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]

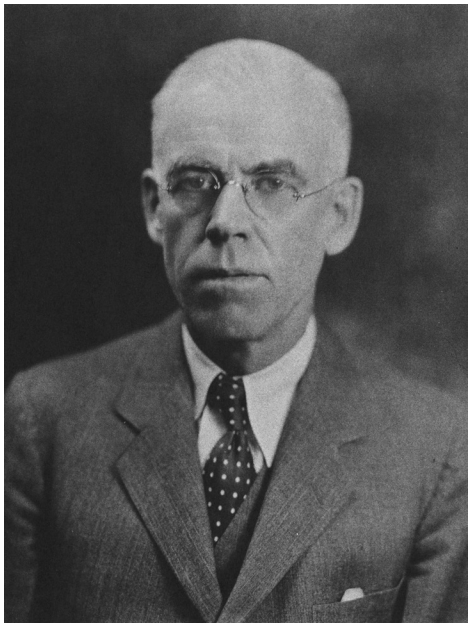
Mendenhall's warnings did not convince Congress to authorize and to fund strategic-mineral investigations, but Interior Secretary Harold Ickes, also head of the Public Works Administration (PWA), allotted PWA funds[7] to enable the USGS to initiate some studies during the fiscal year beginning on July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

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.)



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.)

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]**

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.

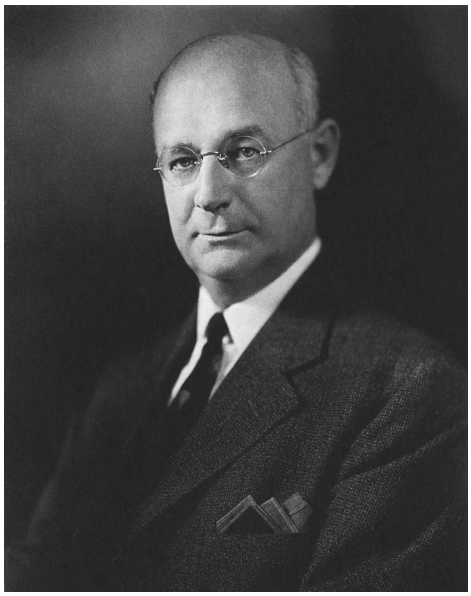
On June 7, 1939, Congress passed the Strategic and Critical Materials Act[17] to provide for acquiring stocks of these materials and to encourage the development of mines and deposits of strategic minerals within the United States. The new law authorized the Secretaries of War, the Navy, and the Interior, 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).

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.)

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

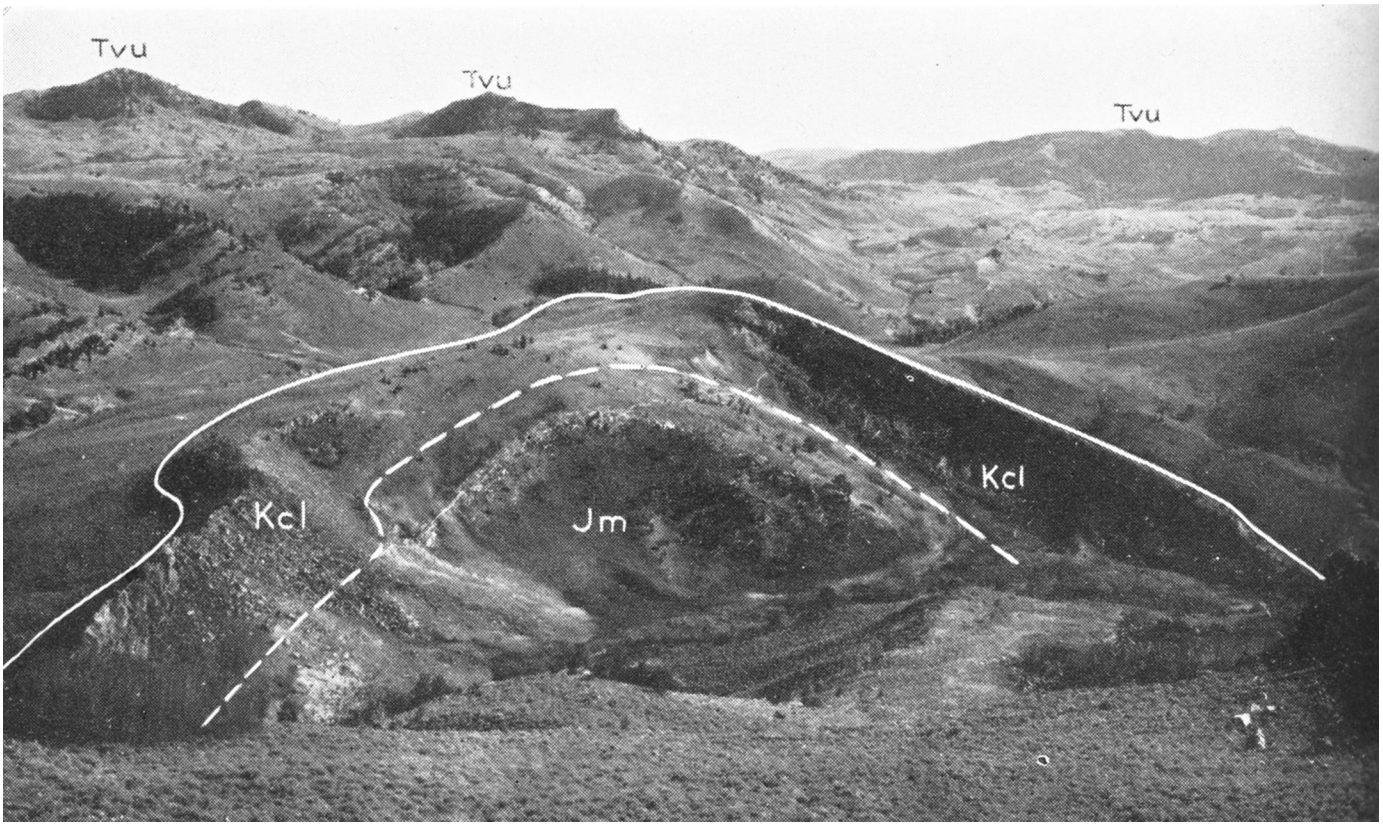


Geologist Gerald Francis Loughlin (1880–1946), after teaching at Yale and Boston College, began working full time for the USGS in 1912. He studied geology and ore deposits in Idaho, the Tintic and other mineral districts in Utah (with Bert S. Butler), and Colorado's Leadville district (with John D. Irving). 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.

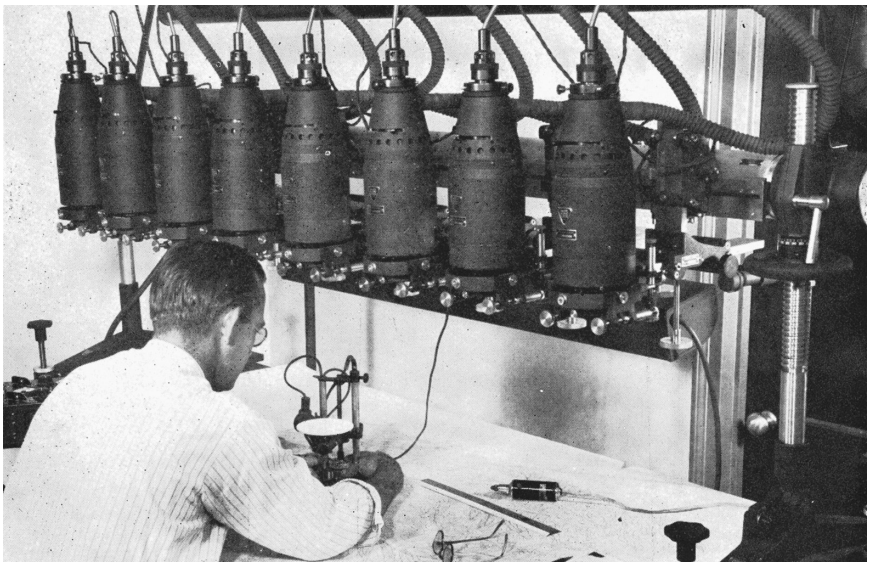
Gerald A. FitzGerald continued to direct all topographic work in Alaska, as he had done since 1937 when he succeeded R. Harvey Sargent after Sargent took over the Topographic Branch's Section of Inspection and Editing following the death of William A. Beaman. FitzGerald's topographers concentrated on 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.

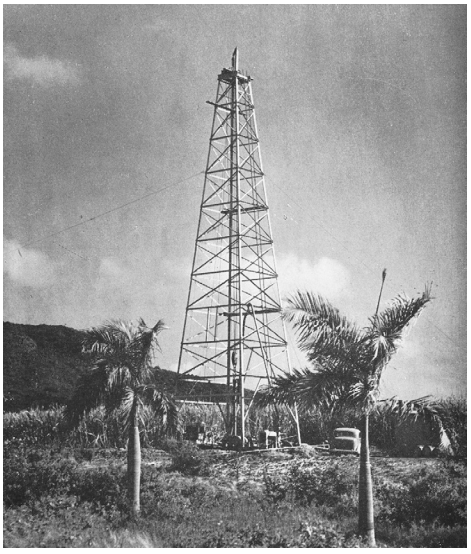
On October 17, 1939, Glenn L. Parker became Chief Hydraulic Engineer, replacing Nathan C. Grover, who had retired on January 31. Carl G. Paulsen, who temporarily replaced Grover while continuing, since 1931, as Chief of the Surface Water Division, moved into the newly created post of Assistant Chief 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.

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.



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*.)

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.

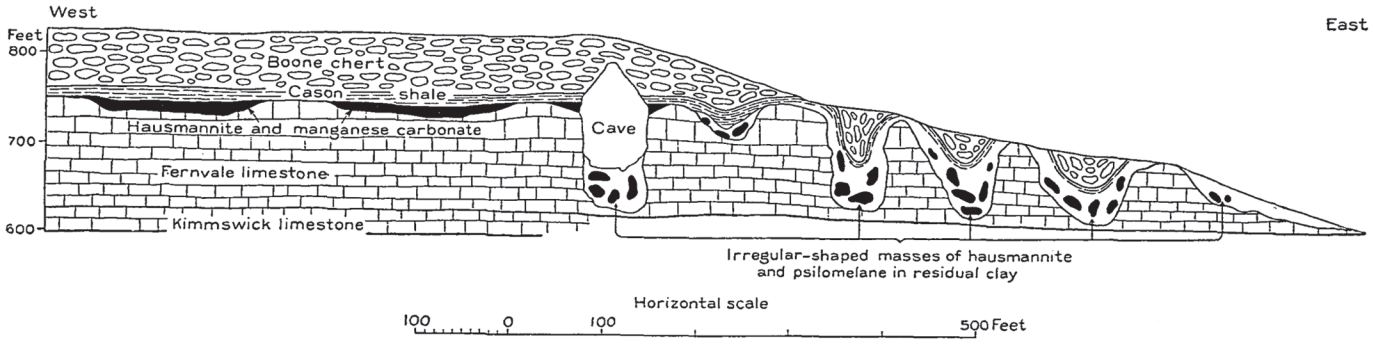
Vannevar Bush believed that victory in war depended on developing new weapons. He welcomed Churchill's and Roosevelt's agreement in July 1940 to exchange scientific and technological information. Henry T. Tizard, who chaired the British Defense Research Policy Committee, led to the United States a British 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.

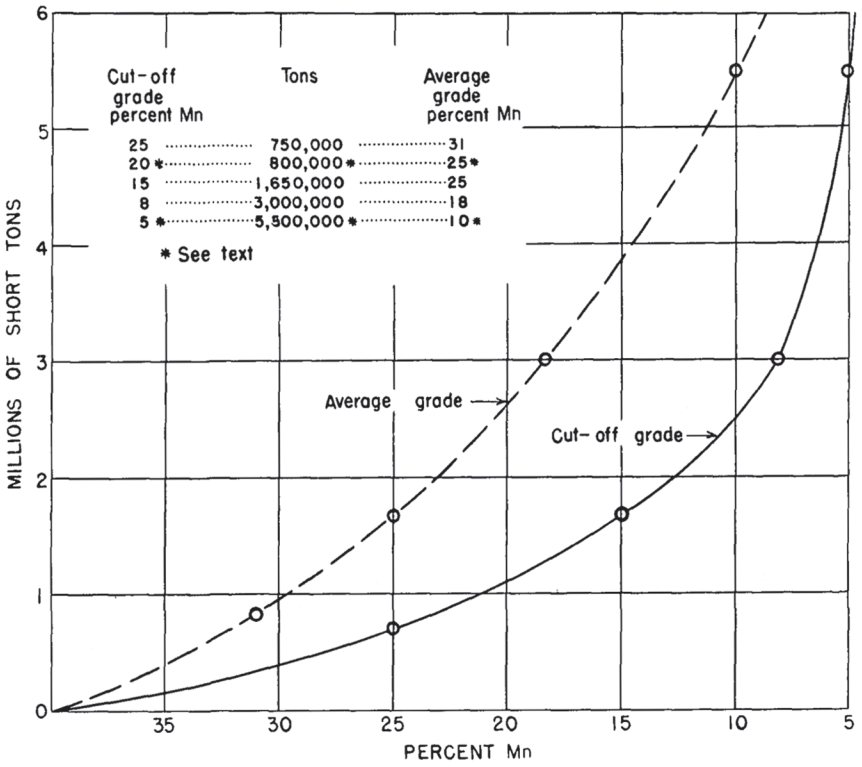
The USGS strategic-minerals program emphasized searches, by another mix of old and new full- and part-time personnel, for manganese and other vital metals and nonmetals. Agency geologists examined manganese deposits in 17 States, including Arkansas, Nevada, Tennessee, Virginia, and Washington. Charles 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.)

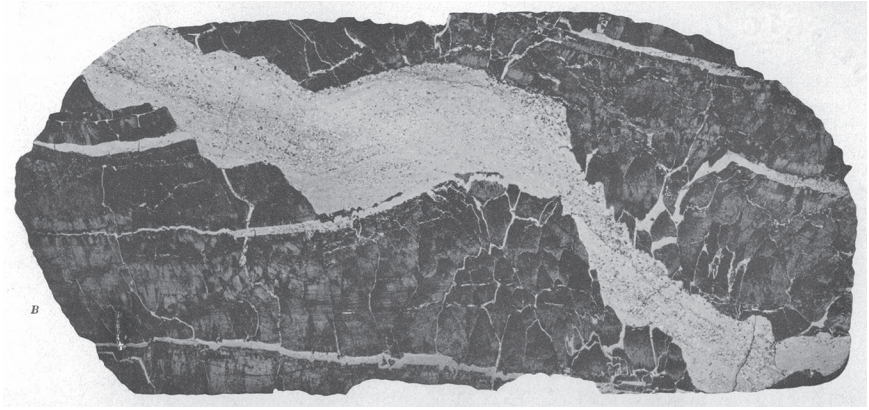


antimony district in Idaho led to recognizing the tungsten-oxide mineral scheelite; further exploration disclosed a large and unusually rich body of tungsten ore closely associated with the antimony deposits. These studies also indicated that antimony could be produced directly in addition to the amount 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.

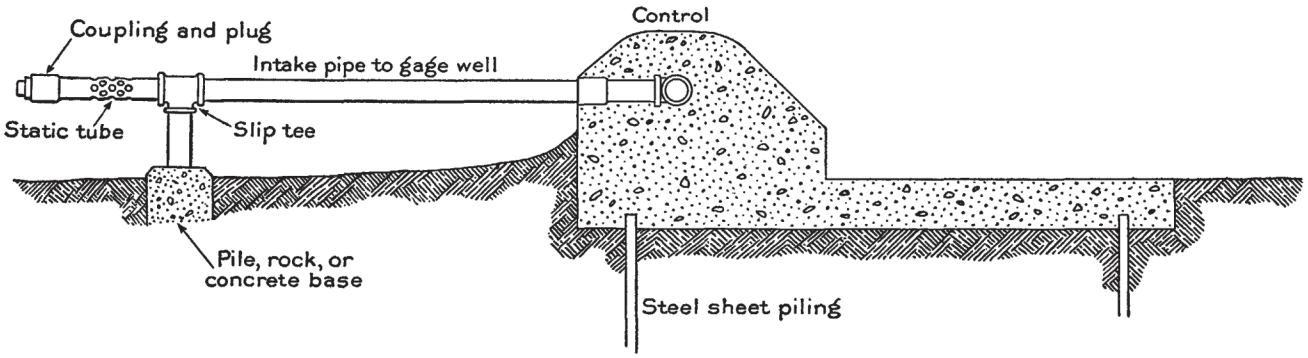
In the Ground Water Division, Oscar Meinzer, recalling the importance of groundwater investigations during World War I, placed David Thompson in charge of the emergency work. Division projects were underway in 41 States, the Territory of Hawaii, Puerto Rico, and the District of Columbia. As in years 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.)

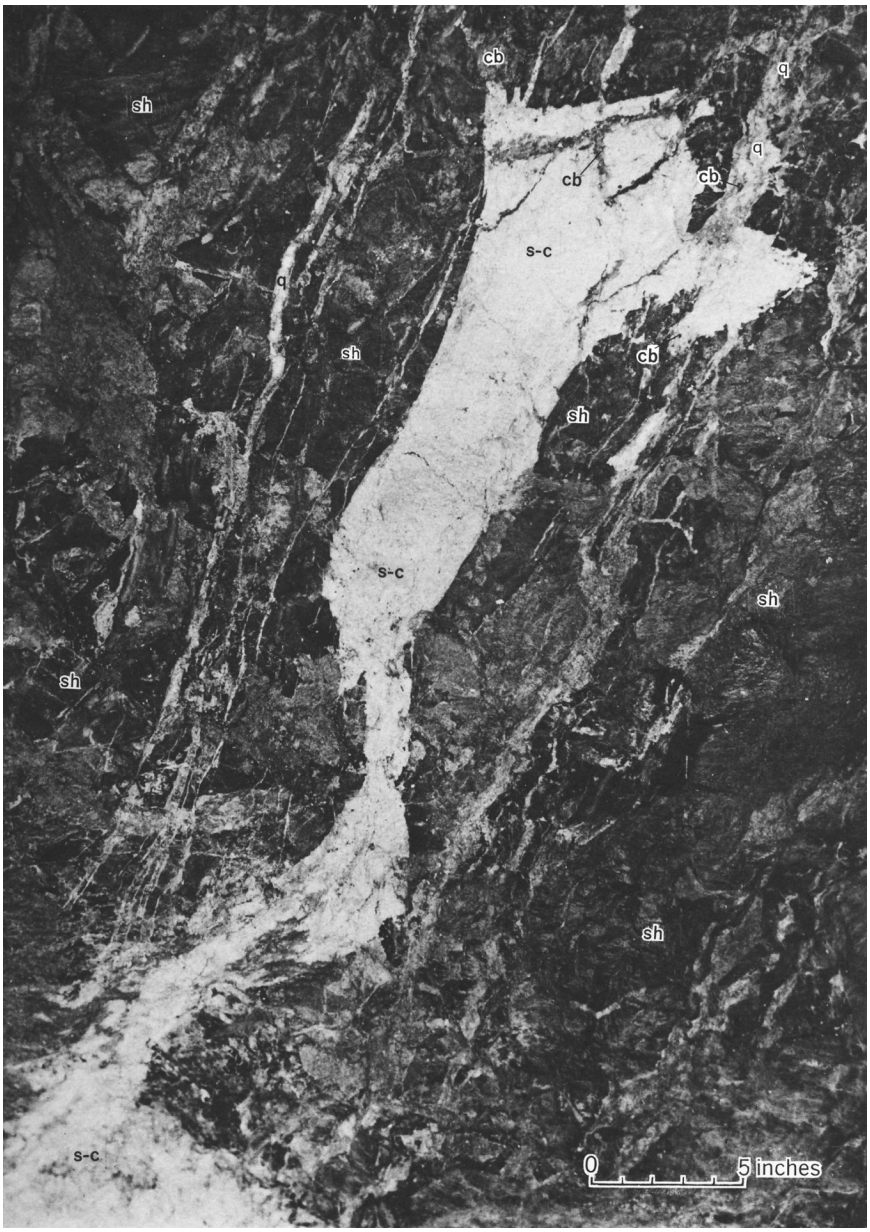
Mountains in California, Dayton in Nevada, Jones Camp in New Mexico, Scappose in Oregon, and Bull Valley in Utah to provide basic data essential to the planning of an iron-and-steel industry in the West. They also looked at other deposits in northeastern Alabama and at Cartersville in Georgia. The aluminum-exploration 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.

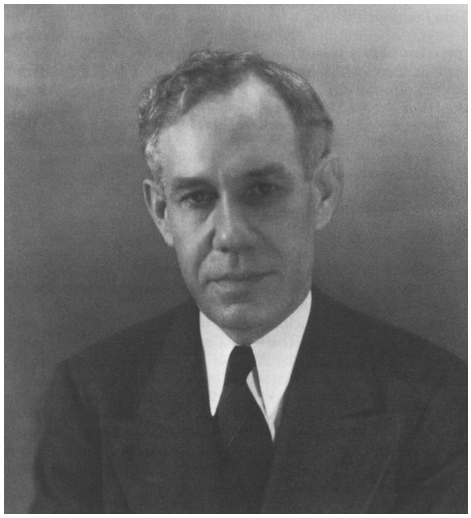
The USGS program did not neglect chromium, manganese, mercury, molybdenum, tungsten, and several nonmetallic minerals. Earlier cooperative geologic studies of chromite led to the construction of a chromite-concentrating plant in Montana's Stillwater district that produced 150–175 tons daily, and two 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.

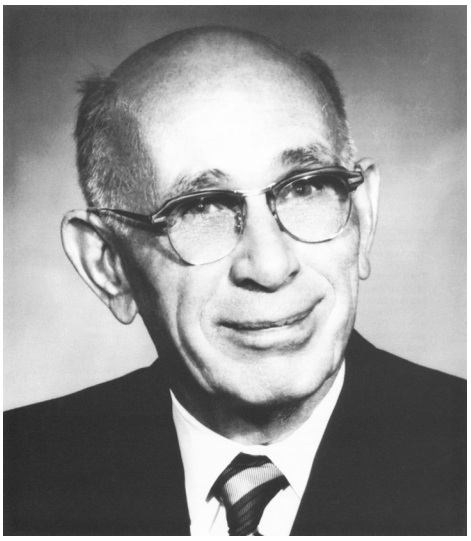
During fiscal year 1941–42, the USGS Topographic Branch drew on about $3,488,000 in total funds (about 1.4 times the sum available in fiscal 1940–41), including the directly appropriated $1,962,500, of which $275,000 was available only for State-municipal cooperation. The States and municipal governments 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.

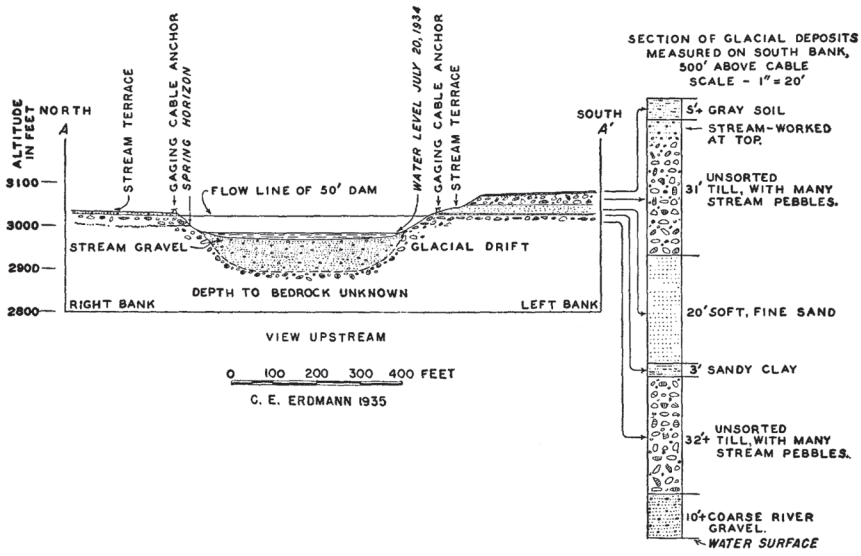


Geohydrologist Charles Vernon Theis (1900–87) spent the summer of 1927 working with USGS geologist Arthur Baker in Utah and then a year with the Army Engineers before joining the USGS Ground Water Division in 1930. His subsequent work, mostly on the High Plains of New Mexico and Texas, led to his continuing 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]