-frequency program issued analyses of the Pacific Slope basins and the basins of the Columbia and Snake Rivers and nationwide summaries of floods in 1953 and 1954. The Branch started a pilot project in the Western Gulf of Mexico Basin to study analytical methods in arid areas. Other efforts included a series of nontechnical reports on the water resources, water-supply demands, and potentials for further development in specific States. Additional work comprised special reports on the frequency and magnitude of floods in States and regions, the frequency of low streamflows, the surface-water resources of specific areas, and yearly reviews of the hydrography and hydrology of streams where they intersected roads, especially the interstate highways. The Branch also supplied hydraulic data for 78 drainage-structure sites to 14 State highway departments. The Branch's reports on Maryland and Washington brought to 41 those on statewide probability of floods. Bruce Colby and David W. Hubbell worked up simpler methods to use the modified Einstein procedure to compute total sediment discharge.

This photograph shows the lower part of the Nisqually Glacier and its valley on Washington's Mount Rainier. In the late 1950s, USGS scientists began extending Federal studies of glaciers in the Cascade Range, which began with those by Clarence King's U.S. Geological Exploration of the Fortieth Parallel in 1870, to try to determine modern and longer term changes in water supply and climate and the geologic and hydrologic hazards. USGS scientists Robert Sigafoos and Ernest Hendricks investigated the terminal moraines left by advances and retreats of three of Mount Rainier's glaciers—Emmons (east-northeast), Nisqually (south), and Tahoma (southwest). They also gathered data on the distribution, sizes, and ages of key trees and tree stands established since glacial recessions and of the 1,000-year-old stands. Their maps of these glaciers showed their advances and retreats since 1635. (Photograph, 1966, from the USGS Denver Library Photographic Collection as Sigafoos, R.S., srs00032, https://www.sciencebase.gov/catalog/item/51ddb1aee4b0f72b4471f648; published with colored lines added [to show past glacial widths and terminuses] in Sigafoos and Hendricks, 1972, as fig. 1 on pl. 2.)

The Ground Water Branch's specialists made periodic measurements at more than 25,000 sites during fiscal year 1959–60. Work continued on collecting basic records and studying areal hydrology and geology and the occurrence and movement of groundwater. Other research done in collaboration with surface-water specialists focused on the relations among surface water, groundwater, and land use; the water resources of areas; and water utilization. Branch members completed a map of the maximum-reported content of fluorine in groundwater as the initial contribution to a series of studies of iodine, selenium, and other elements whose concentrations in water might produce deleterious physiological effects. Earlier studies evaluated the groundwater conditions and storage capacity of California's San Joaquin and Sacramento Valleys. Joseph Poland and his colleagues used the actively subsiding San Joaquin Valley as a natural laboratory to investigate the processes involved in the strain, deformation, and compaction of water-bearing rocks that followed groundwater withdrawals. Poland's studies related subsidence to dewatering and compaction of artesian aquifers' confining beds rather than the dewatering of the aquifer itself. He demonstrated that dewatered and compacted confining beds lacked significant restorage capacity and so would not allow land surfaces to rebound in the subsiding areas.[118] The Branch's investigation of tritium, begun in 1957, continued with the hope of demonstrating its value as an indicator of groundwater recharge, movement, and discharge that could be used in quantitative evaluation through water-budget studies. Branch personnel continued their evaluations of water supplies in the volcanic terranes of the Columbia River Basalt and in a limestone terrane in the Central and Southeast United States. Eugene H. Herrick completed a 1:31,680 map of the groundwater resources and proposed enhancements in the headquarters area of New Mexico's White Sands Missile Range.

In April 1960, Stuart Schoff succeeded Alfred Clebsch as chief of the Ground Water Branch's project at the Nevada Test Site (NTS). Schoff moved the project's headquarters to Denver to coordinate efforts with the Geologic Division's planned Special Projects Branch, which, as of July 1, 1960, became responsible for all USGS operations in support of the NTS tests. John E. Moore, W. Arthur Beetem (who replaced Francis Barker), and others joined the project's staff. Schoff and "Ike" Winograd (who remained based at Las Vegas) supervised the drilling of six wells on Yucca, Frenchman, and Jackass Flats (basins connected by groundwater flow), which reached depths of 1,700 to 2,300 feet. Data from these wells

This map (originally at 1 inch = 1,000 feet) depicts the Nisqually Glacier's terminal moraine, which marks the glacier's maximum modern advance in 1885. The map also shows the locations and the ages of the oldest annual ring (between the years of 1656 and 1953) of the trees selected for dendrochronologic determinations. Arthur Johnson and Robert Sigafoos "located trees, road, and 1840 moraine by plane table survey, August 30, 1958." They fixed other features by photogrammetrically interpreting aerial photographs taken in 1956 and field checked their results during 1958–59. (Quotation and map from Sigafoos and Hendricks, 1961, fig. 6, and its caption.)



indicated that deeper drilling, hydraulic tests, and additional geologic mapping at 1:24,000 would be required in the search for thick nonporous strata and to achieve a more accurate estimate of potential groundwater contamination by the seepage of strontium-90 and other radioisotopes after underground nuclear tests. This and subsequent deeper drilling in the early 1960s confirmed interbasin flow through a major regional aquifer. Also in 1960, Gordon D. Bennett and Eugene P. Patten, Jr., presented their borehole geophysical methods for analyzing specific capacities of multiaquifer wells.

In January 1960, Charles McDonald left his post as Chief of the General Hydrology Branch to lead a hydrology project at Yuma, and the Branch Chief's position remained vacant until August 1961. Late in the 1950s, the Water Resources Division established a National Research Program that involved the Branch in investigations of low- and high-level radioactive and other hazardous wastes, their distribution, the effects of wastes, the paths taken by waste liquids, the length of time that wastes remained hazardous, artificial recharge, and the effects of urbanization on the hydrologic regime. From 1959, John Hem's primer guided Branch studies and interpretations of natural water's chemical characters and Joseph Huffty's residue method facilitated identifications of common minor elements. In 1960, Robert Garrels' analysis of mineral equilibria gave geohydrologists the tools of chemical thermodynamics.[119] Branch members also began studies of three small watersheds, two recently developed and the third as the control area, in the San Francisquito Basin near Menlo Park. Several other and similar-sized basins in California and Nevada were selected for additional investigations. During fiscal year

1959–60, the Branch obtained water-quality data at 907 sites, one-third of which were west of the Mississippi River, and investigated water quality in the basins of the Colorado, Columbia, Mississippi, and other rivers. Branch specialists also studied the factors controlling the solution and deposition of iron and manganese, the absorption of radioactive elements by water-sediment mixtures, and methods to distinguish waters of deep origin. Investigations of sediment loads and movement in streams continued in the Colorado, Missouri, and Middle Rio Grande Basins. Related work involved the mineralogy of river sediments, the effect of variations in roughness and other factors in bed-load transport, and the measurement and analysis of stream-sediment loads. For the Soil Conservation Service, Branch members looked at sediment yields and reservoir trap efficiency in the SCS small test basins. Reports by Branch personnel issued during the year treated flume studies that used medium-sized sand, sediment transport in alluvial channels, ultrasonic measurement of size distribution and concentration of water-suspended sediments, and the effect of fine-sized sediments on water-flow mechanics. Work continued on the comprehensive hydrological study of the Colorado River above Lees Ferry. Branch members planned, funds permitting, to begin comparable work on the river basin below Lees Ferry in July 1960. Studies of phreatophytic plants were extended to the Humboldt River Valley near Winnemucca, Nevada, where large water tanks were installed for controlled investigations of evapotranspiration to measure water use. Branch members continued or began soil and moisture studies of grazing areas, reservoirs, and streams in Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, Utah, and Wyoming.

The Water Resources Division, aided by the ICA's Technical Assistance Program, continued its long-term projects in Afghanistan, Chile, Iran, Libya, Pakistan, the Philippines, Saudi Arabia, Tunisia, and Turkey. Robert Schneider, who joined the USGS as a photogrammetrist in 1941 and then shifted to work in groundwater geology, advised the Brazilian Government on that country's water resources during November–December 1959. Wilbur T. Stuart served with Chase Tibbitts' team in Libya in January–March 1960. Edward Bradley's tour in Jordan ended in the following June. During September–December 1959, F.D. Bertleson and John B. Cooper completed their service in Pakistan; Eugene Patten, Jr., began work there in April 1960. Division personnel also were sent on short-term advisory assignments to Argentina, Egypt, Haiti, and Southern Rhodesia (Zimbabwe). They and their colleagues elsewhere in the Division also helped to train in the United States visiting hydrologists from 17 countries—Argentina, Brazil, Chile, Colombia, Egypt, Ethiopia, Ghana, India, Israel, Kenya, Libya, Pakistan, Peru, the Philippines, the Sudan, Turkey, and Uruguay.

During fiscal year 1959–60, the Conservation Division received nearly $2,797,000, a gain of nearly $101,000 from the previous year, for its 348 employees at year's end or 20 more than in 1958–59. Only seven of the Division's permanent employees depended on reimbursable funds for their salaries. Part of the appropriation from the Interior Department's Office of Oil and Gas passed to the Conservation Division's SIR appropriation, raising it to about $2,749,000 or $314,000 more than in 1958–59. Funds transferred to the Division from nonfederal sources increased by $800 to a total of about $1,800. Lacking any transfer monies from Interior's Office of Oil and Gas, the funds supplied by other Federal agencies declined by nearly $215,000 to a total of about $46,000. During the year, Emmett A. Finley summarized the procedures used by Division members in defining known geologic structures for leasing-law administration.

As before, the requirements of new statutes increased the Division's work. On August 18, 1959, a new law amended Alaska's admission statute by requiring the State to file, "within a period of five years after the date of admission of Alaska into the Union,"[120] an application with the Interior Secretary to select leased, permitted, licensed, or contracted lands covered by the Mineral Leasing Act of 1920 or the Alaska Coal Act of 1914; otherwise, the Federal Government would withdraw those lands. The Mineral Leasing Act was amended again on September 21, 1959, by inserting a provision that relieved persons, associations, or corporations holding valid leases, options, or interests on acreage from responsibility for cancellations or forfeitures, already completed or in process, and extending such interests "for a period of time equal to the period between the filing of the waiver or the order of suspension * * * and the final decision, without the payment of rental."[121] On March 18, 1960, another new statute amended the U.S. mining laws "to provide for the inclusion of certain nonmineral lands in patents to placer claims" for use in "mining, milling, processing, beneficiation, or other operations in connection with such claim." This law restricted these locations to five acres and required payment "at the rate applicable to placer claims which do not include a vein or lode."[122] The Phosphate Mining Act, also signed on March 18, further amended 1920's Mineral Leasing Act "to authorize the issuance of prospecting permits for phosphates in lands belonging to the United States"[123] for intervals of not more than 2 years and areas of 2,560 acres or less. An additional new statute, signed on June 29, authorized "an extension of time [of up to two 3-year periods] for final proof under the desert land laws under certain conditions" and limited its benefits to those persons who then held an uncanceled entry, under the desert land laws, "to reclaim public lands * * * located on the Lower Palo Verde Mesa in the Palo Verde Irrigation District in Riverside County, California,"[124] showing they were not liable for engineering or financial expenses due to the delay in constructing irrigation works.

During fiscal year 1959–60, members of the Mineral Classification Branch processed more than 30,700 cases (2,900 fewer than in the previous year); 7,000 of the cases involved the outright disposal of Federal lands without reserving any minerals or with reserving one or more specific minerals. Branch personnel also handled an additional 21,000 cases involving Federal mineral leases to private enterprises. They defined or revised definitions of 66 producing oil and gas fields on Federal lands, geologically appraised 358 unit-plan and participating-area proposals, fixed the productive limits of 63 producing oil and gas deposits, assessed and reported the geologic significance of 248 new discoveries of oil and gas on or affecting Federal-land leaseholds, reviewed competitive sales of oil and gas leases in 29 public-land parcels, reported 18 appeals from the Bureau of Land Management's disposal of public lands, and prepared for other Federal agencies nearly 200 reports on the mineral potential of specific public lands. Branch members also prepared geologic maps and reports on fields or areas before leasing or legislation: coal at Rifle Gap in Colorado; gas at Gragg and Booneville in Arkansas; helium in Pinta Dome in Arkansas; oil and gas at Soso in Mississippi and also in the San Juan Basin and at Bisti in New Mexico; phosphate in Florida; and potash in southeastern New Mexico. They also reported on the stratigraphy and structure of the Delaware Basin, the Sweetgrass Arch in Colorado, and four oil and gas fields in Montana, North Dakota, and Wyoming.

By the end of fiscal year 1959–60, the Mining Branch supervised almost 3,900 properties in 32 States, of which more than 2,700 were on public lands and the remainder on Indian or acquired lands. The estimated nearly 26 million tons, a decrease of more than 184,000 tons compared to the total in 1958–59, of minerals produced from these lands during the year were valued at more than $165 million, a decrease of nearly $5 million, and yielded royalties of about $7.7 million, or $113,000 less than in the previous year. Uranium production of almost 1.4 million tons was worth $20.3 million. Prospecting on lease and permit lands delineated a minable deposit of potash on and southeast of Utah's Cane Creek anticline and extended known trona deposits in Wyoming's Green River area. Mining companies also located additional lead-zinc deposits in sedimentary sequences and new copper-iron occurrences in basement rocks in southeastern Missouri and began operating a new lead mill near Viburnum in Iron County.

During fiscal year 1959–60, members of the Water and Power Branch worked in Alaska, Colorado, Montana, Oregon, and Washington mapping and examining the waterpower and storage potential of streams and dam sites. They published 18 map sets, completed 6 additional sets, and continued to prepare 8 others that covered 600 miles of stream channels and 40 dam sites. Streams and sites evaluated in these reports included those on the areas in Alaska around Bradley Lake, Lost Lake, Nellie Juan Lake, and the Snow River on the Kenai Peninsula; five lakes on Baranof Island; and an area on the mainland between Thomas Bay, near Petersburg, and Juneau. Other reports covered the Lower Flathead River in Idaho; the Nehalem, Siletz, and Trask Rivers in Oregon; and Dinwoody Creek in Wyoming. Branch members continued to systematically review all waterpower withdrawals. Sites reserved for power and reservoirs now totaled, respectively, more than 7.2 million acres and nearly 131,600 acres. They submitted more than 7,600 reports about waterpower value, acquisition, and withdrawal to the BLM and the Federal Power Commission, a reduction of about 1,000 compared to the total sent forward in 1958–59.

During fiscal year 1959–60, members of the Oil and Gas Leasing Branch supervised 159,000 properties (about 28,000 more than in 1958–59) totaling 125 million acres, or 17.7 million more than in the previous year. The work involved 139,000 properties on 113.6 million acres of public lands and 527 properties on 2.1 million acres of the Outer Continental Shelf. Petroleum companies completed more than 3,400 wells and produced oil and gas from about 2,300 of them. At year's end, nearly 27,700 of the more than 46,600 wells remained producers. These wells yielded almost 261.3 million barrels of oil, 898 million cubic feet of natural gas, and 451.3 million gallons of natural gas liquids. Their value neared $869.6 million, an increase of $409 million, and yielded royalties of $116.2 million, or $59 million more than in the previous year. Branch members approved 94 new unit plans on land and terminated 49 others, leaving 420 plans, a gain of 85, that covered 7.9 million acres, an increase of 1.8 million, operating at year's end. Four OCS plans were approved and 1 was canceled for a new total of 15 that covered 375,800 acres. They also approved 147 drilling units or communitization agreements and ended 2, leaving 1,021 operating on June 30; the 3 new development contracts approved raised the total to 14, covering more than 4.6 million acres. The nearly 1,700 wells on the OCS produced about 41 million barrels of petroleum and 234 billion cubic feet of natural gas. The Branch expected the termination of the interim Federal-Louisiana agreement of 1956 and the resumption of normal leasing to increase even further its workload, as would the growing activity in the Four Corners area and in Alaska. In administering the Connally Act, Branch members monitored more than 4,600 leases and visited nearly 1,200 of them, checked 50 pipelines, visited 411 oil fields, conducted about 1,550 interviews, and detected 12 alleged violations. To the 17 cases of alleged violations extant when the fiscal year began, they added 3 new ones; court action closed 7 cases and yielded fines of $52,900.

The U.S.-Soviet race in space continued during fiscal year 1959–60, as both countries strove to achieve impressive "firsts." The United States placed three Explorers in orbit, out of six launched; one of these satellites, whose apogee exceeded 26,000 miles, further defined the Earth's radiation belts. Two of four Vanguards reached orbit; one of them returned additional data on the Earth's magnetic field. Pioneer 4, launched on March 3, 1959, missed the Moon by some 37,000 miles, or more than twice the distance required to activate its photoelectric cells. Early on September 14 (Moscow time), Korolev's Soviet team won the contest to hard-land a vehicle on the Moon when Luna 2, after a flight of 33.5 hours, smashed into the lunar surface west of Mare Serenitatis and near Crater Autolycus. Luna 2 carried a scintillometer, a Geiger counter, a magnetometer, and a micrometeoroid detector; data from these instruments indicated only a weak lunar magnetic field and no radiation. Two additional U.S. Pioneers failed in September and November. In December, the JPL announced the start of NASA's Project Ranger that planned to use robotic spacecraft to photograph the Moon from increasingly close distances and return the images electronically before the probes crashed on its surface. On March 11, 1960, Pioneer 5 lifted off from Cape Canaveral and returned data about the solar wind's effect on the Earth's magnetic field and other interplanetary information through April 30; signals stopped on June 26 at a point 22.5 million miles from Earth. On April 1, NASA launched from the Cape and orbited its initial Television [and] Infrared Observation Satellite TIROS 1, a weather satellite with two television cameras. The satellite's cameras returned some 23,000 images, including many photographs of clouds, snow cover, and sea ice in areas between 50 degrees north latitude and 50 degrees south latitude. Two Transit satellites, in orbit on April 13 and June 22, aided navigation. The Missile Defense Alarm System satellite MIDAS 2, lofted on May 24, provided initial early warning capabilities to detect launches of Soviet intercontinental ballistic missiles (ICBMs). Explorer 6, launched into orbit on August 7, 1959, deployed solar panels and also returned images of the Earth, but not until November 23, 1960, did photographs from TIROS 2 distinguish ice from clouds.

Meanwhile, the United States and the Soviet Union continued their race to photograph the Moon. Another Soviet Luna failed on June 18, 1959, but on October 7, Luna 3 circled the Moon in polar orbit. The probe's 35-millimeter camera took 29 pictures of about 70 percent of the farside and scanned and transmitted 17 images used to make a photogrammetric map. The photographs confirmed the expected paucity of maria; one of the few discovered was Moscoviense. These images also recorded craters, one named for Konstantin Tsiolkovsky, and a mountain range, later identified as crater rays. Other features honored Giordano Bruno, Thomas Edison, Louis Pasteur, and Jules Verne.[125]

The United States continued to respond to politico-military challenges on the Earth's surface. At Eisenhower's invitation, Khrushchev arrived in the United States on September 15, 1959, for a visit that lasted until the 27th. On January 19, 1960, Japan and the United States signed a new mutual security treaty that extended the agreements of 1951 and 1954 to give the United States almost carte blanche in using its armed forces on and off the Japanese Islands. Amid significant opposition in Japan, both countries ratified the pact in June. On January 20, the multinational discussions designed to produce a test-ban treaty ended without agreement. Khrushchev conditionally approved on March 19 a ban on nuclear tests, except for the small-yield underground explosions that he wished to exclude from any agreement. Members of U.S. Project Vela-Uniform continued to work toward successfully distinguishing the blasts smaller than 5 kilotons from natural seismic events.

As calendar 1959 ended, the Department of Defense gained a new Secretary and a new weapons system. Neil McElroy resigned as Secretary of Defense on December 1 and Thomas S. Gates, Jr., succeeded him on the next day. Gates introduced a single operational plan that eliminated duplication of targets for the strategic nuclear weapons of the U.S. armed services. On December 30, the Navy commissioned *George Washington* as the lead boat in a planned series of nuclear-powered, ballistic-missile submarines. To build the new boat, a *Skipjack*-class submarine under construction was cut in half, and a center section was added to house 16 Polaris A–1 IRBMs, each with a range of 1,200 miles. On July 20, 1960, *George Washington* submerged and successfully launched two Polaris missiles. The new ballistic-missile submarine sortied from Charleston on its initial patrol on November 15 and spent 66 days submerged at sea.[126] *George Washington* and subsequent strategic submarines completed, with the Strategic Air Command's (SAC's) jet bombers and its ICBMs, the U.S. strategic-defense triad. The Navy retired its Regulus-carrying submarines, launched its nuclear-powered aircraft carrier *Enterprise,* and developed an advanced Polaris that extended the missile's reach to 1,500 miles. The Air Force readied its solid-fuel Minuteman ICBM for deployment in 1961, a year ahead of schedule.

In Southeast Asia, coeval developments in Laos threatened to expand the already growing conflict in the Republic of Vietnam. To counter the heightening insurgency in South Vietnam, encouraged and aided by Hõ Chí Minh's regular forces from the north, Eisenhower authorized an increase in U.S. military advisers to 700, more than twice the number allowed by the Geneva Accords in 1954.[127] On December 20, 1960, Vietnamese Communists (Vietcong) formed the National Front for the Liberation of South Vietnam, better known as the National Liberation Front (NLF), and increased their attacks. To the west, Laos and Cambodia separated the two Vietnams from Thailand, where the pro-Western dictatorship of Premier Sarit Thanarat, a former Field Marshal, staged a bloodless coup in September 1957. Both Cambodia and Laos, after many decades as French protectorates, gained their full independence from France in 1954. Cambodia remained reasonably stable under the alternating rule of King Norodom Suramarit, who died in April 1960, and his son Prince (later King) Norodom Sihanouk. When Sihanouk's People's Socialist Community won all the seats in the national assembly in March 1958, he returned as premier and extended diplomatic recognition to the Government of the People's Republic of China.

As Cambodia recognized the PRC, neighboring Laos remained in turmoil. There, the nationalist and pro-Communist Pathet Lao (State of Laos) received Viet Minh aid. The Pathet Lao, opposed since 1951 by the Royal Laotian Government, was aided by France and the United States in a conflict described and analyzed by Bernard B. Fall.[128] At the Bandung conference in 1955, representatives of Cambodia and Laos expressed their preference to remain independent and neutral. The Soviet Union recognized Laos in June 1956. Neutralist Prince Souvannaphouma saw Mao Zedong and Zhou Enlai in Beijing in August. The Laotian national assembly chose Souvannaphouma as premier in April 1957, and Souvannaphouma decided in November to add Pathet Lao representatives to his government and by doing so regained two northern provinces. In July 1958, members of the Pathet Lao, who looked to their own Prince Souvanophong, Souvannaphouma's half-brother, joined the cabinet. Souvannaphouma resigned and the premiership passed in August to Phoui Sananikone, who requested and received increased U.S. support. On February 11, 1959, Phoui renounced the 1954 Geneva agreement and asked the United Nations to intervene and resolve the Laos conflict. Representatives of the Southeast Asia Treaty Organization (SEATO) agreed to intervene only if the U.N.'s peacekeeping effort failed.

U.S. economic and military aid to the pro-Western but corrupt governments of Laos increased in 1959 and 1960, as American military trainers increasingly replaced their French counterparts and the American contribution to the Laotian military budget grew to 100 percent. With the approval of the French Military Mission, 100 men of the U.S. Army Special Forces began training the Royal Laotian Army and its allied tribes in 1959. The Central Intelligence Agency's (CIA's) Civil Air Transport (later Air America) continued to fly cargo and agents into Laos, as well as Cambodia and South Vietnam. Other Americans, some also CIA contractees, flew Royal Laotian aircraft on strike missions against the Pathet Lao's forces, as their colleagues in South Vietnam did against the insurgents there.

During December 1959–December 1960, Laos underwent a national election and a series of military coups and countercoups. During those 13 months, coups ended Phoui's regime, replaced it with one headed by Souvannaphouma, tossed out Souvannaphouma in favor of Phoui and strongman General Phoumi Nosavan, and finally drove Souvannaphouma into exile in Cambodia. Phoumi supported

Prince Boun Oum, the hereditary leader of the southern Laotian kingdom, who renounced his throne, as the new premier. Boun Oum asked for and received additional economic and military aid from the Eisenhower administration, but the Pathet Lao, backed by the Soviets and the Viet Minh, continued to gain territory, including the Hõ Chí Minh Trail to South Vietnam, which controlled or influenced more than two-thirds of Laos. The USGS Military Geology Branch helped the U.S. Army to prepare for possible military intervention. MGB members completed a Special Report, with maps at 1:100,000, in 1959 for the Office of the Chief of Army Engineers on the water supplies, construction materials, cross-country movement, and terrain suitability for constructing depots at the capital Vientiane, with its own airfield, and Savannakhét, another port on the Mekong River in the central part of Laos' panhandle, with its French airfield just to the east at Séno. Their MGB colleagues, supervised by Harold W. Hawkins, finished in 1960 for the Pacific Engineer Intelligence Program a terrain study, at 1:250,000, for airborne operations, airfield construction, construction materials, cross-country movement, roads, and water supplies for all of Laos. They also began a similar study of Thailand, the staging area for any additional U.S. troops, and planned those for Vietnam, Burma, the Malay Archipelago, and Indonesia. Laos would not fall to the Communists, Eisenhower warned on December 31, 1960, but he sent no U.S. Army conventional units there to build facilities and (or) to redress the military balance. The U.S. Air Force honed its plans to use nuclear weapons in Laos if ordered to do so.

Managers of U.S. aerial reconnaissance continued to focus their efforts on the Soviet Union. Since 1956, the CIA's U–2 overflights provided high-resolution photographs of the Soviet nuclear-test site at Semipalatinsk, the air-defense-missile test range at Saryshagan on the western shore of Lake Baikal (Balkash), the satellite-launch complex at Baikonur, the military-industrial complex at Sverdlovsk, the Strategic Rocket Forces' ICBM site at Plesetsk, operational since February 9, 1959, and other key military bases. Richard Bissell convinced Allen Dulles and President Eisenhower to authorize one additional U–2 flight of nearly 3,800 miles across the Soviet Union principally to check progress at Tyuratam, Sverdlovsk, and Plesetsk before the summit conference between the leaders of the United States, Britain, France, and the Soviet Union scheduled to open in Paris on May 15, 1960. Early on May 1, the Soviet national day of celebrations and parades, a U–2 piloted by Francis Gary ("Frank") Powers took off from Peshawar in Pakistan en route for Bodø, in northern Norway, by way of Dushambe, Tyuratam, Chelyabinsk, Sverdlovsk, Kirov, Plesetsk, Archangel, Kandalaksha, and Murmansk. As Michael R. Beschloss described in his book "May Day," Soviet MiG-19s and other aircraft failed to intercept Powers' U–2, flying at altitudes above 60,000 feet, but an antiaircraft battery at Sverdlovsk downed the aircraft with two of its SA–2 Guideline surface-to-air missiles. Powers could not issue a mayday distress call, but his nonarrival at Bodø generated the National Oceanic and Atmospheric Administration's cover story that the U–2, on a weather-research mission, strayed accidentally into Soviet airspace, went missing, and was presumed down.[129]

The U.S. lie exploded when Premier Khrushchev announced, on May 5, that the Soviets captured pilot Powers (a former USAF Lieutenant who had flown for the CIA since 1956), pieces of his aircraft, and some of his equipment, including film and containers. Khrushchev's disclosure forced President Eisenhower to admit 2 days later that he had approved this mission and the 23 earlier spy flights. At the Paris meeting on May 16, Khrushchev denounced the U.S. aerial espionage. When Eisenhower promised to end U–2 flights over the Soviet Union, but refused to apologize for them, Khrushchev walked out, and the meeting ended the next day. In a show trial, the Soviets convicted Powers on August 19 and sentenced him to 10-years' imprisonment, but they exchanged him for a convicted Soviet spy in 1962. The CIA, expecting eventually to lose a U–2 to improved Soviet aircraft or missiles, in 1959 authorized Clarence ("Kelly") Johnson's Skunk Works at Lockheed to develop a supersonic and higher flying successor to the U–2. Johnson's team worked on new reconnaissance aircraft whose engines, shape, titanium skin, and special paint would provide speeds of up to Mach 3, the ability to reach altitudes of more than 85,000 feet, and other capabilities that would make radar detection difficult and interception almost impossible when they began overflights.

Until then, the U–2 flights would continue over mainland China, Cuba, and other countries and areas where missiles or aircraft were (as yet) less dangerous or posed no threat at all to these reconnaissance planes. An agreement signed by Castro and Anastas I. Mikoyan on February 13, 1960, brought Cuba $100 million in Soviet credits in return for 5 million tons of sugar. Castro's Cuban Government began seizing U.S. vegetable and mineral assets on the island in January. On June 29, the Cubans expropriated three oil refineries owned by American and British companies when they refused to accept Soviet petroleum. In response, on July 6, Eisenhower reduced the U.S. quota for Cuban sugar by some 95 percent or 700,000 tons a year. After Khrushchev warned Eisenhower not to move militarily against Cuba on July 9, the President promptly reinforced the Monroe Doctrine. The United States, Eisenhower told Khrushchev, "in conformity with its treaty obligations," would not permit the establishment of "a regime dominated by international Communism in the Western Hemisphere."[130] Foreign ministers of the Organization of American States (OAS), while convened in San José, Costa Rica, on August 28, condemned Soviet and PRC efforts to spread their influence and system in the Western Hemisphere. Nineteen delegates to a meeting in Bogotá, Colombia, voted on September 13 to approve U.S. aid for social development in their countries. Cuban representatives opposed both measures. On October 14, Castro nationalized all banks and remaining industries.

Eisenhower responded to the Cuban Government's actions by quickly reducing the remaining imports of sugar in 1960 and eliminating them for 1961. The administration then embargoed all U.S. exports, except for medicines, to the island, vowed that the United States would defend its naval base at Guantanamo Bay, held under the 1903 treaty, told the OAS about Soviet arms reaching Cuba, promised to oppose by force any Soviet- or Cuban-led invasion of a Central American country, and vowed to devote $1 million to aid Cuban refugees. Eisenhower approved raising from Cuban refugees a brigade of all arms that was planned, recruited, aided, and directed by the CIA's Richard Bissell, with the help of other members of the CIA and the U.S. military. Castro's spies discovered the existence of the clandestine unit, based, with the approval of Nicaragua's president Luis Somoza, at Puerto Cabezas on the northeastern coast of Nicaragua, some 630 miles south of Havana. Eisenhower refused to authorize the carrying out of Operation Zapata, Brigade 2506's planned invasion of Cuba; after the Cuban Government drastically reduced the size of the staff it allowed the U.S. embassy in Havana, he broke diplomatic relations with Castro on January 3, 1961.

In Africa, the civil war in the Republic of Congo (Zaire) continued despite repeated efforts by the United Nations to achieve a peaceful solution.[131] On June 21, 1960, Joseph Kasavubu assumed the presidency and appointed as premier the leftist Patrice Lumumba, the leader of the National Congolese Movement. Nine days later, as promised in 1959, Belgium granted its former colony independence. The Congolese Army promptly mutinied and Moise Tshombe's Katanga Province seceded from the new republic. Katanga's cobalt, copper, diamonds, radium, tin, and uranium (produced by the Union Minière) were still vital to the West. In July, Lumumba appealed for U.N. aid, and the Security Council voted to send a peacekeeping force, eventually totaling 20,000 troops, to replace Belgian forces, end the violence, and restore order. Congo Army troops arrested Lumumba in Leopoldville (Kinshasa) in September. Colonel Joseph Mobutu, who commanded the Republic's army, took over its government after the legislature increased the deposed Lumumba's authority; Kasavubu responded by ordering Soviet diplomats, who supported

Lumumba, out of the country. In November, as the U.N. General Assembly seated Kasavubu's delegation and he tried to gather all Congolese leaders in a peace conference, Lumumba fled to Katanga. In December, the U.N. General Assembly overwhelmingly approved its Resolution 1514, which denounced colonialism and reasserted the rights of all people to independence and self-government. U.N. forces generally kept the peace in the Congo, even after the withdrawal in December of troops from five countries, but they could not save Lumumba, who was killed by Mobutu's soldiers, on Tshombe's order.

At home during fiscal year 1959–60, Congress and the President welcomed another new State into the Union, supported the Oil Import Administration, authorized continued disposals from the Nation's mineral stockpiles,[132] enacted measures designed to increase support for domestic mineral-mining industries, and passed a new civil rights act. Hawaii's voters had begun petitioning for statehood in 1903, bills for achieving that status dated from 1919, and the voters approved an earlier constitution in 1950. Eisenhower signed the congressional enabling act[133] on March 18, 1959; his proclamation[134] of August 21 admitted Hawaii into the Union as its 50th State. Hawaii's land, held mainly in private ownership, included no significant public acreage, but, as time passed, the new State added to its holdings as the Federal Government decided it no longer needed the lands it earlier reserved and returned them to the State. The Oil Import Administration and the Oil Import Appeals Board,[135] established within Interior by Eisenhower in March 1959, continued to implement and monitor the Federal program and handle appeals by those persons and corporations that it adversely affected. On May 6, 1960, a new Civil Rights Act[136] strengthened the 1957 law by providing for judicial enforcement of registration and voting rights, and for criminal penalties for those convicted of threatening or attacking voters and polling places.

The Eisenhower administration continued to sell off parts of U.S. mineral-commodity stockpiles to aid the Nation's economic recovery from the 1957–58 recession and to increase financial aid to education and technological developments in the wake of Sputnik 1. The Office of Defense Mobilization (ODM) established a Special Stockpile Advisory Committee, composed of civilians, including retirees General Walter Smith and Admiral Arthur Radford, to review existing policies and programs for stockpiles worth several billions of dollars. The Committee's report of January 28, 1958, as Alfred Eckes, Jr., later summarized,[137] recommended reducing the interval for emergency procurement from 5 to 3 years, on the basis of the assumed duration and nature of a war with the Soviet Union, giving the ODM's Director more flexible authority to decrease surplus commodities (while keeping those commercially usable), and shifting the stockpile effort's emphasis from raw materials to finished goods. On April 22, Eisenhower and his Cabinet agreed to implement carefully most of those suggestions so as not to disrupt the Nation's domestic economy or its international relations and commitments. Of the 75 items in the strategic-critical stockpiles, nearly 60 were now surplus, including large amounts of aluminum, chromite, rubber, and tin. On September 9, 1959, a congressional resolution authorized the disposal from the national stockpiles of fixed amounts of diamonds, osmium, rhodium, ruthenium, and zircon concentrates.[138] Diamonds could be spared now after being synthesized in a General Electric laboratory in December 1954; the company received in June 1960 a Federal patent for the new process. On September 10, 1959, a second resolution authorized the President to arrange for a review by each Federal department and agency to provide for "increased production and employment in critically depressed domestic mining and mineral industries."[139] This measure reflected the continuing problems in the lead-zinc industry that were partially solved when, on September 22, 1958, Eisenhower further limited the imports of some commodities, but this decision drew vociferous protests from Australia and Peru. The President pocket-vetoed the bill for the proposed Coal Research and Development Commission on September 16, 1959. Eisenhower, who viewed mineral self-sufficiency as a worthy but unrealistic policy, also vetoed, 2 weeks before the 1960 national elections, a measure that provided subsidies for the lead-zinc industry, claiming they would lead to increased taxes, more production problems, and greater free-market instability.

The Interior Department already administered conservation programs for mines but the second Hoover Commission recommended that the Federal Government link functions by its major departments and agencies by their purpose. The Senate held hearings in January 1960 on a bill designed to end restrictions on the U.S. Coast and Geodetic Survey's coverage of the coastlines and continental shelves of the United States and its Territories and possessions. That measure, the Navy protested, would compromise Defense Department surveying and charting. The Navy lost its bid to retain sole control of oceanic mapping and research when the legislators and their staffs found that the detail and accuracy of some of the Navy's ocean charts were as much as 2 centuries behind those of some land maps. Congress and the President authorized the U.S. Coast and Geodetic Survey and the U.S. Coast Guard to conduct oceanographic research whenever and wherever possible. In April, Senator Magnuson held hearings on another bill, for marine science and research, supported by resolutions from a wide group of public and private organizations both civilian and military, designed to advance oceanographic work by Federal and private agencies.

Secretary Seaton returned to Representative Kirwan's House subcommittee on January 13, 1960, an early start in that Presidential-election year, to defend the Interior Department's request for funds, not including those for the reclamation and waterpower agencies, for fiscal year 1960–61. Kirwan, also speaking for his colleagues Fenton, Jensen, and Norrell, welcomed Seaton by saying that they got along with the Secretary "as well as we have with any man I know and he is doing a good job."[140] Seaton thanked Kirwan and then reviewed for the subcommittee operations by Interior and its agencies for 1950–60. During that decade, Interior's funds, excluding those for reclamation and waterpower, increased by $160.5 million, but its staff decreased by 280 persons, not including the nearly 5,400 other positions already discontinued or transferred to other Departments. In the same interval, Interior, including reclamation and waterpower, received appropriations of nearly $6.5 billion and generated revenues of almost $3.2 billion.

Seaton then summarized the accomplishments of each of Interior's agencies during 1950–60. The USGS, he reported, increased its adequate map coverage of the United States from 22 to 45 percent, while reducing the cost of a topographic map sheet by 14 percent and the average cost of printing one map edition by 22 percent. The agency's supervision of operations on mining properties grew by 360 percent, and its supervision of oil and gas leases rose by 450 percent. USGS geological investigations "provided private industry with additional basic data to guide successful information for new mineral deposits," as exemplified by the recent discovery of extensive high-grade silver-lead ore in Utah. Seaton also pointed to the agency's "[s]ignificant advances in * * * the knowledge of the occurrence and availability of our water resources and in the identification of hydrologic principles involved in the utilization of water."[141] He asked the subcommittee to approve $43,365,000 for the USGS in fiscal year 1960–61, or $659,000 more than the adjusted SIR appropriation in 1959–60; most of the requested gain would support land classification and mineral-lease supervision. Seaton estimated that these operations would involve 346,000 cases relating to classification, leases, mines, and wells, whose production and royalty values would rise, respectively, to $1.08 billion and $125 million owing to "the unprecedented rate of development of the Nation's oil and gas resources."[142] In response to Keith Thomson's concern about rising personnel costs and falling program expenditures, Seaton later summarized for the record Interior's total number of paid employees by month between the 62,744 in July 1951 and the 50,471 in November 1959. The USGS hoped to increase its staff in 1960–61 by just 22 persons to a new authorized total of 7,622, including 6,928 permanent appointments and 694 full-time-equivalent positions.

Nolan appeared on January 14 before Kirwan's subcommittee to support the budget requested for the USGS in fiscal year 1960–61. Seaton's promotion of the agency's accomplishments should have made Nolan's task easier, but Kirwan was not in his usual friendly mood. He called the meeting to order and promptly asked Nolan for a statement. Nolan began his remarks by noting that the "nuclear and space age, which has come upon us so rapidly, has created new demands for mineral substances; for more water and better utilization of water resources; and for more maps that accurately depict the face of the Nation."[143] As before, he explained the USGS work in basic and applied science and engineering, pointing out their specific contributions to the common defense and general welfare. The fundamental studies and monitoring by personnel at the Hawaiian Volcano Observatory, Nolan emphasized, aimed at achieving more accurate predictions of volcanic eruptions. He stressed the hydrological investigations that aided the "improved design of river control works, bridges, and other structures." Nolan, like Seaton, also pointed out the studies in Utah's East Tintic District that led "to the recent discovery by a mining company of 'blind' ore bodies."[144] That find greatly increased East Tintic's known reserves of high-grade silver-lead ore in the primarily lead-zinc district, opened new areas to deep exploration, and again demonstrated the value of the agency's geochemical, geological, and geophysical techniques. The USGS, Nolan noted, was aiding the evaluation of problems of nuclear-waste disposal by measuring beta-gamma activity as well as the uranium-radium content in surface water and groundwater at several hundred sites nationwide. The Western Region's topographers now occupied Building 3 at Menlo Park. The topographic mapping of Kentucky at 1:24,000, newly revised in cooperation with that State to aid resource assessments and highway construction, and attract new industries, led to the new cooperative agreement with Ohio's Government to map at the same scale the remaining 75 percent of Ohio's surface within 3 years. The acquisition of new water-stage recorders and improved electronic-computer facilities enabled the more rapid and accurate gathering and processing of hydrologic data. The new Publications Division, now just 6 months old, and improved processing of reports by the program Divisions, Nolan claimed, would significantly speed the publication of the results of USGS operations. A committee, composed of one representative each from the General Accounting Office (GAO) and Interior's Administrative Assistant Secretariat, and the USGS Executive Officer, continued to evaluate the agency's accounting procedures. Walter F. Frese, Professor of Business Administration in Harvard's Graduate School, who earlier directed the GAO's Accounting and Auditing Policy Staff and led the Treasury Department's Fiscal Service Operations and Methods Staff, served as a consultant to the committee. Nolan closed his remarks by reminding the subcommittee that the Independent Offices Appropriation Act[145] for 1960 contained funds for a new headquarters building for the USGS. The General Services Administration would begin work as soon as Congress acted on the construction-project prospectus submitted in September 1959.

The USGS, Nolan reported, expected to receive an estimated total of $64,513,000 in fiscal year 1960–61, a loss of more than $243,000 from 1959–60 but one subject to review by the new administration and the new 87th Congress. Thirty-two States and Puerto Rico, counties, municipalities, and miscellaneous nonfederal sources would provide $11,298,000, a $361,000 gain; another nearly $11,060,000, an almost $1,304,000 decrease, would come from other Federal agencies. The $43,356,000 requested in the SIR appropriation included $14,810,000, an estimated $85,000 gain, for topographic surveys and mapping; $11,837,000, or $74,000 more, for geologic and mineral-resource surveys and mapping;

$12,044,000, a $69,000 increase, for water-resources investigations; $176,000, a gain of $1,000, for soil and moisture conservation; and $3,169,000, a $420,000 increase, for conservation of lands and minerals. The SIR increase included $265,000 of the $392,000 needed for medical insurance required by the Federal Employee Health Benefits Act[146] of September 28, 1959. Total sums, including other Federal and nonfederal sources, accrued for the program Divisions would rise for two of them—Conservation Division funds would increase to $3,217,000 and Water Resources Division funds, to $24,611,000. Total monies would fall for the other two program Divisions—Geologic Division funds to $16,467,000, and Topographic Division funds to nearly $19,489,000. The AEC's Research Division and the Geologic Division agreed to a change of base to the USGS of $337,000 for fundamental research on the crystallography, geochronology, infrared-ultraviolet radiation, stable isotopes, and thermoluminescence of radioactive minerals. Some of the 1960–61 appropriation, Nolan proposed, would fund several specific studies in geology. Those investigations included ore deposits in the older Precambrian rocks of southwestern Montana, the petroleum potential of Cambrian rocks in the northern Rocky Mountains, the 1959 earthquakes and landslides in southwestern Montana, uranium deposits in Wyoming's Shirley Basin, a mapping and mineral-resource evaluation of Nevada's Esmeralda County to be conducted in cooperation with that State, ore deposition in California's Merced Peak area, the geology of helium, increased geologic mapping at 1:250,000 of the 300,000 square miles to be completed in Alaska to assess its mineral potential, and oxygen-isotope measurements in mineral deposits as aids to an increased understanding of ore genesis. Nolan also reminded the subcommittee that only one-sixth of the conterminous States were covered by geologic maps of 1:62,500 or larger scales.

During Kirwan's mostly supportive review of funding requests for the USGS SIR programs, Nolan responded to the Chairman's additional queries about the agency's work for the AEC, the cost of the two USGS aircraft, and the discovery of the new lead-silver-zinc deposit in Utah. Nolan told Kirwan that the AEC increased its transfer by nearly $317,000 to cover additional work by the USGS related to the safety and the geologic and hydrologic environment of underground nuclear shots at the Nevada Test Site. The $130,000, for which the AEC transferred $105,000, for the two USGS aircraft covered the fuel, maintenance, salaries, and special equipment needed for the magnetic and radioactivity surveys, and this cost was not comparable to the money expended on the Bureau of Sport Fisheries' 22 aircraft. When Kirwan emphasized that U.S. stockpiles of lead and zinc were, respectively, four and eight times the maximum wartime requirements, Nolan hoped that the higher grade of the newly discovered deposit at East Tintic would, when eventually developed, enable the Nation to compete more effectively with foreign sources. The International Lead and Zinc Study Group, formed by the United Nations in 1959, held its first meeting in Geneva from January 27 to February 3, 1960, with members of Assistant Secretary Royce Hardy's office in attendance. Meeting participants agreed to continue curtailing shipments of lead by exporters and began new and similar restrictions on zinc; after the market improved, they terminated the latter in May. The Eisenhower administration estimated that expenditures for stockpiling and expanding domestic production for defense would fall below $70 million during fiscal year 1960–61 and would drop further to about $50 million in 1961–62, as materials deliveries were completed, contracts ended, and no new agreements were signed.

Kirwan then renewed a significant complaint about the adequacy and timeliness of USGS accounting methods in its supervision of oil and gas leases. He began by querying the $250,000, the major part of the additional $400,000 requested for the Conservation Division in fiscal year 1960–61, to fund 33 new employees to supervise the ever-growing number of oil and gas leases, especially those on the Outer Continental Shelf, where petroleum production exceeded

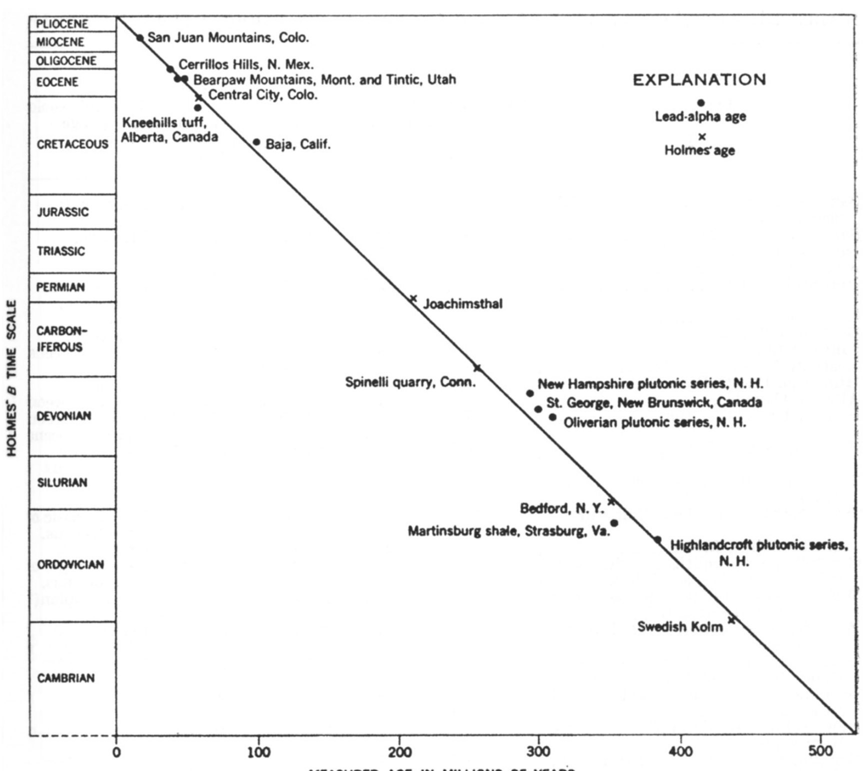
103,000 barrels daily in November 1959. The extra personnel, Nolan explained, would allow the Division to respond positively (by increased and improved efforts in field and office) to yet another critical report by the General Accounting Office in December 1959 of "serious deficiencies in royalty accounting" on the leased lands. "This is the third straight year," Kirwan reminded Nolan, "that we have taken up this General Accounting Office criticism." "One company," Kirwan continued, "had never been billed since 1949."[147] He pointed to "the inadequate procedures used in accounting for royalties in the audit reports issued to the Congress on the Bureau of Land Management, for fiscal years 1953 and 1954; to the Administrative Assistant Secretary [Beasley] in 1955; and to the Director of the Survey in 1956 and 1957." When Kirwan emphasized that "[t]here is something wrong in the method,"[148] Nolan said the review committee's preliminary evaluation of the most recent report by the GAO, which recommended transferring royalty accounting from the Conservation Division to the Administrative Division, yielded explanations of some comments and corrective action on other criticisms. Nolan emphasized that the delays, reflecting the divergence between the BLM and the USGS records, were in recording and did not represent any loss of Federal collections income. He anticipated that a system acceptable to the GAO would be completed within the next few months. The subcommittee, Kirwan responded, expected the USGS to resolve satisfactorily this problem before the appropriations hearing for fiscal 1961–62. If GAO complains to us again, Kirwan warned Nolan,

> **we are going to have to do something about it. I would like to see it corrected without our having to send somebody down there to straighten it out. Seven years is too long.[149]**

After this exchange, additional questions by Kirwan, Fenton, and Thomson proved something of an anticlimax. The three Representatives queried the funds for general administration, new housing for additional employees at the HVO, the new geologic mapping in Ohio, the progress since 1947 in mapping anthracite basins, the seemingly disproportionate increase since 1951 in USGS appropriations, the long-standing allegation of duplication in Federal mapping and possible consolidation of those functions in one agency, and the amounts spent to date on the USGS-State cooperative programs in topographic mapping and water-resources investigations. They also asked about the Nation's water-resources problems involving supply, variability, distribution, quality, pollution, and floods and the USGS responses to help resolve these problems that included collecting and analyzing basic facts about water, making interpretative reports on areas, and continuing research on processes and relationships. These questions and Nolan's answers yielded no surprises. The hearings closed with an exchange about the continuing search for a site for a USGS national center in the Washington metropolitan area. The General Services Administration, Nolan now reported, submitted to the House and the Senate Committees on Public Works on September 15, 1959, 6 days after the Public Buildings Act, the construction-project statement prepared jointly by the GSAd and the USGS. As soon as the committees approved the statement, Franklin G. Floete, the GSAd's Administrator since 1956, assured Seaton and Nolan that the GSAd would proceed with securing a site and preparing plans for the building, using the estimated $2,125,000 from fiscal year 1960–61's appropriation. Congressional approval also would enable the GSAd to confirm that construction was scheduled for fiscal 1962–63 and 1963–64.

On February 2, Secretary Seaton promised Senator Hayden's appropriations subcommittee that he would establish an office of coal research, supported by $1 million in contingency funds, if Congress and the President authorized the newly proposed program and its funds. Seaton also pledged to increase Interior's efforts to conserve and develop helium, as Eisenhower requested in his balanced-budget message of January 18 that contained expected revenues during fiscal year 1960–61 of $84 billion and expenditures of $79.8 billion.[150] Later in 1960, amendments[151] to the 1925 Helium Act, as amended in 1937, enabled, during the next 20–25 years, the Federal Government to contract with private firms to build another extraction plant. During these years, industry would deliver 62.5 billion cubic feet of helium, extracted from natural gas, beyond current needs and store the excess in the USBM's underground facility at Cliffside, just northwest of Amarillo, in Texas. As recommended by the NSF's Advisory Committee on Minerals Research, Seaton emphasized, the USGS proposed to expend a total of $500,000 on three projects—$200,000 on the first year of additional studies in geochronology, $100,000 on lead-isotope investigations, and $200,000 on geologic and topographic mapping related to understanding the occurrence and locating new supplies of the Nation's mineral commodities, especially in the Rocky Mountain area, and developing new exploratory methods and tools.

When the USGS contingent appeared before Senators Carl Hayden, Henry Dworshak, and Thomas Kuchel on February 9, Nolan began his statement by summarizing the requested SIR increase that included $400,000 for lease supervision and land classification and $265,000 for the Federal share of the medical-insurance program. Nolan called for additional SIR appropriations to support USGS studies related to safely disposing of the growing volume of radioactive wastes by investigating suitable underground sites for storage, the mechanisms and mineralogy of ion exchanges, the reactions of mixed electrolytes with rocks and other natural materials, and the dissipation of heat underground. The House and the Senate Committees on Appropriations agreed to add $285,000 to the agency's request for SIR funds for fiscal year 1960–61, $127,000 of which would go to medical insurance and relieve the USGS from absorbing that amount. On July 7, a new law established the Office of Coal Research (OCR) in the Interior Department, to "encourage and stimulate the production and conservation of coal in the United States through research and development by authorizing the Secretary of



This chart compares USGS lead-alpha ages from rocks of known geologic ages with those from the *B* time scale of British geologist and pioneering geochronologist Arthur Holmes (1890–1965). In the 1950s, USGS isotopic geochronologists used lead-alpha, lead-uranium, lead-thorium, and lead-lead methods of dating igneous rocks containing the minerals zircon, monazite, thorite, and xenotime. They compared the results of these techniques with other radiometric dates determined by the newer potassium-argon and strontium-rubidium methods. Dates were considered concordant if they varied within plus or minus 10 percent of each other. Partial or complete melting and recrystallization of minerals after their formation that led to the loss of lead isotopes were among the causes of discordant dates. (From Gottfried, Jaffe, and Senftle, 1959, fig. 6; for a biography of Holmes, see Lewis, Cherry, 2000.)

the Interior to contract for coal research."[152] Industry wanted less abstract research and the USBM wanted immediate practicable and applicable results. The new OCR received up to $2 million during fiscal 1960–61 from unappropriated funds in the Treasury.

On May 13, 1960, President Eisenhower signed his last bill that provided regular appropriations for the Interior Department. The Public Land Administration Act of July 14 authorized the Secretary of the Interior to conduct "investigations, studies, and experiments" and to accept "donations of money, services, and property" to facilitate "the improvement, management, use, and protection of the [public] lands."[153] The USGS, for its land-related and other operations during fiscal year 1960–61, received SIR funds of $43,650,000, of which $7,450,000 could be used only for the State-county-municipal cooperative studies of water resources.[154] A supplemental measure, strongly supported by Senator John S. Cooper (R–KY) as Alben Barkley's successor, and enacted on September 8, gave the USGS an additional $300,000,[155] to equal Kentucky's funds authorized in March for its initial year's contribution to the cooperative geologic mapping of that State. A second supplemental bill, signed on March 31, 1961, added $2,006,000[156] and brought the SIR funds available to the USGS for 1960–61 to $45,856,000, or nearly $3.8 million more than in 1959–60. Other Federal agencies would provide about $13,196,000; States, counties and municipalities would contribute some $11,641,500; and miscellaneous nonfederal sources would add nearly $610,800, to raise USGS funds for fiscal year 1960–61 to just over $71,349,000, an increase of some $6 million above the total for 1959–60.

The Eisenhower administration, while focusing on the coming Presidential election, the State and more local contests, and other significant developments at home, continued to experience successes and failures in dealing with the Soviet Union and in space. U.S.-Soviet relations deteriorated even further after July 1, 1960, when Soviet interceptors shot down an American RB–47 reconnaissance aircraft as it neared the Barents Sea and incarcerated the surviving crewmembers until 1961. In August 1960, Richard Bissell's Project Corona began paying off on its investment, and the Eisenhower administration established an initially civilian group to direct all U.S. aircraft and satellite reconnaissance. In the following year, that group was replaced by the National Reconnaissance Office, with its supporting and CIA-directed National Photographic Interpretation Center to handle the film records. On Aug. 11, Corona personnel successfully recovered from Pacific waters a capsule ejected from the Discoverer 13 satellite; the capsule contained damaged film. This action was the first recovery of a manmade object ejected from an orbiting satellite; several other capsules had sunk at sea, and one was lost on Spitsbergen (Svalbard). On August 19, the crew of American transport *Pelican 9*, one of six Fairchild EC–119J Flying Boxcars, recovered in midair over the Pacific a parachute-suspended capsule, with film intact, returned from Discoverer 14. The initial processed image, taken a day earlier, showed a 10-square-mile area, and within it a Soviet military airfield and other objects as small as 25 feet across, around Cape Schmidt on the northern coast of Chukotka, about 475 miles northwest of Nome, Alaska. The photograph also recorded patterns of vegetation, sediment transport, and waves and currents. On August 19, 1960, Soviet Sputnik 5, a Vostok spacecraft carrying canines "Belka" and "Strelka," achieved orbit; later the two dogs were recovered safely, unlike "Laika," as were three U.S. mice sent aloft aboard an Atlas on October 13. By then, another Pioneer and a Soviet probe to Mars both failed and U.S. Project Mercury continued to encounter difficulties in testing its spacecraft. After failures in July and November, a modified Redstone rocket, launched from Cape Canaveral on December 19, hurled an empty Mercury capsule 135 miles into space and 235 miles downrange in the Atlantic. A helicopter crew recovered the spacecraft and brought it safely aboard aircraft carrier *Valley Forge*.

As the space race continued in 1960, oil was discovered in the Neutral Zone between Kuwait and Saudi Arabia, and the West's petroleum policies gained it a new competitor. On March 10, 1959, Eisenhower moved to protect domestic producers by setting quotas on oil imported into the United States. Attendees at an Arab Oil Congress, held in Cairo in April, signed an informal agreement that Daniel Yergin later viewed as their effort to defend existing prices, nationalize more of their native industries, and increase their revenue shares.[157] Oil production from the Middle East, which held most of the world's reserves, continued to increase during the 1950s, as it did in the Soviet Union, but oil prices continued to fall as the West's major oil companies changed posted prices, as opposed to market values, without first consulting the producing countries. When Standard Oil of New Jersey increased oil prices by 14 cents, or about 7 percent, per barrel on August 9, 1960, the company's failure to obtain advance agreements with other oil-producing nations produced a significant change in Saudi Arabia and also led to the founding of a new international, potentially powerful, and certainly hostile cartel. Crown Prince Faisal promptly replaced Abdullah Tariki, the Saudi oil minister who signed the Cairo agreement in 1959, and appointed lawyer Ahmed Zaki Yamani to the Council of Ministers; during the past 4 years, Yamani, now 30, advised the Finance Ministry's Oil Department and then the Council. On September 8, 1960, Shell increased its price by 2 to 4 cents per barrel. Representatives of five major oil-producing nations—Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela, who together produced 80 percent of the world's exports—met in Baghdad to try to control and stabilize petroleum prices. By September 14, they formed the Organization of the Petroleum Exporting Countries (OPEC), but the new organization received little attention in the CIA's November report on the Middle East. Eventually nine other countries—Algeria, Angola, Ecuador, Gabon, Indonesia, Libya, Nigeria, Qatar, and the United Arab Emirates—joined OPEC. The group's members often disagreed with each other and did not succeed in stabilizing oil prices. As Yergin recorded, they did begin to control production, increased their shares of the profits from a 50:50 split to as high as an 86:14 division, and required the global oil companies to negotiate their proposed changes in price. Policy in Saudi Arabia, the largest of OPEC's oil producers, changed again after Crown Prince Faisal resigned his two ministries at the request of King Saud on December 21, 1960. A week earlier, the Organization for European Economic Cooperation, founded to promote freer trade worldwide, added Canada, Japan, and the United States as member nations to become the Organization for Economic Cooperation and Development. When Faisal returned to power, Yamani became Minister of Petroleum and Mineral Resources and joined Aramco's Board of Directors in 1962.

The U.S. Presidential campaign began in earnest in late July 1960, after both major political parties held their conventions. The Democrats, meeting in Los Angeles on July 13, nominated Massachusetts' Senator John Kennedy, now 43, for President on the first ballot. Kennedy, educated at Harvard, served in Navy intelligence at home and in combat in Patrol Torpedo (PT) boats in the Pacific during World War II. Lieutenant Kennedy received wider attention in 1943, when the Japanese destroyer *Amagiri* rammed and sank his PT–109 during a night patrol in Blackett Strait off Kolombangara in the central Solomons. Two of the PT's crew died, but Kennedy helped to rescue the other survivors and was decorated. Despite continuing problems caused by a reinjured back and Addison's disease, Kennedy served his State as a Democrat in the House from 1947 before being elected to the Senate in 1952. His younger brother Robert F., who served after the war in destroyer *Joseph P. Kennedy, Jr.*, named for their deceased elder brother killed on an aerial-bombing mission in 1944, helped to counsel the second Hoover Commission and McCarthy's subcommittee, and campaigned for JFK, who announced his decision to seek the Presidency on January 1, 1960. Joseph Kennedy, Sr., who opposed his son's try for the Vice Presidential nomination in 1956, now provided funds and political influence. Hubert Humphrey, Jr., the Senate's Democratic whip, who also wanted the Vice Presidential nomination in 1956, now hoped to become the next President. The more liberal Humphrey lost key primary elections in 1960 to the more conservative Kennedy, whom Humphrey and Adlai Stevenson called the Democratic "Nixon," and withdrew from the contest. At the party's national convention, Kennedy achieved a more balanced ticket, especially in the South, by offering the Vice Presidential nomination to Lyndon Johnson, who took the post after running second to Kennedy in the only Presidential ballot. Kennedy and Johnson, rarely campaigning together, promised to get the United States moving again. They pledged to eliminate an alleged Soviet advantage in ICBMs (the so-called but nonexistent missile "gap"), end Soviet dominance in space, improve civil rights for minority citizens, place medical care for older persons under the Social Security system, and begin a policy of looser credit and money.

Republicans convened in Chicago and chose Vice President Richard Nixon as their nominee for President on the initial ballot on July 27, 1960, after Governor Nelson Rockefeller of New York declared that he would not be a candidate. "Prospect for America," the report[158] of Rockefeller's six panels established in 1956, would not appear until 1961. As Nixon's running mate, the delegates selected Henry Cabot Lodge, Jr., the U.S. Ambassador to the United Nations, whom Eisenhower had appointed and given Cabinet rank in 1953. Lt. Colonel Lodge, a Harvard graduate like Kennedy, led armored units in combat in North Africa and Europe during World War II. Lodge, like his grandfather, served Massachusetts as one of its Senators. Lodge served in the Senate during 1937–1944 and 1947–1953; he resigned in 1944 to return to active military duty. In November 1952, Lodge lost his seat to Kennedy after campaigning widely for Eisenhower. Nixon and Lodge pledged to continue Eisenhower's domestic and foreign policies, including establishing a fiscally sound but contributory health program, enforcing the civil rights of all citizens, and increasing funds for national defense. Eisenhower, Nixon, and Defense Secretary Gates denied a missile gap and emphasized the U.S. lead in the space race with the Soviet Union in the number of satellites and probes launched. In the ensuing campaign, Nixon, against Eisenhower's advice, debated Kennedy four times on radio and television, beginning on September 26; the results were mixed. Kennedy convinced additional voters that he was mature and experienced enough to be President and that his Catholic religion would not adversely influence his conduct while in office. Both parties issued policy statements on science and technology, and both candidates for the Presidency employed science advisers; George Kistiakowsky replaced James Killian as Eisenhower's adviser in mid-July 1959.[159] Nixon and his advisers kept Eisenhower on the shelf until the last weeks of the campaign; the President's active participation came too late to affect its result.

Kennedy won by an exceedingly slender margin on November 8, even though more than 8 million new Democrats registered during the campaign. The tally proved so close that recounts in four States, including Illinois, where Mayor Richard J. Daley of Chicago held his city's votes until he knew the downstate totals, delayed the Electoral College's official decision until December 19. Kennedy received just 118,574 popular votes more than Nixon, out of 68,508,943 cast, but he gained 303 electoral votes to Nixon's 219, an 84-vote margin that included Illinois' 27. None of the four minor-party candidates, including Governor Orval Faubus of Arkansas, drew more than 48,000 popular votes. Virginia Senator Harry Byrd, Sr., received the votes of 15 unpledged electors in Alabama (6), Mississippi (8), and Oklahoma (1). The Democrats held Texas (24) and the Old South, except for Florida, Kentucky, Tennessee, and Virginia. Republican electors from California (32), Indiana, Iowa, Ohio (25), Washington, many of the Great Plains and Rocky Mountain States, and a few in New England did not offset the Democrats' total. Nixon could have demanded a recount, but he decided not to contest his loss; he returned to

California, where he intended to run for Governor in 1962. In elections for the 87th Congress, the Democrats kept control of both houses; they led by the same 65–35 margin in the Senate, but the loss of 21 seats in the House reduced their edge there to 263–174.[160]

In response to Kirwan's remarks in January 1960, Nolan and his staff continued to consolidate and simplify USGS administrative services by using electronic data-processing equipment to improve financial-management reports, timely payment of rents under annual contracts, tracking of per diem payments for employees on continuous travel status, space-inventory records, accounting and property control for interdivision services, and cost controls by agency shops. Representatives of the Interior Department and the USGS continued to meet annually with the USGS Science Advisory Committee—Horace Albright, John Frye, William Heroy, Herbert Loper, Donald McLaughlin, George Gaylord Simpson, and Abel Wolman—to evaluate the agency's management and programs. As before, the external advisers also submitted a report of recommendations to the Secretary. The USGS, also as usual, then commented on each evaluated item for the Secretary and the House appropriations subcommittee. The agency's advisers planned to hold their next 2-day meeting in December 1960.

Kirwan's comments also led the USGS to speed the appearance of the results of its research. On June 30, Nolan introduced the initial compilation of "Geological Survey Research," published in two volumes (chapters A and B) as Professional Paper 400. In his foreword, Nolan wrote, "This report is frankly an experiment."[161] He hoped to reduce the interval between the completion and publication of the results of USGS research; perhaps he also wished to decrease the loss of articles to outside periodicals or at least to get brief versions of them earlier into print. Professional Paper 400 summarized the results of recent work by members of the Geologic Division. Chapter A, a "Synopsis of Geologic Results" prepared by Division members under Vincent McKelvey's direction, presented summaries of "important new findings, either as yet unpublished or published"[162] during fiscal year 1959–60. These brief synopses appeared in seven groups—mineral-resources investigations, development of exploration and mapping techniques, geology applied to problems in the fields of engineering and public health, regional geology, geologic investigations in foreign nations, investigations of geologic processes and principles, and analytical and other laboratory techniques. Chapter A also listed the Division's offices, its reports released during the fiscal year, and its in-progress investigations.

USGS Professional Paper 400's Chapter B, "Short Papers in the Geological Sciences," contained 232 articles, most shorter than 1,000 words. Some articles announced "new discoveries or observations on problems of limited scope" in advance of "more detailed and comprehensive reports" that might or might not "be published later." Other articles summarized the conclusions drawn from extensive and long-term investigations; Nolan's foreword said that the conclusions "in large part will be embodied in much longer reports that will be published later." Chapter B's articles were further divided among 13 categories: geology of metalliferous deposits (27 articles); geology of light metals and industrial minerals (8); geology of fuels (7); exploration and mapping techniques (20); geology applied to engineering and public health (11); geology of the Eastern United States (20); geology of the Western conterminous United States (58); geology of Alaska (11); geology of Hawaii, Puerto Rico, Pacific islands, and Antarctica (12); paleontology, geomorphology, and plant ecology (6); geophysics (14); mineralogy, geochemistry, and petrology (20), and analytical and petrographic methods (18). Nolan hoped to include in future annual issues the results of similar comprehensive work by the agency's other program Divisions. He sought "comments and suggestions from those who use the volume" to "help determine the content of the future ones."[163]

In 1961, the Menlo Park chapter of the USGS Pick and Hammer Club printed its program, subtitled "The Collapsis of Geologic Results,"[164] as a "facsimile" of Professional Paper 400. The players burlesqued that volume, especially the delay its preparation imposed on other Geologic Division publications, and the year-old reorganization of the Division.

Chapter B's short-paper potpourri contained reports by older and younger authors from the Geologic Division, and those in affiliated Federal, State, and academic organizations, that summarized on a few pages the results of their wide-ranging recent and ongoing basic and applied research. The AEC provided most of the transfer funds for publication, but support also came from the Arctic Institute of North America, the USAF's Cambridge Research Center, the Army Engineers, the USBM, the Bureau of Public Roads, the USBR, the GSAd, the NSF, the Navy's Bureau of Yards and Docks and its Office of Naval Research, and the Soil Conservation Service. Other organizations providing financial and other aid included State agencies in California, Colorado, Connecticut, Maryland, Nevada, Oregon, and Pennsylvania; Puerto Rico's Economic Development Administration; the University of California at La Jolla and at Riverside; and Caltech. The hypothesis proposed by J. Hoover Mackin (at the University of Washington-Seattle) and Earl Ingerson (at the University of Texas-Austin since 1958) for the origin of ore-forming fluids and a study by John N. Rosholt, Jr., of uranium migration in sandstone-type ore deposits were among the metalliferous-deposit papers. Isidore Zietz, Gordon E. Andreasen, and Arthur Grantz compiled regional aeromagnetic surveys of possible petroleum provinces in Alaska. Paul Averitt summarized U.S. coal reserves as of January 1, 1960. William Fischer evaluated spectral-reflectance measurements as bases for film-filter selection for differentiating rock units on aerial photographs. Articles about studies in Alaska included Robert Chapman's and Hansford T. Shacklette's summary of the results of geochemical exploration in Alaska; an assessment by Gordon W. Greene, Arthur Lachenbruch, and Max Brewer of the effects of Alaska's Richardson Highway, at mile 130, on permafrost; a 1:1,584,000 sketch map of the State's surficial deposits by Thor N.V. Karlstrom and his collaborators; and carbon-14 dates, reported by Henry Coulter, and his Iowa State University coauthors Keith M. Hussey and John B. O'Sullivan, of 38,000 to 9,100 years (before the present) for the upper part of the North Slope's Gubik Formation. Coulter and Karlstrom were part of the in-house group of geologists, including David Hopkins, Troy Péwé, Clyde Wahrhaftig, and James Williams, who planned a glacial map of Alaska.[165]

Chapter B also reported some results of the Geologic Division's work with electronic computers and its continuing efforts at the Nevada Test Site.[166] Martin F. Kane used the USGS Datron 205 to compute terrain corrections for gravity stations in moderately mountainous areas of southern Nevada; Kane expected the cost of the expensive but more rapid and consistent computations to be reduced by three-quarters when the new Datron 220 began operations. Results of work at the NTS included studies by V. Richard Wilmarth, Theodore Botinelly, and Ray Wilcox of how the Rainier nuclear test's explosion altered the containing tuffs. Carl M. Bunker, William Diment, and Wilmarth discussed the distribution of gamma radioactivity, radioactive gas, and temperatures generated by the same test. Diment, Don L. Healey, and Joe C. Roller related gravity and seismic exploration to understanding the geology of the NTS. George V. Keller described the physical properties of the test-containing Oak Spring Formation's tuffs. Francis A. McKeown and Dayton D. Dickey evaluated the effects of the NTS explosions on their geological environment. Wilmarth and McKeown reported the structural effects of the Rainier, Logan, and Blanca tests. Gene Shoemaker, who was acquiring the double-entendre nickname "Supergene," used data from the Rainier-test tuffs and the craters from the Jangle-U and Teapot-ESS nuclear tests in alluvium, his mineralogical and stratigraphic studies of Meteor Crater, and dynamite explosions in Colorado sandstones to develop a scaling law for domain of brecciated mixing of rock by strong shocks that included an equation between the mixing-domain's limit and the energy released.

Other parts of Chapter B extended the geologic-geographic coverage of the Geologic Division's current research. Bill Bromery presented his preliminary interpretation of aeromagnetic data in Pennsylvania's Allentown quadrangle. Samuel W. Stewart, Renner B. Hofmann, and William Diment analyzed some aftershocks of the Hebgen Lake, Montana, earthquake of August 1959, and Wayne H. Jackson reported a profile based on postquake soundings in Hebgen Lake. Henry Joesting and James E. Case assessed salt anticlines and deep-seated structures in the Paradox Basin of Colorado and Utah. Charles Hunt and hydrologist Thomas Robinson proposed possible interbasin circulation of groundwater in the southern Great Basin, and Don R. Mabey summarized regional gravity surveys in the Basin and Range Province. Three articles evaluated volcanism in the Cascade Range, studied by USGS geologists since Clarence E. Dutton began working there in the 1880s. Don R. Mullineaux and Dwight R. ("Rocky") Crandell, protégés of Ray Wilcox at Denver since 1950–51, fixed the age of Washington's Mount St. Helens as late Recent and suggested that its present cone might be less than 1,000 years old. Dallas Peck assessed volcanism and volcanic trends in Oregon's portion of the Cascades, and Louis Pakiser suggested an eruptive mechanism for the Cascade volcanoes within California. Frank Whitmore described fossil mammals collected by Helen Foster's field party on Ishigaki-shima in the Ryukyus. Six other articles represented research on topics of more recent interest to the Geologic Division—Robert Hackman's technique for stereoscopically viewing lunar photographs; Warren Hamilton's new interpretation of Antarctic tectonic features; Harry Ladd's view of the distribution of Cenozoic molluscan faunas in the Pacific, based on fossils from its islands; Donald White's summary of the chemical characteristics of some deep-origin waters; E-an Zen's analysis of the early stages of evaporite deposition; and Richard Doell's and Allan Cox's preliminary assessment of paleomagnetism's relation to polar wandering and continental drift.

Doell and Cox, who published elsewhere in 1960 an extensive review of paleomagnetism,[167] concluded in their brief article for Chapter B that "the paleomagnetic data now available," gathered since George Becker's prediction in 1904, indicated that "the earth's magnetic field had vastly different characteristics during the following periods: post-early Pleistocene, Oligocene to early Pleistocene, Mesozoic to early Tertiary, late Paleozoic, early Paleozoic, and Precambrian." The value of paleomagnetic evidence for or against continental drift, they asserted, required determining "the configuration of the earth's magnetic field during the time when contemporaneous rocks from different continents were magnetized." Only in a few of these six time intervals was the geomagnetic field's configuration "established with sufficient certainty to justify application to the problem of continental drift."[168] The late Pleistocene magnetization directions, all of the same polarity, often differed significantly from the present geomagnetic pole but rarely from the present geographic pole, data that supported the dynamo theory, a transient dipole field, and

> **a total absence of processes causing self-reversal of the remanent magnetization.[169]**

Magnetization directions of half of the Oligocene–lower Pleistocene rocks assessed were oriented nearly 180 degrees to the present field directions, indicating that at least a dozen field reversals occurred during this interval, in which polar wandering and continental displacement were less than 10 degrees. Not one of the more than 40 reported studies of Precambrian rocks showed a virtual geomagnetic pole near the present geographic pole; most of these poles were near the Equator and just east of the 180th meridian.

"Continental drift interpretations" based on the scattered virtual geomagnetic poles of lower Paleozoic rocks, Doell and Cox cautioned, were "extremely hazardous."[170] All but a few of the Permo-Carboniferous poles lay between 30 and 40 degrees of latitude, but those calculated from measurements on European and North American rocks occupied positions between 90 and 180 degrees east, while those from Australia were well to the west. An interpretation based on continental drift during this interval required "rather improbable relative movements between North America and Europe." All of the Permian virtual geomagnetic poles also had the same polarity, a fact that could not be explained by the self-reversing hypothesis. The 50-plus determinations of Mesozoic and lower Tertiary rocks showed no magnetic-field configuration consistent with those of the upper Paleozoic and upper Tertiary rocks; some calculated poles were near the present geographic poles, but many of the others were at low latitudes. Doell and Cox concluded that the Earth's magnetic field during these intervals was insufficiently well fixed "to justify interpretation of the paleomagnetic data as evidence either for or against continental displacement during this time."[171]

While the Geologic and Publications Divisions, and the Government Printing Office, prepared and processed Professional Paper 400, and the USGS began planning for a similar but larger volume in 1961, Anderson and Nolan completed planning late in May 1960 for their reorganization of the Geologic Division effective as of July 1. Their two principal goals reflected political realities and an increased emphasis on academic-style operations, as recommended in a report by an internal committee chaired by Harold James. First, Chief Geologist Anderson and Director Nolan designed the modifications "to bring the budget structure into accord with the organizational structure." The Division's three major subactivities—economic geology, geologic processes, and regional geology—would now be managed by three of the four new Assistant Chief Geologists. The fourth new ACG received "operational responsibility for programs conducted on behalf of other agencies." Second, Anderson and Nolan responded to congressional and other external critics who noted "a lack of supervision"[172] by planning to "facilitate better supervision of the technical operations"[173] by increasing the number of the Division's Branches from 10 to 27. In response to allegations by staff members of the House appropriations subcommittee that the Geologic Division's 27 new Branches led to supervisory duplication, Nolan responded at the hearings in March 1961 that the new Branches each held fewer scientists. Some of the older Branches "had included as many as 300 scientists"; the new ones contained only 20 to 50 scientists. "This rearrangement," Nolan claimed, "should provide much more effective supervision" by reducing "the number of levels of supervision, as well as the number of supervisory positions."[174]

How the Geologic Division's reorganization would reduce job and staff inflation, when each new Branch Chief would need a staff, remained to be demonstrated, but grade inflation could be controlled by giving the Branch Chiefs temporary promotions. No productive scientists would wish to be separated from their research for more than 5 years. If new Branch Chiefs were not already GS–15 scientists, they could become GM–15 managers as an inducement to leaving full-time scientific studies to fill these slots. Those GM–15s would be returned to their former GS rank at the conclusion of their managerial tour, unless during that interval they continued significant research and publication. The results of such work might earn them research appointments as permanent GS–15s. As part of the reorganization, Anderson and Nolan considered abolishing the Regional Geologists' positions at Denver and Menlo Park, reassigning their responsibilities, and replacing them with a committee of four part-time deputies at each locality. Some of these changes in the Geologic Division introduced a new generation of scientist-managers. Some of the new thematic Branches would prosper both financially and operationally; others would not, reflecting in part the loss of ties to mission-specific funding.

Those changes in the Geologic Division became effective on July 1, 1960, but the Pick and Hammer Club commented on them in "The Fox and the Goose or Anderson's Grimmest Fairy Tale," its annual show in May 1961, by suggesting that "Andy—go westward today."[175] At Division level, CG Andy Anderson retained Montis Klepper as Assistant Chief Geologist for Operations but Robert L. Boardman succeeded Harold Bannerman as ACG for Program, with the additional responsibility for Budget. Boardman, an economic geologist, served with the Trace Elements Planning and Coordination Office during 1948–51 and then the Mineral Deposits Branch before becoming a staff geologist with Bannerman in 1957. The three new operational Offices went to ACGs James Balsley, for Geologic Processes, where Edwin Roedder served as Staff Geologist; Warren Hobbs, for Economic Geology; and Walter White, for Regional Geology. White had been Anderson's Assistant Branch Chief during 1954–56. ACG Vincent McKelvey took over Interagency Programs and Special Services.[176]

The need for a fifth program office in the Geologic Division came under increased scrutiny after Preston Cloud, at Nolan's request, testified in May before the House Committee on Merchant Marine and Fisheries' Subcommittee on Oceanography. On March 9, 1959, newly seated Representative Hastings Keith (R–MA), a Colonel in the Army Reserve whose district included the Woods Hole Oceanographic Institution, placed in the *Congressional Record* a warning that "The United States is losing to the Soviet Union the biggest and most important sea battle in mankind's history—the contest to unlock the ocean's secrets for use in peace and war * * * Now that the United States has drawn alongside the Soviets in the race for outer space, it is essential that we concentrate as well on developing to the fullest our capacity for probing the oceans."[177] Cloud began a staff review to advise Anderson and Nolan about the advantages to be gained by establishing an office of marine geology.[178] In June, Cloud replaced William Thurston as the Director's representative to the NAS–NRC's Committee on Oceanography and at the first two meetings of the Interagency Committee on Oceanography and its Subcommittee on Ocean Surveys and Development. Thurston, who left the NAS in 1959 to return to the USGS as a member of the Director's staff, represented the agency on the NAS–NRC's U.S. National Committee on Geology. Nolan, like Cloud, thought research should be intensified on three topics—(1) identifying the Continental Shelf's minerals, rocks, and structure; (2) interpreting the geologic history of movement by the margins of the continents and ocean basins; and (3) developing instruments and rapid techniques for in-place analyses of the chemical and physical properties of sea-floor sediments, to supplement data from coring and dredging.

Warren Hobbs' Office of Economic Geology held five Branches. David Varnes replaced Edwin B. Eckel as Chief of Engineering Geology. Hobbs' four new Branches included Base and Ferrous Metals, led by Philip Guild; Exploration Research, managed by geochemist Garland B. Gott; Light Metals and Industrial Minerals, directed by James J. Norton; and Organic Fuels, under Thomas Hendricks. Norton, who joined the USGS in 1942, mapped chromite with Joe Peoples in Montana and Georgia, investigated mica and beryl pegmatites in the Black Hills and elsewhere in the West, and spent 3 years in Washington managing commodity studies for the DMEA.

James Balsley's Office of Geologic Processes contained six Branches, almost all with strong components in basic as well as applied research. The former Branch of Geochemistry and Petrology was divided into Experimental Geochemistry and Petrology, led by Charles L. Christ, and Field Geochemistry and Petrology, under Robert L. Smith and including the HVO. At the HVO, Jerry Eaton succeeded

Kiguma ("Jack") Murata for a second tour as the Scientist in Charge. Balsley's units also included four new Branches—Crustal Studies, managed by Louis Pakiser, with Charles Bates as head of Vela-Uniform; Geochemical Census, led by Wayne Hall; Isotope Geology, under Samuel Goldich; and Theoretical Geophysics, directed by William Diment. Project Chiefs in Diment's Branch included Richard A. Robie for calorimetry; George V. Keller for electrical sounding and telluric currents; Arthur Lachenbruch for heat flow and geothermal processes; Allan Cox, Richard Doell, and (later) Brent Dalrymple for paleomagnetism; King Hubbert,[179] after he retired from Shell, for petroleum analysis; Eugene C. Robertson for rock mechanics; and E-an Zen for structural-stratigraphic syntheses.

Walter White's new Office of Regional Geology included 11 geographic and programmatic Branches. Two Branches in Regional Geology—Alaskan, where Donald Eberlein succeeded George Gates, and Paleontology and Stratigraphy, under Charles Merriam—were held over without change, except for shortening the name "Alaskan Geology Branch" to "Alaskan Branch." The General Geology Branch was dissolved, and, in July 1960, its chief Fred Smith returned to his studies, begun in August 1955, of Nevada's Railroad district. Among White's new Branches, Regional Geophysics was led by Isidore Zietz. Beginning in September 1961, Lawrence Craig supervised Paleotectonic Maps' completion of the Mississippian and Pennsylvanian folios. The new regional Branches included New England, led by Lincoln Page; Eastern States, under Jarvis ("Jerry") Hadley; Kentucky, directed by Alfred Zapp to March 1961 and then by Paul Richards; Northern Rockies, managed by Gershon Robinson; Southern Rockies, led by Ogden Tweto; Southwestern, directed by Robert Wallace; and Pacific Coast, under Parke Snavely, Jr. Richards returned to the United States in 1960, after 2 years of providing advice on sedimentary geology to the Geological Survey of India's Director, and initially joined the geologic mapping in Kentucky as a regional manager. Snavely began studying the geology and mineral resources of the Coast Ranges and adjacent areas in western Oregon and Washington in 1942; he also supervised the Division's work in the Pacific Northwest Region during 1953–59. Tweto mapped and studied tungsten and other commodities in Colorado from 1940 for Foster Hewett, Thomas Lovering, and other project chiefs in the Metals Section and Mineral Deposits Branch before beginning his tour as a Branch Chief in September 1961.

McKelvey's Office of Interagency Programs and Special Services comprised five Branches. Foreign Geology, led by William Johnston; the Library; and Military Geology, under Donald Dow, continued as before, but Frederick Betz, Jr., left as head of the MGB's European Team to become Executive Secretary of the Geological Society of America in 1960. McKelvey's new Branches included Frank Grimaldi's Analytical Laboratories, enfolding the former TEPCO, and Frank Stead's Special Projects, a partial spinoff from Military Geology. With these and the other changes during the Geologic Division's reorganization in 1960, two additional Branches—Fuels and Mineral Deposits—disappeared from the Division's table of organization.

As fiscal year 1960–61 began, the Geologic Division continued to apply geology for the benefit of public health. Its scientists' studies of radioactivity and geochemistry, conducted with the cooperation of the National Cancer Institute, showed strong correlations between the occurrences of cancer and coronary disease and the composition of rocks and groundwater in the affected areas. Magnetic-balance studies revealed anomalous cell fluid in cancer tissue. Electron-microprobe investigations, now able to spectrographically analyze areas as small as 1 micrometer, disclosed abnormal concentrations of copper in the corneal tissue associated with Wilson's disease.

In other wide-ranging studies, members of the Geologic Division used neutron-activation detection and the sensitivity of analytical chemical procedures to aid searches to reduce the domestic shortage of beryllium and other rare elements.

The recognition of new mineralogical associations of beryllium and niobium, as those earlier with uranium, led to the discovery of new deposits that could be developed to increase the Nation's reserves. The Division published a new estimate of the Nation's coal reserves and a revised coal map of the United States. Division personnel continued geologic studies of major urban areas, including Anchorage in Alaska, Council Bluffs in Iowa and Great Falls in Montana, to determine the sensitivity of their terrain for housing and industrial development, dam-site selection, and highway routes. Landslide and earthquake hazards evaluated in Los Angeles resulted in the closing of a major highway before it was covered by debris.

Cressman and Noger recorded that Kentucky's new Governor Bert T. Combs, inaugurated in January 1960, added his support and that of Lt. Governor Wilson Wyatt, responsible for economic development,[180] to efforts by State Geologist Wallace Hagan and Assistant State Geologist Preston McGrain to finalize the cooperative arrangement by which the USGS would geologically map the Bluegrass State. On September 2, 1960, more than a month after fieldwork began, the USGS and the KGS signed the agreement for the Kentucky Cooperative Mapping Program (KCMP). The USGS and Kentucky's Government agreed to share equally the estimated $12 million required to geologically map the Bluegrass State at 1:24,000.[181] USGS geologists, aided by stratigraphic paleontologists, would use as bases the Topographic Division's newly completed series of 707 same-scale topographic maps of quadrangles that covered the State's 40,400 square miles, and the USGS would publish the resulting geologic maps that were expected to provide additional and needed economic benefits to Kentucky.[182] The KGS also would provide data about drill cores, economic geology, and stratigraphy of the State's mostly Paleozoic rocks, but KGS geologists would not map with USGS field parties. The KCMP enabled Chief Geologist Anderson to arrange for the transfer of USGS personnel, who otherwise might have been let go, from work no longer funded by the AEC to Regional Geology's Kentucky Branch and its KCMP. Additional USGS geologists also formerly paid with AEC funds went to the Engineering Geology Branch, and others returning from assignments abroad were shifted to join the mappers in Kentucky. Alfred Zapp, who cooperated with a program coordinator from the KGS, established his Branch's headquarters in Lexington on July 1, 1960; the first group of his field geologists arrived later that month. The Branch opened its initial field office at Princeton in August; additional offices began at Bowling Green and Pikeville in October, and at Ashland, Columbia, Corbin, and Paducah in November. By the end of November, many of the 30 geologists already assigned to these KCMP field offices were mapping the initial 31 quadrangles selected for priority coverage. The initial four quadrangles—Haldeman and Wrigley (both northeast of Morehead), Ewing (northeast of Middleboro), and Austin (southeast of Bowling Green)—edited in Zapp's new Technical Reports Unit at Lexington were scheduled for publication as numbered GQs during calendar 1961. The Geologic Division planned to add an additional 25–30 geological mappers and supporting personnel to the KCMP in fiscal year 1961–62.

The NSF and the Navy prepared for operations in Antarctica during 1960–61 as the Senate ratified the Antarctic Treaty on August 10, 1960, and Eisenhower signed it on August 18. The treaty was proclaimed on June 23, 1961, and it went into effect on that day. The NSF established a new Office of Antarctic (later Polar) Programs on May 26 to coordinate all U.S. research activities on and around the continent. Meanwhile, on September 2, 1960, the International Council of Scientific Unions' Special Committee for Antarctic Research convened its fourth meeting, in Cambridge, England, where the Scott Polar Research Institute (founded in 1920) had served as a formal subunit of Cambridge University's Department of Geography since January 1957. The NSF provided nearly $5,461,000 for Antarctic research during fiscal year 1960–61.[183] During the austral summer, U.S. operations in Antarctica continued under the direction of Thomas Jones, David Tyree, and Edwin McDonald. The Navy sent nine ships, including icebreakers *Eastwind*, *Edisto*, *Glacier*, and *Staten Island*, to participate as TF 43 in Operation Deep Freeze 61.[184] The Scripps Institution of Oceanography deployed its research vessel *Argo* in the Ross Sea in February 1961. USGS geologist Avery Drake, Jr., and USGS topographer Joel H. Langhofer sailed in *Glacier* to the Bellingshausen Sea to work on map control and the geology of Thurston Island and parts of Ellsworth Land's coast. The Geologic Division's Richard H. Evans, in *Staten Island*, participated in oceanographic studies during the second year of the Navy's Bellingshausen Sea Expedition.[185]

On the continent, Albert Crary led a party in tracked vehicles on a traverse from McMurdo to the South Pole, which the team reached on February 1. USGS topographer Peter M. Bermel, who joined the USGS at Rolla in 1948, and USGS geologist Arthur Ford co-led a geologic-topographic party that included geologists John M. Aaron and Harold Hubbard, glaciologist Bjorn G. Andersen, of the University of Oslo, and assistant David H. Green on map-control and science surveys of the Thiel (formerly Eastern Horlick) Mountains, part of the Transantarctic Range, and the Hudson Mountains in western Ellsworth Land. Bermel and Ford named for each of the seven USGS Directors one feature in a series of knobs, mounts, peaks, and pillars in the eastern part of the Thiel Mountains. Geophysicist John Behrendt, returned from teaching at Wisconsin and now with the Geologic Division, worked on the West Antarctic Ice Sheet and in Marie Byrd Land, and in the Transantarctic Range, from the Amundsen-Scott, Byrd, Hallett, and McMurdo Stations. Thomas E. Taylor's mapping and glaciological studies covered parts of the Ross Ice Shelf and the Beardmore, Mulock, and Shackleton Glaciers. William R. MacDonald served as photography liaison for the Division's aerial mapping. H. Richard Blank, of Victoria University in Wellington, New Zealand, studied the geology of the Royal Society Range on the west side of McMurdo Sound. USGS topographer Joe M. Anderson completed a map-control traverse from the Byrd Station to the Jones Mountains, named for the NSF's Thomas Jones, on the Eights Coast of Ellsworth Land. Leslie B. Robison and George R. Staeffler, also with the Topographic Division, continued map-control surveys in the McMurdo area, and Staeffler conducted similar work in Victoria Land's Willett Range.[186] Assistant Chief Topographic Engineer William Radlinski also came to McMurdo to oversee the ongoing map-control surveys as part of his responsibilities with the Topographic Division's Future Planning Team, as the Division continued its preparations to map the continent.[187]

Director Nolan led the USGS delegation to the 21st International Geological Congress (Norden), held at Copenhagen during August 15–25, 1960.[188] Andy Anderson, Alan Bateman, Frederick Betz, Bill Bradley, George Cohee, William Davies, Charles Erdmann, James Gilluly, William Johnston, Philip King, Konrad Krauskopf, Benjamin Leonard, Kiguma Murata, Joe Peoples, Joseph Poland, John Rodgers, and William Rubey represented the USGS or other U.S. organizations as official delegates, but they did not present papers at the meeting. In the 21st IGC's formal sessions, USGS geologists who were not organizational delegates presented the results of their recent research. They included Glen Brown, William Carter, Preston Cloud, Henry Faul, Michael Fleischer, Warren Hamilton, David Hopkins, Lincoln Page, Troy Péwé, Edwin Roedder, Kenneth Segerstrom, Gene Shoemaker, and E-an Zen. USGS hydrologists William Back, Luna Leopold, Charles McGuinness, and Harold Thomas also discussed the results of their recent work. Representatives of the Geological Surveys of Norway and Sweden told Nolan at Copenhagen that geological organizations in the Soviet Union were providing free geochronological determinations of submitted rock samples. Nolan used this information to support his request in February 1961 for increased funding for the USGS' own work in geochronology, following a recommendation by the President's Science Advisory Committee to the Secretary of the Interior to enhance this effort by the agency.

While USGS scientists participated in the IGC in Copenhagen, members of the Topographic and Water Resources Divisions continued to seek improvements in their equipment and operations. They also reviewed their emphasis on and relations between applied and basic research. The Topographic Division began looking at the possibilities of developing techniques for remote sensing from satellites. The Division also planned to combine online computers, interfacing-analog stereoplotters, and new sensing devices in automated photogrammetry for digital storage and retrieval of orthophotographic data.[189] Automated scanning and correlation of these images would facilitate the preparation of contour maps, profiles, terrain models, and other new products. The American Society of Photogrammetry published its "Manual of Photographic Interpretation," which included a chapter on photogeology written by USGS geologists William Fischer and Wilds W. Olive and their colleagues. James Lawson retired as Rocky Mountain Region Engineer in August. The Water Resources Division's overall program devoted to basic research rose from 1 to nearly 10 percent between 1955 and 1960. If future funding allowed, Luna Leopold hoped to increase his Division's basic-research component to 25 percent. By this change, he intended to stimulate the intellects of, encourage original thought by, promote the exchange of ideas between, sponsor the advanced education of, and recognize significant original achievements by its scientists and engineers. The Division also encouraged universities to develop graduate programs in scientific hydrology and hired in 1960 the initial graduate of the new curriculum. Geologic mapping continued on four areas with immediate water-resources problems—the Delaware River Basin, the South Platte drainage along the mountain-front recharge area in Colorado, the Rio Grande Valley near Del Rio in Texas, and the Carrizo-Corduroy area in Arizona. High-resolution seismic equipment was used to locate water-bearing strata. In September 1960, George C. Taylor, Jr., succeeded Thomas Eakin as Chief of the Office of International Activities, and Tyrus B. Dover, who joined the USGS in 1947, became the District Hydrologist at St. Louis.

The increase of $200,000 in the appropriation for mineral classification during fiscal year 1960–61 enabled the Conservation Division to begin an active classification of the approximately 50 million acres outside Alaska withdrawn for classification since 1900 that remained unclassified and the examination of another 18 million acres for their mineral-resource potential. The Division expected to classify some 750,000 acres during 1960–61. To support these classification activities aimed at aiding the reasoned conservation and development of the Nation's coal, gas, oil, oil shale, phosphate, potash, sodium, and other mineral-commodity resources, the USGS planned the long-range geologic mapping of about 68 million acres (16,400 square miles) on 3,500 multipurpose 1:24,000 quadrangles, mostly in the Western States and at a cost of about $74.7 million. On May 31, 1960, two Supreme Court decisions, *U.S.* v. *Louisiana et al.*[190] (Alabama, Mississippi, and Texas) and *U.S.* v. *Florida et al.*,[191] extended only the boundaries of Texas and Florida 3 leagues (9 statute miles) from the shoreline into the Gulf of Mexico according to their historic limits. On September 2, a new law amended the Mineral Leasing Act of 1920 to include oil and tar sands.[192] Up to 7,680 acres, for one person or corporation per State, could be leased for 5–10 years; the statute set the annual minimum rental at 25 cents to 50 cents per acre in areas lacking known deposits. Combined oil and gas lease options were limited to not more than 246,080 acres per person per State, except in Alaska. Alaska's previous limit was extended to 300,000 acres in both north and south halves of the State. To encourage prospecting, the new law raised the area limits on coal to 15,360 acres, on sodium to 15,360 acres, and phosphate to 10,240 acres. Twelve days later, two additional acts provided increased authority. One clarified the rights of States "to select certain public lands subject to any outstanding mineral lease or permit."[193] The other granted "mineral rights in certain homesteads in the State of Alaska."[194] Of the 7 million acres of public land still withdrawn for water-power or water-storage sites, the Division estimated that up to 2 million might have limited value for such uses and could, after review, be restored to entry for other purposes.

On January 3, 1961, as the 87th Congress convened and President Eisenhower prepared to leave office, an accident at the Federal nuclear plant at Idaho Falls killed three employees and reminded the Nation that it faced dangers from the nuclear industries other than weapons. Eisenhower, during his years as General and President, helped to end two major wars but started none, although he approved increased U.S. assistance and (or) deployment to several ongoing or potential conflicts, including those in Cuba, Guatemala, Iran, Laos, Lebanon, and South Vietnam. Peace came at the price of continued vigilance and the expenditure of natural as well as human resources and vast amounts of capital. In the 1950s, under the pressure of wars hot and cold, U.S. defense spending tripled, from $13 billion to $39 billion, and Eisenhower now projected an additional increase in fiscal year 1961–62 but one that would still leave an estimated surplus of $1.5 billion to be applied to the national debt.[195] In the 8 years between fiscal years 1952–53 and 1960–61, the NSF's appropriations grew from $4.75 million to $175.8 million.[196] During the same interval, the NSF's grants to support science (basic research and facilities, institutional grants, national research centers and programs, and disseminating scientific information) increased from $1.8 million to $102.8 million, and its support for scientific education, in the form of graduate fellowships, institutes, science education, and public understanding, rose from $1.4 million to $66.8 million. Meanwhile, Eisenhower also recalled, completion of the interstate-defense highway system reached 25 percent.

Domestic dangers, like those from abroad, continued to trouble Eisenhower. As "we can no longer risk emergency improvisation of national defense," he emphasized in his farewell address to the American people via radio and television on January 17, "we have been compelled to create a permanent armaments industry of vast proportions" that, including the funds for the 3.5 million men and women directly engaged in defending the Nation, increased these Federal expenditures beyond the level of all U.S. corporate profits. "We recognize the imperative need for this development," the President continued, "[y]et we must not fail to comprehend its grave implications." "In the councils of government," he warned, "we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex" in the power triangle it formed with Congress. "The potential for the disastrous rise of misplaced power exists and will persist."[197] "Yet," Eisenhower urged,

> **in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.[198]**

Future leaders, Eisenhower concluded in these farewell remarks, must "mold," "balance," and "integrate these and other forces, new and old, within the principles of our democratic system—ever aiming toward the supreme goals of our free society."[199]

Chapter 11.
Epilogue: The U.S. Geological Survey, 1939–1961

No epilogue, I pray you; for your play needs no excuse.[1]

—William Shakespeare

The history of the United States and the U.S. Geological Survey (USGS) during 1939–61 played out within two nearly continuous global conflicts—World War II and the early years of the West's subsequent cold war with the Soviet Union. In the Second World War, leaders of Allied and Axis Nations believed that the contributions by their scientists and engineers were essential to their efforts to win the war. In the United States, this civilian-military mobilization produced new organizations that devised novel means of attack and defense. The National Defense Research Committee, the Office of Scientific Research and Development, the Army Engineers' Manhattan Engineer District, and the academic radiation and metallurgical laboratories, among others, facilitated the American-British development or refinement of the atomic bomb, the airborne magnetometer, the proximity fuse, radar, sonar, and other war-winning devices.

In 1945, the coalition of Allied Nations won the worldwide conflict and formalized their association as the United Nations. The Allies partitioned Germany and then the Western powers reunited parts of it as a democracy, the American Marshall Plan helped to rebuild Europe, U.S. forces occupied Japan and aided its democratic development, and a Communist government unified mainland China. Thereafter, the Korean war and lesser conflicts tested the United States and the United Nations. The overriding cold war with the Soviet Union and its Warsaw Pact allies challenged the United States and the other countries of the North Atlantic Treaty Organization. Two subsequent and similar pacts—the Central Treaty Organization and the Southeast Asia Treaty Organization—extended the West's long-term strategy of containing and deterring the Soviet Union and its allies.

In the United States, wartime rationing was followed by a postwar baby boom, the construction of more affordable and better housing for veterans, Federal support for veterans' education, the beginning of the modern civil-rights movement, the end of segregation in the military, and other significant socio-economic reforms. Despite financial bubbles and recessions, the domestic economy continued to grow. America's postwar years also encompassed the evolution of national policies for minerals (including stockpiling of those deemed critical and strategic), fuels, and water resources; the advent and growth of a national foundation for research and education in science; the development of a national science policy; and the appointment of a formal science adviser to the President.

In those years, the USGS provided personnel, other programmatic resources, and advice for defense at home and then war abroad but at the cost of repeated drains on its research capital. Changing conditions and demands fueled continuing debates within the agency about the emphases placed on basic (or fundamental) versus applied (or practical) research. The USGS tried to determine what percentage of its human and monetary resources should be devoted to basic research as part of its efforts to improve understanding of the principles behind the observations. Most of the Federal committees on mineral- and water-resources policies stressed the need for more basic data and assessment. As a result, USGS emphasis on and plans for supporting basic research during the interval increased from a low of 1 percent to a high of about 10 percent.

Most of the agency's practical work retained some percentage of fundamental studies, reflecting an arrangement begun by Director Clarence King in 1879. That continuing effort helped to facilitate the huge growth of the USGS during the postwar years. As part of USGS efforts to understand geologic processes, including the origin and distribution of nonliving resources as guides to exploration, the agency successfully introduced new or modified ground and airborne technology and methods in geochemistry and geophysics, especially in surveys of magnetism and radioactivity. Members of the USGS also developed other equipment and procedures to improve their understanding of earthquakes and volcanic eruptions, to develop an ability to predict them, and to distinguish between earthquakes and nuclear tests. Agency personnel and cooperators drilled to basement rocks below coral atolls and confirmed the Darwin-Dana model of their origin, expanded and diversified their studies of military geology abroad and at home, began work on landslides and urban engineering geology, assessed options for radioactive-waste disposal, improved spectrographic analyses of minerals, secured more accurate radiometric ages of rocks, and analyzed their deformation, magnetism, and thermodynamics.

The USGS also devised or adopted new tools and techniques in topographic mapping and water-resources investigations and increased its work in supervising the leasing of and resource production from the onshore and offshore public lands. By 1960, the USGS expanded its adequate domestic topographic coverage of the continental United States to 45 percent. Similar geologic coverage rose to 17 percent, aided by new methods in photogeology. Improvements in map preparation and printing, including the results of pioneering efforts in orthophotogrammetry and automation, promised to enable the agency in the coming decades to fulfill its long-standing promise to complete, funds permitting, national topographic coverage at a standard large scale of 1:24,000. The agency also worked toward its long-term goal of establishing a network of self-recording gaging stations and observation wells to provide data for a more systematic accounting of the Nation's surface-water and groundwater resources. The USGS increasingly focused on the broad fundamental aspects of hydrology to continue to solve practical problems in the occurrence, availability, and quality of water resources while adding to the scientific knowledge of streamflow and sediment movement through process-oriented analytical and interpretative studies like those in geology. The USGS expanded its partnerships with Federal, State, county, and municipal government agencies, and with academia, industry, and private citizens, to further the preservation or wise use of the public lands and their nonliving resources. USGS supervisory activities on mining properties by the Conservation Division increased by 60 percent; those on oil and gas leases, especially on the Outer Continental Shelf, grew by 450 percent.

New methods and tools of automation enhanced the processing, storing, and analyzing of USGS administrative data, as well as scientific and technical data. Advances in code breaking and gunnery enhanced data processing during World War II. In the 1950s, computers were more accurate, more adaptable, faster, and more reliable than those of the 1940s. Increasingly, fully electronic computers replaced those electromechanical, digital systems succeeded analog-based versions, magnetic tape and magnetic cores supplanted paper tape and punch cards, and transistors succeeded vacuum and cathode-ray tubes. A USGS advisory committee and a formal administrative unit increased in-house familiarity with the capabilities of existing computers and also planned for the future rapid acquisition and use of improved versions.

The USGS increased its work abroad during and after World War II. The agency's work outside the national domain had begun with an externally funded study of Hawaiian volcanoes in 1882 and thereafter spread to the Philippines and locales in the Caribbean and Central America. USGS operations expanded to Brazil in 1941 and to seven other Latin American countries as the war progressed. In 1944, the agency began mapping and geohydrologic studies in Saudi Arabia sponsored by the Departments of Agriculture and State. The USGS resumed work in the Philippines during the immediate postwar years. In the 1950s, these efforts spread to Afghanistan, India, Indonesia, Iran, Iraq, Jordan, Libya, Pakistan, South Korea, Thailand, and Turkey. In 1958, the USGS gained specific statutory authority to continue to study and map in the United Nations Trust Territory of the Pacific Islands (TTPI) and in Antarctica to support the International Geophysical Year and follow-on operations on the continent. Under that rubric, the USGS completed work begun in the TTPI in 1946, with Army Engineer support, and continued efforts in Antarctica started in 1946–47 as part of Navy operations. In 1959–60, the USGS extended its investigations across other new geographical frontiers as part of the scientific-technological contest with the Soviet Union. The USGS expanded its operations into outer space by compiling a preliminary geologic map of the Moon's nearside and beginning a formal unit on astrogeology. The agency also lent its expertise acquired in deep drilling on oceanic islands to U.S. operations in inner space aimed at drilling through the Earth's crust into its mantle.

Within this two-decade context, a series of external and internal events and decisions modified and expanded USGS missions and increased the agency's funds and staff. Federal organizations sought and paid for enlarged cooperative services by the USGS during World War II. In the postwar years, these entities increased their requests and funding for services old and new under the demands of wars cold and hot. Between fiscal years 1939–40 and 1960–61, the agency's total funds rose from just over $7.2 million to about $71.3 million, while its staff grew from some 1,320 persons to more than 6,900 permanent and 1,100 seasonal employees as of June 1961. During that interval, direct appropriations to the USGS increased from $3.3 million to $45.9 million, funds transferred by other Federal agencies rose from $1.9 million to $13.2 million, and transfer and repay monies from State, county, and municipal cooperators and from other nonfederal sources climbed from $1.25 million to more than $12.1 million. Although the monetary percentages supplied by each of these sources to each of the four programmatic Divisions in the USGS varied widely, the overall trend during those decades showed a rise in direct over indirect funding, enabling the agency to increase control over its own programs and to hire and keep a qualified specialist staff funded by its own appropriations. In fiscal 1960–61, the direct Federal appropriation for the Conservation Division represented 98 percent of its funds, and that percentage was twice as large as the Water Resources Division's. The Water Resources Division's lower percentage reflected in part its statute-required assignment of funds to match those from nonfederal sources for half of those cooperative programs. In that fiscal year, the Geologic Division received 65 percent of its monies from direct appropriations, and the Topographic Division took in 75 percent of its funds from the same source.

Three principal changes in the 1950s restored, modified, and (or) extended USGS managerial and operational control, flexibility, and influence. The initial alteration followed an agreement by the legislative and executive branches to restore financial and programmatic flexibility to the USGS that was lost in the late 1880s as one result of the failure of Director John Powell's policies and programs.[2] Required line itemization of USGS budgets proved to be a 62-year millstone. Not until 1950 did the Interior Department and the USGS convince Congress and President Truman to end the required line itemization of the agency's budgets in an effort to increase economy and efficiency. The new statutory agreement returned USGS appropriations to the original block funding of 1879–87, a general and brief format rewritten to provide for surveys, investigations, and research (SIR). The 1950 accord retained the equal-shares requirements, enacted in 1926 and 1928, respectively, of the agency's cooperative topographic mapping and water-resources investigations with the States, counties, and municipalities. The 1950 agreement also continued the dollar limits on the USGS funds that could be spent only for the water-resources cooperative work. With SIR funding, the USGS could and did modify its internal distributions of funds and staff and determine priorities among its program elements without having to consult Congress. That freedom enabled more rapid and efficient responses to changing external circumstances, especially the less predictable types of natural or people-caused emergencies.

In the 1950s, the second boost to USGS managerial style confirmed the centralized control of its operations, via firm lines of authority, when the agency refused Interior's request to regionalize USGS management as part of a departmentwide effort to centralize supervision as well as operations. Beginning in 1949, the two Hoover Commissions and several other examining groups authorized by statute or Executive order, the General Accounting Office (GAO), external committees from academia and industry established by Secretaries of the Interior, and the USGS' own external Science Advisory Committee of scientists and engineers carefully and critically reviewed the agency's management and operations. Those nonpartisan evaluations generally lauded the quality of the agency's personnel and work, but they recommended changes in organization that led to needed reforms, including the better integration of the results of research and improvements in administration. The USGS, also advised by outside financial consultants, responded to the GAO's report to Congress about problems in the agency's accounting and other business practices by instituting significant changes, including the appointment of a Chief Inspector. Among the modifications were those that improved USGS supervision of mineral leases on and resource production from Federal onshore and offshore lands, an agency responsibility since 1925.

The USGS did not adopt the reviewers' recommendations for regional management, a style utilized for the regulatory functions of the Bureau of Land Management, established in 1946, but one not yet proved beneficial in a science and mapping agency. William Wrather, the sixth Director (1943–56), convinced Interior Secretaries Oscar Chapman and Douglas McKay that USGS field operations were almost completely regionalized, as they had been under King before being centralized by Powell, but Wrather continued to oppose the Secretaries' requests to appoint regional directors. Regional directors and their required staffs, Wrather decided, would siphon off funds and personnel better devoted to operations and also would disrupt the enforcement of long-standing high and uniform standards in hiring, ethics, and products throughout the agency. In lieu of regional management, Wrather established a field committee at the center for the Eastern Region, also the national headquarters, at Washington, D.C. He also began similar committees at Denver, Colorado, for the Central Region and at Menlo Park, California, for the Western Region, both with headquarters founded during the postwar years. The regional committees functioned only as advisers; each group was chaired, in regular rotation, by one of its members, and reported to the USGS Executive Committee.

The third change also involved administration within the USGS. The agency's Division Chiefs continued to report to the Directors, who operated without a formal deputy through the tenure of Walter Mendenhall, the fifth Director (1930–43). In 1944, a year after Wrather succeeded Mendenhall, Secretary Ickes approved establishing an Assistant Director for the USGS. This new post was filled by Thomas Nolan, who served as Acting Director during Wrather's detail to Interior's on-site assessment of the Middle East's oil resources led by Everette DeGolyer. Nolan, as Assistant Director, functioned as the agency's chief executive officer, aided from 1948 by a formal Executive Officer, a post vacant since 1894. In the 1950s, Wrather and Nolan served as alternate members of and technical advisers to Cabinet, departmental, and other Federal committees convened to improve national mineral- and water-resources policies to assure long-term supplies for economic development and national security. When Nolan succeeded Wrather as Director in 1956, Secretary McKay authorized an Associate Director, a position filled by USGS geologist and administrator Arthur Baker. USGS topographic engineer Robert Lyddan replaced Nolan as Assistant Director. Nolan, as Director (1956–65), divided the day-to-day oversight for the Divisions between Baker, responsible for the Conservation, Geologic, and Publications units, and Lyddan, responsible for Administrative, Topographic, and Water Resources units. Baker and Lyddan, like Nolan, were aided by the agency's Executive Committee, its General Staff Committee, and its Science Advisory Committee composed of outside specialists, who received compensation only for their expenses in attending meetings.

During these decades, the USGS continued its practice, begun under King, of trying to hire the best available young specialists and assigning them to ongoing or new projects, where they could be mentored by older and more experienced scientists and engineers. In 1960, 14 USGS scientists were members of the National Academy of Sciences (NAS); 9 of them served full time with the agency, and the remaining 5 were academics employed part time by the agency.[3] USGS scientists, whether NAS members or not, continued to serve on National Academy of Sciences-National Research Council advisory groups, as alternates on or advisers to Federal committees and commissions, and on visiting committees at academic institutions.

A related event provided a more subtle but no less important and pervasive modification of USGS abilities and operations. In 1950, as Congress and President Truman approved SIR funding for the USGS, they also agreed to establish the National Science Foundation (NSF). That decision extended USGS activities in providing science advice and in aiding science education. The USGS–NSF relationship also gave the agency another, if less direct, benefit. The NSF significantly increased during 1956–60 its funds for grants for research and education in the earth sciences. USGS management responded to this shift in funding emphasis by continuing its efforts to increase its direct appropriations and reorganizing its operations and products, especially in the Geologic Division, to reflect a more politically aware and academic style. Recognizing the postwar need for additional trained geologists, the USGS began in 1946 new cooperative programs with several major universities that had been sources of agency employees since 1879. The NSF advanced this relationship when USGS scientists were approved as secondary investigators in requests to the NSF for research grants by their academic colleagues, several of whom continued to serve part time with the USGS. Some of these educators recommended their graduate students for pregraduation and postgraduation employment by the agency to help fulfill its missions and advance science.

Notes and References Cited

This part of volume 4 (1939–61) contains the endnotes followed by the list of references cited. Mary C. Rabbitt's volumes 1 ("Before 1879"), 2 (1879–1904), and 3 (1904–1939) appeared in large quarto as USGS unnumbered special books (Rabbitt, 1979, 1980, 1986); they also are online in the USGS Publications Warehouse at http://pubs.er.usgs.gov/publication/800000 (volume 1), http://pubs.er.usgs.gov/publication/800002 (volume 2), and http://pubs.er.usgs.gov/publication/800003 (volume 3). Mary Rabbitt (1989) provided a brief overview of USGS history before 1985.

The notes, separately numbered for each chapter in volume 4, identify the sources of materials used in preparing the narrative analysis. The sources quoted directly include the U.S. Statutes at Large (Stat. L.); presidential addresses, messages, proclamations, and related public papers; Executive orders (Ex. O.); the Federal Register (Fed. Reg.); Interior Secretarial orders (Secr. O.); Survey (USGS) orders (Surv. O.); the Congressional Record (Cong. Rec.); the hearings held by the House and Senate subcommittees responsible for approving Interior Department and USGS budget requests; other congressional documents; treaties and agreements; and U.S. Supreme Court decisions. Many of these documents also are available on the Web by subscription at HeinOnline and at ProQuest Congressional Collections and in Readex's U.S. Congressional Serial Set. Many of the executive branch documents are in the printed volumes of the Public Papers and Addresses (PPA) for each year of the Presidencies of Herbert Hoover, Franklin D. Roosevelt (FDR), Harry S. Truman (HST), and Dwight D. Eisenhower (DDE). The PPA volumes, also available at HeinOnline, are cited herein by the last names of their compilers and editors: Jean Eisinger, Faye Rosser, and Michael Sullivan (Hoover); Samuel Rosenman (FDR); and Warren Reid and others (HST and DDE). Some of their documents plus others are in the Public Papers of the Presidents of the United States (PPPUS), part of John Woolley's and Gerhard Peters' American Presidency Project (1999–) at the University of California at Santa Barbara (UCSB), at www.presidency.ucsb.edu/ws.

Quotations from the annual reports of the Secretary of the Interior and of the Director of the U.S. Geological Survey and from other USGS serial publications are cited, but paraphrased sections are not referenced. All USGS books, maps, and charts issued between 1879 and December 1961 are listed in the compilation by the U.S. Geological Survey (1964a); of them, only those providing quotes or figures or otherwise cited are among the references cited in volume 4. These internal and many of the external publications by USGS authors also are listed in the USGS Bulletins (937 [1929–39], 1049 [1940–49], 1195 [1950–59], 1196 [1960], 1197 [1961], and 1232 [1962]) that form the Bibliography of North American Geology for 1929–62. Most of the USGS publications now are available online in the Publications Warehouse at http://pubs.er.usgs.gov.

The USGS Water Resources Division's internal history covers the years to 1994 in three mimeographed and five printed volumes. In this set, Follansbee (1954), Ferguson and others (1990), and Hudson and others (1996) combined to treat the 1939–61 interval. Gere (1979) contains a brief history of the USGS Conservation Division, from its founding to 1979, 3 years before its transfer to form Interior's Minerals Management Service (since 2011, in part, the Bureau of Ocean Energy Management). The text of the USGS Topographic Division's mimeographed internal history covered mapping by direct predecessor surveys from 1867 to 1879 and work by the USGS Division from 1879 to 1954; it was completed in 1954 for the USGS' 75th anniversary and was published without significant modification as Evans, R.T., and Frye (2009). All reports prepared during 1942–61 by USGS military geologists for the U.S. Army Corps of Engineers are listed in Bonham and Leith (1997). The USGS Pick and Hammer Club shows were held during 1904–1986 in Washington, D.C.; Denver, Colorado; Menlo Park, California; and Reston, Virginia, and programs (G(226)/P58p) are in the Rare Book Room (RBR) in the USGS Library in Reston.

Volume 4, like its three predecessors, is a framework history that depends heavily on printed primary and secondary sources for its national and international context. Gilbert, Martin (1997, 1999), Howard and Louis (1998), Reynolds (1999), Roberts, J.M. (1999), and Stearns, P.N. (2001), provided principally international perspectives. Kissinger (1994) and McCormick (1995) held useful information about diplomacy. Boorstin (1973), Manchester (1973), Burns, J.M. (1989), Cohen, W.I. (1993), Morris, J.B., and Morris, R.B. (1996), Patterson (1996), Kennedy, David (1999), and Boyer (2001) furnished mostly national overviews. Significant biographies and administration histories consulted for three presidents include the following: for FDR, McJimsey (2000) and Smith, J.E. (2007); for HST, McCoy (1984) and McCullough (1992); and for DDE, Ambrose (1983, 1984), Pach and Richardson (1991), and Smith, J.E. (2012). Hall (2002, 2005, 2009) and Zelizer (2004) supplied historical overviews of the U.S. Congress, the U.S. Supreme Court, and American jurisprudence. Millett and Maslowski (1984), Chambers (1999), and Holmes (2001) provided military perspective, and Rothenberg (2001) supplied a similar overview of the history of science. Cohen, S.B. (1998), furnished a global guide to place names.

Of the several manuscript collections also consulted, the most important was Record Group (RG) 57 (USGS) maintained by the National Archives and Records Administration (NARA) in College Park, Maryland, at the building known informally as

Archives II (NARA II). The inventory of RG 57 by Jaussaud (2000) included the documents accessioned there through 1997. The holdings at NARA's regional archives have not yet been added to the inventory, but see Ulibarri (1982) for a guide to Alaskan documents in Federal archives. Matchette and others (1995) provided a guide to other Record Groups, and Ashby and others (1971) and Ehrenberg (1987) furnished guides to cartographic collections at NARA and elsewhere in the Washington, D.C., area. Some of the photographs reproduced in volume 4 likewise may be found in the USGS Denver Library Photographic Collection. As in the preceding volumes, images in volume 4 were chosen principally from USGS publications to show the development of the techniques of USGS scientific illustration, as well as the agency's contributions to science and technology. Although the reproduction quality of some older images does not meet digital standards, the figures are still significant historically. Burger (1990) provided a guide to the collections in NARA's Still Picture Branch.

For additional biographical information about the persons mentioned in volume 4, readers may wish to consult entries in the volumes of American Men and Women of Science, the American National Biography, the Biographical Directory of the United States Congress, Biography and Genealogy Master Index (2d edition, with culmination and yearly volumes), the Dictionary of American Biography, the Dictionary of Scientific Biography, the National Cyclopedia of American Biography, the New Dictionary of Scientific Biography, Notable American Women, and Who Was Who in America. Several of these biographical compilations also are available online. Other biographical information is in the memoirs and memorials series of the National Academy of Sciences (NAS) and the Geological Society of America (GSAm), and in the individual articles published in the serial periodicals issued by other professional societies of science and engineering.

Notes

Title Page

The title of this series, "Minerals, Lands, and Geology for the Common Defence and General Welfare," is based on article I, section 8 of the Constitution, which provides that "The Congress shall have Power To lay and collect Taxes, Duties, Imposts and Excises, to pay the Debts and provide for the common Defence and general Welfare of the United States." This section authorizes the appropriation and expenditure of public funds for scientific research. (Quotation from Morris, J.B., and Morris, R.B., 1996, p. 1194.)

Chapter 1. Prologue: U.S. Geological Survey Mandates, 1879–1939

[1]Shakespeare, "The Tempest," Act 2, Scene 1: Wells, Stanley, and others, 1987, v. 2, p. 968, lines 258–259 (reproduced by permission of Oxford University Press).

[2]This and the preceding quotation: USGS Organic Act, U.S. Statutes at Large (Stat. L.), v. 20, p. 394, March 3, 1879 (hereinafter 20 Stat. L., 394).

[3]Indian lands are now known as Native American tribal lands.

[4]22 Stat. L., 329, August 7, 1882.

[5]Ibid.

[6]25 Stat. L., 526, October 2, 1888.

[7]Ibid., 527.

[8]28 Stat. L., 398, August 18, 1894.

[9]28 Stat. L., 900, March 2, 1895.

[10]30 Stat. L., 623, July 1, 1898.

[11]32 Stat. L., 388, June 17, 1902.

[12]40 Stat. L., 145, June 12, 1917.

[13]This and the preceding quotation: 33 Stat. L., 1187, March 3, 1905.

[14]Coolidge, Executive Order (Ex. O.) 4239, June 4, 1925.

[15]See McCartney (2008) to supplement and extend the analysis in Noggle (1962), which also is cited in Rabbitt, M.C. (1986).

[16]43 Stat. L., 1011, February 27, 1925.

[17]44 Stat. L., 486, May 10, 1926.

[18]Ibid.

[19]45 Stat. L., 232, March 7, 1928.

[20]This and the two preceding quotations: Mendenhall, 1929, p. 12.

[21]Hoover, State of the Union Message to Congress, December 3, 1929: Eisinger, Rosser, and Sullivan, 1974, p. 432; also in HeinOnline and in PPPUS 1929/document 295 (hereinafter 1929/295).

[22]46 Stat. L., 1147, February 14, 1931.

[23]47 Stat. L., 119, April 22, 1932.

[24]Ickes, Secretarial Order (Secr. O.) 678, September 12, 1933.

[25]48 Stat. L., 1269, June 28, 1934; amended by 49 Stat. L., 1976, June 26, 1936. Franklin D. Roosevelt's Ex. O. 6910, November 26, 1934, withdrew the lands for classification to facilitate administration of the new law's provisions. See Rosenman, 1938, p. 477–478; also in HeinOnline and in PPPUS 1934/192.

[26]48 Stat. L., 1269, June 28, 1934.

[27]Ibid., 1272.

[28]Mendenhall, January 20, 1938, *in* Hearing before Subcommittee on Interior Department, House Committee on Appropriations (hereinafter House hearing), 75th Congress, 3d session, p. 390.

[29]53 Stat. L., 811, June 7, 1939.

[30]Ibid., 812.

[31]Bruce, 1987, p. 4.

Chapter 2. Pursuing Simultaneous Courses, 1939–1941

[1]FDR, commencement address, University of Virginia, June 10, 1940: Rosenman, 1941b, p. 264; reproduced in HeinOnline, from which differ slightly the versions in the Cong. Rec., v. 86, pt. 16, appendix, p. 3741, and in the PPPUS 1940/59.

[2]The German-Soviet trade and nonaggression pacts of August 20–23, 1939, facilitated the German invasion of Poland; see Read and Fisher (1988).

[3]Mendenhall, December 11, 1935, *in* House hearing, 74th Cong., 2d sess., p. 240.

[4]Dugan and Lafore, 1973, p. 184. For the significance of the Ethiopian and earlier and later crises in the history of the League of Nations, see Bendiner (1975). Italy withdrew from the League on December 11, 1937. For an evaluation of Mussolini, see Bosworth (2002).

[5]For the history of the Third Reich, see Shirer (1960) and Evans, R.J. (2004, 2005, 2009). For an evaluation of Hitler, see Kershaw, Ian (1998, 2000). Germany and Japan withdrew from the League of Nations in 1933.

[6]Mendenhall, January 20, 1938, *in* House hearing, 75th Cong., 3d sess., p. 390.

[7]52 Stat. L., 809, June 21, 1938, provided $965 million for the Public Works Administration.

[8]Eckes (1979, p. 58), drawing on works primarily by Leith and Emeny, listed as most important chromite, coal, copper, iron, manganese, mica, nickel, oil, tin, and tungsten. Emeny (1934, plates) noted that America remained especially dependent on imports of antimony, chromite, manganese, nickel, tin, tungsten, and rubber.

[9]Barnhart (1987) analyzed Japan's drive for autarky.

[10]Leith, 1939, p. 441. See also Leith (1940).

[11]Leith, 1939, p. 442.

[12]Ibid.

[13]See Beevor (2006). For an evaluation of Franco, see Preston (1994).

[14]This and the preceding quotation: 52 Stat. L., 235–236, April 26, 1938.

[15]53 Stat. L., 770, May 25, 1939.

[16]53 Stat. L., 722, May 10, 1939, not including the $7,000 provided for stationery and the $6,000 for the purchase or exchange of books during the year (ibid., p. 688). 53 Stat. L., 697, May 10, 1939, authorized the Office of Indian Affairs (renamed a Bureau in 1947) to transfer to the USGS $116,000 for examining mineral deposits, inspecting mines, and supervising mining operations on Indian lands; $100,000 actually was provided.

[17]53 Stat. L., 811, June 7, 1939.

[18]The USBM and the USGS quickly explored, as Eckes (1979, p. 103) noted, for high-grade deposits of antimony, chrome, manganese, mercury, mica, nickel, quartz crystals, tin, and tungsten. Under the Strategic and Critical Materials Act, Congress subsequently approved an additional $60 million.

[19]53 Stat. L., 812, June 7, 1939. On August 11, 1939, 53 Stat. L., 1407, facilitated "the exchange of surplus [domestic] agricultural commodities * * * for reserve stocks of strategic and critical materials produced abroad."

[20]53 Stat. L., 1317, August 9, 1939. A subsequent section (p. 1326–1327) allotted $10 million to the Procurement Division in the Treasury Department's Branch of Supply "for the acquisition, transportation, maintenance, storage, and rotation of strategic and critical materials in accordance with * * * the Act of June 7, 1939."

[21]In the appropriations hearing on February 9, 1940, the USGS reported a grand total of $6,713,000 in funds available for fiscal year 1939–40, which would not end until June 30, 1940. The USGS *Annual Report* for that fiscal year (published by February 6, 1941) listed $7,246,000 in funds available versus $6,880,000 in obligations for the whole agency, leaving a balance of $366,000. In addition to Branch totals given in this chapter's text, the *Annual Report* includes $150,000 for salaries of Director's Office personnel, $474,000 for publishing (printing and binding texts, preparation of illustrations, and engraving and printing geologic and topographic maps), and $82,000 in funds for purposes not identified by Branch but likely intended for topographic and water-resources work.

[22]FDR, fireside chat, by radio to the Nation, September 3, 1939: Rosenman, 1941a, p. 463; PPPUS 1939/120. On September 5, Ex. O. 8233 prescribed regulations governing neutrality enforcement.

[23]Rosenman, 1941a, p. 463.

[24]Ibid., p. 461–462.

[25]FDR, Ex. O. 8248, September 8, 1939: Rosenman, 1941a, p. 491; PPPUS 1939/127.

[26]This and the preceding quotation: FDR, address to Congress, September 21, 1939, *in* Cong. Rec., v. 85, pt. 1, p. 11; Rosenman, 1941a, p. 517; PPPUS 1939/132.

[27]54 Stat. L., 10, November 4, 1939.

[28]This and subsequent totals for the funds available to the Branches for fiscal year 1939–40 include direct appropriations, transfers, repayments, and adjustments.

[29]53 Stat. L., 1317, August 9, 1939. On June 7, 1939, 53 Stat. L., 812, provided for the transfer to the USGS of $150,000 from the USBM's appropriation intended to increase the acquisition of strategic and critical minerals. This latter sum was not listed in the USGS *Annual Report* as being received.

[30]Reserve data from American Gas Association and American Petroleum Institute, 1946, table 3, p. 10. Production data from DeGolyer and MacNaughton, 1990, p. 20.

[31]USGS Pick and Hammer Club show program, March 1, 1940, "Persons" and song 1; copies are in the Rare Book Room (RBR) in the USGS Library in Reston, Va.

[32]Ibid., song 5.

[33]Ibid., song 6. Henry ("Fergie") Ferguson reviewed all manuscripts in Hewett's Section.

[34]Ibid.

[35]Ickes, Secretarial Order (Secr. O.) 1415, August 16, 1939. The U.S. Department of the Interior's Library in Washington, D.C., contains a complete run, in paper and microfilm copies, of these orders.

[36]For a dictionary of Alaska place names, see Orth (1967).

[37]The Public Roads Administration (PRA) was the former Bureau of Public Roads, renamed and transferred from the Agriculture Department to join the Public Buildings Administration, the Public Works Administration (PWA), the Work Projects Administration (WPA, known

from 1935 to 1939 as the Works Progress Administration), and the Federal Housing Administration in the new Federal Works Agency on July 1, 1939. FDR terminated the PWA in 1943.

[38]For an overview of the historical development of photogrammetric methods, see Blachut and Burkhardt (1988). Gruner (1962) summarized the Multiplex's history, and Struck (1952) compared the Multiplex, Kelsh, and Wild Autograph plotters.

[39]In 1941, the Bureau of the Budget established the original accuracy standards for map production, including 1/40 of an inch horizontal tolerance for 1:24,000 maps. Thompson (1988, p. 102–104) discussed these standards and their revisions in 1943 and 1947.

[40]For a brief history of classifying lands for water-power and water-storage sites, see Lawrence, F.F., Nordeen, and Pumphrey (1957).

[41]California's NPR–1 (Elk Hills) covered nearly 39,000 acres, and its NPR–2 (Buena Vista) held more than 29,000 acres. The Conservation Branch also supervised shut-in production within the 9,500 acres of NPR–3 (Teapot Dome) in Wyoming north of Casper. NPR–4, which encompassed about 23 million acres in northwestern Alaska (north of the Brooks Range), awaited detailed exploration.

[42]The League of Nations expelled the Soviet Union on December 14, 1939, an act that Bendiner (1975, p. 397) thought futile.

[43]FDR, State of the Union Message to Congress, January 3, 1940: Rosenman, 1941b, p. 2; PPPUS 1940/1.

[44]Rosenman, 1941b, p. 5.

[45]Ibid., p. 6.

[46]Leavy, February 19, 1940, *in* Cong. Rec., v. 86, pt. 13, Appendix, p. 837.

[47]This and the four preceding quotations: Ickes, February 8, 1940, *in* House hearing, 76th Cong., 3d sess., p. 4–5. The report of the Secretaries of War, Commerce, and the Interior on topographic mapping is 76th Cong., 1st sess., Senate Doc. 54 (serial 10315).

[48]Johnson, February 9, 1940, *in* House hearing, 76th Cong., 3d sess., p. 532.

[49]Mendenhall, ibid.

[50]Hayden, January 16, 1940, to amend H.R. 7805, *in* Cong. Rec., v. 86, pt. 1, p. 353. See also Hayden to Ickes, December 18, 1939, *in* Cong. Rec., v. 86, pt. 13, Appendix, p. 359.

[51]McKellar, April 4, 1940, *in* Hearing before Subcommittee on Interior Department, Senate Committee on Appropriations (hereinafter Senate hearing), 76th Cong., 3d sess., p. 326.

[52]Mendenhall, ibid.

[53]This and the preceding quotation: Schley, ibid., p. 327.

[54]54 Stat. L., 509, June 24, 1940.

[55]54 Stat. L., 441, June 18, 1940. 54 Stat. L., 509 authorized the transfer of $1,210,350 for topographic surveys and mapping from the War Department's civil-functions appropriations to the USGS, provided the latter used the funds to map "in strategic areas, in accordance with priorities to be determined by the Secretary of War."

[56]German warships sunk or damaged during the campaign in Norway left a heavy cruiser as the largest operational unit.

[57]Churchill, W.S. [2d], 2003, p. 206. For evaluations of Churchill during the war and postwar years, see Gilbert, Martin (1983, 1986b, 1988, 1991), Jenkins (2001), and Manchester and Reid, Paul (2012).

[58]For a recent evaluation of de Gaulle, see Fenby (2012).

[59]54 Stat. L., 573, June 25, 1940.

[60]54 Stat. L., 714, July 2, 1940, is part of an act to "expedite the strengthening of the national defense" (712).

[61]FDR, proclamation 2413, 54 Stat. L., 2713, July 2, 1940: Rosenman, 1941b, p. 278; PPPUS 1940/68. Before these restrictions, the United States sent to Japan 90 percent of the latter's aviation fuel, 75 percent of its scrap iron and steel, and 67 percent of its machine tools.

[62]54 Stat. L., 779, July 19, 1940, authorized and funded the construction that added to the Navy some 260 ships, including the *Essex*-class fleet carriers and the *Iowa*-class fast battleships.

[63]Rosenman, 1941b, p. 184; PPPUS 1940/43.

[64]Rosenman, 1941b, p. 187.

[65]On May 25, 1938, 52 Stat. L., 442–443 authorized the temporary detail of United States employees with "special scientific or other technical qualifications" for up to 1-year's service in the American Republics, Liberia, and the Philippines, as agreed by those Governments. 53 Stat. L., 653, of May 3, 1939, extended that interval by 6 months.

[66]Hale, 1916, p. 507–508.

[67]Rhodes, 1986, p. 313–314.

[68]This and the three preceding quotations: Einstein to FDR, Peconic, New York, August 2, 1939, Roosevelt Papers, FDR Library, Hyde Park, New York. Facsimile in Stoff, Fanton, and Williams, R.H., 1991, p. 18–19. Also printed in Reingold and Reingold (1981, p. 469–470) and Williams, R.C., and Cantelon (1984, p. 12–14). Stoff, Fanton, and Williams (1991, p. 20) reproduced Roosevelt's reply of October 19, 1939.

[69]FDR, Ex. O. 8807, June 28, 1941; PPPUS 1941/70.

[70]See Zimmerman (1996) and Phelps (2010).

[71]For an overview of code breaking in World War II, see Budiansky (2000). See Sebag-Montefiore (2000) for an analysis of deciphering the Enigma codes.

[72]54 Stat. L., 441, June 18, 1940.

[73]54 Stat. L., 1041, October 9, 1940.

[74]Johnston (1947) briefly summarized USGS work in Latin America during the 1940s.

[75]54 Stat. L., 440, June 18, 1940.

[76]For radar's contribution to defeating the Luftwaffe, see Zimmerman (2001).

[77]For an account and analysis of the attack on Taranto, and its subsequent significance, see Lowry and Wellham (1995).

[78]Morris, J.B., and Morris, R.B., 1996, p. 408.

[79]FDR, press conference, December 20, 1940: Rosenman, 1941b, p. 631; PPPUS 1940/152.

[80]FDR, fireside chat, by radio to the Nation, December 29, 1940: Rosenman, 1941b, p. 643; PPPUS 1940/154.

[81]Rosenman, 1941b, p. 667; PPPUS 1941/3.

[82]Rosenman, 1941b, p. 668.

[83]Ibid., p. 669. For an overview of U.S. defense preparations, see Klein, Maury (2013).

[84]FDR, Ex. O. 8629, January 7, 1941: Rosenman, 1941b, p. 689; PPPUS 1941/5.

[85]Rosenman, 1941b, p. 691.

[86]Ibid., p. 690.

[87]Burns, J.M., 1970, p. 52. Stimson's papers are at Yale.

[88]FDR, Ex. O. 8607, December 10, 1940.

[89]FDR, Ex. O. 8617, December 20, 1940.

[90]FDR, Ex. O. 8631, January 10, 1941.

[91]FDR, Ex. O. 8693, February 25, 1941: PPPUS 1941/unnumbered document (hereinafter doc.) between 19 and 20; and Ex. O. 8694, February 25, 1941.

[92]Truman, having read the reports (1863–66) of the Joint Committee on the Conduct of the War (1861–65), did not intend to repeat that partisan committee's mistakes (Miller, Merle, 1973, p. 165). But the Truman committee's actual congressional analog during the Civil War was the House Select Committee on War Contracts (1861–63).

[93]55 Stat. L., 31, March 11, 1941. FDR's Ex. O. 8926, October 28, 1941, established the Office of Lend-Lease Administration, and its Administrator, in the Office for Emergency Management: Rosenman, 1950a, p. 445; PPPUS 1941/118. Kimball (1969) traced the development of the Lend-Lease Program during 1939–41. For the Lend-Lease Program's aid to the Soviet Union, see Jones, R.H. (1969). FDR also had decided late in 1940 to increase U.S. aid to China by a second loan to be repaid with additional supplies of Chinese tin, tungsten, and tung-tree oil. The loan principally funded the American Volunteer Group (AVG, better known as the "Flying Tigers"). The AVG, led by retired Major (later Major General) Claire L. Chennault, became the U.S. Army Air Forces' 23d Fighter Group. Ford (2007) provided a comprehensive account and analysis of the AVG's founding and its operations against the Japanese between December 20, 1941, and July 4, 1942.

[94]Cryolite, or "Greenland spar," was important in aluminum production. The world's largest deposit of this commodity was then at Ivittuut on the island's southwest coast.

[95]FDR to Ickes, July 1, 1941, *in* Ickes, 1954, p. 567.

[96]FDR, Ex. O. 8785, June 14, 1941: Rosenman, 1950a, p. 217; PPPUS 1941/64. Ex. O. 8785 amended Ex. O. 8389 of April 10, 1940.

[97]55 Stat. L., 341, June 28, 1941.

[98]55 Stat. L., 752, October 28, 1941. 54 Stat. L., 603, June 26, 1940, authorized USBM "exploration of manganiferous deposits."

[99]The Civil Service Commission gave the USGS, as a war agency, the authority to make appointments for the war's duration but not to exceed 6 months thereafter. FDR's Ex. O. 9067, February 20, 1942, authorized the transfer of executive branch employees to war agencies.

[100]Schley, May 21, 1941, *in* Senate hearing, 77th Cong., 1st sess., p. 146.

[101]55 Stat. L., 752, October 28, 1941.

[102]Survey Order (Surv. O.) 143, July 23, 1941. Copies of Survey orders (1911–59) for the U.S. Geological Survey are in the Director's Office, Central Classified Files, Record Group 57 (RG 57), National Archives and Records Administration's Archives II facility (NARA II), College Park, Md.

[103]As Theis continued his investigations, Hubbert (1940) critiqued the theory of groundwater motion.

[104]Ickes, Secr. O. 1466, April 15, 1940.

[105]Ickes, Secr. O. 1527, October 29, 1940.

[106]FDR, fireside chat, by radio to the Nation, September 11, 1941: Rosenman, 1950a, p. 390; PPPUS 1941/100.

[107]Rosenman, 1950a, p. 391.

[108]FDR, message to Congress on the arming of U.S. merchant ships, October 9, 1941: Rosenman, 1950a, p. 406; PPPUS 1941/106. The authority is 55 Stat. L., 764, November 17, 1941.

[109]FDR, Ex. O. 8832, July 26, 1941: Rosenman, 1950a, p. 281–282; PPPUS 1941/80.

[110]FDR, Ex. O. 8839, July 30, 1941; Rosenman, 1950a, p. 290; PPPUS 1941/83.

[111]Ibid.

[112]FDR, Ex. O. 8832, July 26, 1941; Rosenman, 1950a, p. 281.

[113]Ickes, 1954, p. 588. Utley (1985) summarized America's passage during 1937–41 to war with Japan.

[114]See Anderson, I.H. (1975). For an overview of U.S. economic diplomacy during 1933–91, see Dobson (2002). Ketchum (1989) provided a comprehensive review of America's passage from peace to war during 1938–41; Heinrichs (1988) concentrated on the interval between March and December 1941.

[115]Atlantic Charter, 55 Stat. L., 1603, January 1, 1942.

[116]Ibid.

[117]Ickes, 1954, p. 606, 616.

[118]Ibid., p. 606. FDR, Ex. O. 8875, August 28, 1941, established the Supply Priorities and Allocations Board (SPAB): Rosenman, 1950a, p. 349; PPPUS 1941/95.

[119]The Japanese began detailed planning for Operation Z, the attack on Pearl Harbor, in January 1941. Lowry and Wellham (1995) briefly described the 3-week visit, during May–June 1941, to Taranto by a Japanese delegation led by a rear admiral and the subsequent planning, preparations, and attack. For additional details, see Prange, Goldstein, and Dillon (1981).

[120]Rhodes, 1986, p. 384–386. In 1998, Michael Frayn's two-act play "Copenhagen" dramatized the Bohr-Heisenberg meeting.

[121]Rhodes, 1986, p. 378.

[122]Ickes, 1954, p. 649.

[123]FDR to Hirohito, December 6, 1941: Rosenman, 1950a, p. 513; PPPUS 1941/137.

[124]For details of the casualties, see Prange, Goldstein, and Dillon (1981, p. 539–540).

[125]FDR, address to Congress, December 8, 1941: Rosenman, 1950a, p. 514; PPPUS 1941/138.

[126]This and the preceding quotation: ibid., p. 515.

[127]Arthur Vandenberg, December 8, 1941, *in* Cong. Rec., v. 87, pt. 9, p. 9505.

[128]FDR, fireside chat, by radio to the Nation, December 9, 1941: Rosenman, 1950a, p. 524; PPPUS 1941/140.

[129]This and the two preceding quotations: Rosenman, 1950a, p. 528.

[130]Ibid., p. 530.

[131]See Weinberg (2005) for a comprehensive one-volume account and analysis of World War II; the text of Keegan's book (1989a) and the maps and tables in Keegan's atlas (1989b) provide significant supplements. See also Dear and Foot (1995), Murray and Millett (2000), Hastings (2011), and Beevor (2012).

Chapter 3. Washington Madhouse, 1941–1943

[1]FDR, State of the Union Address to Congress, January 7, 1943: Rosenman, 1950c, p. 29; PPPUS, 1943/4.

[2]Bedini, 1975, title page.

[3]On February 19, 1942, FDR approved Ex. O. 9066 authorizing the mass removal of Japanese-American citizens and Japanese resident aliens from Pacific coast and international border areas to inland camps; see Robinson, Greg (2001).

[4]Eckes, 1979, p. 83. Eckes based his subsequent discussion (p. 83–84) on Pehrson (1942). Elmer W. Pehrson, Chief of the USBM's Economics and Statistics Branch, estimated that Axis control of the world's oil would rise significantly above 7 percent if its forces occupied the principal Soviet fields. The Axis also doubled or tripled its access to copper, lead, and zinc.

[5]This and the preceding quotation: FDR, State of the Union Address to Congress, January 6, 1942: Rosenman, 1950b, p. 36, 38; PPPUS 1942/5.

[6]Ickes, Secr. O. 1629, December 16, 1941. FDR authorized a minimum wartime workweek of 48 hours in Ex. O. 9301, February 9, 1943: Rosenman, 1950c, p. 69; PPPUS 1943/15.

[7]Also on January 14, 1942, FDR transmitted to Congress the National Resources Planning Board's "Development of National Resources—Report for 1942": Rosenman, 1950b, p. 52; PPPUS 1942/8.

[8]This and the five preceding quotations: Ickes, Secr. O. 1636, January 14, 1942.

[9]FDR, Ex. O. 9036, January 22, 1942, and Ex. O. 9067, February 20, 1942; the latter is in PPPUS 1942/unnumbered doc. between 22 and 23.

[10]FDR, letters of May 28 and November 5, 1941. See FDR, Ex. O. 9276, December 2, 1942, and Ex. O. 9332, April 19, 1943: Rosenman, 1950b, p. 496, and 1950c, p. 167; PPPUS 1942/135 and 1943/39.

[11]55 Stat. L., 838, December 18, 1941.

[12]FDR, Ex. O. 9024, January 16, 1942: Rosenman, 1950b, p. 54–56; PPPUS 1942/9. Ex. O. 9040, January 24, 1942: PPPUS 1942/unnumbered doc. between 10 and 11. Ex. O. 8629, January 7, 1941, established the Office of Production Management (OPM): Rosenman, l941b, p. 689–692; PPPUS 1941/5. The SPAB replaced OPM's Priorities Board by Ex. O. 8875, August 28, 1941: Rosenman, 1950a, p. 349–353; PPPUS 1941/95. For a history of the War Production Board (WPB), see U.S. Civilian Production Administration (1947).

[13]FDR, Ex. O. 9128, April 13, 1942; copy in the DoI Library, in Washington, D.C.

[14]FDR, Ex. O. 8982, December 17, 1941.

[15]Jesse Jones continued to oppose stockpiling after 1940.

[16]56 Stat. L., 539, July 2, 1942.

[17]Ibid., 545–546.

[18]This and the three preceding quotations: Ickes, Secr. O. 1743, October 5, 1942.

[19]Terman, 1998b, p. 49. See U.S. Geological Survey and U.S. Army Corps of Engineers (1945, cover 2); Hunt, C.B. (1946, p. 94–96); and Terman (1998b, table 1) for lists of persons who served in the USGS Military Geology Unit (MGU) during 1942–45. For the origin of and operations by the MGU in World War II, see Nelson, C.M., and Rose, E.P.F. (2012).

[20]For organizational and operational evaluations, see Häusler (2000), Häusler and Willig (2000), and Rose, E.P.F., Häusler, and Willig (2000).

[21]E.C. Eckel later returned to consulting, but he left his practice in 1933 to serve as the TVA's chief geologist. Eckel died on November 22, 1941.

[22]USGS topographers served as officers in the Army Engineers and in the Coast Artillery; see Rabbitt, M.C., 1986, p. 196.

[23]Brooks, 1920, p. 124. For additional perspective on American geologists in World War I, see Pittman (1998).

[24]Johnson, D.W. (1940); Leith (1940); and Bucher (1941).

[25]Hotchkiss (1942); Johnson, D.W. (1942); and Paige (1942).

[26]This and the three preceding quotations: Daly, 1942, p. 71.

[27]This and the preceding quotation: Aldrich, 1942, p. 10.

[28]Ibid., p. 11.

[29]Rubey, 1947, p. 1.

[30]Ibid., p. 1–2

[31]Hotchkiss and others (1942). The committee's report is Hotchkiss and others (1943).

[32]This and the two preceding quotations: Rubey, 1947, p. 2.

[33]This and the three preceding quotations: ibid., p. 3.

[34]Ibid., p. 5.

[35]Ibid. Liberia, just south of Sierra Leone and a republic since 1847, gave air- and naval-base rights to the United States on March 31, 1942.

[36]Ibid., p. 6.

[37]See Hunt, C.B., 1982, p. 12. The map of "Alpine Quadrangle," published in 1949 in USGS Circular 46, obverse leaf 5, seems to fit more closely the terrain of Alpine, Texas, rather than Alpine, Arizona.

[38]This and the two preceding quotations: Rubey, 1947, p. 7.

[39]See Turner, Gordon-Cumming, and Betzler (1961); Keegan (1989a,b); and Weinberg (2005) for overviews of the Madagascar campaign.

[40]Beck and others, 1985, p. 49. See also Loper (1943) for his evaluation, as a photogrammetrist, of the effectiveness of applied photogrammetry during the war prior to January 1943.

[41]Army Engineer-USGS agreement of October 26, 1942: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II; copy in Rubey, 1947, p. 10.

[42]Hunt, C.B., 1982, p. 13.

[43]For a complete list, see Bonham and Leith (1997).

[44]Loughlin, memorandum, August 29, 1942: Geologic Division, General Correspondence Files, 1899–1952, RG 57, NARA II.

[45]Ibid.

[46]Sydney H. Ball: Ball served as an Assistant Geologist with the USGS during 1903–07 and then traveled widely in Africa, Asia, Europe, and

North America as a consulting mining engineer and mineralogist. By 1934, Ball also had directed (sequentially) the AIMME, the Society of Economic Geologists (SEG), and the Mining and Metallurgical Society of America.

[47]Schmedeman (1948) evaluated the ores in the Dominican Republic, Haiti, and Jamaica.

[48]The USGS sponsored and Philip S. Smith, the Chief Alaskan Geologist, co-planned fieldwork on permafrost in Alaska during 1935; results were published in Taber (1943). The MGU's initial study of permafrost and its engineering problems appeared in Muller, S.W. (1943). For a brief history of permafrost studies, see Péwé (1991).

[49]For a history of the Alcan Highway that includes the Canol pipeline, see Twichell (1992).

[50]The Canol pipeline, which required 14,000 workers during its 2 years' construction, supplied gas and oil for the Alcan Highway and the air-transfer route. Fairbanks began receiving oil in February 1944: Dod, 1966, p. 338.

[51]Lyddan, 1983, p. 1057.

[52]FDR, Ex. O. 9094, March 10, 1942: PPPUS 1942/unnumbered doc. between 28 and 29.

[53]Mendenhall, Surv. O. 145, November 24, 1942.

[54]See Meinzer (1943).

[55]Ickes, Secr. O. 1740, September 26, 1942.

[56]FDR, Ex. O. 9246, September 17, 1942: Rosenman, 1950b, p. 379; PPPUS 1942/97.

[57]FDR, Ex. O. 9250, October 3, 1942: Rosenman, 1950b, p. 396; PPPUS 1942/100.

[58]FDR, Ex. O. 9257, October 15, 1942. Ex. O. 9257 expanded NPR–1 (Elk Hills) by adding to it other lands in Kern County.

[59]Harding, Ex. O. 3797–A, February 27, 1923.

[60]FDR, Ex. O. 9276, December 2, 1942: Rosenman, 1950b, p. 496; PPPUS 1942/135. For a history of the PAW, see Frey and Ide (1946).

[61]For an account and evaluation of the Battle of Midway, see Prange, Goldstein, and Dillon (1982) and Symonds (2011). For an analysis of the war in Alaska and the Aleutians, see Garfield (1995).

[62]For a comprehensive analysis of the Guadalcanal campaign, see Frank (1990); Hornfischer (2011) concentrated on naval operations during the struggle.

[63]The Germans restored production, but it reached only 70 barrels per day before Soviet forces recaptured Maikop in January 1943: Yergin, 1991, p. 336.

[64]Morris, J.B., and Morris, R.B., 1996, p. 428, 1185.

[65]FDR, State of the Union Address, January 7, 1943: Rosenman, 1950c, p. 31; PPPUS 1943/4.

[66]Stoff, Fanton, and Williams, 1991, p. 21–26, reproduced Bush's letter (and its two appendixes), in which he reported 26 contracts let for about $3.6 billion, and Roosevelt's reply of March 11. For an evaluation of earlier work in Britain on nuclear weapons, see Farmelo (2013).

[67]Jones, V.C., 1985, p. 43.

[68]Ibid., p. 8.

[69]Helmreich (1986) assessed diplomatic efforts in acquiring uranium during 1943–54.

[70]Rhodes, 1986, p. 455–457, 512–517.

[71]George, February 15, 1943, *in* Cong. Rec., v. 89, pt. 1, p. 900.

[72]FDR, Ex. O. 8628, January 4, 1941, and Ex. O. 9030, January 20, 1942.

[73]Mendenhall, March 11, 1942, *in* House hearing, 77th Cong., 2d sess., p. 854; partial and uncited quote *in* Nolan, 1975, p. 322. As part of Interior's Defense Resources Committee, established in 1940 by Ickes' Secr. O. 1496 (June 15) and Secr. O. 1502 (July 3), Mendenhall oversaw mineral and oil resources. Mendenhall also served occasionally as Acting Secretary or as Acting Assistant Secretary, also responsible for the OIA, the GLO, and the USBM.

[74]Engineering and Mining Journal, 1943, p. 48. For a summary of Mendenhall's career, see Nelson, C.M. (1999a).

[75]Letter of Paul H. Price (President) and Robert H. Dott (Sr., Secretary, Association of American State Geologists) to Ickes, February 19, 1943, *in* Dott, 1943, p. 6.

[76]Carlisle, 1964, p. 58. In 1907, Wrather served with Frank Calkins' party mapping the geology and mineral deposits of the Philipsburg (1:125,500) quadrangle in western Montana and earned thanks for his "efficient aid": Emmons and Calkins, 1913, p. 26.

[77]Wrather earned his Ph.B. in geology at Chicago in February 1908. Wrather decided against joining the Land Classification Branch, newly established in the USGS. Instead, he worked as a scout for wildcatters, convinced some of them of the value of geology in finding oil, discovered the Desdemona field (the largest since Spindletop in 1901), sold his share for $750,000, and in 1918 became an independent consultant in Dallas. For a summary of Wrather's career, see Nelson, C.M. (1999b).

[78]This and the preceding quotation: Wrather, n.d., p. 257.

[79]American Association for the Advancement of Science, 1943, p. 80.

[80]Ibid.

[81]Ibid. "Mr. Wrather is its [NAS] first choice": Ickes to Roosevelt, April 7, 1943: General Records, Office of the Secretary of the Interior, RG 48, NARA II. Wrather also confirmed that his "name headed the list of recommended candidates" (Wrather, n.d., p. 188), although he "didn't see the list" (Carlisle, 1964, p. 61).

[82]Ickes, 1944b, p. 26.

[83]Wrather, n.d., p. 229.

[84]Ibid., p. 258.

[85]Dott, 1943, p. 35.

[86]Wrather, n.d., p. 190.

[87]This and the preceding quotation: Ladd to Josiah Bridge, July 10, 1943: Box 6, Paleontology and Stratigraphy Branch (PSB), Bridge office files, 1922–53, Geologic Division, RG 57, NARA II.

[88]FDR, Ex. O. 9332, April 19, 1943: Rosenman, 1950c, p. 167; PPPUS 1943/39.

[89]Ickes, Secr. O. 1894, November 9, 1943. The new Coal Mines Administration dealt with the strikebound industry by seizing some 3,000 nonoperating mines to restore and maintain full production.

[90]57 Stat. L., 163, June 25, 1943.

[91]Johnson, March 17, 1943, *in* House hearing, 78th Cong., 1st sess., p. 2.

[92]Johnson, May 20, 1943, *in* Cong. Rec., v. 89, pt. 4, p. 4689.

[93]This and the previous quotation: ibid., p. 4693.

[94]Wrather, May 28, 1943, *in* Senate hearing, 78th Cong., 1st sess., p. 245.

[95]This and the three preceding quotations: ibid., p. 206.

[96]Baker, ibid., p. 207.

[97]McCarran, ibid.

[98]Wrather, ibid.

[99]Philip Smith, May 31, 1943, *in* Senate hearing, 78th Cong., 1st sess., p. 249. Smith also noted that seepages were "widely known throughout the Territory," especially on the Alaska Peninsula and on Alaska's south-central coast.

[100]Reed, J.C. (Sr.), 1958a, p. 3.

[101]57 Stat. L., 477, July 12, 1943.

[102]Wrather, n.d., p. 201.

[103]FDR, Ex. O. 9380, September 25, 1943: Rosenman, 1950c, p. 406; PPPUS 1943/107.

[104]Sommers, 1945, p. 97.

[105]Ibid., p. 18; Hunt, C.B., 1982, p. 14; Terman, 1998b, p. 53.

[106]The completed quadrangles included 192 at 1:24,000 and 61 at 1:62,500; 49 at 1:24,000 and 41 at 1:62,500 were in progress.

[107]56 Stat. L., 1086, December 24, 1942.

[108]For a review of USGS work on water resources abroad during 1940–70, see Taylor, G.C., Jr. (1976).

[109]This and the preceding quotation: FDR, Ex. O. 9347, May 27, 1943: Rosenman, 1950c, p. 233, 232; PPPUS 1943/57.

[110]Robertson, 1994, p. 323.

[111]FDR, Ex. O. 9361, July 15, 1943: Rosenman, 1950c, p. 298; PPPUS 1943/82.

[112]Willkie, 1943, p. 165.

[113]Ibid., p. 179.

[114]Ibid., p. 202–203. Willkie based his volume on his global tour, by B–24 Liberator bomber, in 1942; he died on October 8, 1944.

[115]U.S. equipment and supplies increasingly helped to revitalize the Red Army and improve its mobility; for evaluations of this part of the Lend-Lease Program during and immediately after the war, see Jones, R.H. (1969), and Herring (1973).

[116]For details of the campaign in Sicily, see D'Este (1988) and Kennedy, Paul (2013). Rose, E.P.F., and Clatworthy (2007) evaluated the role of British military geologists in the campaign. See also Nelson, C.M., and Rose, E.P.F. (2012).

[117]Hunt, C.B., 1982, p. 13.

[118]Sommers, 1945, p. 97; and reprinted, March 21, 1945, *in* House hearing, 79th Cong., 1st sess., p. 626.

[119]This and the previous quotation: Reybold to Wrather, September 3, 1943: "File SPETI," Director's Office, Central Classified Files, 1912–53, RG 57 (NARA II, College Park, Md.) and RG 77 (NARA I, Washington, D.C.). Two deception operations before the invasion of Sicily succeeded in diverting German reinforcements from Sicily to the Balkans and Sardinia; see Macintyre (2010).

[120]The House voted 320 to 29 to pass Fulbright's resolution: Cong. Rec., v. 89, pt. 6, p. 7728.

[121]FDR, signing address, November 9, 1943: Rosenman, 1950c, p. 503; PPPUS 1943/127.

[122]Jones, V.C. 1985, p. 241.

[123]Dallek, 1979, p. 420 (by permission of Oxford University Press). The United Nations Relief and Rehabilitation Administration, established by the international agreement (57 Stat. L., 1164), met between November 9 and December 1, 1943.

[124]FDR, fireside chat, by radio to the Nation, December 24, 1943: Rosenman, 1950c, p. 558; PPPUS 1943/142.

[125]Ibid., p. 561.

[126]FDR, message to Congress on the progress of the war, September 17, 1943: Rosenman, 1950c, p. 402; PPPUS 1943/106. FDR also reported gains of 40 percent for bituminous coal, 106 percent for steel, and 125 percent for iron ore.

[127]Yergin, 1991, p. 375–376. On July 19, 1944, the Big Inch pipeline began moving crude oil between Texas and Pennsylvania.

[128]The PRCo's records form part of RG 234, NARA II.

[129]This and the preceding quotation: Heroy, 1943, p. 957.

[130]Lea committee, *in* 78th Cong., 1st sess., House Report 663, p. 7 (serial 10763).

[131]Ibid.

[132]Yergin, 1991, p. 291. Most of the discussion herein is drawn from Yergin's volume, but see also Anderson, I.H. (1981), and Sampson (1993).

[133]Yergin, 1991, p. 300. Dammam No. 7 produced more that 3,800 barrels of free-flowing oil per day. In 1940, another Casoc well more than doubled Dammam No. 7's daily output.

[134]Ibid., p. 301.

[135]Ibid., p. 398.

[136]Ralph, 1943, p. 12. The article reported the DeGolyer party's departure, but it also printed a posed photograph that included four persons: DeGolyer, Fortas (who did not join the mission), "Murrell" (Morrell), and Wrather.

[137]This and the four preceding quotations: Wrather to Nolan (c/o Ogden Tweto), November 3, 1943: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II. Nolan would have, Wrather predicted, "clear sailing so far as the Survey is concerned": ibid. For a summary of Nolan's career, see Nelson, C.M. (2002b).

Chapter 4. A Double Task, 1943–1945

[1]FDR, budget message to Congress, January 10, 1944: Rosenman, 1950d, p. 7; PPPUS 1944/3.

[2]FDR, State of the Union Message to Congress, January 11, 1944: Rosenman, 1950d, p. 32; PPPUS 1944/4.

[3]This and the two preceding quotations: ibid., p. 32.

[4]Ibid., p. 36.

[5]This and the four preceding quotations: ibid., p. 37.

[6]This and the three preceding quotations: ibid., p. 41.

[7]Alexander, J.H. (1995, p. 76–77), analyzed the unusual tide and its effects on the battle for Betio.

[8]This and the preceding quotation: Ickes, 1944b, p. 26. Kapstein (1990) assessed the political aspects of energy crises since 1944.

[9]This and the two preceding quotations: Ickes, 1944b, p. 27.

[10]This and the five preceding quotations: DeGolyer, 1944, p. 919.

[11]This and the two preceding quotations: ibid., p. 920.

[12]This and the preceding quotation: ibid., p. 921.

[13]This and the two preceding quotations: 58 Stat. L., 190, April 5, 1944.

[14]58 Stat. L., 495, June 28, 1944.

[15]59 Stat. L., 1219, February 3, 1944; effective November 8, 1945.

[16]Ickes, Secr. O. 1946, May 2, 1944.

[17]This and the preceding quotation: Acting Secretary Abe Fortas, Secr. O. 1972, July 20, 1944.

[18]This and the two preceding quotations: Brewster and Moore, Senate Resolution 253, February 3, 1944, *in* Cong. Rec., v. 90, pt. 2, p. 1469.

[19]Wrather, n.d., p. 194.

[20]Ibid., p. 204–205.

[21]Ibid., p. 205.

[22]Ibid., p. 202.

[23]Kirwan, March 6, 1944, *in* House hearing, 78th Cong., 2d sess., p. 337.

[24]54 Stat. L., 573, June 25, 1940.

[25]Wrather, May 12, 1944, *in* Senate hearing, 78th Cong., 2d sess., p. 565.

[26]This and the preceding quotation: Jensen, June 20, 1944, *in* Cong. Rec., v. 90, pt. 5, p. 6308.

[27]58 Stat. L., 463, June 28, 1944; the USGS section begins on p. 491.

[28]Thompson's brigade formed part of the Provisional Engineer Special Brigade Group; see Snyder, C.T. (1957), and Beck and others (1985).

[29]Stearns, H.T. (1945), evaluated water supplies for the invasion.

[30]Wrather, n.d., p. 203.

[31]This and the two preceding quotations: ibid., p. 205.

[32]Wrather, Surv. O. 146, July 13, 1944. For a summary of Bradley's career, see Nelson, C.M. (2005).

[33]Loughlin began work on New England's metamorphic rocks and aided the preparation of a new geologic map of Connecticut, but he died in Washington on October 22, 1946.

[34]This and the seven preceding quotations: Hewett and others, Report, May 3, 1944: Geologic Division, General Correspondence Files, 1899–1952, RG 57, NARA II.

[35]This and the preceding quotation: ibid.

[36]Hendricks, S.B., Goldich, and Nelson, R.A. (1945), described the portable differential-thermal-analysis unit used in exploration for bauxite.

[37]This and the preceding quotation: Balsley, 1946b, p. 1. See also Balsley (1946a).

[38]This and the preceding quotation: ibid.

[39]This and the two preceding quotations: ibid.

[40]Hanna, 1990, p. 67.

[41]This and the preceding quotation: Balsley, 1946b, p. 2.

[42]This and the preceding quotation: ibid.

[43]American Association for the Advancement of Science, 1945a, p. 137. For the NRC Committee's brief report, see Fuller (1945).

[44]Bush, A.L., 1987, p. 1.

[45]Reed, J.C. (Sr.), 1958a, p. 33.

[46]Byers and others, 1947, p. 41.

[47]This and the preceding quotation: Wilcox, 1959, p. 418. Byers and others (1947, p. 41) reported the June 1 quake as being of "moderate intensity" and "lasting 1 minute."

[48]For a recent evaluation of the Novarupta-Katmai eruption of 1912, see Hildreth and Fierstein (2012).

[49]This and the preceding quotation: Wilcox, 1959, p. 418.

[50]Robinson, G.D., 1948, p. 514.

[51]This and the preceding quotation: Wilcox, *in* Fournelle, 1998, p. 7.

[52]This and the two preceding quotations: Wilcox, 1959, p. 419.

[53]See Rose, E.P.F., and Pareyn (1995, 1998), Pareyn and Rose, E.P.F. (2000), and Rose, E.P.F. (2008). For U.S. input, see Kaye (1957), Snyder, C.T. (1957), and Nelson, C.M., and Rose, E.P.F. (2012).

[54]Bonham and Leith, 1997, p. 7.

[55]For additional information about the Benson Program, begun by the British in 1942 and named for an RAF airfield in Oxfordshire, see Beck and others (1985, p. 294, 296).

[56]Kaye, 1957, p. 49.

[57]Ibid., p. 50.

[58]Rose, E.P.F., and Clatworthy, 2009, fig. 2.

[59]Hunt, C.B., 1946, p. 80. See also Nelson, C.M., and Rose, E.P.F. (2012).

[60]McCurdy and others (1944).

[61]FitzGerald (1944a,b) described the methods and results of aeronautical-chart production.

[62]Nolan (1944) provided a preliminary view of postwar plans for the Branch's photogrammetric-mapping program.

[63]Straus on Wrather's memorandum for Ickes, August 10, 1944: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II.

[64]Wrather, memorandum for Ickes (through Straus), November 8, 1944; ibid. Attached was a memo from Richard W. Cooper (the FEA's Personnel Officer) to Wrather, November 3, requesting Brown's service, via a reimbursable loan, "for approximately one year." The FEA paid all travel and living expenses and transferred Brown's official station to Dharhan on January 17, 1945. The 1938–39 statutes continued to authorize USGS work in the American Republics, Liberia, and the Philippines (when liberated).

[65]Wrather to Crowley, November 28, 1944; ibid.

[66]See Hart (1998) and the 1945 photograph of Ibn Saud, Rogers, and Brown at Kharj on p. 101. See also Jacobs (2011).

[67]Rogers to Wrather, February 5, 1945: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II.

[68]See Brown, G.F. (1949). Jackson (1990) provided a brief summary of USGS operations in Saudi Arabia during 1944–73.

[69]For a brief coeval summary of military water-supply operations, see Sayre (1945).

[70]58 Stat. L., 484, June 28, 1944.

[71]See Eckes (1975) for an analysis of the meeting and its effects.

[72]FDR, budget message to Congress, January 3, 1945: Rosenman, 1950d, p. 476–477; PPPUS 1945/1.

[73]This and the two preceding quotations: FDR, message to Congress, February 12, 1945: Rosenman, 1950d, p. 553.

[74]This and the preceding quotation: Ickes, 1944a, p. 21.

[75]Ickes, Secr. O. 2012, December 1, 1944.

[76]58 Stat. L., 776, October 3, 1944.

[77]FDR, Ex. O. 9488, October 3, 1944: Rosenman, 1950d, p. 304 (reference only).

[78]For FDR's views on conservation during this interval, see Nixon (1957); for Pinchot's role, see Miller, Char (2001). For overviews of U.S. environmental politics since 1945, see Hays, S.P., and Hays, B.D. (1987), and Hays, S.P. (2000). Stoll (2007) provided a brief history, including selected documents.

[79]FDR to Stettinius, November 22, 1944, *in* Smith, F.E., 1971, p. 378 (reprinted with the permission of the publisher).

[80]Neufeld, 1995, p. 263; the preceding information about the V–2 project also is from Neufeld.

[81]This and the preceding quotation: Kaye, 1957, p. 52. For the USGS engineering-geology mission, see Eckel (1945).

[82]Dod, 1966, p. 584.

[83]FDR to Vannevar Bush, November 17, 1944, *in* Bush, Vannevar, 1945, p. VIII.

[84]This and the preceding quotation: ibid., p. VII.

[85]This and the six preceding quotations: ibid., p. VIII.

[86]Morris, J.B., and Morris, R.B., 1996, p. 428.

[87]59 Stat. L., 887, December 22, 1944. See Pick (1948) and Ridgeway (1955) for the subsequent history of the Pick-Sloan Plan.

[88]Nolan, 1978, p. 24.

[89]This and the preceding quotation: ibid., p. 26.

[90]This and the two preceding quotations: ibid., p. 59.

[91]Wrather, Surv. O. 147, December 20, 1944.

[92]Ibid.

[93]Rabbitt, M.C., 1989, p. 35.

[94]This and the preceding quotation: Nolan, 1978, p. 43.

[95]Wrather, n.d., p. 203.

[96]Ibid., p. 202.

[97]This and the three preceding quotations: FDR, State of the Union Message to Congress, January 6, 1945: Rosenman, 1950d, p. 506–507; PPPUS 1945/2.

[98]FDR, fourth inaugural address, January 20, 1945: Rosenman, 1950d, p. 524; PPPUS 1945/7.

[99]For accounts of FDR's last year as President, see Bishop (1974) and Ferrell (1998).

[100]For an analysis of the Yalta conference, see Plokhy (2010).

[101]FDR, address to Congress, March 1, 1945: Rosenman, 1950d, p. 571; PPPUS 1945/16.

[102]This and the two preceding quotations: ibid., p. 575.

[103]This and the preceding quotation: ibid., p. 580.

[104]Ibid., p. 579.

[105]Ibid., p. 580.

[106]Ibid., p. 581.

[107]This and the preceding quotation: ibid., p. 584.

[108]This and the preceding quotation: ibid., p. 585.

[109]This and the preceding quotation: ibid., p. 584.

[110]Ickes, March 1, 1945, *in* House hearing, 79th Cong., 1st sess., p. 3.

[111]Ibid., p. 3–4.

[112]Ibid., p. 8.

[113]For an account of the construction, see Anders (1965); Webster, Donovan (2003), evaluated the effort as part of a history of the China-Burma-India Theater.

[114]See Roberts, R.J. (1945).

[115]See Swenson (1948).

[116]Sears, March 21, 1945, *in* House hearing, 79th Cong., 1st sess., p. 588.

[117]Kirwan, ibid., p. 589.

[118]Norrell, ibid., p. 610.

[119]Bradley, ibid., p. 621.

[120]Ibid., p. 623.

[121]This and the preceding quotation: ibid., p. 631.

[122]Ibid., p. 624. Sommers (1945, p. 98) wrote "the Army's engineering officers." Sommers (1945) was reprinted in Bradley, March 21, 1945, *in* House hearing, 79th Cong., 1st sess., p. 625–627.

[123]Mikesh, 1972, p. 1. Mikesh's volume provided the details for the summary of the balloon-bomb project herein, which expands his brief section (p. 34–35) about the MGU's contribution. Lewis, J.M., 2003, p. 366, cited a 1945 estimate that increased the balloons' travel time across the Pacific to 72–120 hours. For more on the USGS role, see Coen, 2014, p. 114–115. Balloon bombs continued to be found in North America through 2014. For an overview of the military use of balloons during World War II, see Christopher (2004).

[124]See White, Michael (2005).

[125]See Harris (2002) and Barenblatt (2003).

[126]Johnson, March 21, 1945, *in* House hearing, 79th Cong., 1st sess., p. 636.

[127]This and the preceding quotation: Parker, ibid., p. 639. Rogers to Judd, February 26, 1945, is printed on p. 640.

[128]This and the three preceding quotations: Nolan to Rogers, March 26, 1945, *in* House hearing, 79th Cong., 1st sess., p. 641.

[129]58 Stat. L., 284, June 22, 1944. See also Bennett, M.J. (1996), and Humes (2006).

[130]Hadden, 2008, p. 250. In 1946, these materials passed to the USGS to form the Heringen Collection, now held in the National Center's Library in Reston, Va.

[131]Frank (1999) provided a comprehensive overview, including the casualty estimates, of the planning for Operation Downfall.

[132]Truman, 1955, p. 5. See McJimsey (2000) for an overview and evaluation of Roosevelt's Presidency.

[133]HST, Ex. O. 9568, June 8, 1945: PPPUS 1945/unnumbered doc. between 55 and 56. Ex. O. 9604, August 25, 1945, amended and extended Ex. O. 9568.

[134]For a history of the Holocaust, see Gilbert, Martin (1986a) and Dwork and van Pelt, R.J. (2002).

[135]Ickes, *in* Senate hearing, May 7, 1945, 79th Cong., 1st sess., p. 122.

[136]Johnson, April 24, 1945, 79th Cong., 1st sess., House Report 437, p. 19 (serial 10932). The House cuts reduced the estimate by some $1,703,000.

[137]This and the preceding quotation: Wrather, May 14, 1945, *in* Senate hearing, 79th Cong., 1st sess., p. 560.

[138]59 Stat. L., 345, July 3, 1945.

[139]Ibid.

[140]See Schlesinger (2003) for the establishment of the U.N.

[141]This and the preceding quotation: Reinke and Olsen, 1984a, p. 3. See also Leet (1945, 1946).

[142]Leet, *in* Reinke and Olsen, 1984a, p. 4.

[143]See Gutenberg (1946).

[144]Leet, *in* Reinke and Olsen, 1984a, p. 5.

[145]Leet, 1946, p. 209, and Reinke and Olsen, 1984a, p. 6.

[146]Reinke and Olsen, 1984a, p. 6, where they suggest that "Leet's H-wave * * * is composed of one or more higher modes of the Rayleigh wave." See also Reinke and Olsen (1984b). For a history of U.S. seismograph stations, see Poppe (1979). Howell (1990) published a history of seismological research.

[147]Rhodes, 1986, p. 605; see p. 605–610 for all of the Alsos mission's accomplishments and the account herein. See also Goudsmit (1947), Pash (1969), and Szasz (2001).

[148]Bernstein, 1993, p. 1925, confirming Goudsmit's earlier conclusion. See also Bernstein and Cassidy (1995) and Bethe (2000). For the Manhattan Project's physics, see Reed, B.C. (2011).

[149]See Bower (1987), Hunt, Linda (1991), and Jacobsen (2014).

[150]Second Lieutenant (later 1st Lt.) R. Gordon Arneson, Secretary, interim (Stimson) committee meeting notes, May 31, 1945, Office of the Secretary of War, RG 107, NARA II; facsimile *in* Stoff, Fanton, and Williams, 1991, p. 110.

[151]FDR and others, meeting minutes, White House, May 31, 1945; facsimile *in* Stoff, Fanton, and Williams, 1991, p. 150.

[152]This and the two preceding quotations: 1st Lt. R. Gordon Arneson, memorandum for George L. Harrison, June 25, 1945, Office of the Secretary of War, RG 107, NARA II; facsimile *in* Stoff, Fanton, and Williams, 1991, p. 157.

[153]Feis, 1966, p. 85.

[154]Hardy to Spaatz, July 24, 1945; *in* Truman, 1955, p. 420; *in* Groves, 1962, p. 308.

[155]Morison, 1960, p. 633.

[156]Truman, 1955, p. 416.

[157]Ibid. See also Ferrell (1996).

[158]Churchill, W.S. [1st], 1953, p. 670.

[159]Truman, 1955, p. 416.

[160]Holloway (1994) traced the Soviet Union's development of its own atomic bombs.

[161]Truman, 1955, p. 391; Stoff, Fanton, and Williams, 1991, p. 215 (Potsdam Declaration, July 26, 1945).

[162]Truman, 1955, p. 391; Stoff, Fanton, and Williams, 1991, p. 216.

[163]Truman, 1955, p. 392; Stoff, Fanton, and Williams, 1991, p. 215.

[164]Truman, 1955, p. 392; Stoff, Fanton, and Williams, 1991, p. 216.

[165]HST, statement, August 6, 1945: Reid and others, 1961b, p. 199; PPPUS 1945/93.

[166]Hirohito, August 14, 1945, *in* Rhodes, 1986, p. 745.

[167]Ibid., p. 746.

[168]See MacArthur, 1964, p. 275.

[169]This and the preceding quotation: HST, statement, August 6, 1945: Reid and others, 1961b, p. 199–200.

[170]Ibid., p. 200. See also Dobbs (2012).

Chapter 5. Pioneering a New Course, 1945–1947

[1]Chapman, February 4, 1946, *in* House hearing, 79th Cong., 2d sess., p. 6.

[2]HST, radio address to the American people, September 1, 1945: Reid and others, 1961b, p. 257; PPPUS 1945/122.

[3]HST, address at the U.N.'s closing session in San Francisco, June 26, 1945: Reid and others, 1961b, p. 141; PPPUS 1945/66.

[4]W.S. Churchill [1st], speech at Westminster College, Fulton, Missouri, March 5, 1946, *in* Churchill, W.S. [2d], 2003, p. 414.

[5]Dreyer (1995) and Westad (2003) reviewed the wars in China during 1941–50. For recent evaluations of Chiang and Mao, see, respectively, Fenby (2003) and Pantsov and Levine (2012).

[6]For histories of the ensuing war in Indochina to 1954, see Fall (1963), Lawrence, M.A., and Logevall (2007), and Morgan, Ted (2010). For the U.S. role during 1940–63, see Brown, W.A. (1975), and Logevall (2012).

[7]HST, Ex. O. 9568, June 8, 1945; PPPUS 1945/unnumbered doc. between 55 and 56.

[8]HST, Ex. O. 9604, August 25, 1945.

[9]HST, Ex. O. 9599, August 18, 1945.

[10]HST, Ex. O. 9630, September 27, 1945; PPPUS 1945/unnumbered doc. between 147 and 148.

[11]This and the preceding quotation: HST, special message to Congress, September 6, 1945: Reid and others, 1961b, p. 271; PPPUS 1945/128.

[12]Ibid., p. 293.

[13]Vannevar Bush to HST, July 5, 1945, *in* Bush, Vannevar, 1945, p. V.

[14]See Baxter (1946). See also Stewart, Irvin (1948), Pursell (1979), and Kennedy (2013).

[15]England, 1982, p. 21. Most of the account herein of the founding and early history, to 1957, of the National Science Foundation is drawn from England's book. For subsequent history, see U.S. Library of Congress, Legislative Reference Service, Science Policy Research Division (1965) and Lomask (1976).

[16]Bush, Vannevar, 1945, p. 4.

[17]For additional perspective on the volume's origin and its effects on U.S. research policy, see Kevles (1977), Rossiter (1985), Reingold (1987), and Kleinman (1995). For a biography of Vannevar Bush, see Zachary (1997).

[18]Bush, Vannevar, 1945, p. 25.

[19]Ibid., p. 26.

[20]This and the preceding quotation: ibid., p. 27.

[21]Ibid., p. 33.

[22]This and the two preceding quotations: ibid., p. 75.

[23]This and the three preceding quotations: ibid., p. 76.

[24]This and the two preceding quotations: ibid., p. 77.

[25]This and the five preceding quotations: Huxley, 1935, p. 253.

[26]Kilgore, 1945, p. 631.

[27]This and the two preceding quotations: ibid. England (1982, p. 28–36) described the hearings.

[28]Kilgore, 1945, p. 632.

[29]Ibid, p. 633.

[30]Ibid., p. 638.

[31]HST, Proclamation 2667, 59 Stat. L., 884, September 28, 1945: Reid and others, 1961b, p. 352; PPPUS 1945/150.

[32]HST, Proclamation 2668, 59 Stat. L., 885, September 28, 1945: PPPUS 1945/unnumbered doc. between 149 and 150.

[33]HST, Ex. O. 9633, September 28, 1945: PPPUS 1945/unnumbered doc. between 149 and 150.

[34]HST, Ex. O. 9634, September 28, 1945.

[35]This and the preceding quotation: HST, Proclamation 2667, September 28, 1945.

[36]HST, Proclamation 2668, September 28, 1945.

[37]Critz (1947) and Pratt (1947) evaluated the petroleum potential of the U.S. Continental Shelves. Vietor (1984) assessed business-government relations in the formulation and conduct of U.S energy policy since 1945.

[38]HST, Ex. O. 9633, September 28, 1945.

[39]HST, special message to Congress, October 3, 1945: Reid and others, 1961b, p. 365; PPPUS 1945/156.

[40]This and the preceding quotation: ibid., p. 366.

[41]HST, Ex. O. 9613, September 13, 1945: PPPUS 1945/unnumbered doc. between 132 and 133.

[42]This and the three preceding quotations: HST, Ex. O. 9701, March 4, 1946: PPPUS 1946/unnumbered doc. between 50 and 51.

[43]Krug, Secr. O. 2188, April 19, 1946.

[44]60 Stat. L., 762, August 1, 1946.

[45]HST, Ex. O. 9816, December 31, 1946: PPPUS 1946/unnumbered doc. between 271 and 272. On the same day, Truman officially proclaimed the end of hostilities in World War II.

[46]HST, news conference, December 12, 1946: Reid and others, 1962, p. 491; PPPUS 1946/262. Truman also appointed John R. Steelman as "Assistant to the President": ibid.

[47]HST, Ex. O. 9829, February 21, 1947, extending Ex. O. 9177, May 30, 1942.

[48]This and the preceding quotation: Ickes, Secr. O. 2089, August 21, 1945.

[49]American Association for the Advancement of Science, 1945b, p. 640.

[50]Wrather, n.d., p. 210.

[51]USGS Pick and Hammer Club show program, 1947, Wonderment 234; copy in the RBR.

[52]Ibid., cast list.

[53]Ibid., 15th song.

[54]This and the three preceding quotations: Wrather, n.d., p. 210.

[55]Ibid., p. 211.

[56]61 Stat. L., 715, August 1, 1947.

[57]HST, Ex. O. 9691, February 4, 1946: PPPUS 1946/unnumbered doc. between 28 and 29.

[58]This and the four preceding quotations: Wrather, n.d., p. 205.

[59]Ibid., p. 205–206.

[60]This and the preceding quotation: ibid., p. 206.

[61]This and the two preceding quotations: ibid.

[62]This and the preceding quotation: ibid.

[63]HST, Message to the Congress on the State of the Union and on the Budget for 1947, January 21, 1946: Reid and others, 1962, p. 41; PPPUS 1946/18.

[64]This and the preceding quotation: ibid., p. 60.

[65]Ibid., p. 83.

[66]Wrather, n.d., p. 259; Nolan later agreed. Wrather called Ickes "a good friend" and described their relationship as "very pleasant" (Carlisle, 1964, p. 61). Both men appreciated Ickes' practice of consulting all staffers connected with an issue before making a decision.

[67]USGS Pick and Hammer Club show program, 1947, 9th song; copy in the RBR.

[68]This and the preceding quotation: Wrather, op. cit. Krug (1946) described the administration's view on national mineral policies.

[69]This and the three preceding quotations: Chapman, February 4, 1946, *in* House hearing, 79th Cong., 2d sess., p. 6.

[70]Wrather, February 12, 1946, *in* House hearing, 79th Cong., 2d sess., p. 221.

[71]Ibid., p. 221 and 223.

[72]This and the two preceding quotations: ibid., p. 223.

[73]This and the three preceding quotations: ibid., p. 222.

[74]Kennan, 1967, p. 557, as part of the reprint of the entire telegram, which was published initially in Kennan (1947) and reprinted in Kennan (1951). From "Memoirs, 1925–1950," by George F. Kennan. Copyright ©1967 by George F. Kennan. By permission of Little, Brown and Company. All rights reserved.

[75]W.S. Churchill [1st], speech at Westminster College, Fulton, Missouri, March 5, 1946, *in* Churchill, W.S. [2d], 2003, p. 420.

[76]Wrather, May 17, 1946, *in* Senate hearing, 79th Cong., 2d sess., p. 246.

[77]This and the preceding quotation: ibid., p. 248.

[78]This and the preceding quotation: ibid.

[79]60 Stat. L., 371, July 1, 1946. The additional $90,000 for gaging streams provided in 61 Stat. L., 111, May 26, 1947, was available only for State-county-municipality cooperation and increased these cooperative funds to $1,710,000.

[80]Hewlett and Anderson, O.E., Jr., 1962, p. 531. Hewlett and Duncan (1969) and Hewlett and Holl (1989) evaluated the AEC's administration and operations during 1947–61.

[81]Hewlett and Anderson, O.E., Jr., 1962, p. 538.

[82]See U.S. Department of State (1946).

[83]The Armed Forces Special Weapons Project issued in 1947 a three-volume technical report of Bikini's scientific resurvey. For an overview of Operation Crossroads, see Weisgall (1994).

[84]See Belcher and Hinds (1843).

[85]For evaluations of Darwin's contributions to coral-reef theory and other aspects of his work in geology, see Herbert (2005).

[86]For summaries of Wilkes' expedition, see Stanton (1975), Viola and Margolis (1985), and Philbrick (2003).

[87]For an overview of coral-reef studies, see Stoddart (1994).

[88]This and the preceding quotation: Charles Darwin to Alexander Agassiz, May 5, 1881, CUL MS.DAR. 143:11, Darwin Papers, Department of Manuscripts and Library Archives, Cambridge University, Cambridge, England, published here by permission of the Syndics of Cambridge University Library. Originally published *in* Darwin, Francis, and Seward, A.C., eds., 1903, v. 2, p. 198, and also available at <http://fig.lib.harvard.edu/fig/?bib=002801427>.

[89]David and Sweet (1904) and Hinde (1904) described, respectively, Funafuti's geology and the cores from the borings. For additional perspective, see also MacLeod (1988).

[90]Emery, Tracey, and Ladd, 1954, p. 76; drill hole 2B's section, with lithology and paleontology (including key foraminifers), is shown on p. 83. See also Ladd, Tracey, and Lill (1948).

[91]This and the three preceding quotations: Ickes, 1946, p. 4. Brinkley (2011) assessed conservation efforts in Alaska during 1879–1960.

[92]This and the five preceding quotations: Wrather, Surv. O. 150, May 17, 1946.

[93]Wrather, Surv. O. 153, July 22, 1946.

[94]This and the preceding quotation: 60 Stat. L., 751, July 31, 1946.

[95]Wrather, n.d., p. 223.

[96]This and the three preceding quotations: Wrather, Surv. O. 156, September 27, 1946.

[97]Reed, J.C. (Sr.), 1958a, p. 43, who also noted the initial focus "on the possibility of stratigraphic traps" in addition to those anticlinal. The discussion herein of the work in NPR–4 is drawn principally from Reed's volume. For a summary of U.S. exploration in the Arctic since 1939, see Reed, J.C. ([Sr.] 1970).

[98]Reed, J.C. (Sr.), 1958a, p. 33–34.

[99]This and the preceding quotation: ibid., p. 47.

[100]This and the preceding quotation: Wrather, n.d., p. 225. After Smithsonian Secretary Alexander Wetmore also approved the idea, archeologist Ralph Solecki spent a field season with the USGS in northern Alaska tracing human migration routes into North America.

[101]This and the four preceding quotations: Reed, J.C. (Sr.), 1958a, p. 43.

[102]This and the three preceding quotations: ibid., p. 59.

[103]This and the preceding quotation: ibid., p. 60.

[104]60 Stat. L., 482, July 8, 1946.

[105]Reed, J.C. (Sr.), 1958a, p. 49.

[106]Wrather, n.d., p. 225.

[107]This and the preceding quotation: Wilcox, 1959, p. 419.

[108]See Robinson, G.D. (1947).

[109]Ibid., p. III.

[110]Wilcox, *in* Fournelle, 1998, p. 7.

[111]Parícutin's eruption ended in 1952; for an overview, see Luhr and Simkin (1993).

[112]In 1948, the U.S. Board on Geographic Names accepted "Fisher Caldera," proposed by Bernard Fisher's USGS colleagues for the 7-mile-long feature they discovered west of Shishaldin Volcano on Unimak.

[113]See Bodle (1946).

[114]See Powers (1946) and Macdonald, Shepard, and Cox, D.C. (1947).

[115]See U.S. Coast and Geodetic Survey (1949); for the System's performance during 1948–67, see Cox, D.C. (1968).

[116]60 Stat. L., 596, July 23, 1946.

[117]This and the preceding quotation: ibid., p. 599.

[118]Chapman, Secr. O. 2269, October 30, 1946.

[119]For a history of the Section (later Branch) of Geophysics, see Kronstedt (1957).

[120]During that time (1948–54), Hilpert rediscovered the site in northwestern Colorado of the notorious Diamond Hoax of 1872, an American "Kimberley" exposed as fraudulent by Clarence King and members of his U.S. Geological Exploration of the Fortieth Parallel. As Hilpert did not publish the results of his find, see Faul (1972) and Hausel and Stahl (1995).

[121]HST, Ex. O. 9718, May 3, 1946; Reid and others, 1962, p. 233 (reference only); PPPUS 1946/unnumbered doc. between 95 and 96. Truman abolished the Solid Fuels Administration for War on May 6.

[122]Krug, Secr. O. 2193, May 6, 1946.

[123]Krug, Secr. O. 2309, March 29, 1947.

[124]This and the two preceding quotations: Patterson to Krug, March 8, 1946: Military Geology, Miscellaneous Memoranda and Data File, Box 7, and Josiah Bridge Office Files, Geologic Division, RG 57, NARA II.

[125]See the initial summary, work aided from March 1946 by USBM specialists, by Schenck (1946); the full report is Supreme Commander for the Allied Powers, Natural Resources Section (1949). Schonberger (1989) evaluated the U.S. restoration of Japan during 1945–52.

[126]This and the four preceding quotations: Whitmore, F.C., Jr., 1946, p. 1242. For a history of USGS military geology during 1945–72, see Terman (1998a). Rose, E.P.F., and Rosenbaum (1993a,b, 1998) evaluated British military geology in World War II and the cold war.

[127]See Johnson, C.G. (1946).

[128]Corwin (1998) and Whitmore, F.C., Jr. (2001), reviewed the Pacific Geologic Mapping Program's operations and results.

[129]The moribund League of Nations ceased to exist on April 19, 1946; see Bendiner (1975, p. 405).

[130]Corwin used his study as his doctoral dissertation at the University of Minnesota in 1951.

[131]Admiral Marc A. Mitscher, *in* Rose, L.A., 1980, p. 41.

[132]For a comprehensive chronology of Antarctic expeditions, see Headland (1989), who listed Highjump's ships and staff on p. 314. For the history of science on Antarctica, see Fogg (1992, 2005). Alberts (1995) provided a guide to the geographic names of the Antarctic.

[133]For a summary of all USGS participants in the scientific study and mapping of Antarctica during 1946–2006, see Meunier (2007a), who listed Balsley and Howard on p. 4. See also Meunier (2007b, p. 4, 7).

[134]See Sullivan (1957, p. 241–243) and Rose, L.A. (1980, p. 226–227).

[135]Wrather, Surv. O. 160, January 2, 1947.

[136]This and the preceding quotation: Wrather, Surv. O. 151, June 3, 1946.

[137]Wrather, Surv. O. 150, May 17, 1946.

[138]This and the preceding quotation: Wrather, n.d., p. 206.

[139]Wrather, Surv. O. 157, October 1, 1946.

[140]Wrather, Surv. O. 152, July 1, 1946.

[141]For a summary of Operation Windmill, named for its many helicopters, see Smith, L.O. (1968). See also Headland (1989, p. 322) and Meunier (2007a, p. 4, and 2007b, p. 5, 8).

[142]Headland (1989, p. 321).

[143]This and the two preceding quotations: Wrather, n.d., p. 211.

[144]This and the preceding quotation: ibid.

[145]Krug, Secr. O. 2257, September 26, 1946.

[146]60 Stat. L., 1100, July 16, 1946; Reorganization Plan No. 3 was transmitted May 17, 1946.

[147]Wrather, Surv. O. 158, November 13, 1946.

[148]Krug, Secr. O. 2201, May 31, 1946.

[149]Jacob, 1946, p. 198. Jacob established a "partial differential equation" for the aquifer with "vertical leakage in proportion to the drawdown": ibid.

[150]Jacob's article earned the American Society of Civil Engineers' Rudolph Herring Medal in 1948.

[151]20 Stat. L., 394, March 3, 1879.

[152]This and the three preceding quotations: Wrather, n.d., p. 229.

[153]Wrather, Surv. O. 153, July 22, 1946.

[154]HST, Ex. O. 9701, March 4, 1946.

[155]Krug, Secr. O. 2188, April 19, 1946.

[156]Chapman, Secr. O. 2333, June 10, 1947.

[157]Burns, J.M., 1970, p. 608. Harriman was the U.S. Ambassador to the Soviet Union from October 23, 1943, to January 24, 1946; then he was the U.S. Ambassador to the United Kingdom in 1946 until he became the U.S. Secretary of Commerce on October 7, 1946.

[158]England, 1982, p. 43.

[159]Meyerhoff, 1946, p. 97.

[160]This and the three preceding quotations: ibid., p. 98; *in* England, 1982, p. 58.

[161]See England, 1982, p. 62–63.

[162]HST, Ex. O. 9791, October 17, 1946: PPPUS 1946/unnumbered doc. between 232 and 233; reprint *in* U.S. President's Scientific Research Board, 1947, v. 1, p. 70–71.

[163]HST, statement, October 17, 1946: Reid and others, 1962, p. 456; reprint *in* U.S. President's Scientific Research Board, 1947, v. 1, p. 69.

[164]HST, Ex. O. 9791, October 17, 1946: PPPUS/op. cit.; reprint *in* U.S. President's Scientific Research Board, 1947, v. 1, p. 70.

[165]This and the three preceding quotations: HST, signing statement, October 17, 1946: Reid and others, 1962, p. 456; reprint *in* U.S. President's Scientific Research Board, 1947, v. 1, p. 69.

[166]Morris, J.B., and Morris, R.B., 1996, p. 497, 1185.

[167]Richard Tolman began representing the United States on the United Nations Atomic Energy Commission in 1946.

[168]HST, State of the Union Message to Congress, January 6, 1947: Reid and others, 1963, p. 8; PPPUS 1947/2.

[169]For a history of the ONR, see Sapolsky (1990).

[170]60 Stat. L., 779, August 1, 1946.

[171]This and the preceding quotation: Wrather, February 3, 1947, *in* House hearing, 80th Cong., 1st sess., p. 743.

[172]Jones, ibid., p. 808.

[173]Bradley, ibid.

[174]This and the preceding quote: Krug, May 5, 1947, *in* Senate hearing, 80th Cong., 1st sess., p. 9.

[175]This and the three preceding quotations: ibid., p. 10.

[176]This and the preceding quotation: 61 Stat. L., 478, July 25, 1947.

[177]HST, special message to Congress, March 12, 1947: Reid and others, 1963, p. 178–179; PPPUS 1947/56.

[178]After Baruch used the term "cold war," Walter Lippmann popularized it in 1947: Halle, 1967, p. 136, note 1.

[179]Kennan, 1947, p. 575; *in* Kennan, 1951; *in* Miscamble, 1992, p. 32. See also Kuklick (2007) and Gaddis (2011).

[180]61 Stat. L., 103, May 22, 1947.

[181]Marshall, address, June 5, 1947, *in* Pogue, 1987, p. 527.

[182]This and the preceding quotation: 61 Stat. L., 934, December 17, 1947.

[183]This and the preceding quotation: ibid., p. 935.

[184]HST Ex. O. 9875, July 18, 1947: Reid and others, 1963, p. 347 (reference only); PPPUS 1947/unnumbered doc. between 146 and 147.

[185]61 Stat. L., 397, July 18, 1947.

[186]This and the two preceding quotations: 62 Stat. L., 15, January 28, 1948.

[187]61 Stat. L., 246, July 7, 1947.

[188]61 Stat. L., 696, July 31, 1947.

[189]61 Stat. L., 940, December 19, 1947.

[190]61 Stat. L., 380, July 18, 1947.

[191]This and the preceding quotation: 61 Stat L., 495, July 26, 1947.

[192]61 Stat. L., 136, June 23, 1947; PPPUS 1947/unnumbered doc. between 58 and 59.

[193]HST, Ex. O. 9835, March 21, 1947.

[194]Krug, Secr. O. 2308, March 9, 1947.

[195]HST established the President's Committee on Civil Rights in Ex. O. 9808, December 5, 1946; PPPUS 1946/unnumbered doc. between 259 and 260.

[196]Wrather, Surv. O. 164, July 9, 1947.

[197]This and the two preceding quotations: Wrather, Surv. O. 163, June 6, 1947.

[198]This and the three preceding quotations: Reed, J.C. (Sr.), 1958a, p. 62.

[199]This and the two preceding quotations: ibid., p. 74.

[200]Ibid., p. 82.

[201]Wrather, June 7, 1949, *in* Senate hearing, 81st Cong., 1st sess., p. 1606. Other sources indicated that the official transfer was not completed until December. An appropriation of $10,960 principally supported the salaries and operations by the HVO's two full-time staff members.

[202]This and the seven preceding quotations: Wrather, n.d., p. 250.

[203]61 Stat. L., 456, July 25, 1947. President Benjamin Harrison authorized the BGN by Executive order on September 4, 1890.

[204]Burns, J.P., 1981, p. 995. See also Kelsh (1949).

[205]In 1951, the Division's Trimetrogon Section modified a Kelsh plotter "to demonstrate the possibility of its use with oblique (trimetrogon) photographs": Thompson, 1958, p. 16.

[206]HST, Ex. O. 9908, December 5, 1947: PPPUS 1947/unnumbered doc. between 230 and 231.

[207]61 Stat. L., 913, August 7, 1947.

[208]Mather, 1947, p. 608. Mather expected U.S. proved reserves to peak in 1950 and "thereafter * * * descend toward zero": ibid., p. 605.

[209]This and the two preceding quotations: ibid., p. 608.

[210]Leith, 1947, p. 87.

[211]This and the preceding quotation: HST, memorandum of disapproval of the NSF bill, August 6, 1947: Reid and others, 1963, p. 368; PPPUS 1947/169.

[212]This and the two preceding quotations: ibid., p. 369.

[213]Ibid., p. 370.

[214]This and the two preceding quotations: ibid., p. 371.

[215]England, 1982, p. 85; see also Bush, Vannevar (1970).

[216]England, 1982, p. 82.

[217]This and the preceding quotation: HST, memorandum of disapproval of the NSF bill, August 6, 1947: Reid and others, 1963, p. 371; PPPUS 1947/169.

[218]U.S. President's Scientific Research Board, 1947, v. 1, p. 3. Blanpied (1999) evaluated the Steelman report.

[219]This and the four preceding quotations: U.S. President's Scientific Research Board, 1947, v. 1, p. 6.

[220]This and the nine preceding quotations: ibid., p. 7.

[221]See Bronk (1974). For overall reviews of science advice to the President, see Golden (1980) and Herken (2000). Golden (1995) extended coverage to Congress and the Judiciary.

[222]This and the preceding quotation: HST, signing statement, Ex. O. 9912, December 24, 1947: Reid and others, 1963, p. 531; PPPUS 1947/241.

[223]HST, Ex. O. 9913, December 26, 1947: PPPUS 1947/unnumbered doc. between 241 and 242.

[224]Vogt, 1947, p. 483.

[225]60 Stat. L., 754, August 1, 1946.

[226]This and the preceding quotation: U.S. President's Scientific Research Board, 1947, v. 1, p. 38.

[227]Ibid., p. 5.

Chapter 6. Replenishing the Research Capital, 1947–1950

[1]Wrather, February 3, 1947, *in* House hearing, 80th Cong., 1st sess., p. 744. The chapter's title paraphrases Wrather's coeval view that geology especially needed to replenish its capital of fundamental research, so that it might have the best tools and background to work effectively in helping to overcome the Nation's existing deficiencies in vital mineral resources.

[2]HST, State of the Union Message to Congress, January 7, 1948: Reid and others, 1964a, p. 7; PPPUS 1948/2.

[3]HST, special message on civil rights to Congress, February 2, 1948: Reid and others, 1964a, p. 121–126; PPPUS 1948/20.

[4]HST, Ex. O. 9980 and Ex. O. 9981, July 26, 1948: PPPUS 1948/unnumbered doc. between 164 and 165.

[5]This and the four preceding quotations: HST, budget message to Congress, January 12, 1948: Reid and others, 1964a, p. 47; PPPUS 1948/5.

[6]Wrather, March 15, 1948, *in* House hearing, 80th Cong., 2d sess., p. 508.

[7]Ibid., p. 509.

[8]FitzGerald, ibid., p. 513.

[9]Ibid., p. 522.

[10]Norrell, ibid., p. 520.

[11]Wrather, ibid., p. 523.

[12]This and the preceding quotation: Bradley, ibid., p. 524.

[13]Wrather, ibid., p. 525.

[14]This and the five preceding quotations: ibid., p. 532.

[15]This and the preceding quotation: ibid., p. 569.

[16]Ibid., p. 534.

[17]Ibid., p. 547.

[18]This and the preceding quotation: ibid., p. 548.

[19]Ibid., p. 509, 586.

[20]This and the preceding quotation: Jensen, ibid., p. 597.

[21]This and the four preceding quotations: ibid., p. 584.

[22]This and the two preceding quotations: Krug, April 29, 1948, *in* House hearing, 80th Cong., 2d sess., p. 1111.

[23]62 Stat. L., 1135, June 29, 1948.

[24]Noted in the USGS Annual Report for 1948–49 as $364,900 for general administration, including $15,000 from the Office of the Secretary.

[25]62 Stat. L., 1134–1135, June 29, 1948.

[26]Ibid., p. 1135.

[27]63 Stat. L., 259, June 23, 1949.

[28]62 Stat. L., 1135, June 29, 1948.

[29]Lodge to William E. Chandler (R–NH), *in* Cong. Rec., v. 33, pt. 7, p. 6212. Chandler agreed that a USGS navy was inevitable; for the wider context of their exchange, see Rabbitt, M.C., 1980, p. 301.

[30]In 1987, the Aerospace Museum of California at McClellan Park, in north Sacramento, acquired the C–53D for restoration to its wartime state for the Normandy invasion in 1944 and for display.

[31]Gelvin (2005) reviewed the conflicts in Palestine after 1900.

[32]Dupuy, R.E., and Dupuy, T.N., 1993, p. 1224. For additional details and analyses, see Dupuy, T.N. (1978), and Morris, Benny (2008).

[33]Yergin, 1991, p. 422, and map of Middle East consortiums on p. 423. The subsequent discussion herein also is based primarily on Yergin's account.

[34]HST, special message to Congress, March 12, 1947: Reid and others, 1963, p. 178–179; PPPUS 1947/56. 61 Stat. L., 103, May 22, 1947, endorsed the Truman Doctrine.

[35]62 Stat. L., 137, April 3, 1948.

[36]Ibid., p. 138. For a recent evaluation of the Marshall Plan's effectiveness, see Behrman (2007).

[37]For an overview of the Berlin blockade, see Holloway, 1994, p. 258–263. See also Zubok (2007).

[38]Sudoplatov and others, 1994, p. 210.

[39]62 Stat. L., 604, June 24, 1948.

[40]Tusa and Tusa, 1988, p. 374. See also Reeves (2010).

[41]Millett (2005) described and analyzed the 1945–50 interval in the struggle to control the Korean Peninsula.

[42]This and the preceding quotation: NSC–20/4, reprinted in NSC–68; see Drew (1994).

[43]Krug, Secr. O. 2428, May 14, 1948.

[44]Krug, Secr. O. 2429, May 18, 1948.

[45]Krug, Secr. O. 2438, July 1, 1948.

[46]This and the preceding quotation: Wrather, n.d., p. 216.

[47]Wrather, Surv. O. 168, May 10, 1948.

[48]Wrather, Surv. O. 169, June 25, 1948.

[49]This and the preceding quotation: ibid.

[50]Wrather, Surv. O. 173, December 15, 1948.

[51]This and the two preceding quotations: USGS Pick and Hammer Club show program, 1948, p. 11; copy in the RBR.

[52]Wrather, Surv. O. 174, December 31, 1948.

[53]Hein, Perkins, and McIntyre (2004) traced the development of ideas about the origin of these rocks and their principal commodity.

[54]This and the preceding quotation: Wrather, Surv. O. 178, June 24, 1949.

[55]USGS Pick and Hammer Club show program, 1949, p. 9; copy in the RBR.

[56]Sears, Surv. O. 171, September 29, 1948.

[57]This and the preceding quotation: 62 Stat. L., 6, January 27, 1948.

[58]Ibid., p. 10.

[59]Ibid., p. 6.

[60]Sears, Surv. O. 171, September 29, 1948.

[61]Reed, J.C. (Sr.), 1958a, p. 82–83.

[62]This and the two preceding quotations: ibid, p. 83.

[63]This and the preceding quotation: ibid., p. 90.

[64]Wrather, Surv. O. 166, February 5, 1948.

[65]For a brief history of the Hawaiian Volcano Observatory, see Babb, Kauahikaua, and Tilling (2011).

[66]See Bonham and Leith (1997).

[67]Rodgers (1948) evaluated the islands' phosphate deposits; he identified high-grade, but marginally economic, reserves only on Kitadaito-jima and Angaur.

[68]USGS Pick and Hammer Club show program, 1948, p. 12; copy in the RBR.

[69]Nolan, memorandum, December 6, 1948; Director's Office, Central Classified Files, 1912–53, RG 57, NARA II. Nolan was responding to the November 23 memorandum from Interior's Acting Director of Information requesting information for the Secretary's memorandum to key people in the Department.

[70]See Gustafson and Fennell (1950).

[71]Radlinski, 1985, p. 976.

[72]This and the three preceding quotations: Thompson, 1979, p. 1612.

[73]This and the preceding quotation: Thompson, 1958, p. 18.

[74]This and the two preceding quotations: Wells, J.V.B., 1975, p. 3.

[75]Jacob and Lohman, 1952, p. 564.

[76]This and the two preceding quotations: 62 Stat. L., 1155, June 30, 1948.

[77]This and the preceding quotation: ibid., p. 1158.

[78]63 Stat. L., 31, April 6, 1949.

[79]Sayre (1948) summarized groundwater investigations in the United States.

[80]See Carslaw and Jaeger (1947).

[81]See Ferris (1948).

[82]See Ferris (1949). The editors of the volume that included Ferris' chapter dedicated their book to Robert E. Horton for his efforts toward developing a science of hydrology (Wisler and Brater, 1949, p. [v]). Oscar Meinzer's "Hydrology" (1942), the earlier standard reference, was reprinted in 1949 by Dover.

[83]See Durum (1978) for a history of USGS water-quality laboratories. Milazzo (2006) assessed congressional concern about clean water during 1945–72.

[84]This and the two preceding quotations: Ferguson and others, 1990, p. 110. "The allegation that Nace selected the site for the [radwaste] burial ground had no substance.": ibid.

[85]This and the three preceding quotations: Davidson, Secr. O. 2505, December 30, 1948.

[86]HST, Ex. O. 10052, April 20, 1949: PPPUS 1949/unnumbered doc. between 82 and 83.

[87]62 Stat. L., 1291, August 16, 1948. See also HST, signing statement, August 16, 1948: Reid and others, 1964a, p. 449; PPPUS 1948/176.

[88]Morris, J.B., and Morris, R.B., 1996, p. 499, 1185.

[89]HST, State of the Union Message to Congress, January 5, 1949: Reid and others, 1964b, p. 6; PPPUS 1949/2.

[90]Ibid., p. 7.

[91]This and the preceding quotation: HST, inaugural address, January 20, 1949: Reid and others, 1964b, p. 112; PPPUS 1949/19.

[92]Ibid., p. 113.

[93]This and the 10 preceding quotations: ibid., p. 114.

[94]This and the two preceding quotations: ibid.

[95]This and the preceding quotation: ibid., p. 115.

[96]62 Stat. L., 1225, July 2, 1948.

[97]Qing (2007) assessed the nature and results of U.S.-China diplomacy during 1945–60; Zhang (1992) evaluated the two countries' confrontations from 1949 to 1958. Chang (1990) reviewed relationships among the United States, China, and the Soviet Union, during 1948–72.

[98]Barlow (1994) provided a detailed account of the admirals' revolt, from which the narrative herein is principally drawn.

[99]This and the two preceding quotations: U.S. Commission on Organization of the Executive Branch of the Government, 1949b, p. 6.

[100]Ibid., p. 7.

[101]Ibid.

[102]This and the preceding quotation: ibid., p. 19.

[103]Ibid., p. 20.

[104]This and the two preceding quotations: ibid., p. 50.

[105]This and the six preceding quotations: ibid., p. 51. U.S. Bureau of Mines and U.S. Geological Survey (1948) provided a summary of U.S. mineral resources.

[106]Ibid., p. 51.

[107]This and the preceding quotation: ibid., p. 52.

[108]Ibid., p. 52–53.

[109]This and the three preceding quotations: U.S. Commission on Organization of the Executive Branch of the Government, 1949a, p. 21.

[110]Ibid., p. 22.

[111]U.S. Commission on Organization of the Executive Branch of the Government, 1949c, p. 1.

[112]Ibid., p. 9.

[113]Ibid., p. 43.

[114]This and the five preceding quotations: ibid., p. 44.

[115]This and the seven preceding quotations: U.S. Department of the Interior, 1949, p. 1.

[116]This and the two preceding quotations: ibid., p. 3.

[117]This and the six preceding quotations: ibid., pt. VII [Water Resources Development], p. 5.

[118]Ibid., p. 6.

[119]U.S. Commission on Organization of the Executive Branch of the Government, 1949d, p. 41.

[120]This and the five preceding quotations: 63 Stat. L., 203, June 20, 1949.

[121]Ibid., p. 205.

[122]64 Stat. L., 1262, May 24, 1950.

[123]63 Stat. L., 377, June 30, 1949; Sec. 101 (a), on p. 379, established the General Services Administration (GSAd).

[124]This and the preceding quotation: 63 Stat. L., 954, October 28, 1949.

[125]This and the two preceding quotations: Krug, January 26, 1949, *in* House hearing, 81st Cong. 1st sess., p. 7.

[126]Wrather, February 2, 1949, ibid., p. 224.

[127]This and the six preceding quotations: ibid. p. 227.

[128]Krug, May 23, 1949, *in* Senate hearing, 81st Cong., 1st sess., p. 27.

[129]Wrather, June 7, 1949, *in* Senate hearing, 81st Cong., 1st sess., p. 1580.

[130]Ibid., p. 1587–1588.

[131]Ibid., p. 1605.

[132]63 Stat. L., 785–786, October 12, 1949, but not including the $19,500 provided elsewhere for the yearly supplies of stationery (ibid., p. 766).

[133]Krug, Secr. O. 2537, October 3, 1949.

[134]64 Stat. L., 296, June 29, 1950.

[135]This and the three preceding quotations: Nolan, Surv. O. 181, July 18, 1949.

[136]This and the three preceding quotations: Wrather, Surv. O. 188, November 17, 1949.

[137]This and the preceding quotation: Wrather, Surv. O. 189, January 4, 1950.

[138]Wrather, Surv. O. 197, May 11, 1950.

[139]This and the 11 preceding quotations: Wrather, Surv. O. 194, March 29, 1950.

[140]Wrather, Surv. O. 196, April 21, 1950.

[141]Wrather, Surv. O. 199, June 16, 1950.

[142]This and the preceding quotation: Wrather, Surv. O. 198, June 16, 1950.

[143]Wrather, Surv. O. 187, October 14, 1949.

[144]This and the preceding quotation: Wrather, Surv. O. 190, January 5, 1950.

[145]Lasky (1950) described the appraisal's goals and methods.

[146]The Mineral Investigations Field Studies (MF) series began in 1950 with MF 1, a 1:31,680-scale geologic map, by John A. Straczek and Douglas M. Kinney, of the Batesville manganese district in northeastern Arkansas. Manganese remained vital for making stronger steel, and shipments from the district continued until 1959. See Straczek and Kinney (1950).

[147]This and the preceding quotation: Hubbert, 1949, p. 108.

[148]See Bonham and Leith (1997). Hunt, C.B. (1950), published an overview of military geology's applications to engineering practice.

[149]This and the preceding quotation: 63 Stat. L., 627, August 24, 1949.

[150]Reed, J.C. (Sr.), 1958a, p. 97.

[151]For historical perspective on U.S. influence on the Philippines, see Karnow (1989).

[152]This and the nine preceding quotations: Wrather, Surv. O. 193, March 22, 1950.

[153]Wrather, Surv. O. 160, January 2, 1947.

[154]Wrather, Surv. O. 193, March 22, 1950.

[155]Skop (1947) described the 1:250,000 program just before it left the Army Map Service (AMS).

[156]This and the five preceding quotations: Wrather, Surv. O. 193, March 22, 1950.

[157]This and the preceding quotation: Wrather, Surv. O. 192, February 6, 1950. See Snyder, J.P. (1982), for map projections used by the USGS.

[158]Wrather, *in* U.S. Department of the Interior, 1950, p. 182.

[159]An existing USGS-Kentucky cooperative but intermittent program of investigations of surface and groundwater resources ran from 1915 to 1938 and then continued uninterrupted.

[160]Thompson, 1958, p. 18. See also Thompson, 1979, p. 1612. Bean (1953, 1954) discussed the development and use of the ER–55 projector.

[161]This and the preceding quotation: HST, Ex. O. 10095, January 3, 1950; PPPUS 1950/unnumbered doc. preceding 1.

[162]Cooke worked for Gifford Pinchot in Pennsylvania, led the Rural Electrification Administration for FDR, served as a consultant to the Office of Production Management, and led the U.S. technical mission to Brazil in 1942.

[163]This and the two preceding quotations: Krug, Secr. O. 2530, August 16, 1949.

[164]This and the preceding quotation: Krug, Secr. O. 2537, October 3, 1949.

[165]Duncan (1950) described the Conservation Division's organization and operational functions.

[166]Cook, Don (1989), traced the evolution of NATO during 1945–50. Kaplan (1999) evaluated subsequent years.

[167]63 Stat. L., 2241, July 25, 1949.

[168]See Holloway (1994) for a detailed analysis. Shimkin (1949) summarized current knowledge of the Soviet Union's uranium deposits, especially the significant ones discovered "in Central Asia within the last decade": ibid., p. 60.

[169]63 Stat. L., 66, May 11, 1949.

[170]63 Stat. L., 578, August 10, 1949.

[171]This and the preceding quotation: 63 Stat. L., 711, October 6, 1949.

[172]This and the preceding quotation: ibid., p. 714.

[173]HST, statement, January 31, 1950; Reid and others, 1965a, p. 138.

[174]64 Stat. L., 204, June 5, 1950.

[175]Ibid., p. 209.

[176]HST, State of the Union Message to Congress, January 4, 1950: Reid and others, 1965a, p. 2; PPPUS 1950/2.

[177]This and the preceding quotation: ibid., p. 3.

[178]Ibid., p. 10.

[179]For overviews of the McCarthy era and its impact on the Federal Government, see Goldston (1973), Caute (1978), and Johnson, Haynes (2005); for the effects of these times on science and scientists in America, see Wang, Jessica (1999).

[180]Espionage by Hiss and other Americans was confirmed after the end of the cold war in 1989 by the results of searches in Soviet files by Allen Weinstein and other historians from the United States, Russia, and Hungary and the publication of memoirs by spymaster Pavel Sudoplatov (Sudoplatov and others, 1994) and other Soviet officials.

[181]64 Stat. L., 987, September 23, 1950.

[182]The discussion herein is based principally on England (1982, p. 85–106).

[183]This and the five preceding quotations: Webster, B.M., 1947, p. 444.

[184]Ibid., p. 445.

[185]Wolfle, 1950, p. 81.

[186]American Association for the Advancement of Science, 1950, p. 506.

[187]This and the eight preceding quotations: 64 Stat. L., 149, May 10, 1950.

[188]Ibid., p. 150.

[189]Ibid., p. 156.

[190]This and the four preceding quotations: Wrather, n.d., p. 259.

[191]This and the three preceding quotations: ibid., p. 260.

[192]Wrather, n.d., p. 212–213.

[193]Ibid., p. 213.

[194]This and the two preceding quotations: ibid., p. 214.

[195]Ibid., p. 260.

[196]This and the preceding quotation: ibid., p. 214.

[197]Kirwan, January 10, 1950, *in* House hearing, 81st Cong., 2d sess., p. 1.

[198]This and the three preceding quotations: Chapman, ibid., p. 2.

[199]Ibid., p. 99 and p. 100.

[200]This and the preceding quotation: Kirwan, January 16, 1950, *in* House hearing, 81st Cong., 2d sess., p. 250.

[201]This and the two preceding quotations: Wrather, ibid., p. 240.

[202]Jackson, February 8, 1950, ibid., p. 1643.

[203]Nolan, April 5, 1950, *in* Senate hearing, 81st Cong., 2d sess., p. 104.

[204]Hayden, ibid., p. 105.

[205]FitzGerald, ibid., p. 106.

[206]This and the preceding quotation: Nolan, ibid., p. 107.

[207]This and the five preceding quotations: Nolan, ibid., p. 108.

[208]Hayden, ibid.

[209]Paulsen, ibid., p. 109.

[210]Nolan, ibid., p. 110.

[211]Truman to Acheson, January 31, 1950, *in* Drew, 1994, p. 33.

[212]NSC–68: ibid., p. 97.

[213]Ibid., p. 18. NSC–68/1, of September 21, 1950, suggested spending $35 billion for defense during fiscal year 1950–51, $57.2 billion in 1951–52, and $63.4 billion in 1952–53 (ibid., p. 110).

[214]See Shen (2012) for details of this and subsequent decisions by the triumvirate and the economic and military aid Stalin gave to Mao and Kim.

Chapter 7. Natural Resources and National Security, 1950–1953

[1]HST, budget message to Congress, January 15, 1951: Reid and others, 1965b, p. 85; PPPUS 1951/13.

[2]Millett (2010) described and analyzed the 1950–51 portion of the Korean conflict; the third volume of his planned trilogy will treat 1951–53. For a single-volume overview of the entire war, see Stokesbury (1988).

[3]This and the preceding quotation: 64 Stat. L., 477, August 28, 1950.

[4]This and the three preceding quotations: HST, radio and television report to the American people, September 1, 1950: Reid and others, 1965a, p. 613; PPPUS 1950/232.

[5]Wrather, *in* U.S. Department of the Interior, 1951a, p. 189.

[6]This and the two preceding quotations: 64 Stat. L., 583, September 5, 1950.

[7]This and the preceding quotation: ibid., p. 584.

[8]This and the five preceding quotations: ibid., p. 585.

[9]Chapman, Secr. O. 2615, February 12, 1951.

[10]This and the preceding quotation: 64 Stat. L., 1262, May 24, 1950.

[11]Chapman, Secr. O. 2574, July 17, 1950, as amended on July 17 and August 15, 1950. Chapman's Secr. O. 2599, December 1, 1950, revoked Secr. O. 2574.

[12]This and the six preceding quotations: Chapman, Secr. O. 2598, November 24, 1950.

[13]Chapman, Secr. O. 2602, December 1, 1950, established the Office of the Assistant Secretary for Mineral Resources.

[14]The Division of Oil and Gas was responsible for the functions not transferred to the Petroleum Administration for Defense (PAD).

[15]Chapman, Secr. O. 2577, July 28, 1950.

[16]Wrather, n.d., p. 263.

[17]This and the preceding quotation: Princeton University, Appraisal and Evaluation Committee, 1950, pt. I, p. 1. [Interior Committee-Princeton report.]

[18]Ibid., p. 28.

[19]This and the three preceding quotations: ibid., p. 29.

[20]This and the preceding quotation: ibid., p. 30.

[21]This and the three preceding quotations: ibid., p. 31.

[22]Ibid., p. 32.

[23]Princeton University, Appraisal and Evaluation Committee, 1950, pt. II, p. 116.

[24]This and the preceding quotation: ibid., p. 127.

[25]Ibid., p. 116.

[26]This and the four preceding quotations: ibid., p. 117.

[27]Ibid., p. 131.

[28]Ibid., p. 132.

[29]This and the three preceding quotations: ibid., p. 139.

[30]Ibid., p. 138.

[31]Ibid., p. 149.

[32]This and the preceding quotation: ibid., p. 150.

[33]Ibid., p. 149.

[34]Wrather received the Interior Committee-Princeton report on October 25. Wrather's "Policies and Plans of the Geological Survey" closed by questioning "the advisability of imposing an ill-adapted organizational pattern on an agency * * * [that] emphasizes management at the expense of accomplishment.": Wrather to Chapman, December 21, 1950, p. 9; Director's Office, Central Classified Files, 1912–53, RG 57, NARA II.

[35]64 Stat. L., 690, September 6, 1950.

[36]Ibid.

[37]This and the preceding quotation: ibid.

[38]This and the five preceding quotations: ibid.

[39]HST, Ex. O. 10159, September 8, 1950: Reid and others, 1965a, p. 624 (reference only); PPPUS 1950/unnumbered doc. between 239 and 240.

[40]This and the seven preceding quotations: 64 Stat. L., 798, September 8, 1950.

[41]Ibid., p. 800.

[42]HST, Ex. O. 10161, September 9, 1950: Reid and others, 1965a, p. 631 (reference only); PPPUS 1950/unnumbered doc. between 240 and 241.

[43]64 Stat. L., 1056, September 27, 1950.

[44]This and the preceding quotation: Wrather, Surv. O. 203, October 13, 1950.

[45]332 U.S. 19. The U.S. Supreme Court rejected similar claims by Louisiana in 339 U.S. 699 and by Texas in 339 U.S. 706.

[46]Chapman, Secr. O. 2588, September 18, 1950.

[47]Chapman, Secr. O. 2591, October 3, 1950; amended on December 21, 1950, and on January 29 and March 23, 1951. For a history of the PAD, see Brown, B.K. (1965).

[48]65 Stat. L., 131, July 31, 1951.

[49]Chapman, Secr. O. 2605, December 4, 1950.

[50]HST, Ex. O. 10200, January 3, 1951; PPPUS 1951/unnumbered doc. before 1.

[51]This and the preceding quotation: 65 Stat. L., 60, June 2, 1951.

[52]Wrather, Surv. O. 205, December 22, 1950.

[53]Wrather, Surv. O. 208, January 15, 1951.

[54]Fischer, R.P. (1950), summarized knowledge about the uranium-bearing sandstones and the USGS long-range program of diamond-drilling exploration.

[55]This and the preceding quotation: 64 Stat. L., 1035, September 25, 1950.

[56]Kiersch (1951) discussed the engineering geology of underground installations; for a history of engineering geology, see Kiersch (1955).

[57]The USGS Aleutian Volcano Investigations Unit used the Adak facilities during 1949–54. The Unit was principally funded by the Department of Defense.

[58]Wrather, Surv. O. 200, August 2, 1950.

[59]For Alaska's place in a continental evaluation of potential petroleum provinces, see Gryc, Miller, D.J., and Payne (1951).

[60]Reed, J.C. (Sr.), 1958a, p. 134.

[61]Ibid., p. 118.

[62]Ibid., p. 135.

[63]Ibid., p. 136.

[64]Ibid., p. 138.

[65]HST, Ex. O. 10159, September 8, 1950: Reid and others, 1965a, p. 624 (reference only); PPPUS 1950/240.

[66]Yergin, 1991, p. 442.

[67]Wrather, Surv. O. 206, December 22, 1950.

[68]Bean, 1955, p. 531.

[69]See U.S. Congress, House of Representatives, Committee on Public Lands (1950).

[70]This and the preceding quotation: U.S. President's Water Resources Policy Commission, 1950, v. 1, p. 10. For the DoI's review and suggested revision of the Commission's report, see U.S. Department of the Interior (1951b,c).

[71]See U.S. President's Water Resources Policy Commission, 1950, v. 3.

[72]See U.S. President's Water Resources Policy Commission, 1950, v. 2.

[73]U.S. President's Water Resources Policy Commission, 1950, v. 1, p. 12.

[74]Ibid., p. 15.

[75]This and the preceding quotation: ibid., p. 17.

[76]64 Stat. L., 319, July 3, 1950.

[77]For an analysis of U.S. military assistance in Vietnam during 1945–50, see Pach (1991).

[78]HST, Ex. O. 10281, August 28, 1951: Reid and others, 1965b, p. 491 (reference only); PPPUS 1951/unnumbered doc. between 204 and 205.

[79]This and the preceding quotation: 65 Stat. L., 373, October 10, 1951.

[80]Ibid., p. 382.

[81]England (1982, p. 124) published the full list.

[82]Golden, *in* ibid., p. 125.

[83]The NSF occupied four headquarters during 1951–65; see the photographs in England (1982, following p. 160).

[84]Morris, J.B., and Morris, R.B., 1996, p. 501, 1185.

[85]General (later Marshal) Peng Teh-huai (Peng Dehuai) replaced General Lin as leader of the Chinese forces on February 16, 1951.

[86]64 Stat. L., 1121, December 28, 1950.

[87]65 Stat. L., 75, June 19, 1951.

[88]This and the five preceding quotations: HST, economic report to Congress, January 12, 1951: Reid and others, 1965b p. 35; PPPUS 1951/11.

[89]This and the preceding quotation: HST, State of the Union Message to Congress, January 8, 1951: Reid and others, 1965b, p. 8; PPPUS 1951/4.

[90]Chapman, *in* U.S. Department of the Interior, 1951a, p. IV.

[91]Ibid., p. VII.

[92]Ibid., p. XI. See also p. XII.

[93]This and the three preceding quotations: HST, budget message to Congress, January 15, 1951: Reid and others, 1965b, p. 84; PPPUS 1951/13.

[94]This and the preceding quotation: ibid., p. 85.

[95]This and the two preceding quotations: ibid., p. 87.

[96]This and the five preceding quotations: HST to Paley, January 19, 1951 (released on the 22d): Reid and others, 1965b, p. 118; PPPUS 1951/19.

[97]This and the two preceding quotations: Wrather, *in* House hearing, February 23, 1951, 82d Cong., 1st sess., p. 830.

[98]This and the preceding quotation: ibid., p. 831.

[99]This and the two preceding quotations: ibid., p. 830.

[100]Ibid., p. 831.

[101]Norrell, ibid., p. 856.

[102]Jensen, ibid., p. 857.

[103]Kirwan, ibid., p. 857.

[104]See MacArthur, 1964, p. 405.

[105]Chapman, *in* Senate hearing, May 8, 1951, 82d Cong., 1st sess., p. 7.

[106]This and the preceding quotation: Wrather, *in* Senate hearing, May 11, 1951, 82d Cong., 1st sess., p. 130.

[107]O'Mahoney, ibid., p. 137.

[108]Hayden, ibid., p. 131.

[109]FitzGerald, ibid.

[110]This and the preceding quotation: Wrather, ibid., p. 136.

[111]65 Stat. L., 258, August 31, 1951.

[112]USGS Pick and Hammer Club show program, 1952, title page; copy in the RBR.

[113]Ibid, p. 5.

[114]This and the preceding quotation: ibid., p. 9. C.G. = Chief Geologist.

[115]This and the preceding quotation: Wrather, *in* U.S. Department of the Interior, 1953, p. 219.

[116]HST, letter to Congress, January 15, 1952, copy bound with U.S. National Science Foundation (1951) in the USGS Library in Reston, Va.

[117]This and the three preceding quotations: Conant, ibid., text p. VIII.

[118]See Rubey (1951) as an example of his coeval research, aimed in part at increasing the knowledge of ore formation.

[119]See Ringholz (1989).

[120]See U.S. Atomic Energy Commission and U.S. Geological Survey (1951).

[121]Eckel, E.B. (1952), provided a guide to interpreting geologic maps for engineers.

[122]Drilling data are from Ladd and others (1953) and Ladd and Schlanger (1960).

[123]Emery, Tracey, and Ladd, 1954, p. 2. Ladd and others (1953) initially summarized the results of drilling on Enewetak.

[124]See Rhodes (1995). The initial test of a thermonuclear device, at Enewetak on May 9, 1951, yielded a 225-kiloton blast.

[125]Wrather, Surv. O. 216, March 10, 1952.

[126]Ibid.

[127]Reed, J.C. (Sr.), 1958a, p. 149.

[128]This and the two preceding quotations: ibid., p. 150.

[129]Ibid., p. 160.

[130]HST, Ex. O. 10077 (September 7, 1949), 10137 (June 30, 1950), 10264 (June 29, 1951), and 10265 (also June 29, 1951).

[131]Wrather, Surv. O. 216, March 10, 1952.

[132]65 Stat. L., 373, October 10, 1951.

[133]See Irving, E.M. (1952).

[134]This and the preceding quotation: Randolph W. ("Bill") Bromery, letter to C. Ervin Brown, July 15, 2002, p. 2; copy in the RBR. See also Vacquier and others (1951) and Spall and Davis, R.E. (2002).

[135]Wrather, Surv. O. 213, December 27, 1951.

[136]See Loper (1951).

[137]FitzGerald (1951) discussed USGS surveying and mapping in Alaska.

[138]See Eckert (1951).

[139]The Soviet Union, Poland, and Czechoslovakia were not represented at the meeting.

[140]The treaty did not recognize Soviet sovereignty over the Kurils; in 2013, Japan still claimed the southernmost four islands.

[141]HST, budget message to Congress, January 21, 1952: Reid and others, 1966, p. 89; PPPUS 1952/18.

[142]Congress added a year to the Defense Production Act's life on June 30, 1952, but with less rigorous controls on the national economy.

[143]Chapman, *in* House hearing, January 25, 1952, 82d Cong., 2d sess., p. 615.

[144]Wrather, *in* House hearing, January 21, 1952, 82d Cong., 2d sess., p. 327.

[145]This and the two preceding quotations: ibid., p. 328.

[146]FitzGerald, *in* Senate hearing, April 25, 1952, 82d Cong., 2d sess., p. 420.

[147]This and the preceding quotation: Wrather, ibid., p. 424.

[148]This and the preceding quotation: U.S. President's Materials Policy Commission [Paley Commission], 1952, v. I, p. 3.

[149]This and the preceding quotation: ibid., p. 169.

[150]This and the preceding quotation: ibid., p. 26.

[151]This and the preceding quotation: ibid., p. 27.

[152]This and the two preceding quotations: ibid., p. 28.

[153]This and the preceding quotation: ibid., p. 29.

[154]This and the preceding quotation: ibid., p. 163.

[155]U.S. President's Materials Policy Commission, 1952, v. IV, p. 2.

[156]Ibid., p. 3.

[157]This and the four preceding quotations: ibid., p. 25. Herres (1952) discussed the pluses and minuses of the Paley Commission's report for the U.S. mining industry.

[158]This and the two preceding quotations: U.S. President's Materials Policy Commission, 1952, v. I, p. 110.

[159]HST, Ex. O. 10426, January 16, 1953: Reid and others, 1966, p. 1203 (reference only); PPPUS 1953/unnumbered doc. between 378 and 379.

[160]U.S. President's Materials Policy Commission, 1952, v. I, p. 130.

[161]This and the preceding quotation: ibid., p. 171.

[162]This and the eight preceding quotations: ibid., p. 55.

[163]Ibid.

[164]66 Stat. L., 454, July 9, 1952.

[165]Sears, Surv. O. 222 (Administrative Division) and Surv. O. 223 (Publications Office), February 17, 1953.

[166]Wrather, Surv. O. 225, March 19, 1953.

[167]Bannerman (1952) emphasized the problems involved in securing adequate supplies of 15 of the strategic nonmetallic minerals.

[168]Kirk Bryan, Arthur Buddington, Fritiof Fryxell, Herbert Hawkes, Clifford Kaye, Esper Larsen, Jr., Dwight Lemmon, Louis Ray, John Rodgers, and Nelson Sayre also attended the 18th IGC. For a review of that initial postwar meeting, see Trümpy (2004).

[169]Wrather attended scientific meetings during 1946–50 in Brazil, Britain, and The Netherlands. Alan Bateman, Glen Brown, Henry Faul, William Johnston, Thomas Lovering, Vincent McKelvey, John Rodgers, Nelson Sayre, and Wendell Woodring also attended the 19th IGC. See Durand-Delga (2005) for a review of that meeting.

[170]Wrather, n.d., p. 246.

[171]See Snyder, G.L. (1954), and Wilcox (1959, p. 419–420). Dome-building activity began at Trident in 1954.

[172]Reed, J.C. (Sr.), 1958a, p. 152.

[173]This and the preceding quotation: USGS Pick and Hammer Club show program, 1953, p. 17; copy in the RBR.

[174]For a history of the Arctic Research Laboratory (renamed the Naval Arctic Research Laboratory [NARL] in 1967) at Barrow, see Reed, J.C. ([Sr.] 1969); Reed, J.C. (Sr.), and Ronhovde (1971) provided a longer version, covering 1947–66.

[175]This and the preceding quotation: Gryc, 1985, p. C14.

[176]Reed, J.C. (Sr.), 1958a. Reed, J.C. (Sr.), and French (1975) delineated the boundaries and status of the lands and resources in NPR–4.

[177]See DeGoes and Neal (1998) for a review of military geology activities in the Arctic during 1950–70.

[178]HST, Ex. O. 10408, November 10, 1952: PPPUS 1952/unnumbered doc. between 327 and 328.

[179]Members of the Branch of Paleontology and Stratigraphy established criteria for correlating oil-bearing zones in the Williston Basin (in the Dakotas and Montana). They used paleobotanical evidence to determine the Cretaceous-Tertiary boundary in the Hiawatha gas field (in Wyoming and Colorado); that determination helped the Conservation Division to resolve a significant royalty problem.

[180]This and the preceding quotation: USGS Pick and Hammer Club show program, 1953, p. 10; copy in the RBR.

[181]This and the three preceding quotations: ibid.

[182]Wrather, Surv. O. 219, October 14, 1952.

[183]This and the five preceding quotations: Wrather, Surv. O. 220, December 5, 1952.

[184]Wrather, *in* U.S. Department of the Interior, 1954, p. 260.

[185]Thompson, 1979, p. 1612. See also Southard (1984). Burns, J.P. (1958), compared operations by the Kelsh and Balplex (Twinplex) plotters. See also Landen (1952) for a history of photogrammetry to the early 1950s.

[186]For histories of these and subsequent computers and computing, see Rojas (2001), Agar (2003), and Ceruzii (2003).

[187]See Bennett, H.G. (1952), for surveying and mapping under the Point Four Program.

[188]66 Stat. L., 328, July 3, 1952.

[189]This and the three preceding quotations: ibid.

[190]For the development of the nuclear Navy during 1946–62, see Hewlett and Duncan (1974).

[191]Yergin, 1991, p. 455.

[192]66 Stat. L., 163, June 27, 1952.

[193]Morris, J.B., and Morris, R.B., 1996, p. 502, 1185.

[194]HST, statement on DDE's election as President, November 5, 1952: Reid and others, 1966, p. 1048; PPPUS 1952/325.

[195]Smith, F.E., 1971, p. 658–678, contains a reprint of the Bureau of the Budget's Circular A–47 from December 31, 1952.

[196]HST, Ex. O. 10318, January 3, 1952: Reid and others, 1966, p. 9 (reference only); PPPUS 1952/unnumbered doc. between 1 and 2.

[197]BoB Circular A–16 (15 p.) was revised by adding an undated 5-p. Exhibit A, "Procedure for Programming and Coordination of Federal Topographic Activities."

[198]HST, State of the Union Message to Congress, January 7, 1953: Reid and others, 1966, p. 1126; PPPUS 1953/366.

[199]HST, farewell address, January 15, 1953: Reid and others, 1966, p. 1199; PPPUS 1953/378. For a view of how the world's principal political leaders might otherwise have operated to greater advantage during 1945–53, see Dallek (2010).

[200]This and the two preceding quotations: HST, farewell address, January 15, 1953: Reid and others, 1966, p. 1201.

Chapter 8. Partnership in the Natural-Resources Program, 1953–1955

[1]DDE, State of the Union Message to Congress, February 2, 1953: Reid and others, 1960a, p. 26; PPPUS 1953/6.

[2]See Pach and Richardson (1991). See also Smith, J.E. (2012).

[3]See Stegner (1955).

[4]See Stegner (1954).

[5]For an evaluation of this struggle in the wider context of development and preservation in the Truman-Eisenhower years, see Richardson (1973).

[6]DDE, Ex. O. 10432, January 24, 1953: 18 Federal Register (Fed. Reg.) 617, January 29.

[7]67 Stat. L., 142, July 10, 1953.

[8]For a review of the Eisenhower administration's foreign economic policy, see Kaufman (1982).

[9]This and the preceding quotation: DDE, inaugural address, January 20, 1953: Reid and others, 1960a, p. 1; PPPUS 1953/1.

[10]Ibid., p. 2.

[11]This and the three preceding quotations: DDE, State of the Union Message to Congress, February 2, 1953: Reid and others, 1960a, p. 12; PPPUS 1953/6.

[12]This and the preceding quotation: ibid., p. 19.

[13]Ibid., p. 23.

[14]This and the preceding quotation: ibid., p. 24.

[15]DDE, Ex. O. 10450, April 27, 1953; PPPUS 1953/unnumbered doc. between 58 and 59. For a history of background investigations of Federal employees and other activities by the FBI, see Weiner (2012).

[16]American Association for the Advancement of Science, Editorial Board, 1953, addendum, p. 3.

[17]See American Association for the Advancement of Science, 1953, p. 683. See also Cochrane (1966).

[18]This and the three preceding quotations: DDE, State of the Union Message to Congress, February 2, 1953: Reid and others, 1960a, p. 26; PPPUS 1953/6.

[19]Smith, F.E., 1966, p. 279.

[20]67 Stat. L., 29, May 22, 1953.

[21]Ibid., p. 32.

[22]This and the preceding quotation: 67 Stat. L., 462, August 7, 1953.

[23]347 U.S. 272, March 15, 1954.

[24]On February 5, 1953, the Air Force's Louisiana OCS funds passed to the Interior Department by Public Land Order 884: 18 Fed. Reg. 846. Bartley (1953) analyzed the tidelands oil controversy.

[25]McKay, *in* House hearing, February 24, 1953, 83d Cong., 1st sess., p. 4.

[26]This and the two preceding quotations: ibid., p. 5.

[27]This and the preceding quotation: Jensen, ibid., p. 10.

[28]McKay, ibid., p. 11.

[29]This and the two preceding quotations: Wrather, *in* House hearing, February 25, 1953, 83d Cong., 1st sess., p. 84.

[30]This and the preceding quotation: ibid.

[31]FitzGerald, ibid., p. 87.

[32]Wrather, ibid.

[33]This and the two preceding quotations: Jensen, ibid., p. 128.

[34]This and the preceding quotation: McKay, *in* Senate hearing, April 14, 1953, 83d Cong., 1st sess., p. 2.

[35]Wrather, *in* Senate hearing, April 20, 1953, 83d Cong., 1st sess., p. 197.

[36]Cordon, ibid.

[37]Wrather, ibid., p. 201–202.

[38]This and the preceding quotation: ibid., p. 202.

[39]This and the preceding quotation: Cordon, ibid.

[40]This and the preceding quotation: Cordon, ibid.

[41]Wrather, ibid.

[42]Wrather, ibid., p. 203.

[43]FitzGerald, ibid., p. 207.

[44]67 Stat. L., 269, July 31, 1953.

[45]U.S. Department of the Interior, Secretary's Survey Committee on the Geological Survey [Van Pelt Committee], 1954, p. 1.

[46]This and the three preceding quotations: ibid., p. i.

[47]Ibid., p. 1.

[48]Ibid.

[49]Ibid., p. iii–vii.

[50]Ibid., p. 13.

[51]This and the eight preceding quotations: Wormser to Wrather, April 28, 1954: Director's Office, Central Classified Files, 1953–74, RG 57, NARA II.

[52]This and the three preceding quotations: Wrather, Administrative Circular 55, June 29, 1953: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II; copy attached as Exhibit 6 to U.S. Department of the Interior, Secretary's Survey Committee on the Geological Survey, 1954.

[53]Ibid.

[54]This and the preceding quotation: Wrather, Administrative Circular 59, September 11, 1953: Director's Office, Central Classified Files, 1953–74, RG 57, NARA II; copy attached as Exhibit 5 to U.S. Department of the Interior, Secretary's Survey Committee on the Geological Survey, 1954.

[55]Wrather, *in* House hearing, February 25, 1953, 83d Cong., 1st sess., p. 110.

[56]Sears, Surv. O. 222, February 17, 1953: Director's Office, Central Classified Files, 1912–53, RG 57, NARA II.

[57]Mowitt, *in* House hearing, February 25, 1953, 83d Cong., 1st sess., p. 110.

[58]This and the two preceding quotations: ibid., p. 111.

[59]This and the two preceding quotations: Wrather, ibid., p. 125.

[60]See Snyder, G.H. (1966).

[61]DDE, State of the Union Message to Congress, January 7, 1954: Reid and others, 1960b, p. 6; PPPUS 1954/3.

[62]Ibid., p. 8.

[63]This and the two preceding quotations: ibid., p. 18.

[64]For a critical biography of Mossadegh, see De Bellaigue (2012).

[65]See Kinzer (2008, 2013) and Abrahamian (2013); for an overview and evaluation of worldwide operations by the CIA, see Weiner (2007).

[66]In 1954, Anglo-Iranian renamed itself British Petroleum; the yellow letters BP on a green shield formed the company's new logo.

[67]Yergin, 1991, p. 476.

[68]Ibid., p. 477.

[69]For an account of Operation Vautour (Vulture), see Prados (1983).

[70]See the overviews in Fall (1963) and Morgan, Ted (2010).

[71]See the summary in Randle (1969).

[72]The United States was not officially represented at Bandung.

[73]See the account in Immerman (1982) and the overviews in Ranelagh (1987), Prados (2006), and Weiner (2007).

[74]For a history of Castro's insurgency, see Ruiz (1968).

[75]Leighton, 1953, p. 14, provided all the percentages and comparisons.

[76]This and the preceding quotation: ibid.

[77]U.S. President's Materials Policy Commission [Paley Commission], 1952, v. I (overview) and II (details on mineral commodities).

[78]At the GSAm's annual meeting in Boston during November 1952, Lovering recommended promoting security and peace through a domestic Marshall Plan, by which a U.S. "government-supported [minerals] market would give dollars to foreign nations in exchange for raw materials." Twenty-five years of these subsidies, Lovering projected, would yield industrial reserve stocks (in addition to the military stockpiles) of essential durable minerals "at least equivalent to about five years' consumption": Lovering, 1953, p. 102.

[79]See U.S. President's Commission on Foreign Economic Policy (1954) and Eckes, 1979, p. 203–206.

[80]67 Stat. L., 639, August 1, 1953.

[81]This and the four preceding quotations: 67 Stat. L., 417, August 7, 1953.

[82]DDE, Ex. O. 10480, August 14, 1953: PPPUS 1953/unnumbered doc. between 165 and 166.

[83]This and the two preceding quotations: DDE to McKay, October 26, 1953: Reid and others, 1960a, p. 713; PPPUS 1953/228.

[84]Ibid.

[85]McKay, Secr. O. 2756, April 30, 1954.

[86]The Cosmos Club occupied the Townsend Mansion, its new home at 2121 Massachusetts Ave., N.W., in 1952.

[87]This and the three preceding quotations: U.S. National Science Foundation, 1954, p. 9–10.

[88]This and the preceding quotation: ibid., p. 109.

[89]This and the preceding quotation: ibid., p. 10.

[90]DDE, Ex. O. 10521, March 17, 1954: Reid and others, 1960b, p. 336 (reference only); PPPUS 1954/unnumbered doc. between 56 and 57.

[91]DDE, Ex. O. 10521.

[92]Douglas McKay and others to DDE, November 30, 1954, p. 1 of the 3-page letter accompanying U.S. President's Cabinet Committee on Minerals Policy (1954); copy in the DoI Library in Washington, D.C.

[93]This and the three preceding quotations: U.S. President's Cabinet Committee on Minerals Policy, 1954, p. 1.; copy in the DoI Library in Washington, D.C.

[94]This and the preceding quotation: ibid., p. 2.

[95]Ibid., p. 3.

[96]Ibid., p. 5–6.

[97]Ibid., p. 16.

[98]Ibid., p. 13.

[99]67 Stat. L., 434, August 7, 1953.

[100]This and the two preceding quotations: Wrather, n.d., p. 262.

[101]Wrather, 1954, p. 3A.

[102]See Rabbitt, J.C., and Rabbitt, M.C. (1954).

[103]See Rabbitt, M.C. (1954).

[104]Nolan, Surv. O. 231, January 11, 1954.

[105]See Rothrock, and others (1953). Bergenback and Terriere (1953) described the Scurry Reef's petrography and petrology. Stafford (1957) summarized the field's geology and production.

[106]Nolan, Surv. O. 232, January 11, 1954.

[107]Hawkes (1976) described some of the early efforts in exploration geochemistry.

[108]Nolan, Surv. O. 234, September 17, 1954.

[109]USGS Pick and Hammer Club show program, 1953, p. 15; copy in the RBR.

[110]Wrather, Surv. O. 236, November 1, 1954.

[111]USGS Pick and Hammer Club show program, 1954, p. 11; copy in the RBR.

[112]This and the two preceding quotations: U.S. Geological Survey, Engineering Geology and Ground Water Branches, 1953, p. [1].

[113]See Fischer, W.A. (1954), for a summary of the use of aerial photographs in geologic mapping.

[114]See Juhle and Coulter (1955) and Wilcox (1959, p. 420–423). Muller, E.H., Juhle, and Coulter (1954) reported the activity at Katmai.

[115]Wilcox, 1959, p. 441–470.

[116]This and the four preceding quotations: Wright and Takahashi, 1989, p. xix.

[117]USGS Pick and Hammer Club show program, 1953, p. 11; copy in the RBR.

[118]Ibid., p. 17.

[119]For a history of research in the Paleontology and Stratigraphy Branch, by one of its subsequent Chiefs, see Dutro (2004).

[120]USGS Pick and Hammer Club show program, 1954, p. 6; copy in the RBR.

[121]Reed, J.C. (Sr.), 1958a, p. 168.

[122]DDE, Ex. O. 10470, July 17, 1953.

[123]DeGolyer to F.E. Wellings, Iraq Petroleum's Chief Geologist, December 24, 1953, *in* Yergin, 1991, p. 499. Everette L. DeGolyer, Sr., papers, courtesy of the DeGolyer Library, Southern Methodist University, Dallas, Texas. See also Painter (1986) and Randall, S.J. (2005).

[124]USGS Pick and Hammer Club show program, 1953, p. 17; copy in the RBR.

[125]Wrather, Surv. O. 228, November 6, 1953.

[126]DDE, budget message to Congress, January 21, 1954: Reid and others, 1960b, p. 128; PPPUS 1954/14.

[127]This and the preceding quotation: ibid., p. 130.

[128]This and the five preceding quotations: McKay, *in* House hearing, January 31, 1954, 83d Cong., 2d sess., p. 3.

[129]This and the preceding quotation: Wrather, *in* House hearing, February 2, 1954, 83d Cong., 2d sess., p. 437.

[130]This and the two preceding quotations: Bradley, ibid., p. 454.

[131]Fenton, ibid., p. 456.

[132]This and the preceding quotation: Wrather, ibid.

[133]This and the preceding quotation: Paulsen, ibid., p. 463.

[134]This and the preceding quotation: Fenton, ibid., p. 467.

[135]Duncan, ibid., p. 480.

[136]The John Fritz Medal, Biography of William Embry Wrather, Medalist for 1954: New York, John Fritz Medal Book Supplement, February 1954, p. [i]; copy bound as part of Wrather, n.d. The list of awardees during 1905–54 is on p. [ii].

[137]This and the preceding quotation: Jensen, *in* House hearing, February 2, 1954, 83d Cong., 2d sess., p. 488.

[138]This and the two preceding quotations: McKay, *in* Senate hearing, April 12, 1954, 83d Cong., 2d sess., p. 4.

[139]Hayden, *in* Senate hearing, April 16, 1954, 83d Cong., 2d sess., p. 178.

[140]Cordon, ibid., p. 175.

[141]FitzGerald, ibid., p. 171.

[142]USGS Pick and Hammer Club show program, 1954, p. 10; copy in the RBR.

[143]68 Stat. L., 368, July 1, 1954.

[144]McKay, Secr. O. 2781, January 6, 1955.

[145]This and the preceding quotation: Wrather, Surv. O. 237, December 16, 1954.

[146]Wrather, Surv. O. 238, December 16, 1954.

[147]USGS Pick and Hammer Club show program, 1955, p. 10 (Wonderment 268); copy in the RBR. Charles A. ("Andy") Anderson succeeded Olaf Rove as Chief of the Mineral Deposits Branch in 1953; see James (1993).

[148]Wrather, Surv. O. 239, January 6, 1955.

[149]See Martin (1954).

[150]Wrather, Surv. O. 236, November 1, 1954.

[151]See Isachsen, Mitcham, and Wood (1955).

[152]This and the two preceding quotations: Fournelle, 1998, p. 8.

[153]Wright and Takahashi, 1989, p. xxii. See Macdonald and Eaton (1964).

[154]Nolan, Surv. O. 234 (revised): May 19, 1955.

[155]See Bonham and Leith (1997).

[156]See Chapman (1953, 1960), Berkner (1954), and Van Allen (1983), from which most of the summary herein was drawn. Van Allen moved to the University of Iowa in 1951.

[157]Headland, 1989, p. 115 (Bellingshausen in *Vostok*) and 118 (Palmer in *Hero*). See also Day (2013).

[158]Headland, 1989, p. 357; Meunier, 2007a, p. 4; and Meunier, 2007b, p. 5, 8.

[159]68 Stat. L., 666, August 4, 1954.

[160]68 Stat. L., 92, May 13, 1954. Willoughby (1961) described the politico-diplomatic process that led to the binational agreement.

[161]68 Stat. L., 666, August 4, 1954.

[162]68 Stat. L., 708, August 13, 1954. 69 Stat. L., 367, July 23, 1955, amended the act of 1947 (61 Stat. L., 681).

[163]69 Stat. L., 138, June 16, 1955.

[164]68 Stat. L., 935, August 30, 1954.

[165]See Boyne (2007) and Neufeld (1989), from which the account herein principally was derived.

[166]For additional details and perspective, see Goldston (1973), Caute (1978), and Johnson, Haynes (2005).

[167]For an overview of the espionage trials, see Haynes and Klehr (2006).

[168]68 Stat. L., 775, August 24, 1954.

[169]Morris, J.B., and Morris, R.B., 1996, p. 505, 1185.

[170]347 U.S. 483, May 17, 1954. For evaluations and results, see Patterson (2001) and Kluger (2004).

[171]68 Stat. L., 1105, September 1, 1954.

[172]69 Stat. L., 172, June 28, 1955.

[173]This and the eight preceding quotations: DDE, State of the Union Message, January 6, 1955: Reid and others, 1959a, p. 7; PPPUS 1955/4.

[174]DDE, special message, January 11, 1955: Reid and others, 1959a, p. 41–46; PPPUS 1955/8.

[175]DDE, national-security message, January 13, 1955: Reid and others, 1959a, p. 72–78; PPPUS 1955/12.

[176]DDE, budget message, January 17, 1955: Reid and others, 1959a, p. 86–185; PPPUS 1955/17.

[177]McKay, *in* House hearing, January 31, 1955, 84th Cong., 1st sess., p. 6.

[178]This and the preceding quotation: ibid., p. 18.

[179]This and the two preceding quotations: Kirwan, ibid., p. 11.

[180]This and the preceding quotation: Kirwan, ibid., p. 12.

[181]Nolan, *in* House hearing, February 1, 1955, 84th Cong. 1st sess., p. 138.

[182]Kirwan, ibid., p. 141.

[183]USGS Pick and Hammer Club show program, 1955, p. 16; copy in the RBR.

[184]Kirwan, *in* House hearing, January 31, 1955, 84th Cong., 1st sess., p. 142.

[185]This and the two preceding quotations: Jensen, ibid., p. 155.

[186]McKay, *in* Senate hearing, February 28, 1955, 84th Cong., 1st sess., p. 11. The dollar amounts are on p. 102.

[187]Hayden, ibid., p. 107.

[188]Nolan, ibid., p. 141.

[189]Hayden, ibid.

[190]The USGS appropriation is 69 Stat. L., 145, June 16, 1955.

[191]70 Stat L., 169, May 19, 1956.

[192]This and the six preceding quotations: U.S. Commission on Organization of the Executive Branch of the Government [II], 1955c, p. 22.

[193]U.S. Commission on Organization of the Executive Branch of the Government [II], 1955a, p. 35.

Chapter 9. The Need for More Research, 1955–1958

[1]Nolan, *in* House hearing, January 17, 1956, 84th Cong., 2d sess., p. 193.

[2]See Peebles (1991). For a review of the military use of balloons during the cold war, see Christopher (2004).

[3]Sears, Surv. O. 222, December 17, 1953.

[4]This and the preceding quotation: Nolan, Surv. O. 243, March 7, 1956.

[5]DDE, Ex. O. 10610, May 9, 1956.

[6]This and the preceding quotation: USGS Pick and Hammer Club show program, 1956, p. 18; copy in the RBR.

[7]See Varnes and Scott (1967).

[8]70 Stat. L., 374, June 29, 1956.

[9]See Moon (1994) for a brief history of the interstate highway system.

[10]This and the preceding quotation: J.R. Balsley [Jr.], memorandum to W.H. Bradley, June 20, 1956; copy in the RBR.

[11]The 1:500,000 quadrangle maps of Saudi Arabia appeared in the I-Map series of USGS Miscellaneous Geologic Investigations Maps during 1956–64. Both the 1:2,000,000 geologic map (I–270–A, 1963) and the 1:2,000,000 geographic map (I–270–B–1, 1958, which was superseded by I–270–B–2, 1963) depicted the entire Arabian Peninsula.

[12]Dufek (1957) summarized Operation Deep Freeze [I] and its results. See also Headland (1989, p. 361–362), who listed Henry Wexler as chief scientist.

[13]Meunier, 2007a, p. 4, and Meunier, 2007b, p. 5, 8, 9.

[14]DDE to McKay, May 26, 1954: Reid and others, 1960b, p. 509; PPPUS 1954/122.

[15]U.S. Commission on Organization of the Executive Branch of the Government [II], 1955b, p. 38–39.

[16]This and the preceding quotation: ibid., p. 38.

[17]This and the two preceding quotations: ibid., p. 27.

[18]This and the two preceding quotations: ibid., p. 36.

[19]Ibid., p. 37.

[20]This and the preceding quotation: Davis, C.A., 1956, p. 21. See also U.S. Presidential Advisory Committee on Water Resources Policy (1956).

[21]This and the preceding quotation: Davis, C.A., 1956, p. 20.

[22]This and the preceding quotation: Nolan, Surv. O. 244, May 3, 1956.

[23]See Ferris and Sayre (1955).

[24]For contemporary concern about disposing of radioactive waste (radwaste) on land, see Hess (1957). Walker, J.S. (2009), traced the development of U.S. policy on radwaste.

[25]69 Stat. L., 352, July 15, 1955.

[26]69 Stat. L., 367, July 23, 1955.

[27]69 Stat. L., 434, August 1, 1955. The original act is 20 Stat. L., 89, June 3, 1878.

[28]69 Stat. L., 654, August 11, 1955.

[29]This and the two preceding quotations: 69 Stat. L., 679, August 11, 1955.

[30]69 Stat. L., 681, August 11, 1955.

[31]36 Stat. L., 847, June 25, 1910.

[32]70 Stat. L., 105, April 11, 1956.

[33]For the status of offshore exploration for oil during 1947–72, see Berryhill (1974).

[34]69 Stat. L., 172, June 28, 1955.

[35]McKay, *in* House hearing, January 13, 1956, 84th Cong., 2d sess., p. 9.

[36]This and the two preceding quotations: ibid., p. 4.

[37]Wrather, n.d., p. 262. Wrather's progressive paraplegia confined him to a wheelchair in 1955; his eyesight also was failing (Nelson, C.M., 1999b, p. 896). Wrather died in 1963.

[38]Wrather, n.d., p. 262.

[39]Columbia University, 1954, p. [1]. Li Kuo-chin discovered the world's largest tungsten deposit in 1911 in southeastern China, co-invented the Li Process for manufacturing tungsten carbide, and co-authored, with Wang Chung-yu, a comprehensive volume on tungsten in 1943. Li was Chairman of the Board and Chief Engineer of the Wah Chang Smelting and Refining Company of America when he funded and Eisenhower approved the Li Medal and Prize in 1948.

[40]This and the two preceding quotations: Nolan, *in* House hearing, January 17, 1956, 84th Cong., 2d sess., p. 192.

[41]This and the preceding quotation: ibid., p. 193.

[42]This and the preceding quotation: ibid., p. 198.

[43]Ibid., p. 198–199.

[44]This and the two preceding quotations: ibid., p. 199.

[45]This and the preceding quotation: Kirwan, ibid., p. 200.

[46]This and the preceding quotation: Nolan, ibid.

[47]Ibid., p. 203.

[48]This and the two preceding quotations: USGS Pick and Hammer Club show program, 1956, p. 15; copy in the RBR.

[49]The Federal Government condemned and purchased the Heurich Brewery in 1961; its buildings, on a site more valuable for transportation improvements than additional Federal offices, were razed in 1962.

[50]Nolan, *in* House hearing, January 17, 1956, 84th Cong., 2d sess., p. 206.

[51]Ibid., p. 207.

[52]McKay, *in* Senate hearing, February 27, 1956, 84th Cong., 2d sess., p. 13.

[53]70 Stat. L., 261, June 13, 1956.

[54]Nolan, Surv. O. 246, April 5, 1957.

[55]This and the three preceding quotations: Morse to Nolan, June 27, 1956, page 1 of a 2-page letter transmitting U.S. General Accounting Office, Civil Accounting and Auditing Division (1955).

[56]Ibid.

[57]This and the preceding quotation: U.S. General Accounting Office, Civil Accounting and Auditing Division, 1955, p. 30.

[58]Nolan, Surv. O. 247, June 25, 1957.

[59]USGS Pick and Hammer Club show program, 1957, p. 5; copy in the RBR.

[60]70 Stat. L., 579, July 19, 1956.

[61]70 Stat. L., 766, July 31, 1956.

[62]Nolan, Surv. O. 236 (revised), June 14, 1957.

[63]This and the preceding quotation: USGS Pick and Hammer Club show program, 1957, p. 19; copy in the RBR.

[64]This and the preceding quotation: ibid., p. 17.

[65]Ibid.

[66]U.S. National Science Foundation, 1958, p. 110–111.

[67]70 Stat. L., 921, August 1, 1956.

[68]Glen, 1982, p. 96–97.

[69]See Balsley and Buddington (1954).

[70]See Balsley and Buddington (1961).

[71]See Reed, E.C., and others (1958).

[72]The MGB worked with the Army Engineers' Cold Regions Research Establishment, later the Cold Regions Research and Engineering Laboratory.

[73]For the results of MGB research for airfield sites in the Arctic, see Davies (1961) and Krinsley (1998).

[74]See Bonham and Leith (1997) for a full list.

[75]This and the nine preceding quotations: USGS Pick and Hammer Club show program, 1957, p. 9; copy in the RBR.

[76]For an overview of the 20th IGC, see Mazadiego-Martínez and Puche-Rivart (2009).

[77]See Headland (1989, p. 370–371), who listed Albert Paddock as chief scientist.

[78]Meunier, 2007a, p. 4, and Meunier, 2007b, p. 6, 8, 9.

[79]For a history of photomechanical techniques in map production, see Cook, K.S. (2002).

[80]Radlinski (1957) reappraised research in photogrammetry.

[81]For the use of the Orthophotoscope, see Bean and Thompson (1957).

[82]For perspective on scribing, see Deardorf (1957).

[83]Bull, 1986, p. 947. Bull, also a geomorphologist, served with the USGS-WRD during 1956–76; he joined the University of Arizona's faculty in 1968.

[84]70 Stat. L., 1078, August 7, 1956. See DDE, signing statement, August 7, 1956: Reid and others, 1958a, p. 659–660; PPPUS 1956/167.

[85]See Stallman (1956).

[86]Lyddan, Surv. O. 245, October 31, 1956.

[87]For Eisenhower's role in the Suez Crisis, see Neff (1981) and Nichols (2011); for an overview, see Whetten (1974). Louis (2006) and Wawro (2010) provided wider historical contexts. DDE soon regretted deciding against his NATO allies.

[88]See Gati (2006) and Lendvai (2008).

[89]Yergin, 1991, p. 217–218.

[90]Morris, J.B., and Morris, R.B., 1996, p. 507, 1185.

[91]DDE, special message to Congress, January 5, 1957: Reid and others, 1958b, p. 15; PPPUS 1957/6.

[92]This and the preceding quotation: DDE, State of the Union Address to Congress, January 10, 1957: Reid and others, 1958b, p. 28; PPPUS 1957/8.

[93]DDE, budget message to Congress, January 16, 1957: Reid and others, 1958b, p. 38; PPPUS 1957/13.

[94]68 Stat. L., 1112, September 1, 1954.

[95]This and the preceding quotation: DDE, second inaugural address, January 21, 1957: Reid and others, 1958b, p. 60; PPPUS 1957/15.

[96]This and the preceding quotation: ibid., p. 61.

[97]This and the two preceding quotations: Saud, comments on arrival in the United States, January 30, 1957: Reid and others, 1958b, p. 109; PPPUS 1957/23.

[98]71 Stat. L., 5, March 9, 1957.

[99]70 Stat. L., 1119, August 8, 1956.

[100]This and the preceding quotation: Kirwan, *in* House hearing, January 22, 1957, 85th Cong., 1st sess., p. 1.

[101]This and the three preceding quotations: ibid., p. 10.

[102]This and the preceding quotation: ibid., p. 27.

[103]Nolan, *in* House hearing, January 15, 1957, 85th Cong., 1st sess., p. 232.

[104]This and the seven preceding quotations: ibid., p. 227.

[105]Kirwan, ibid., p. 245.

[106]Ibid.

[107]Ibid., p. 250.

[108]For an analysis of Lyndon B. Johnson's rise to power and his service in the Senate, see Caro (1982, 1990, 2002).

[109]71 Stat. L., 634, September 9, 1957.

[110]For an account and analysis of the Little Rock crisis, see Jacoway (2007). Williams, Juan (1987), and Weisbrot (1990) provided overviews of the civil rights movement in America.

[111]This and the preceding quotation: Nolan, *in* Senate hearing, March 15, 1957, 85th Cong., 1st sess., p. 111.

[112]This and the two preceding quotations: ibid., p. 112.

[113]Ibid.

[114]Ibid., p. 125.

[115]71 Stat. L., 261, July 1, 1957.

[116]This and the three preceding quotations: DDE, remarks on the opening of the IGY, June 30, 1957: Reid and others, 1958b, p. 512; PPPUS 1957/122.

[117]See Sullivan, 1961, p. 1–2. Wilson (1961) supplemented and extended Sullivan's overview of the IGY.

[118]See Boorstin, 1973, p. 591. See also Dickson (2001).

[119]This and the preceding quotation: DDE, news conference, October 9, 1957: Reid and others, 1958b, p. 730; PPPUS 1957/210.

[120]Ibid., p. 731.

[121]See McDougall (1985) and similar overviews by Heppenheimer (1997) and Burrows (1998). Launius (1994) concentrated on NASA; Oberg (1981), on the Soviet space program. The account herein is based on all these books.

[122]Rhodes (2007) assessed the arms race between the United States and the Soviet Union.

[123]Neufeld, 2007, p. 311.

[124]DDE, radio and television address to the Nation, November 7, 1957: Reid and others, 1958b, p. 789; PPPUS 1957/230.

[125]For details of Eisenhower's response to Sputnik, see Divine (1993).

[126]See Killian (1977) for an account of his service.

[127]For a history of the President's Science Advisory Committee after Sputnik to its demise in 1972, see Wang, Zuoyue (2008).

[128]For a history of Project Vanguard, see Green and Lomask (1971).

[129]This and the preceding quotation: DDE, budget message to Congress, January 13, 1958: Reid and others, 1959b, p. 17; PPPUS 1958/5.

[130]U.S. National Science Foundation, 1959, p. 12.

[131]DDE, Ex. O. 10758, March 4, 1958: PPPUS 1958/unnumbered doc. between 40 and 41.

[132]A photograph of this event was reproduced by Pyne (2010, plate facing p. 236), who emphasized the differing and competing views of Pickering, Van Allen, and von Braun on the principal goal of the U.S. space program.

[133]For overviews of Project Corona, see Peebles (1997) and Day, Logsdon, and Latell (1998). Cloud, John (2001), evaluated the Project's impact on the earth sciences. For a wider perspective, see Brugioni (2010).

[134]For an assessment of the Keyhole program, see Richelson (1990).

[135]DDE, Ex. O. 10807, March 13, 1959.

[136]After NASA's founding, its Administrator joined the Federal Council for Science and Technology (FCST).

[137]DDE, special message to Congress, April 2, 1958: Reid and others, 1959b, p. 271; PPPUS 1958/64.

[138]Cochrane, 1978, p. 555.

[139]Members of the Berkner Panel viewed "the detection system as one which will gradually evolve with time and reach a high level of detection capability only after several years": U.S. President's Science Advisory Committee, Panel on Seismic Improvement, 1959, p. 16.

[140]Rainier, the first U.S. underground nuclear test, did not vent any radioactive products. It was part of Operation Plumbbob at the Nevada Test Site (May–October 1957), which included 25 aboveground nuclear tests and 3 detonations in open shafts. The atmospheric tests released large amounts of radioactive iodine.

[141]For a brief review of seismic-array development, see Carpenter (1965). Peterson (1992) discussed the system's development during 1960–67.

[142]Bates, Gaskell, and Rice, 1982, p. 129.

[143]Ibid.

[144]Divine (1978) and Greene (2007) reviewed the test-ban debate during 1945–63.

[145]72 Stat. L., 319, July 3, 1958.

[146]Ibid.

[147]Smith, F.E., 1971, p. 681 (reprinted with the permission of the publisher).

[148]This and the two preceding quotations: Seaton, *in* House hearing, January 13, 1958, 85th Cong., 2d sess., p. 2.

[149]Ibid., p. 3.

[150]This and the three preceding quotations: Hardy, ibid., January 16, 1958, p. 345. For perspective on the environmental effects of natural-resources development, see McNeill (2000).

[151]This and the preceding quotation: ibid., p. 346.

[152]This and the two preceding quotations: Nolan, ibid., p. 346.

[153]Ibid., p. 347.

[154]This and the two preceding quotations: ibid.

[155]This and the two preceding quotations: ibid., p. 348.

[156]Ibid., p. 352.

[157]This and the two preceding quotations: ibid., p. 353.

[158]For a brief account of the geologic aspects of the tests, see Eckel and others (1957).

[159]This and the preceding quotation: Nolan, *in* House hearing, January 16, 1958, 85th Cong., 2d sess., p. 359.

[160]Kirwan, ibid.

[161]Nolan, ibid., p. 368.

[162]This and the preceding quotation: Kirwan, ibid.

[163]Nolan, ibid., p. 372.

[164]Jesse Johnson to Nolan, January 20, 1958, ibid., p. 373.

[165]This and the preceding quotation: Jensen, ibid., p. 379.

[166]This and the preceding quotation: Nolan, ibid., p. 384.

[167]Ibid., p. 385.

[168]This and the preceding quotation: Kirwan, ibid., p. 400.

[169]Hayden, *in* Senate hearing, March 25, 1958, 85th Cong., 2d sess., p. 65.

[170]Ibid., p. 73.

[171]DDE, Ex. O. 10753, February 15, 1958: PPPUS 1958/unnumbered doc. between 29 and 30. Ex. O. 10753 superseded Ex. O. 10156, August 26, 1950.

[172]This and the two preceding quotations: Libby to Seaton, March 19, 1958, *in* Senate hearing, March 25, 1958, 85th Cong., 2d sess., p. 179.

[173]For a retrospective view of Project Plowshare, see Kirsch (2005). Johnson, G.W. (1959), discussed using nuclear explosions to mine oil shale. Neal (1988) reviewed the project's military geology aspects, and Cowan (1961), its scientific applications.

[174]Hayden, *in* Senate hearing, March 25, 1958, 85th Cong., 2d sess., p. 182.

[175]Nolan, ibid., p. 182.

[176]This and the preceding quotation: Hayden, ibid., p. 189.

[177]This and the two preceding quotations: Nolan, ibid.

[178]72 Stat. L., 159, June 4, 1958.

[179]72 Stat. L., 874, August 27, 1958.

[180]73 Stat. L., 57, May 20, 1959.

[181]72 Stat. L., 54, March 28, 1958.

[182]Nolan, *in* House hearing, January 28, 1959, 86th Cong., 1st sess., p. 172.

[183]Nolan, Surv. O. 248, February 13, 1958.

[184]This and the preceding quotation: Baker, Surv. O. 249, April 8, 1958.

[185]Nolan, Surv. O. 250, May 13, 1958.

[186]For a summary of the dispute about Meteor Crater's origin, see Hoyt (1987).

[187]See Gilbert, G.K. (1893), and the evaluations by El-Baz (1980) and Pyne (1980).

[188]See Daly (1946), Dietz (1946, 1959, 1960), and Baldwin (1949).

[189]Shoemaker, *in* Wilhelms, 1993, p. 27, ©1993 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

[190]USGS Pick and Hammer Club show program, 1958, p. 12; copy in the RBR.

[191]Ibid., p. 15.

[192]Ibid., p. 14.

[193]Ibid., p. 18.

[194]This and the two preceding quotations: ibid.

[195]Estabrook, 1956, p. 686.

[196]Munk, *in* Bascom, 1961, p. 47.

[197]Hess and Munk, *in* ibid.

[198]Ibid., p. 49.

[199]Ibid., p. 50. Lill and Maxwell, 1959, p. 1408, reprinted the International Union of Geodesy and Geophysics' (IUGG's) Resolution 11.

[200]The NAS elected Menard a member in 1968.

[201]Rabi, *in* Bascom, 1961, p. 51.

[202]Cochrane, 1978, p. 559.

[203]See van Keuren (2001) for an account of the NSF's support of the ocean sciences during 1951–65.

[204]See Bascom (1959), Hess (1959), Lill and Bascom (1959), and Lill and Maxwell (1959).

[205]This and the preceding quotation: The AMSOC proverb, *in* Lill and Maxwell, 1959, p. 1410; also *in* Greenberg, 1967, p. 179. On January 23, 1960, the U.S. Navy's bathyscape *Trieste*, purchased in 1958, modified, and crewed by oceanographer Jacques Piccard and Lt. (later Captain) Don Walsh, reached bottom at a depth of about 35,800 feet in the Mariana Trench's Challenger Deep near Guam. See Piccard and Dietz (1961).

[206]For a history of the Carnegie Institution of Washington's Geophysical Laboratory, see Yoder (2005).

[207]Nolan, Surv. O. 236 (2d revision), May 13, 1958.

[208]Bush, A.L., 1987, p. 5.

[209]See Varnes (1958).

[210]See Reed, J.C. ([Sr.] 1958b), for a summary of IGY activities in the Arctic. See also Launius, Fleming, and DeVorkin (2010) for a wider perspective.

[211]See Lachenbruch (1957).

[212]See Bonham and Leith (1997).

[213]Headland, 1989, p. 376–377.

[214]Behrendt served as assistant seismologist in Edward C. Thiel's party at Ellsworth. For the account of their continuous work in Antarctica between November 1956 and January 1958, see Behrendt (1998). See Behrendt (2005) for details of his subsequent work on the continent that resumed in 1960.

[215]Meunier, 2007a, p. 4; Meunier, 2007b, p. 6, 8–9.

[216]See Whitmore, G.D. (1958). See also Rostow (1982).

[217]U.S. Geological Survey and others, 1970, p. vii. For a brief history of national atlases, see Monmonier (1994).

[218]DDE, Ex. O. 10752, February 12, 1958: PPPUS 1958/unnumbered doc. between 28 and 29. The Executive order made Secretary Seaton responsible for enforcing the Connally "Hot Oil" Act. The law (49 Stat. L., 30) was signed on February 22, 1935, and regulated interstate and foreign commerce in petroleum and its products.

[219]Seaton, Secr. O. 2826, February 14, 1958.

[220]71 Stat. L., 341, August 13, 1957.

[221]The Weather Bureau was transferred to the Commerce Department in 1940. In 1966, the Bureau passed to the new Environmental Science Services Administration (ESSA). In 1970, the ESSA became the National Oceanic and Atmospheric Administration, and the Bureau was renamed the National Weather Service. For histories of the National Weather Service and its antecedents, see Whitnah (1961), Hawes (1966), and Hughes (1970).

[222]The U.S. Coast Guard shifted to the Department of Transportation in 1967 and then passed to the new Department of Homeland Security in 2002. For histories of the USCG and its antecedents, see Evans, S.H. (1951), and Johnson, R.E. (1987).

Chapter 10 A New Cycle, 1958–1961

[1]Nolan, 1959, p. 214.

[2]72 Stat. L., 426, July 29, 1958.

[3]Ibid., p. 427.

[4]This and the two preceding quotations: ibid., p. 426.

[5]This and the preceding quotation: ibid., p. 427.

[6]Ibid., p. 432.

[7]72 Stat. L., 613, August 14, 1958, and 72 Stat. L., 873, August 27, 1958.

[8]See Wolfe (1979). Major General Charles E. ("Chuck") Yeager and the other civilian and military pilots of the X–15 and other USAF programs who flew their aircraft to altitudes above 50 miles earned designations as pilot-astronauts.

[9]For perspective on attaining the Law of the Sea, see Alexander, L.M. (1967), Wenk (1972), and Duff (2004).

[10]U.N. General Assembly Resolution 1472 in 1959 formally established the Committee on the Peaceful Uses of Outer Space.

[11]See Bates (1961); for retrospectives of Project Vela, see Kisslinger (1971) and Kerr (1985).

[12]For an overview of the Lebanon crisis, see Dowty (1984).

[13]See Welch (1985) for an analysis of U.S. responses during 1959–61 to Castro's revolution. For an overview of Castro's and other insurgencies and counterinsurgencies since 1945, see Boot (2013).

[14]The United States did not become a signatory member of CENTO.

[15]72 Stat. L., 514, August 6, 1958.

[16]This and the preceding quotation: Meyerhoff, 1958, p. 12.

[17]72 Stat. L., 1580, September 2, 1958. See also Clowse (1981).

[18]This and the three preceding quotations: 71 Stat. L., 623, September 7, 1957.

[19]72 Stat. L., 339, July 7, 1958.

[20]73 Stat. L., c16, January 3, 1959.

[21]Morris, J.B., and Morris, R.B., 1996, p. 509, 1185.

[22]Nolan, Surv. O. 222 (2d revision), March 9, 1959.

[23]Charles Leith died in 1957, but Elmer Pehrson continued to promote a greater appreciation of the importance of the International Cooperation Administration's role in emphasizing mineral resources in international affairs; see Pehrson (1959).

[24]Keller, G.V., and Licastro (1959); see also Keller G.V. (1959).

[25]McKelvey and others (1959).

[26]James Gilluly, memorandum to Fuels Branch staff, August 6, 1958, 3 p.; copy in the RBR.

[27]For a history of the HVO's sesimic network during 1950–79, see Klein and Koyanagi (1980) and Babb, Kauahikaua, and Tilling (2011).

[28]Eaton (1959) described the portable water-tube tiltmeter.

[29]Glen, 1982, p. 154, 177.

[30]This and the preceding quotation: Becker, 1904, p. 552.

[31]This and the two preceding quotations: Balsley, 1989, p. 7. See also Hill (1959).

[32]Glen, 1982, p. 163.

[33]Ibid., p. 180.

[34]Curtis, Evernden, and Joseph I. Lipson reported K-Ar dates for a number of Mesozoic and Cenozoic intrusive rocks in California and elsewhere. Their coauthored articles were published during 1956–58; for example, see Curtis, Evernden, and Lipson (1958).

[35]See Tocher and Miller, D.J. (1959), Tocher (1960a,b), and Stover and Coffman (1993, p. 54–55). In Greenwich Mean Time (now Coordinated Universal Time), the Lituya earthquake occurred on July 10, 1958.

[36]Pomeroy, 1982, p. 1.

[37]See Kuiper (1960a,b).

[38]See Kuiper (1954).

[39]Wilhelms, 1993, p. x–xi. Most of the discussion herein of the USGS lunar program is based on Wilhelms' book, ©1993 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

[40]Ibid., p. xi.

[41]72 Stat. L., 837, August 23, 1958.

[42]76 Stat. L., 427, September 5, 1962.

[43]This and the preceding quotation: 72 Stat. L., 959, August 28, 1958.

[44]72 Stat. L., 837, August 23, 1958.

[45]Headland, 1989, p. 384.

[46]Meunier, 2007b, p. 6–7, 9; Meunier, 2007a, p. 5.

[47]This and the three preceding quotations: Seaton, Secr. O. 2829, July 10, 1958, as amended on August 8, 1958.

[48]Fagerholm (1959) discussed photogrammetry's application to land-use planning.

[49]See Landen (1959) for an assessment of photogrammetry's impact on geology.

[50]For an evaluation of techniques and applications, see Southard (1958). See also Thompson (1979) and Southard (1984).

[51]USGS Pick and Hammer Club show program, 1959, p. 6; copy in the RBR.

[52]See Cooper, H.H., Jr. (1959).

[53]See Hem (1959).

[54]This and the preceding quotation: 72 Stat. L., 596, August 14, 1958.

[55]72 Stat. L., 632, August 19, 1958.

[56]72 Stat. L., 700, August 21, 1958.

[57]Seaton, unnumbered Secretarial order, September 11, 1958; Federal Register, v. 23, p. 7181, September 17, 1958, and supplemented by Secr. O. 2833 and 2834, September 22, 1958.

[58]Kirwan, *in* House hearing, January 27, 1959, 86th Cong., 1st sess., p. 1.

[59]Seaton, ibid.

[60]This and the preceding quotation: Nolan, *in* House hearing, January 28, 1959, 86th Cong., 1st sess., p. 169.

[61]Ibid., p. 183.

[62]Ibid., p. 183–184.

[63]This and the preceding quotation: ibid., p. 184.

[64]Ibid., p. 186. The NSF's Advisory Committee on Minerals Research included Astin, Bateman, James Boyd, Ewing, Graton, Leith, Nolan, Rubey, Slichter, Wrather, and Zinner.

[65]Ibid., p. 187.

[66]This and the preceding quotation: Kirwan, ibid., p. 189.

[67]This and the preceding quotation: Nolan, ibid.

[68]Nolan, ibid., p. 193.

[69]Kirwan, ibid., p. 194.

[70]This and the preceding quotation: Nolan, ibid.

[71]Kirwan, ibid., p. 208.

[72]42 Stat. L., 20, June 10, 1921, established the Bureau of the Budget and the General Accounting Office.

[73]Nolan, ibid.

[74]This and the preceding quotation: Nolan, *in* Senate hearing, May 18, 1959, 86th Cong., 1st sess., p. 632.

[75]Hayden, ibid.

[76]73 Stat. L., 96, June 23, 1959.

[77]Nolan, Surv. O. 252, July 17, 1959.

[78]73 Stat. L., 479, September 9, 1959.

[79]Seaton, Secr. O. 2846, January 22, 1960.

[80]Pecora (1913–72) later served as Chief Geologist (1964–65) and Director (1965–71) of the USGS before being named Under Secretary of the Interior (1971–72). For a career summary, see Yoder (1999).

[81]Bascom, 1961, p. 55, incorrectly credited the USGS show to the "Washington Geological Society."

[82]USGS Pick and Hammer Club show program, 1960, p. 15; copy in the RBR.

[83]Ibid, p. 17.

[84]Ibid., p. 3.

[85]Ibid., p. 17.

[86]Ibid.

[87]U.S. National Science Foundation, 1962, p. 188. See also the accounts and evaluations of Project Mohole in Bascom (1961), Greenberg (1964, 1967, 1981), Lomask (1976), and Maxwell (1993).

[88]See American Geological Institute (1960b) and Horton (1961) for the preliminary results of drilling operations at the sites off La Jolla and off Guadalupe Island. See also the brief summary by Maxwell (1993).

[89]See Miller, Payne, and Gryc (1959).

[90]See Cashion (1959).

[91]The Branch's work continued to include isotope geochemistry; for a brief history, see Doe (1979).

[92]See Cressman and Noger (1981).

[93]See Witkind (1960), Tocher (1962), and Witkind and others (1962).

[94]See U.S. Geological Survey (1964b).

[95]See Eaton and Richter (1961).

[96]For a brief history of geologic photogrammetry in the USGS, including the establishment of the Photogrammetric Plotter Laboratory at Denver, see Pillmore (1989).

[97]See Corwin (1983); P.E. Cloud, Jr., like Rubey, was interested in the geochemistry of seawater, especially carbonate precipitation; for an example, see Cloud (1962). In the late 1940s, the BoB twice rejected a USGS request proposed by Thomas Hendricks for $60 million for a 10-year study of the U.S. Continental Shelves (ibid., p. 18).

[98]See his view of terrain intelligence in Whitmore, F.C., Jr. (1960).

[99]Carder (1961) discussed phototopography for the lunar chart.

[100]See also Hackman (1961).

[101]Wilhelms, 1993, p. 38, ©1993 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

[102]See Chao (1960).

[103]USGS news release, June 17, 1960; copy in the USGS Library in Reston, Va. See also American Geological Institute (1960a).

[104]See Chao, Shoemaker, and Madsen (1960).

[105]See Shoemaker (1960).

[106]Wilhelms, 1993, p. 46, ©1993 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

[107]For a chronology of the Astrogeology Branch's activities during 1960–73, see Schaber (2005).

[108]See Shoemaker and Hackman (1962). The 1;1,000,000 Copernicus sheet (I–515), by H.H. Schmitt, Newell J. Trask, and Shoemaker, appeared in 1967. Geologist-astronaut Harrison H. ("Jack") Schmitt went to the Moon on the Apollo 17 mission in 1972.

[109]This and the two preceding quotations: Wilhelms, 1993, p. 70, ©1993 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

[110]See Cox, D.C., and Mink (1963); also see Cox, D.C. (1968), for an evaluation of the Seismic Sea Wave Warning System's performance.

[111]U.S. National Science Foundation, 1961, p. 168.

[112]Headland, 1989, p. 391.

[113]Meunier, 2007a, p. 5.

[114]This and the preceding quotation: Antarctic Treaty (12 UST 794), signed in Washington on December 1, 1959. Reprinted in Joyner and Theis, 1997, p. 197. See also Klotz (1990).

[115]U.S. Geological Survey and others, 1970, p. vii.

[116]This summary of Bagnold's career is based on the biography by Kenn (1993).

[117]Leopold, *in* Kenn, 1993, p. 92. For a brief history of research in the Water Resources Division, see Langbein (1981). For the importance of Langbein's own contributions to scientific hydrology, see Dooge (1996).

[118]See Poland (1960).

[119]See Garrels (1960).

[120]73 Stat. L., 395, August 18, 1959.

[121]73 Stat. L., 572, September 21, 1959.

[122]This and the two preceding quotations: 74 Stat. L., 7 (Public Law 86–390), March 18, 1960.

[123]74 Stat. L., 7 (Public Law 86–391), March 18, 1960.

[124]This and the preceding quotation: 74 Stat. L., 257, June 29, 1960.

[125]For a history of lunar mapping and place names, see Whitaker (1999).

[126]Polmar, 1998, p. 68. For histories of the cold war, see Newhouse (1989), Walker, M. (1993), and Gaddis (2005).

[127]For histories of the Indochina and Vietnam Wars, see Karnow (1997), Herring (2002), Olson and Roberts (2008), and Prados (2009). The maps in Summers (1995) provide a significant supplement. In 1960, in a rare counter-insurgency success during postwar times, Britain ended the conflict in Malaya; for an account and analysis, see Barber (1972).

[128]See Fall (1969). Castle (1993) assessed the nature and amount of U.S. military aid to Laos during 1955–75. See also Rust (2012).

[129]Beschloss, 1986, p. 16–17, 22–27, and endpapers map.

[130]This and the preceding quotation: DDE, statement, July 9, 1960: Reid and others, 1961a, p. 568; PPPUS 1960/227.

[131]Weissman (1974) evaluated U.S. foreign policy in the Congo during 1960–64.

[132]For a national view, by a member of the ODM's Special Stockpile Advisory Committee, see Morgan, J.D., Jr. (1960).

[133]73 Stat. L., 4, March 18, 1959.

[134]73 Stat. L., c74, August 21, 1959.

[135]DDE, Proclamation 3279, 73 Stat. L., c25, March 10, 1959; Seaton, Sections 2 and 21, Oil Import Regulation No. 1, March 13, 1959. See DDE, signing statement, March 10, 1959: Reid and others, 1960c, p. 240–241; PPPUS 1959/51.

[136]74 Stat. L., 86, May 6, 1960.

[137]Eckes, 1979, p. 217–218. Holmon D. Pettibone, Chairman of Chicago Title and Trust's Board, chaired the Special Stockpile Advisory Committee.

[138]73 Stat. L., B19, September 9, 1959.

[139]73 Stat. L., B20, September 10, 1959.

[140]Kirwan, *in* House hearing, January 13, 1960, 86th Cong., 2d sess., p. 1.

[141]This and the preceding quotation: Seaton, ibid., p. 3.

[142]Ibid., p. 9.

[143]Nolan, *in* House hearing, January 14, 1960, 86th Cong., 2d sess., p. 294.

[144]This and the preceding quotation: ibid., p. 295.

[145]74 Stat. L., 425, July 12, 1960. The statute authorized a total of nearly $73.5 million for Federal Office Buildings 8, 9, and 10 in the District of Columbia.

[146]73 Stat. L., 708, September 28, 1959.

[147]This and the four preceding quotations: Kirwan, *in* House hearing, January 14, 1960, 86th Cong., 2d sess., p. 326.

[148]This and the preceding quotation: ibid., p. 327.

[149]Ibid., p. 329.

[150]DDE, budget message to Congress, January 18, 1960: Reid and others, 1961a, p. 37–110; PPPUS 1960/13.

[151]74 Stat. L., 918, September 13, 1960. The Helium Act, authorizing the "conservation, production, and exploitation of helium gas," but prohibiting its export without permission from the President, is 43 Stat. L., 1110, March 3, 1925.

[152]74 Stat. L., 336, July 7, 1960. Doherty, 1971, p. 783–785, reprinted the statute.

[153]This and the two preceding quotations: 74 Stat. L., 506, July 14, 1960.

[154]74 Stat. L., 108, May 13, 1960.

[155]74 Stat. L., 828, September 8, 1960.

[156]75 Stat. L., 37, March 31, 1961.

[157]Yergin, 1991, p. 518.

[158]See Rockefeller, N.A., and Rockefeller, L.S. (1961).

[159]See Kistiakowsky (1976).

[160]Morris, J.B., and Morris, R.B., 1996, p. 510, 1185. For a recent analysis of the 1960 election, see Rorabaugh (2009).

[161]Nolan, 1960, p. III.

[162]Ibid.

[163]This and the five preceding quotations: ibid.

[164]USGS Pick and Hammer Club show program, Menlo Park, 1961, cover 1; copy in the RBR.

[165]Glen, 1982, p. 162.

[166]Eckel, E.B. (1968), summarized the increased knowledge of the NTS geology.

[167]See Cox, A.V., and Doell (1960).

[168]This and the three preceding quotations: Doell and Cox, A.V., 1960, p. B426.

[169]Ibid.

[170]This and the preceding quotation: ibid.

[171]This and the preceding quotation: ibid., p. B427. See also the retrospective in Verhoogen (1985).

[172]This and the two preceding quotations: Nolan, *in* House hearing, March 1, 1961, 87th Cong., 1st sess., p. 471.

[173]Ibid., p. 448.

[174]This and the three preceding quotations: ibid., p. 471.

[175]USGS Pick and Hammer Club show program, Washington, D.C., May 5, 1961, p. 11; copy in the RBR. Charles ("Andy") Anderson, like Wilmot ("Bill") Bradley, strongly supported basic research in the Geologic Division: Glen, 1982, p. 368.

[176]McKelvey (1916–87) completed his tour as an ACG in 1965; he later served as Chief Geologist (1971) and Director (1971–78) of the USGS. For a career summary, see Nelson, C.M. (2002a).

[177]Keith, March 9, 1959, *in* Cong. Rec., v. 105, pt. 19, p. A1950.

[178]The USGS established an Office of Marine Geology in fiscal year 1962–63.

[179]In addition, Hubbert and William Rubey collaborated in evaluating the role of fluid pressure in the mechanics of overthrust faulting; see Hubbert and Rubey (1959, 1960) and Rubey and Hubbert (1959).

[180]Cressman and Noger, 1981, p. 4.

[181]Ibid., p. 2.

[182]For the return on the investment, see Bhagwat and Ipe (2000).

[183]U.S. National Science Foundation, 1962, p. 173.

[184]Headland, 1989, p. 397–398.

[185]Meunier, 2007a, p. 5–6.

[186]Ibid.

[187]See Radlinski (1961).

[188]Sørensen (2007) summarized the meeting.

[189]Whitmore, G.D., Thompson, and Speert (1959) reported the status of the photogrammetric-electronic system that speeded map production. McHaffie (2002) analyzed the development of the "automated map factory" in the USGS during 1950–74.

[190]363 U.S. 1, May 31, 1960; formal decree, 354 US 502, December 12.

[191]363 U.S. 121, May 31, 1960; formal decree, 364 US 502, December 12.

[192]74 Stat. L., 781, September 2, 1960.

[193]74 Stat. L., 1024, September 14, 1960.

[194]74 Stat. L., 1028, September 14, 1960.

[195]DDE, budget message to Congress, January 16, 1961: Reid and others, 1961a, p. 934–1028; PPPUS 1961/414.

[196]U.S. National Science Foundation, 1954, p. 59, and U.S. NSF, 1962, p. 173.

[197]This and the six preceding quotations: DDE, farewell address, January 17, 1961: Reid and others, 1961a, p. 1038; PPPUS 1961/421. For historical perspective on the military-industrial complex, see Koistinen (1980).

[198]This and the preceding quotation: DDE, farewell address, January 17, 1961: Reid and others, 1961a, p. 1039; PPPUS 1961/421. Eisenhower mentioned later in the 1960s that in 1961 he had von Braun and Teller in mind as representatives of the "scientific-technological elite": Neufeld, 2007, p. 352–353. For an analysis, see Ledbetter (2011).

[199]This and the two preceding quotations: DDE, farewell address, January 17, 1961: Reid and others, 1961a, p. 1039; PPPUS 1961/421.

Chapter 11. Epilogue: The U.S. Geological Survey, 1939–1961

[1]Shakespeare, "A Midsummer Night's Dream," Act 5, Scene 1: Wells, Stanley, and others, 1987, v. 2, p. 598, lines 349–350 (reproduced by permission of Oxford University Press).

[2]During 1887–92, three Congresses and Presidents Grover Cleveland and Benjamin Harrison marked John Powell's failures by requiring the line itemization of USGS budget requests, terminating the agency's Irrigation Survey for lack of promised results, and cutting half of the agency's appropriations and one-third of its statutory scientific positions. Powell responded by conducting a 15-percent, USGS-wide reduction in force, one that fell most heavily on the agency's geologic unit. Powell resigned in 1894, just before Congress and President Cleveland reduced his statutory salary from $6,000 to $5,000. Charles Walcott, Powell's successor as Director, quickly restored congressional and executive confidence in the USGS; gained continuous funding for water-resources investigations; acquired responsibilities in reclamation, minerals research and technology, and other missions; and kept only those in which a basic-science component existed or could be developed. By fiscal year 1899–1900, the agency's total funds rose to a level higher than that of any year under Powell. For details of this transition, see the narrative analyses in chapters 5–11 of volume 2 (Rabbitt, M.C., 1980) of this history, based principally on published sources, and the summaries and extensions in Nelson, C.M. (2007a,b), the latter based primarily on unpublished sources.

[3]Of the geologists, hydrologists, and paleontologists hired for full- or part-time work by the USGS during Mendenhall's 13 years as Director, 14 were elected to the NAS. Members hired during 1930–43 and inducted by the NAS during and after that interval include Charles Anderson (1957), Milton Bramlette (1954), Arthur Buddington (1943), Preston Cloud, Jr. (1961), Robert Garrels (1962), Harold James (1962), Konrad Krauskopf (1959), Walter Langbein (1970), William Pecora (1965), Francis Pettijohn (1966), John Rodgers (1969), Chester Stock (1948), Aaron Waters (1964), and Donald White (1973).

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Abbreviations and Acronyms

AAAS	American Association for the Advancement of Science
AAPG	American Association of Petroleum Geologists
AASG	Association of American State Geologists
ACG	Assistant Chief Geologist (USGS)
ACHE	Assistant Chief Hydraulic Engineer (USGS)
ACIC	Aeronautical Chart and Information Center (USAF)
ACS	Aeronautical Chart Service (USAAF and USAF)
ACSM	American Congress on Surveying and Mapping
ACSP	Advisory Committee on Scientific Personnel (CSC)
ACTE	Assistant Chief Topographic Engineer (USGS)
ACU	Advisory Committee on Uranium
AEC	U.S. Atomic Energy Commission
AEF	American Expeditionary Force (World War I)
AGI	American Geological Institute
AGU	American Geophysical Union
AIMME	American Institute of Mining and Metallurgical Engineers
Alcan	Alaskan-Canadian Highway
Alcoa	Aluminum Company of America
AMNH	American Museum of Natural History
AMS	Army Map Service
AMSOC	American Miscellaneous Society (NAS–NRC)
ANMB	Army and Navy Munitions Board
ANZUS	Australia, New Zealand, United States (treaty)
API	American Petroleum Institute
Aramco	Arabian-American Oil Company
Army Engineers	U.S. Army Corps of Engineers
ARPA	Advanced Research Projects Agency (USAF)
ASG	Astrogeologic Studies Group (USGS)
AVG	American Volunteer Group (1941–42)
BDSA	Business and Defense Services Administration
BEW	Board of Economic Warfare
BGN	Board on Geographic Names
BIA	Bureau of Indian Affairs (from 1947)
BLM	Bureau of Land Management
BoB	Bureau of the Budget
BTL	Bell Telephone Laboratories
C	Coal Investigations (USGS Charts and Maps)
CAF	Clerical, Administrative, and Fiscal Service
Caltech	California Institute of Technology
Caltex	Casoc and Texaco partnership
Canol	Canadian Oil (pipeline)
Casoc	California Arabian Standard Oil Company
CEDL	Columbus (Ohio) Equipment Development Laboratory (USGS)
CENTO	Central Treaty Organization
CG	Chief Geologist (USGS)
CIA	Central Intelligence Agency
CIW	Carnegie Institution of Washington
CND	Council of National Defense
CNMI	Commonwealth of the Northern Mariana Islands
CNO	Chief of Naval Operations
Comecon	Council for Mutual Economic Assistance
COMINCH	Commander in Chief of the U.S. Fleet
Cominform	Communist Information Bureau
Cong.	Congress
Cong. Rec.	Congressional Record
COSPAR	Committee for Space Research (ICSU)
CPC	Crafts, Protective, Custodial
CS	Custodial Services
CSAGI	Comité Spécial de l'Année Géophysique Internationale
CSC	U.S. Civil Service Commission
CTE	Chief Topographic Engineer (USGS)
CUSS I	freight barge modified for ocean drilling and operated by a consortium of four oil companies—Continental, Union, Shell, and Superior
D	Democrat
DARPA	Defense Advanced Research Projects Agency (DoD)
DDE	Dwight David Eisenhower

DDT	dichlorodiphenyltrichloroethane
DEW	Distant Early Warning
DMA	Defense Minerals Administration (DoI)
DMEA	Defense Minerals Exploration Administration (DoI)
DMPA	Defense Materials Procurement Agency
DNPR	Director of Naval Petroleum and Oil Shale Reserves (USN)
doc., docs.	document(s)
DoD	Department of Defense
DoI	Department of the Interior
DoS	Department of State
DPA	Defense Production Administration
DPRK	Democratic People's Republic of Korea (North Korea)
DTM	Department of Terrestrial Magnetism (CIW)
ECA	Economic Cooperation Administration
ECO	Export Control Office
EDB	Economic Defense Board
EDC	European Defense Community
EIS	Engineer Intelligence Study
EPS	Emergency Procurement Service
ER–55	ellipsoidal reflector-55
ExComm	Executive Committee (USGS)
Ex. O.	Executive order
FBI	Federal Bureau of Investigation
FCST	Federal Council for Science and Technology
FDR	Franklin Delano Roosevelt
FEA	Foreign Economic Administration
Fed. Reg.	Federal Register
FHA	Federal Housing Administration
FOA	Foreign Operations Administration
FPB	Federal Petroleum Board (DoI)
FPC	Federal Power Commission
FTE	full-time equivalent
FWS	Fish and Wildlife Service
GAO	General Accounting Office
GATT	General Agreement on Tariffs and Trade
GL	Geophysical Laboratory (CIW)
GLO	General Land Office
GMC	General Motors Corporation
GP	Geophysical Investigations (USGS Maps)
GPO	Government Printing Office
GQ	Geologic Quadrangle (USGS Maps)
GRB	Geophysics Research Board (NAS–NRC)
GS	General Schedule
GSAd	General Services Administration (For clarity, "GSA" is replaced by "GSAd" and "GSAm" in this volume.)
GSAm	Geological Society of America
GSC	General Staff Committee (USGS)
GSI	Geological Survey of India
GSK	Geological Survey of Korea (Republic of Korea)
GX	Geochemical Exploration (Section, USGS)
HA	Hydrologic Investigations Atlas (USGS)
HEW	Health, Education, and Welfare Department
H.R.	House of Representatives (U.S.)
HST	Harry S. Truman
HVO	Hawaiian Volcano Observatory (USGS)
I	Miscellaneous Geologic Investigations (USGS Maps)
IAEA	International Atomic Energy Agency (U.N.)
IBM	International Business Machines
ICA	International Cooperation Administration
ICBM	intercontinental ballistic missile
ICSRD	Interdepartmental Committee on Scientific Research and Development
ICSU	International Council of Scientific Unions
IGC	International Geological Congress
IGY	International Geophysical Year
IRBM	intermediate-range ballistic missile
ISTD	Inter-Services Topographical Department (Britain)
IUGG	International Union of Geodesy and Geophysics
JCS	Joint Chiefs of Staff (U.S.)
JFK	John Fitzgerald Kennedy
JHU	Johns Hopkins University
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
JPL	Jet Propulsion Laboratory (Caltech)
JRDB	Joint Research and Development Board (Army and Navy)
KCMP	Kentucky Cooperative Mapping Program (KGS–USGS)
KGS	Kentucky Geological Survey

LBJ	Lyndon Baines Johnson
LC	Library of Congress
LGO	Lamont Geological Observatory (Columbia University)
loran	long-range navigation
Lt.	Lieutenant
MAC	Mineral Advisory Committee
MAD	Magnetic Airborne Detector
MED	Manhattan Engineer District (Army Engineers)
Met Lab	Metallurgical Laboratory (University of Chicago)
MF	Mineral Investigations Field Studies (USGS Maps)
MGB	Military Geology Branch (USGS, 1949–72)
MGS	Military Geology Section (USGS, 1947–49)
MGU	Military Geology Unit (USGS, 1942–47)
MiG	Mikoyan-Gurevich
MIT	Massachusetts Institute of Technology
MR	Mineral Investigations Resource (USGS Maps)
MSA	Mutual Security Agency
NAACP	National Association for the Advancement of Colored People
NACA	National Advisory Committee for Aeronautics
NARA	National Archives and Records Administration
NARA I	National Archives and Records Administration, Archives I (Washington, D.C.)
NARA II	National Archives and Records Administration, Archives II (College Park, Md.)
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NBS	National Bureau of Standards
NDRC	National Defense Research Committee
NEL	U.S. Navy Electronics Laboratory
NKPA	North Korean People's Army
NLF	National Liberation Front (Vietnam)
NMB	National Munitions Board
NOAA	National Oceanic and Atmospheric Administration
NOL	Naval Ordnance Laboratory
NORAD	North American Air Defense
NOSR	Naval Oil Shale Reserve
NPA	National Production Authority
NPR	Naval Petroleum Reserve (also known as "Pet")
NPS	National Park Service
NRC	National Research Council
NRL	Naval Research Laboratory
NRPB	National Resources Planning Board
NSB	National Science Board (NSF)
NSC	National Security Council (U.S.)
NSF	National Science Foundation
NSFA	Naval Support Force Antarctica
NSRB	National Security Resources Board
NTS	Nevada Test Site (AEC)
OAS	Organization of American States
OC	Oil and Gas Investigations Charts (USGS)
OCE	Office of the Chief of Engineers (U.S. Army)
OCR	Office of Coal Research (DoI)
OCS	Outer Continental Shelf
ODM	Office of Defense Mobilization
OEM	Office for Emergency Management
OES	Office of Economic Stabilization
OEW	Office of Economic Warfare
OIA	Office of Indian Affairs (to 1947)
OM	Oil and Gas Investigations Maps (USGS)
OME	Office of Minerals Exploration (DoI)
OMM	Office of Minerals Mobilization
ONPR	Office of Naval Petroleum and Oil Shale Reserves (USN)
ONR	Office of Naval Research
OPEC	Organization of the Petroleum Exporting Countries
OPM	Office of Production Management
OPS	Office of Price Stabilization
OSRD	Office of Scientific Research and Development
OSU	Ohio State University
OWM	Office of War Mobilization
OWMR	Office of War Mobilization and Reconversion
PAD	Petroleum Administration for Defense
PAW	Petroleum Administration for War
PLUTO	Pipeline Under the Ocean
PMPC	President's Materials Policy Commission
PPA	Public Papers and Addresses of the Presidents
PPPUS	Public Papers of the Presidents of the United States
PRA	Public Roads Administration
PRC	People's Republic of China
PRCo	Petroleum Reserves Corporation
PSAC	President's Science Advisory Committee

PSB	Paleontology and Stratigraphy Branch (USGS)
PSRB	President's Scientific Research Board
PSS	Professional and Scientific Service
PT	Patrol Torpedo
PTE	Preliminary Terrain Estimate (USGS reports)
PWA	Public Works Administration
R	Republican
Rad Lab	Radiation Laboratory (MIT)
radwaste	radioactive waste
RAF	Royal Air Force (Britain)
RBR	Rare Book Room (USGS Library, Reston, Va.)
RFC	Reconstruction Finance Corporation
RG	Record Group (NARA)
ROK	Republic of Korea (South Korea)
RSL	Royal Society of London
SAC	Strategic Air Command (USAAF and USAF)
SACEUR	Supreme Allied Commander Europe (NATO)
SAGE	Semi-Automatic Ground Environment
SCAR	Special Committee for Antarctic Research (ICSU)
SCOR	Special Committee for Oceanic Research (ICSU)
SCS	Soil Conservation Service (USDA)
SEATO	Southeast Asia Treaty Organization
Secr. O.	Secretarial order (DoI)
SES	Strategic Engineering Study
sess.	session
SHAEF	Supreme Headquarters Allied Expeditionary Forces (Europe, World War II)
shoran	short-range navigation
SIO	Scripps Institution of Oceanography
SIR	surveys, investigations, and research (USGS)
SMC	Scientific Manpower Commission
Socal	Standard Oil Company of California
SPAB	Supply Priorities and Allocations Board
SPAMS	Special Alaska Magnetic Survey (USGS)
SSB	Space Science Board
Stat. L.	U.S. Statutes at Large
Surv. O.	Survey order (USGS)
TCA	Technical Cooperation Administration (DoS)
TCP	Technological Capabilities Panel (ODM)
TEPCO	Trace Elements Planning and Coordination Office (USGS)
TEU	Trace Elements Unit (USGS)
TF	Task Force
TM	Technical Manual (U.S. Army)
TNT	trinitrotoluene
TPDU	Technical Planning and Development Unit (USGS)
TTPI	Trust Territory of the Pacific Islands (U.N. and U.S.)
TVA	Tennessee Valley Authority
UAR	United Arab Republic
UCD	University of California at Davis
UCLA	University of California at Los Angeles
U.N.	United Nations
UNAEC	United Nations Atomic Energy Commission
UNCLOS	United Nations Conference on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIVAC	Universal Automatic Computer
USAAC	U.S. Army Air Corps (1926–41)
USAAF	U.S. Army Air Forces (1941–47)
USAF	U.S. Air Force (from 1947)
USBM	U.S. Bureau of Mines
USBR	U.S. Bureau of Reclamation
USC	University of Southern California
USCG	U.S. Coast Guard
USCGS	U.S. Coast and Geodetic Survey
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service (USDA)
USGS	U.S. Geological Survey
USN	U.S. Navy
USNM	U.S. National Museum (now National Museum of Natural History)
USNR	U.S. Naval Reserve
UST	United States Treaty
UTM	Universal Transverse Mercator
WHOI	Woods Hole Oceanographic Institution
WPA	Works Progress Administration (1935–39); Work Projects Administration (1939–43)
WPB	War Production Board
WRD	Water Resources Division (USGS)
YMCA	Young Men's Christian Association

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