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

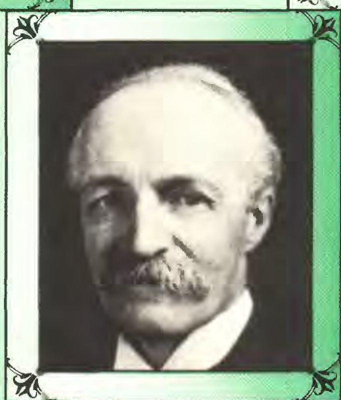
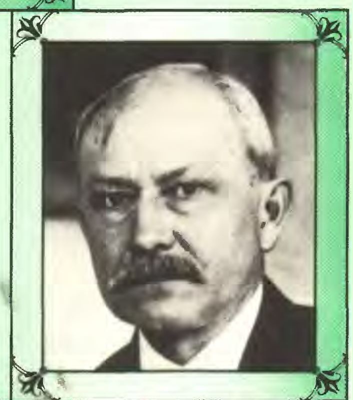
Volume 3, 1904–1939

UNITED STATES
GEOLOGICAL SURVEY

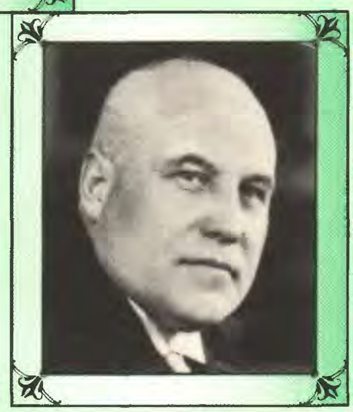








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U.S. Geological Survey topographic engineers, accompanied by hydraulic engineer W. G. Hoyt, traveled by boat through the spectacular canyon of the Snake River from Huntington, Oregon, to Lewiston, Idaho, in 1920 to make a plane-table survey and assess the water-power potential. (Photograph by Hoyt from the files of the U.S. Geological Survey.) ▶

◀ See page x for identification of portraits.

Minerals, Lands, and Geology for the Common Defence and General Welfare Volume 3, 1904–1939

By Mary C. Rabbitt

UNITED STATES GEOLOGICAL SURVEY

A History of Geology in Relation to the Development of Public-Land, Federal-Science, and Mapping Policies and the Development of Mineral Resources in the United States From the 25th to the 60th Year of the U.S. Geological Survey

UNITED STATES GOVERNMENT PRINTING OFFICE: 1986

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary
U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

Foreword

In March 1986, the U.S. Geological Survey observed the 107th anniversary of its establishment by Congress with its name intact and its principal missions essentially unchanged. That continuity, in itself, might be sufficient justification for a history of the organization, but an evaluation of the Survey's response to the challenges and opportunities of its many assignments during those years also offers a useful perspective for evaluating the Survey's current work and for planning its future programs.

Mary C. Rabbitt's four-volume history deals with the role of the geosciences in general and the Geological Survey in particular in the development of public-land, Federal-science, and mapping policies and the use of natural resources. In the first two volumes, she analyzed the predecessor surveys and the first 25 years of the U.S. Geological Survey. When the Survey was founded, the Nation was in the early stages of industrialization. In an effort to aid that development by providing needed information on the Nation's mineral resources, the first Director devised the mission orientation of the Survey programs. Later Directors extended the programs to include investigations to aid all material industries affected by a greater understanding of the processes and history of the Earth. From the beginning, Survey programs were never wholly practical in nature but contributed to the advancement of science by seeking knowledge needed to solve particular practical problems. Perhaps the most notable achievement of the first 25 years was the development of economic geology as a science distinct from applied geology, but there were advances in such other fields as petrography, petrology, and glacial geology, and in geologic mapping, geophysics, and geochemistry as well. Topographic mapping expanded beyond the needs of the geologists alone to serve great engineering works, and efforts toward the conservation of water led to the establishment of the Reclamation Service, initially under the Survey's aegis.

Mrs. Rabbitt's third volume covers the years 1904 to 1939, from the beginning of the conservation movement under Theodore Roosevelt to the beginning of World War II. From a national perspective, these were years of great development and change in the use of energy, trouble in the coal industry, and a great expansion in the oil industry. They were also years in which the public perceived for the first time that the Nation's mineral resources are not infinite, and the mineral industry realized its dependence on international trade. In these years, water became an increasingly valuable commodity, and the need for a national mapping program became abundantly evident. These were also the years when the Federal Government for the most part practiced stringent economy in funding science, but State and municipal agencies increasingly sought the services of the Survey's topographic and water specialists to aid in the solution of local problems. The balance maintained between fundamental and practical research during the first 25 years was more than once upset during the next 25 years, but the successful struggle to maintain a significant level of research laid the groundwork for the tremendous expansion in the Survey in the subsequent years.

Dallas L. Peck, Director
U.S. Geological Survey

Preface

Although several historians have considered Federal conservation policies and Federal science during the period covered in this volume, the relation of geology and the history of the U.S. Geological Survey to these matters has gone almost unexplored. At first glance, the subject does not present a very appealing prospect. The growth of the geological sciences in the Survey's first quarter-century had been spectacular, but the excitement began to subside in the middle of the first decade of the twentieth century. Seemingly, the Survey passed beyond youth and settled down to a quiet middle age, struggling to make ends meet as it continued its work. By 1912, the Survey was accused of having become nothing more than a department of practical geology, and in the late 1920's of having outlived its usefulness.

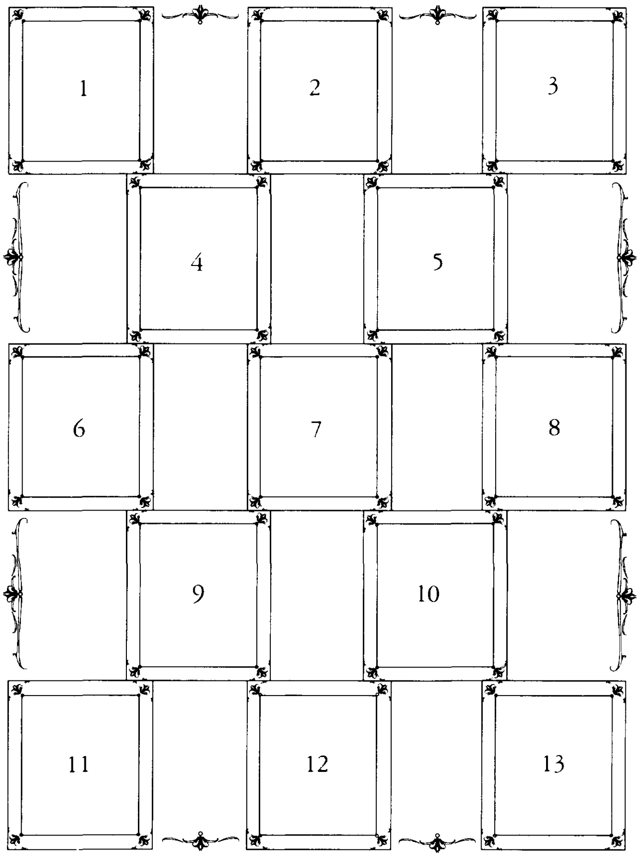
Outward appearances, however, are often deceiving, and so it is with the U.S. Geological Survey and geology in general during the period covered by this volume. More detailed study revealed an almost dramatic story that might be summed up as the eclipse of basic research as the result of demands for practical research brought on by its early success and its renaissance through the persistence of a few individuals. At one time, history was considered simply the biography of great men, but more recently, history has been viewed as a process of evolution, a series of inevitable results proceeding from clear causes, in which individuals are merely the expression of the great social, economic, or other forces of the times. Most historians acknowledge, however, that at times during the history of the world, commanding figures—such as Caesar, Napoleon, Christ, Mohammed—have appeared who become great forces in themselves. Something similar undoubtedly occurs in history on a much smaller scale, and it may well be surmised that the great forces of history originate not in outer space but in the minds of certain lesser known but charismatic individuals. Such indeed happened in the history of geology and of the U.S. Geological Survey from 1904 to 1939. A few individuals, notably David White, Chief Geologist, 1912–1922, and Chairman of the Division of Geology and Geography of the National Research Council, 1924–1927, and Walter C. Mendenhall, Chief Geologist, 1922–1930, and Director, 1930–1943, nurtured and encouraged fundamental research, even prodded it on until it eventually almost exploded with new vitality.

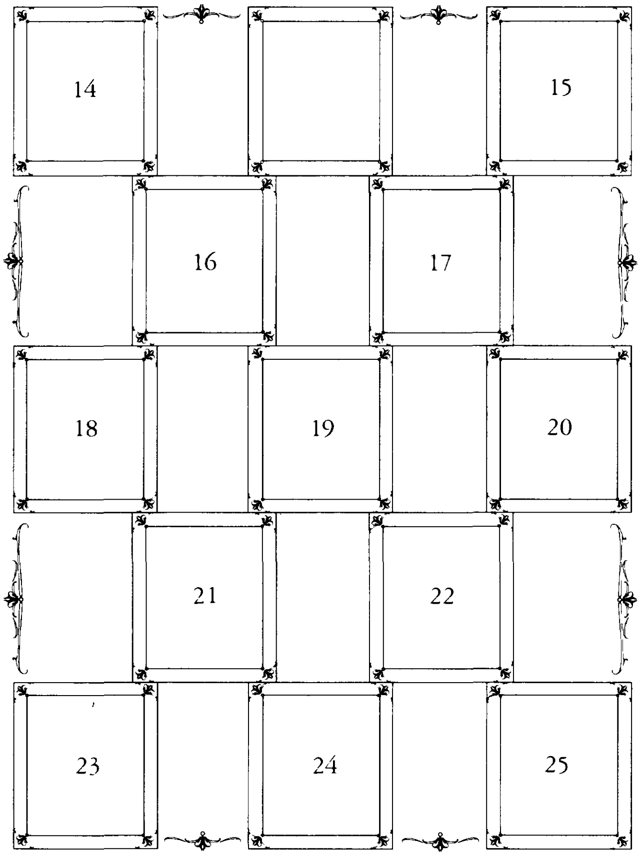
I wish to acknowledge my indebtedness to many members of the Geological Survey for their aid in the preparation of this volume. In particular, I wish to thank Thomas B. Nolan, Assistant Director and Director, 1944–1965, for his interest, encouragement, advice, and many useful discussions and Arthur A. Baker, Administrative Geologist and Associate Director, 1953–1969, for a thorough and detailed review of the manuscript. Both Mr. Nolan and Mr. Baker joined the Survey during the latter part of the period under discussion and both have extraordinary recollection of events in their early Survey years. I also thank

Clifford M. Nelson, Staff Geologist, not only for reviewing the manuscript critically and shepherding it through the publication process but for listening and asking questions about my versions of history as they developed and for keeping me straight on matters paleontological.

A final word of caution to readers. Although we are entering the "modern" period of geology in this volume, no effort has been made to anticipate future developments beyond what the geologists of the era themselves suggested, and stratigraphic and other terminology is not present-day usage but the usage at the time of publication of the matters discussed.

Keys to portraits on end papers





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Chapter 1. The Third Stage

In the growth of the country and gradual development of the natural resources there have been three noteworthy stages. * * * In the first stage the resources received little thought. In the second they were wastefully used. In the third stage which we are now entering wise and beneficial uses are essential, and the checking of waste is absolutely demanded.

—National Conservation Commission, 1909

In 1904, the U.S. Geological Survey celebrated the 25th anniversary of its establishment by act of Congress on March 3, 1879. Its field at that time had been defined as "classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain," but in later years it had been given additional duties. In 1882, it had been given responsibility for preparation of the geologic map of the United States, and beginning in 1887, its topographic mapping, paleontological research, and physical and chemical research had been authorized by annual appropriations. In 1894, the Survey was given responsibility for gaging the streams and determining the water supply of the United States, and in 1897, for examining and surveying the forest reserves. Then in 1902, when Congress passed the Newlands Act establishing a fund to be used for planning, construction, and maintenance of dams and other irrigation works in 16 Western States and Territories, the agency to carry out the work was by presidential order set up as an adjunct to the Geological Survey.

In its first 25 years the Survey had grown from an organization that had 38 employees at the end of its first year to one with 678 employees (187 of them in the Reclamation Service) in 1904. Congress had appropriated $106,000 for its first year and $1.4 million for the fiscal year that ended June 30, 1904. The Survey had also become the leading geologic institution in the the United States—*American Men of Science* said that "In geology the U.S. Survey overshadows the universities among which Yale, Harvard, Chicago, and Wisconsin are in the lead." Of the 100 geologists whose work was considered most significant by a group of their peers and whose names were starred in the 1903 edition, the first five, arranged in order of merit, were all associated with the Survey: T. C. Chamberlin, Professor of Geology at the University of Chicago and Geologist-in-charge of the Survey's Section of Glacial Geology, whose planetesimal hypothesis of the origin of the earth was then widely discussed; G. K. Gilbert, whose studies of the Great Basin region had become classics; C. D. Walcott, Director of the Survey and paleontologist-stratigrapher extraordinary; C. R. Van Hise, who had been Geologist-in-charge of the Survey's Section of Metamorphic Geology before leaving in 1903 to become President of the University of Wisconsin; and S. F. Emmons, Geologist-in-charge of the Survey's Section of the Economic Geology of Metalliferous Ores. C. W. Hayes, the Geologist-in-charge of the Division of Geology and Paleontology and of the Section of the Economic Geology of Nonmetalliferous Ores, and G. F. Becker, the Geologist-in-charge of the Division of Chemical and Physical Research, were 12th and 13th on the list, and of all those who had been given scientific control of the work in the organization of 1900, only David T. Day, of the Division of Mining and Mineral Resources, was missing. At least one-third of the staff of the Geologic Branch was on the list, among them three future Chief Geologists, Waldemar Lindgren, David White, and T. W. Stanton.

The Survey itself, in a bulletin describing its organization and operations during these 25 years, reported that it had finished mapping, on more or less detailed scales, 26 percent of the area of the country, including Alaska, and that its topographic maps had "greatly expedited investigations by cities of their water supply," and had "been of the highest value to railway companies and State highway bureaus in designing and planning their projects." The geologic mapping of about 171,000 square miles had been completed. Laboratory investigations had been made of the physical characteristics of rocks in various processes of formation, of volcanic and geyser action, and rock composition and structure. Paleontologists had also aided in solving stratigraphic and structural problems. The hydrographers had recorded the maximum, minimum, and mean discharges of all the more important rivers for 15 years and of lesser streams for shorter periods of time. The physical characteristics of river basins had been studied in order to estimate the volume or runoff of streams. Data had been accumulated to aid the development of the water powers of the country, and on the irrigable lands of the public domain. Some reservoir and irrigation projects had been studied in detail and construction by the Reclamation Service had been approved. Some 110,000 square miles had been examined in detail and classified as forested, grazing, desert, or cultivable.

The Survey concluded, however, that

> **Perhaps the immediate value to the people of the work of the Geological Survey is best shown by the aid it extends in developing the mineral resources and in forwarding important engineering projects in which the people, as well as the State and Federal Governments, are interested.**

The aid the Survey extended in developing the mineral resources stemmed from the foresight exercised by its first Director, Clarence King, in laying out the program in 1879. To establish the value of the new organization, he chose to direct its work toward the production of immediate results of practical import. The United States was then in the early stages of industrial expansion, a time in which King observed

> **Our real industrial problem is to utilize with the highest technical skill and with the utmost scientific economy, all elements of national wealth.**

King therefore proposed that the Survey aid industrial development by providing information that would permit the mineral resources of the Nation to be used "with the highest technical skill and with the utmost scientific economy." He planned a two-fold program of mineral-resource investigations: geologic and technical studies of mining districts and the collection of mineral statistics, not just production figures but geographic, geologic, chemical, and other data as well. Although the immediate aim was practical, King's ultimate goal was scientific: the accumulation of data could in time be used to make possible a scientific classification of ore deposits and permit a determination of their origin. The program was in no sense merely applied geology but rather involved the concept of a mission to provide a service or aid a cause.

King remained as Director for less than 2 years and was succeeded in 1881 by John Wesley Powell, who abandoned the mission approach. Powell believed that practical geology was the highest form of the science but before practical geology became possible all the basic facts had to be determined. Under Charles D. Walcott, the Survey's third Director, the mission approach was revived, broadened, and more explicitly stated. The Survey would conduct scientific investigations to aid in every possible manner the development of all material industries affected by knowledge of the earth, and these investigations would include the acquisition of scientific or technical knowledge needed to solve geologic problems. Under Walcott, not only were the mineral-resource investigations extended from the metallic ores of the earliest studies to nonmetalliferous deposits and construction materials but also to water, which is, although seldom thought of as, a mineral.

During the Survey's first 25 years, the United States become the world's leading industrial nation, a transformation accelerated by the great wealth of its mineral resources. Mineral production during these 25 years nearly quadrupled. In 1880, the first year for which figures are available, the annual value of the mineral production was $367,463,000; in 1904 it was $1,359,181,000. Industrial supremacy belonged to the nation that could produce the cheapest steel. The United States had enormous resources of coal and iron although it seemed to lack the low-phosphorus iron needed for the Bessemer process, and one of the infant Survey's first projects had been a survey of American iron ores, including their chemical analysis. The introduction of the open-hearth process, which used all types of iron, greatly increased American steel-making capacity, and thereafter the United States rapidly overtook Old World nations in the production of cheap steel. With the use of bituminous coal for smelting and the development of cheap transportation, the Lake Superior iron ores could be shipped to Pennsylvania for smelting, and western Pennsylvania became the center of American steel production. In 1904, the Survey noted with satisfaction that its investigation of the origin and geologic relations of the Lake Superior iron ores had "so effectively directed the prospector in the discovery of the deposits and the miner in economical methods of development that this region now leads the world in the production of iron ore."

Undoubtedly the most influential mineral-resource investigation of the 25-year period, however, was S. F. Emmons' study of the geology and mining industry of Leadville, Colorado, which became known as the "miners' Bible." That study had not only "guided exploration and secured economical mining in a district that had produced between $200,000,000 and $400,000,000" but had been "of even more beneficial results in teaching the mining engineer and the miner the practical importance of geologic study in carrying out their work; in other words, it has greatly improved mining methods throughout the whole country."

The Survey made no claim for anything more than educational influence on the mining industry. S. F. Emmons, who was president of the Geological Society of America and vice-president of the American Institute of Mining Engineers in 1903, in his presidential addresss to GSA in late December 1903, merely noted that since 1853, when the United States completed its occupation of all the territory now encompassed in the 48 contiguous States, "the unexampled rapidity with which * * * civilization and industry have spread over the mountainous regions of the West has been due to the development of the mineral resources—a development to which geological science has in no small part contributed."

Emmons' modest claim for a geological contribution, however, included the development, largely influenced by the Survey's investigations, of an entirely new field of specialization within geology, that of economic geology, which may be traced back to the dual purpose of Clarence King's mineral-resource program. In 1879, the study of ore deposits was lagging behind other branches of geology and the most advanced opinion of the time was not very different from that in J. D. Whitney's textbook of 1854. In 1904, the origin of ore deposits was a hotly debated issue and tentative attempts at a genetic classification of ore deposits were widely reported in both *Science* and the *Engineering and Mining Journal.* None of the Survey investigations had been devoted solely to the description of deposits or the application of geologic principles to mining. Petrographers, petrologists, mineralogists, and chemists had been called on to aid the mining geology studies and their sciences had developed at the same time, not only contributing to but being advanced by the development of economic geology. By 1904, the community of economic geologists was well enough established to plan the launching of a new journal for papers on both the description of mineral deposits and the application of geology to mining but also the genesis of ore deposits. On the latter score, most economic geologists agreed: future progress demanded new methods of investigation, and experimental research of the most fundamental character was needed.

There was no thought at the time of establishing a separate society. The geological community in the early years of the 20th century was relatively small and simple. Most geologists belonged to the Geological Society of America and the American Association for the Advancement of Science, most economic geologists to the American Institute of Mining Engineers as well. The meeting of the Geological Society of America in December 1903, held in St. Louis where a World's Fair to celebrate the 100th anniversary of the Louisiana Purchase was in preparation, attracted 51 fellows. Sessions were held in a high school classroom and 39 papers were read or presented by title on subjects that ranged from "Geology under the planetesimal hypothesis of earth origin" to "System of keeping the records of a State geological survey." Most, however, were regional studies. William Morris Davis, President of the Section of Geology and Geography of the AAAS, which met in St. Louis at the same time, thought geology was dominating geography and deemed the formation of a society of geographers analogous to the Geological Society of America necessary for the future of geography in the United States. (Within a year he became the first president of the Association of American Geographers.) Ira Remsen, in his address as retiring president of the AAAS, foresaw a great future for American science. Great progress had been made in the preceding 25 years, but

> **No matter in what direction we may look we are aware of great unexplored territories, and even in those regions in which the greatest advances have been made it is evident that the knowledge gained is almost insignificant as compared with that which remains to be learned.**

The progress in the preceding quarter century Remsen attributed to the development of American universities and the support given by the Government to its different scientific bureaus such as the Geological Survey, the Department of Agriculture, the Coast and Geodetic Survey, and the National Bureau of Standards. If as much progress could be made in the next quarter century, he believed the United States could compete with the foremost nations of the world in scientific investigation. G. F. Becker and C. R. Van Hise at the International Congress of Arts and Sciences in St. Louis in 1904 looked forward to immense opportunities and challenges in geology and geophysics involving experimental and theoretical work of the most fundamental kind.

In 1904, the United States was in the early stages of a period of change, just as it had been when the Survey began in 1879. This new period was one of reform in which national policies that had prevailed in the late 19th century were abandoned, social and economic reforms were enacted, and the role of the Federal Government was transformed. Beyond that, in the words of Samuel Eliot Morison, the American people underwent "profound changes in their environment, their racial composition, their mental processes, and their moral climate." It would be interrupted by World War I and the revival of laissez faire in the 1920's, then resumed in the 1930's, only to be more profoundly interrupted by the outbreak of World War II in 1939.

More than one historian has noted the correlation between this period of change and changes in the use of energy; Morison went so far as to pinpoint the change as the effect of the invention of the internal combustion engine and its multifarious applications to transport and power. Changes in the use of energy in turn affected the development of natural resources, especially the fossil fuels and water, and these in turn resulted in changes in the geological sciences.

The Survey had to some extent anticipated the changes in the use of energy resources for it had been reporting for some years that an increasing proportion of the value of the annual mineral production of the United States was being contributed by the nonmetalliferous resources. In 1898, when problems had begun to develop in the coal industry, causing consumers to turn to other kinds of fuel, Director Walcott had suggested to Congress a thorough investigation of the coals and cokes of the United States, including complete chemical investigations, determinations of calorific values, and practical tests so the coals might be used to the best advantage, thus echoing King's thought that the mineral resources should be used with the utmost scientific economy. In the organization of the Geologic Branch in 1900, the economic geology of metalliferous ores and of nonmetalliferous deposits were given equal status, although not equal budgets, and both sections contributed to the annual *Contributions to Economic Geology*, which was inaugurated in 1902 to meet the growing demand from the mineral industry for prompt publication of Survey work. By 1904, the detailed areal mapping and subsurface structural studies of Appalachian coal areas were "placing the development of its coal, petroleum, and gas resources upon a scientific basis and relieving these branches of the mineral industry of a large part of the hazard and uncertainty which has always hitherto been associated with them." Some investigations of petroleum were made elsewhere as well, especially after the discovery of Spindletop in 1901, and the investigations, according to E. L. DeGolyer, laid the "foundation for the more general acceptance of the geologist by the oil industry."

In 1904, the Survey took advantage of the opportunity presented by the Louisiana Purchase Exposition to make a practical demonstration of the value of the more comprehensive investigations of coal and coke that had been recommended in 1898 but not funded, and obtained an appropriation for an exhibit showing the analysis and testing of coal to determine fuel values and the most economic method of utilization for different purposes. The exhibit was an immediate success, so successful that the coal industry demanded additional work, and Congress appropriated funds for a continuation of the coal testing and also for the structural-materials testing that had been begun at the exposition by the American Portland Cement Manufacturers.

These testing programs were unlike the Survey's other geologic programs, being far more in the nature of applied science, and thereby posed a possible threat to basic research. Congress by and large preferred practical or applied science, and Federal science depended on annual appropriations of funds by Congress. Under Walcott's direction, the Survey's research, like the minerals being studied in its laboratories, was seldom one of the end members, neither pure basic or pure applied, but like the intermediate members of a eutectic series, ranged from research with remote applications to practical problems to research with immediate applications to practical problems. The administrator of Federal science, however, has to make adjustments, or, as Walcott put it, had to aim at the nearest attainable approximation to the desired object; later developments made it evident that Walcott aimed at the gradual introduction of basic research into the testing programs. Under George Otis Smith, who succeeded Walcott as Director on May 1, 1907, however, they became purely practical and, despite his opposition, in 1910 were transferred from the Survey. The coal-testing program became the nucleus of the newly established Bureau of

Mines and the structural-materials testing became part of the National Bureau of Standards.

The conservation program, which Theodore Roosevelt considered one of the greatest achievements of his administration, also became a stumbling block to Survey research. That resources should be used without waste was an accepted idea in Europe, and American scientists had long argued against their wasteful use. Until late in the 19th century, however, the American public had commonly regarded all resources as inexhaustible, some of them even an obstruction to the development of the country. In this belief, forests were destroyed, every man was granted a farm for the asking, and only the richest ores were mined, and these wastefully. Customs and laws were based on this public perception rather than on scientific facts.

Serious efforts to prevent the wholesale destruction of forests and to develop a rational forest policy began in the 1870's. In 1877, Congress established a division of forestry in the Department of Agriculture and in 1891 authorized the creation of national forest reserves. The Division of Forestry, however, was given neither the funds nor the authority to deal with forest problems, and after authorizing the forest reserves in 1891 Congress took another 6 years to pass the Forest Management Act. The lack of sufficient water for ordinary agriculture in the arid and semiarid regions of the West was also given attention in the late 1870's with a Congressionally authorized investigation of the possibility of irrigation, George Perkins Marsh's report on irrigation, and John Wesley Powell's "Report on the Lands of the Arid Region of the United States." In 1888, Congress authorized the Geological Survey to investigate the extent to which the arid region of the United States could be redeemed by irrigation and the Secretary of the Interior to withdraw from private entry specified areas for this purpose. The Irrigation Survey was discontinued after 2 years because of its slow progress and because the public domain was closed to entry until it was completed.

Private citizens also began tentative efforts at conservation during the late 1870's, primarily the preservation of the forests and of big game, and their efforts were instrumental in obtaining passage of the bill creating forest reserves and in establishing the forest commission of 1896. As the East became more and more urbanized, there also developed a movement to preserve some of the remaining untouched natural areas. Several of the large forest reserves and Yosemite, Sequoia, Mount Rainier, and Crater Lake National Parks were created to fulfill this need. Preservationists were disappointed in 1897, however, when Congress passed the Forest Management Act, giving the Geological Survey responsibility for surveying and classifying the forest reserves but at the same time opening the existing reserves to mining and grazing. In the late 1890's, the drive for a permanent irrigation service gathered strength, stressing the positive aspect of reclamation of land rather than conservation of water, and Congress passed the Reclamation Act in 1902. When the Reclamation Service became an adjunct of the Geological Survey, much of the administration's conservation efforts were thus associated with the Survey and its sister agency in Interior, the General Land Office.

Once the Reclamation Service was successfully launched, Secretary of the Interior Hitchcock, having received information that frauds of a serious nature in the acquisition of public lands had been and were being perpetrated under the Forest Lieu Land Act, began a thorough investigation of public-land management. President Roosevelt urged Congress to undertake a thorough revision of the public-land laws, setting up, if necessary, a commission of experts to advise it. When Congress did not respond, Roosevelt set up his own commission composed of the Commissioner of the General Land Office, W. A. Richards, the Chief Forester, Gifford Pinchot, and the Chief Engineer of the Reclamation Service and Chief Hydrographer of the Geological Survey, F. H.

Newell. The commission, as might perhaps be expected from its composition, concerned itself chiefly with the control, use, and disposal of forest lands and the control of water. It made no recommendations about changes in mineral-land laws, which had been a major concern of the Public Lands Commission of 1879, although it conceded that changes were necessary. In the spring of 1905, Congress repealed the Forest Lieu Land Act and transferred the management of the forest reserves from the Department of the Interior to the Department of Agriculture. The classification of the forest reserves was then transferred from the Geological Survey to the newly renamed Forest Service. The Reclamation Service was already becoming less dependent on the Geological Survey, although it did not become a fully independent agency until 1907, so that by the middle of 1905, most of the conservation responsibilities had been shifted from the Geological Survey.

There was at this time no organized effort to promote the conservation of other resources. The disappearance of forests and the consequences of a lack of water were readily apparent. Moreover, it was conceivable that the measures planned would be effective, that forests could be managed so that the annual yield balanced annual consumption, that great engineering works could trap every drop of water and permit its redistribution to better purpose than nature did. The need for conservation of soil was apparent in many areas but was regarded as next to impossible to achieve because the use of the soil had to be balanced against depletion of its nutrients and loss through erosion. The necessity of conserving mineral resources was simply beyond the comprehension of most people. Scientists knew that in the use of metals, some part is necessarily consumed and the total supply of the world's available metals was thereby being steadily diminished, and that in the use of mineral fuels, the mineral resources are destroyed and the total supply even more rapidly diminished, but the average American had experienced no deprivation or even inconvenience.

The conservation of mineral resources, moreover, is complicated by the fact that they are for the most part hidden resources, and without extensive and intensive investigations, the total available supply cannot even be approximated. Experience has also shown that some resources that might be of too low a grade to be economically exploited at a given time or in a given place might be used under different conditions, and minerals considered of minor value might in time become important or might become a substitute or replacement for another.

Already there was some concern about the known supplies of coal and iron, the staples of industry, so the Survey in 1905 obtained an additional appropriation to increase its investigations of these deposits. Some considered coal the more important of the two. Ira Remsen, in his AAAS speech, had said that

> **Unless by means of scientific investigation man is taught new methods of rendering the world's store of energy for the production of heat and motion, the age of the human race is measured by the extent of the supply of coal and other forms of fuel.**

He discounted the importance of oil, although noting that existing knowledge was insufficient to make any predictions of value, but noted that if the theory that petroleum is constantly being formed by the action of water on carbides in the interior of the Earth should prove correct, a supply of oil was assured and the problem was one of transportation. M. R. Campbell of the Survey also considered oil of lesser importance, although used extensively in some parts of the country, because of its limited occurrence. "Coal," he said, "is the fuel of the present, and, so far as can be seen, will continue to lead in this particular for a long time to come," but "although the amount of coal in the various fields seems to be so great as to be well-nigh inexhaustible, the consumption is increasing so rapidly that already the question of a future supply of fuel is a serious one." To John Stewart, Professor of Economics and History at Lehigh

University, however, "The serious problem from the economic side is expressed in the fear of an early exhaustion of iron ore. Thus we have the frank recognition of our dependence on the economic geologist."

The Roosevelt administration embarked on the conservation of mineral resources in dramatic fashion in June 1906 when the President ordered the Secretary of the Interior "to report as soon as possible the coal lands where the Department considered the coal deposits of such value that we ought to withdraw lands from entry." The suggestion had come from the former Governor, then Senator from Wisconsin, Robert M. LaFollette, as evidence began to mount of fraud in the acquisition of public and Indian coal lands. The Attorney General did not believe the President had the authority to withdraw the land by Executive order, but when the Senate failed to act on measures to reserve the land or to make a thorough investigation of the coal resources of the public lands, the President took matters into his own hands. Within a month, the Secretary began the withdrawal of lands on the basis of recommendations from the Geological Survey and the Forest Service that by December amounted to nearly 67 million acres.

From that point on, the Roosevelt conservation program began to develop rapidly. In March 1907, an Inland Waterways Commission was appointed to prepare a comprehensive plan for use of inland waters. From the Inland Waterways Commission came the inspiration for a Conference of Governors at the White House to dramatize the need for conservation, which the President had declared in his December 1907 State-of-the-Union address to be "the fundamental problem which underlies almost every other problem of our national life." From the Governors Conference came the National Conservation Commission that in the record time of 5 months, with the aid of Government scientific agencies, prepared an inventory of natural resources that the President sent to Congress in January 1909. The Commission report contained not only estimates of the various mineral resources but predictions of the time of exhaustion. It also emphasized the need for surveys and investigations of mineral and water resources, for topographic surveys of catchment sites and sites available for the control of waters, and a thorough study and revision of the public-land laws. Conservation thus came to take on an entirely new look.

In its original meaning conservation referred primarily to the prevention of waste and destruction of resources and was considered a scientific or technological matter. Gifford Pinchot, the Chief Forester and architect of much of the Roosevelt conservation policy, insisted that what was new was only the integration of the conservation of all resources into a single policy. To Professor Richard T. Ely, Director of the School of Economics, Political Science, and History at the University of Wisconsin, however, what came to be called conservation in the United States was in Germany political economy, of which conservation in its original sense was a part. In Germany it was considered necessary to use the natural resources with the utmost care and to improve them where possible in order to provide for a rapidly growing population, and it was natural for the Government to exert some controls. American economists, especially those who, like Ely, had studied in Germany in recent years, also considered "conservation" part of economics, and many of them had been involved in promoting the conservation of forest resources. Like Ely, they believed that the state should play a positive role in the economy, and that governmental functions should be extended to conservation measures. Ely himself had proposed the socialization of mineral deposits in his "Socialism and Social Reform" published in 1894 and in a course of lectures at the University of Wisconsin in 1898 had discussed measures that he claimed were those that were later generally recommended. Ely admitted, however, that in the United States, even if the economists had helped prepare the way, it was "under the leadership of President Roosevelt and such men as President Van Hise and Gifford Pinchot, the public first became conscious of the real import of conservation policies'' and called Van Hise's book ''The Conservation of Natural Resources in the United States'' epoch-making.

The most striking difference between the Roosevelt conservation program and German conservation was the virtual restriction of Roosevelt conservation to the public domain, and the consequent withdrawal from entry and locking up of resources of millions of acres for the second time in less than 20 years. The extension of the meaning of conservation immediately made it a controversial issue. Politically, it arrayed East against West and progressive against conservative. Economists recognized that in the industrial evolution of a community or nation there are different stages in each of which the interrelation of natural resources, labor, and capital is different. In the earliest stages of development, some waste of natural resources can be tolerated in order not to delay the natural expansion of the population and development of industrial resources. Thus, as Clarence King pointed out in the Tenth Census report, when transportation and wages were considered, American methods of mining were not as crude and wasteful as Europeans believed. In the later stages of industrial development and maturity, however, economic progress depends on the maintenance of productive stability, and then wisdom would suggest that natural resources should be reserved for their highest use, that partially exhausted resources should be restored where possible, and that nonrenewable resources be used prudently. Clearly these objectives could be more easily achieved by government regulation than private initiative. Just as clearly, the regulations should be based on a thorough knowledge of the resources involved. When the first mineral lands were withdrawn from entry in 1906, however, the different sections of the United States were in different stages of industrial development, and knowledge of the resources of the withdrawn lands could best be described as meager. Thus what was looked upon as wisdom in the East was to the West an attempt to enslave it by locking up its resources and denying it an opportunity for growth.

Most of the progressive reform movements were based on the premise that economic individualism and political democracy had once existed in the United States but had somehow been destroyed by the rise of the great corporations and political machines, and their aim was to restore that individualism and democracy. The most zealous reformers saw only evil in large corporations, and thus regarded any large corporation as a foe of conservation even if, on the basis of the profit motive alone, it might be most economical in its development of mineral resources, or even if, in areas such as Alaska, private capital offered the only hope of immediate development. When the Government withheld lands from development, that was conservation and good; when a corporation acquired lands for future development, that was monopoly and bad. To the extremely conservative, on the other hand, the word ''conservation'' became anathema, and as Congress was controlled by the conservative element, programs associated with the conservation program, including the Survey's water-resources investigations, experienced difficulties in obtaining appropriations.

The new conservation policy even created divisions among scientists and conservationists. To those who equated conservation with preservation, the idea of development, even prudent development, was wrong. Among scientists there was a special problem. Some clung to the original meaning of the word, some adopted the new meaning. Thus we had the strange spectacle at the White House Conference in 1908 of industrialist Andrew Carnegie arguing for scientific research to achieve conservation while scientist C. R. Van Hise called for government control. In 1910, T. C. Chamberlin pointed out in the *Journal of Geology* that the protection of natural values against wastage and the possession of those values were two separate things, and the best ownership might not be correlated with the best conservation. Ownership was a political and sociological matter, conservation a scientific and technical matter, and geologists he thought, would do well to stick to the scientific and technical. A clearly exasperated C. W. Hayes defined conservation in the *Mining and Scientific Press* as "utilization with a maximum efficiency and minimum waste," and espoused the "heretical" view that the "soulless trust" was probably the best agency of conservation as it had to provide for its continued existence far beyond the lifetime of an individual.

The new conservation policy had an immediate effect on the Geological Survey program, causing a decline in research that took years to reverse. Although the Organic Act of the Geological Survey charged it with responsibility for classification of the public lands, until 1906 the interpretation of Clarence King and the Public Lands Commission of 1879 that the Survey's classification was meant to be a scientific classification rather than classification in advance of and as the basis for disposition of the public lands had prevailed with only a few exceptions. When millions of acres of supposed coal lands were withdrawn from entry, however, classification of public lands in advance of disposition became a major activity of the Survey.

In the spring of 1907, the new Secretary of the Interior, James R. Garfield, chose George Otis Smith to succeed Charles D. Walcott, newly elected Secretary of the Smithsonian Institution, as the fourth Director of the Geological Survey. Smith remained as Director, with the exception of one year in which he served as Coal Commissioner, until December 22, 1930, or thoughout nearly all the Survey's second quarter-century. Smith's views on the nature and purpose of Survey work were radically different from those of his predecessors. He had come to Garfield's attention as a member of a subcommittee of a presidential commission set up in 1906 to introduce modern business methods into the Federal Government and had become interested in developing a business policy for the management of the public domain. Unlike King, Powell, and Walcott, all members of the National Academy of Sciences, who emphasized that the Survey was a bureau of research even though they adoped different stances with regard to the relation of Survey research to practical results, Smith, who was never elected to the Academy, held that the Survey's work was primarily although not exclusively practical, a view more in accord with the prevalent political opinion of the day. Unlike King, Powell, and Walcott, who had all maintained that the Survey must be national in scope, Smith also insisted for several years on the primacy of the work on the public domain. In time, Smith came to adopt many of the viewpoints of his predecessors, sometimes citing the wisdom of the first Director as he did so. During the first 20 years of his directorate, Federal appropriations for the Survey were essentially static, the appropriation for the fiscal year ending June 30, 1927, only six percent more than the appropriation for the fiscal year ending June 30, 1907. Total funds available to the Survey during the same period increased by 53 percent but as the percentage of outside funds steadily increased from 8 to more than 36 percent so did the influence of outside agencies on Survey programs.

At the time the coal lands were withdrawn from entry in 1906, the Coal Lands Act of 1873 permitted entry and patenting of a limited number of acres of coal land by individuals or groups at minimum prices that varied according to the distance from a completed railroad. It became the Survey's task not only to classify the lands as coal or non-coal but to place a value on the coal lands so they could be sold at more than the minimum price. The President and his Secretary of the Interior, both of whom were loose constructionists of the law, withdrew from private entry new classes of land whenever new needs for conservation were perceived. Oil lands near Coalinga in California were withdrawn to prevent their fraudulent acquisition, lands near the Caddo oil field in Louisiana were withdrawn from entry pending an investigation by the Survey to prevent waste of natural gas, millions of acres of supposed phosphate lands in Idaho, Wyoming, and Utah were withdrawn pending new legislation for their disposal, and shortly before the end of the Roosevelt administration, millions of acres controlling water-power sites on 16 Western rivers were withdrawn from entry. In the fall of 1909, millions of acres of Western oil lands were withdrawn from all forms of location and entry. Despite presidential prodding, Congress made only a minor change in mineral-land laws during the Roosevelt administration. The stalemate continued through the Taft administration except for the grudging agreement in 1910 that the President did have the power to withdraw lands from private entry and reserve them for public purposes, including classification. During the Wilson administration, Congress authorized the leasing of coal lands in Alaska and of potassium lands but did not act on the overall problem of the disposal of the mineral lands until 1920. Congress appropriated no funds for the classification program so it had to be carried out with funds appropriated for research and mapping. In the Survey, a Land Classification Board was established in 1908 to carry on the administrative work associated with the program, and in 1912 the Board was raised to Branch status, on a par with the Geologic, Topographic, and Water Resources Branches. With no funds of its own, it had to exist on assessments of the funds appropriated for those branches.

Loss of personnel also contributed to the decline of basic research in the Geological Survey. Both industry and academia turned to the Survey for scientists and engineers to staff their programs and classrooms, and the exodus of scientists and engineers from the Survey for higher paying or more rewarding positions elsewhere accelerated as the public-lands work increased. That basic research survived at all in the agency was owing to the persistent endeavors of a few individuals, especially in the Geologic Branch. In the Water Resources Branch, which was saddled with an immense volume of classification work even though its funds had been severely cut, the title of the head of the branch was changed when M. O. Leighton resigned in 1913 from Chief Hydrographer to Chief Hydraulic Engineer; the function of the branch became chiefly one of gathering data, without much opportunity for generalizations.

World War I reoriented conventional views on mineral resources. In August 1914, when the war began in Europe, the Survey was inundated with requests from industry for information on sources of mineral raw materials. In response, George Otis Smith, exhibiting a cheery optimism but a certain amount of naivete as well, issued a bulletin entitled "Our Mineral Reserves—How to Make America Industrially Independent," according to which there were only five essential minerals of first rank of which the United States had no known supply commensurate with its needs although some minor minerals might cause problems because the United States had hitherto depended on foreign sources; on the other hand, the reserves of mineral fuels and iron were so enormous that no problems would arise. Within 2 years, however, difficulties in obtaining some mineral raw materials developed, and the Survey reoriented its work to aid the search for both metals and fuels. In 1917, when the United States entered the war, there were a dozen minerals that were inadequate in quantity or quality or both, and another half dozen for which domestic supplies were adequate for peacetime needs but not for war. The discovery of new supplies of iron ores and the development of methods for making low-grade ores available were considered vital. Coal had become high priced and hard to get. The production of petroleum barely met the Nation's normal demand and was much too small for the abnormal demands of war so that strict economy of use was imperative. The petroleum situation sparked a Congressional inquiry and a symposium on the geology of petroleum at the meeting of the Geological Society of America in 1916. In Feburary 1917, a gathering of geologists in Tulsa organized the Southwestern Association of

Petroleum Geologists, which became the American Association of Petroleum Geologists in 1918.

The war presented Congress with the opportunity as well as the necessity to exert some controls over mineral resources. In August 1917, Congress passed the Lever Act empowering the President to make regulations and issue orders to stimulate and conserve the production and control the distribution of fuels necessary to the war effort. A similar bill for the control of other mineral commodities, drawn up by a War Minerals Committee, was passed shortly before the war ended but never put into effect.

The war also altered the world movement of minerals and the United States mineral industry rather abruptly realized its dependence on international trade. When the war began, about two-thirds of the minerals produced in the world were used in the countries of origin and the other third was exported. However, most of the demands for mineral imports were met by drawing heavily on sources of limited geographic extent and the minerals tended to move toward a few consuming centers where there were favorable conditions for smelting and a high development of industry. During the war, the character and distribution of the demand changed, some customary sources of supply were cut off, and financial disturbances and ship shortages modified the movement of materials. Again, governmental controls had to be exercised in order to prosecute the war most effectively.

The Geological Survey proved to be an invaluable source of information for the various war boards because of the statistics on mineral resources it had been accumulating since 1880, and it also carried on an intensive search for new sources of needed minerals at home and in Latin America. The Survey, however, was largely overlooked when the National Research Council was established in 1916 to encourage "every form of investigation, whether for military and industrial application or for the advancement of knowledge without regard to its immediate practical bearing." The Director of the Bureau of Mines represented the Department of the Interior on the National Research Council, and the Geological Society of America, asked to form a committee on geology, named only geologists from universities and a few State geologists.

After the war was over, those who had been most closely associated with wartime mineral problems hoped for the adoption of a national policy for the use of mineral resources that would take into consideration world distribution and trade as well as tariffs, taxes, and conservation. A centralized international control was proposed that would further the aims of the League of Nations and serve the interests of conservation by allowing the minerals to be drawn from their natural sources of supply, but as C. K. Leith, mineral adviser to the War Industries and Shipping Boards and the Peace Commission, pointed out, international control would entail difficulties that were particularly burdensome on the United States because the few minerals for which the United States was dependent on foreign countries were more than offset by the many in which the United States was dominant and on which there might be export limitations. In any event, the United States became dominantly isolationist in sentiment after the war ended. Leith pleaded for "recognition of the necessity of a systematic study of the world's mineral resources from the world's standpoint to supplement the studies made of the domestic resources, both by the mineral industry itself and by governmental and other agencies." Leith served as chairman of the Committee on Foreign and Domestic Mining Policy established by the Mining and Metallurgical Society of America and worked in cooperation with the Committee on Industrial Preparedness of the American Institute of Mining Engineers in making studies of strategic and critical minerals.

The war had a pronounced effect on American science in general. Industry became convinced of the value of research, scientists also became accustomed to working together for the quick solution of an immediate problem, as Government scientists had been doing for many years, and scientists in both the public and private sectors became acquainted with other disciplines than their own. The National Research Council was made a permanent part of the National Academy of Sciences as the war was drawing to a close and given the task of stimulating research "in the mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening national defense, and of contributing in other ways to the public welfare." Unlike the wartime Council, the new National Research Council, organized in February 1919, included several members of the U.S. Geological Survey. Director George Otis Smith was a member of the Division of Government Relations, which included representatives of each of the scientific bureaus of the Government. A. H. Brooks, Whitman Cross, T. Wayland Vaughan, and Chief Geologist David White were all members of the Division of Geology and Geography composed of representatives of the Association of American Geographers, the American Geographical Society, the Geological Society of America, the Paleontological Society (formed in 1909 as an affiliate of the Geological Society of America), the National Geographic Society, and members at large chosen by the Division. To facilitate the international exchange of information, representatives of the sciences in the Allied and associated nations met in Brussels in July 1919 to complete the organization of an International Research Council and to form international unions, affiliated with the Council, representing the individual sciences. The American Geophysical Union was set up at this time as an arm of the National Research Council and the American representative of the International Union of Geodesy and Geophysics. Within the American geological community, two new societies were formed, the Mineralogical Society "for the advancement of mineralogy, crystallography, and allied sciences," and the Society of Economic Geologists, for the "advancement of the science of geology in its application to mining and other industries."

Federal science, however, at this time suffered for lack of support. So great was the demand for economy in the Federal Government that only one percent of the budget for the fiscal year beginning July 1, 1919, was used for education and scientific research and development, and even that small amount was carefully scrutinized. Many scientists left the Government at this time to accept more remunerative positions in industry. The oil industry, which had become increasingly aware of the value of science in the search for oil recruited geologists from the Geological Survey with such success that Director Smith remarked ruefully that he felt like the head of a high-class employment agency. The oil industry was followed by the universities, and between them they raided the Survey staff so successfully that in some sections of the Geologic Branch too few scientists were left to train newcomers, so the slow process of rebuilding the geologic staff had to begin again.

In the immediate aftermath of the war, all the mineral industries were in some state of disarray but few of their problems lent themselves to a scientific solution. The search for domestic sources of metals had been so successful that the metals industries had an oversupply for peacetime uses and demanded from the Government relief measures ranging from financial assistance to mineral embargoes. The coal industry was badly overextended as the result of the expansion to cope with wartime demands. Because employment in the coal mines was intermittent at best, the postwar contraction created unusual hardships for the miners so in 1919 they went on the first of several strikes seeking increased wages. Production from known American oil fields was becoming increasingly difficult because of the much greater depths to which it was necessary to drill to obtain oil. In 1919, there was a shortfall in petroleum production and oil had to be drawn from storage or imported to meet the demand.

The combination of the coal strike and petroleum shortage brought on an energy crisis that forced Congress to come to a decision on the disposition of the reserved mineral lands and water-power sites. On February 25, 1920, the Mineral Leasing Act was approved. The Coal Lands Acts of 1873 and the Placer Act as it applied to oil and gas, phosphate, and oil shale were repealed, and the mineral lands were made available for lease by competitive bidding. On June 10, 1920, the Federal Water Power Act was approved, and the Federal Power Commission was established to issue licenses for the development of water power.

Leases and licenses were only a superficial solution to the energy problem. Although the United States was well endowed with natural sources of energy and was the largest producer of energy in the world, it was also the world's largest consumer of energy. Moreover, fuel was cheap because of the competition among the different energy sources and there had been little interest in developing more efficiency in the use of energy. Research had brought about an increase in the amount of useful energy that could be secured from a ton of coal, but coal, which had been the Nation's chief source of energy at the turn of the century, had been losing ground since 1913 to other sources of energy. The postwar shortage of petroleum caused some concern about the long-term supply of petroleum, and led some to consider conservation. Others, however, preferred tax incentives to encourage exploration, and still others, among them Director Smith of the Geological Survey, the acquisition of foreign oil reserves. Chief Geologist David White, on the other hand, called for more basic research. Petroleum geologists, he believed, could find new domestic fields, but fundamental research was even more vital because the geologic principles controlling the distribution of oil and gas were still known only in part.

In the decade following World War I, engineering was considered more important than science. The expanding population and increasing urbanization of the United States after the war, the development of the automobile industry and the consequent need for good roads, and the demand for hydroelectric power all created problems that the engineering skills of the Survey's topographic and hydraulic engineers could help solve. Other Federal, State, and municipal agencies were willing to pay for these services, and so both the Topographic and Water Resources Branches of the Geological Survey gradually surpassed the Geologic Branch in size of staff and available funds. Both branches became so deeply involved in these cooperative investigations, however, that they were unable to formulate or adhere to any national plan of investigations or surveys. In 1925, Congress passed the Temple Act calling for the completion of the topographic map of the United states in 20 years, but then made it impossible to achieve by forcing the Survey to rely on cooperative funds for the major part of the program. The Water Resources Branch was so burdened with outside demands for its services that it could not undertake major investigations, as of great floods, when opportunities arose. Both branches endeavored to continue some research. The Topographic and the Alaskan Branches both investigated the use of aerial photographs in mapping. In the Water Resources Branch, a small group of ground-water geologists headed by O. E. Meinzer continued the fundamental work that W. C. Mendenhall had begun in the early part of the century and by the end of the 1920's significant results were presented to the American Institute of Mining Engineers and the Society of Economic Geologists. The Section of Hydrology was established in the American Geophysical Union as the American representative of the International Association of Scientific Hydrology.

Although its research effort was circumscribed by limited funds and loss of personnel, the Geologic Branch resumed its long-range investigations as far as possible once the wartime investigations were completed. David White retired as Chief Geologist in 1922 but his successor, Walter C. Mendenhall, had the same view of the necessity of basic research. His was the task of rebuilding the staff after the raids by the oil industry and the universities but his also the opportunity to rebuild it on the basis of his frequently expressed adage that without science to apply there can be no applied science. Much time was given to the compilation of State geologic maps, leading finally to the preparation of the geologic map of the United States. Broad regional stratigraphic studies were carried out, basic research investigations were made in the laboratories, and, after the middle of the decade, mining district studies were increased with the aid of cooperative funds.

By 1922, the mineral industry had begun to readjust to a peacetime basis. Large stocks of metals were reduced, and an increase in iron and steel production created a demand for manganese and other steel-hardening metals. Petroleum production reached a record high although the year had begun with a pessimistic USGS – AAPG statement about the amount of the Nation's reserves. Petroleum production continued to soar and in 1929 exceeded 1 billion barrels. The coal industry, however, experienced the greatest and longest strike in its history in 1922. The coal industry was troubled not only by competition from other forms of energy but also by competition within the industry itself because of striking differences in salaries in southern and northern fields. To end the strike in 1922, Congress established a Coal Commission to investigate the coal industry and study its problems, but once the strike was over took little interest in the commission's findings and recommendations.

By the middle of the decade, the conservation of oil acquired renewed importance. In 1925, the Geological Survey was given a new responsibility for supervision of mineral-leasing activities on the public lands, and its Land Classification Branch was renamed the Conservation Branch. Supervision of mineral-leasing activities had been assigned to the Bureau of Mines after the Mineral Leasing Act became law in 1920. When Herbert Hoover became Secretary of Commerce in 1921, however, he took seriously the responsibility of his department, as expressed in its Organic Act, to help "foster, promote, and develop" commerce and industry and therefore cast a covetous eye on the Bureau of Mines and the Survey's Division of Mineral Resources to help foster, promote, and develop the mining industry. In 1925, he succeeded in obtaining their transfer from Interior to Commerce. Because the public-lands activities had to remain in Interior, the Survey took on a new assignment. At the time of the transfer, there were new requirements in the supervision of leasing activities. In the wake of the Teapot Dome scandal, the Coolidge administration had adopted conservation measures, and Coolidge had established a Federal Oil Conservation Board, with George Otis Smith as chairman of its advisory committee, in December 1924. At the time, however, the rapid increase in oil supply was beginning to weaken the price structure so it may be that the administration's motive for adopting conservation measures was not unmixed.

The postwar expansion of the oil industry from oil famine in 1920 to oil glut in 1930 contributed to a striking development in the geological sciences. David White complained in 1920 that petroleum geology amounted to little more than the application of the methods of stratigraphy, with specialization in structural study, to the discovery of oil pools. Within a few years, however, petroleum geology became a complex science. Micropaleontology and microlithology became adjuncts of petroleum geology, and after core-drilling was introduced for mapping shallow underground structure and for sampling oil sands, subsurface geology became a major element of petroleum geology. The introduction of geophysical methods of exploration in the 1920's was also an important factor in increasing the finding rate of new oil fields. The coming of age of these specializations was marked by the formation of two new professional societies. In 1926, the first steps were taken toward the formation of a Society of Economic Paleontologists and Mineralogists, which became a technical division of the American Association of Petroleum Geologists in 1930. The Society of Exploration Geophysicists was formed in 1931. Neither society was devoted entirely to applied science. In fact, in the first issue of the *Journal of Sedimentary Petrology* in 1931, an editorialist proclaimed subsurface geology to the "one of the most fascinating fields of investigation of all times." Even though it was "pursued with an obvious economic motive, every scrap of the work involved is fundamental geology which gains slowly, but surely, in some place or other from the continued effort to unravel its secrets."

David White seems to have had a hand in many if not all these developments in petroleum geology. As Chief Geologist of the Geological Survey he had initiated some of the Survey's first studies in micropaleontology, and had obtained the assistance of the Coast and Geodetic Survey in making gravity measurements over Damon Mound in Texas, which anticipated the gravity method of exploration. He had also supported efforts to determine a relationship between subsurface temperatures and oil pools and continued to facilitate them as a member and later chairman of the Division of Geology and Geography of the National Research Council. In another unusual investigation for a paleobotanist, he considered the possible use of radioactivity in oil-field location. He was also one of the small group that planned the formation of the Society of Economic Paleontologists and Mineralogists. White was also largely responsible for obtaining grants from John D. Rockefeller and the Universal Oil Products Company for a 5-year cooperative program of geological, paleontological, chemical, and physical research on the origin of oil, administered by a Central Petroleum Committee of the National Research Council. White himself supervised several of the 38 projects funded by this grant.

Basic research, rather than petroleum geology, was White's greatest interest. Mendenhall, who had known him since 1893 when they had spent their first field season in the Appalachian region in M. R. Campbell's party, called him an "intellectual imperialist, engaged in constantly extending the domain of the human mind." When White became chairman of the Division of Geology and Geography of the National Research Council in 1924, several new research committees were set up, among them Committees on the Improvement of Methods in Gravity Measurements, the Measurement of Geologic Time by Atomic Disintegration, the Testing of Isostasy in the Great Basin, Securing Quantitative Data of Geological Processes, Shoreline Investigations, and Obtaining Scientific Data from Commercial Examinations and Explorations, as well as Studies in Petroleum Geology. The Council had no funds to support the research its committees proposed but the U.S. Geological Survey as well as State surveys, universities, and private research institutions began such research whenever their means and staff permitted.

Basic research also came to the fore as metals geologists experienced a sort of renascence in the mid-1920's. Publication of the reports of the Committee on Industrial Preparedness of the American Institute of Mining and Metallurgical Engineers and the Leith Committee on Foreign and Domestic Mining Policy of the Mining and Metallurgical Society in 1925 precipitated new debates on the meaning of "economic" in economic geology. Many held that the lack of progress in economic geology was due to the paucity of basic research, and under White's successor as chairman of the Division of Geology and Geography, Waldemar Lindgren, a Committee on Processes of Ore Deposition was set up.

The National Academy of Sciences also developed a plan to support and promote basic research through a National Research Endowment. A Board of Trustees set up in 1925 under the chairmanship of Secretary of Commerce Herbert Hoover, who had been a member of the Academy since 1922, was unable to secure the needed funds. The plan, however, did bring Hoover to public attention as a proponent of pure science. Three years later, in 1928, Hoover was elected President of the United States. As Secretary of Commerce, he had been involved in the conservation of both water and oil as well as fostering the development of the mineral industry, and so his inauguration on March 4, 1929, one day after the Survey's 50th anniversary, promised new hope for both conservation and Federal science.

Hoover was hardly in office before beginning to take action on conservation. He recognized three urgent problems in the conservation of the public lands: overgrazing, which diminished the value of the lands and imperiled the water supply through the destruction of the natural cover; the best method of reclamation to gain real conservation of water; and the conservation of oil and gas resources. On March 12, 1929, he announced the most complete conservation of Federal oil and followed that with a proposal for an interstate oil compact to regulate production of oil from Government and non-Government lands. In a major piece of conservation legislation, which finally recognized that oil is a migratory mineral that cannot be forced to take heed of the legal divisions and subdivisions of public-land surveys, Congress in 1930 authorized the Government to participate in unit operation and development of single oil pools involving public lands, thus permitting their development with a minimum waste of gas and oil and the elimination of overproduction as the result of offsetting. He ordered planning for river-basin development to begin along the lines of the Colorado River Compact, and appointed a Public Lands Commission to study the problems of the public domain. The Conservation Branch of the Geological Survey, which had been studying the problems of the agricultural lands in cooperation with the Department of Agriculture, was called on to assist the Public Lands Commission. In his first annual address to Congress in December 1929, Hoover called for reorganization of the conservation work of the Federal Government so there could be "proper development and adherence to broad national policies" and a "central point where the searchlight of public opinion may concentrate itself."

Hoover's first budget proposed increased funds for scientific agencies, including $100,000 earmarked for fundamental research in the geological sciences, the first substantial increase in Federal funds for geologic investigations since 1915. In December 1930, he appointed George Otis Smith to the newly reorganized Federal Power Commission and then appointed Walter C. Mendenhall to succeed Smith as Director of the Geological Survey, honoring not only a commitment to appoint the heads of scientific agencies from within the civil service but also a commitment to support basic research.

The depression robbed the Hoover administration of the opportunity to accomplish many of its conservation objectives. Some goals, however, were achieved during the next administration even if by somewhat different methods and with different results than Hoover envisioned. Eventually there was an Interstate Oil Compact to control production, and, in 1937, after a quarter-century of Congressional and Executive investigations, the Bituminous Coal Act finally brought the coal industry under public regulation. The grazing lands were placed under control, although of the Federal Government rather than the States, and part of the Survey's Conservation Branch was spun off to form the nucleus of the Grazing Service. Great dams were built on Western rivers although the power they generated was public rather than private. The conservation work of the Federal Government, however, remained divided, and both the Department of Agriculture and the Department of the Interior jockeyed to become the central point for conservation.

For a time, because of the long process of preparing budgets and appropriating funds, Federal expenditures for scientific research continued to increase despite the depression. The Geological Survey received its largest-ever appropriation for the fiscal year beginning July 1, 1931, some 63 percent more than the appropriation during the last year of the Coolidge administration.

Thereafter, however, Federal funds declined precipitously and continued to decline with but few exceptions during Roosevelt's first and much of his second administration.

The new Roosevelt administration was pro-conservation but took no strong stand on science. Science had become somewhat of a political issue in the waning days of the 1932 presidential election campaign after Hoover declared that progress in the last generation had been due to scientific research and that if the American system was not destroyed and if scientific research was stimulated, future generations would enjoy the same advantages. Some people interpreted the election of Roosevelt as a repudiation of Hoover's scientific policies as well as his economic policies, and even some who realized the importance of scientific research thought research could be postponed and priority given to the economic crisis. Although the administration gave first priority to the state of the national economy, conservation benefited from the legislation of the first 100 days. The Civilian Conservation Corps was established, the Tennessee Valley Authority was set up, and the National Industrial Recovery Act, which included the conservation and development of natural resources among public works, provided $3.3 billion to revive business and industrial activity and reduce unemployment. In July 1933, Secretary of the Interior Ickes was designated Public Works Administrator and promptly set up a National Planning Board to aid in formulating a comprehensive plan for public works. Beginning in mid-August, the Public Works Administration made grants to the Survey for stream-gaging stations, topographic surveys, investigations of ground-water problems, and safety measures on the public lands that by November 1 amounted to more than $3.7 million. By the end of the fiscal year, the total of outside funds from PWA and other agencies as well as cooperative funds amounted to four times the Federal appropriation. Unlike the cooperative and repay funds, the grants from PWA and TVA could be and were used in part to extend the Survey programs of water- and mineral-resources investigations and topographic mapping into new areas and to support research studies such as those of the relation of rainfall to runoff, flood frequency, and photogrammetric methods in mapping. The Federal appropriation for the Geological Survey was not restored to its former level until the fiscal year beginning July 1, 1938, but except for a short period of austerity in 1932 and 1933, Survey work continued to be well funded.

For a time, a Science Advisory Board, set up by President Roosevelt at the end of July 1933 and placed under the jurisdiction of the National Academy of Sciences and the National Research Council, attempted to deal with the problems of Federal science. One of its first efforts was the preparation of a report on science progress that was submitted to Secretary Ickes in mid-September with the declaration that

> **scientific research is an essential element of any far-sighted comprehensive program for planning and improving the national prosperity.**

The Board proposed a $16 million program to be funded by PWA to support research in the natural sciences and their applications. Ickes, however, indicated that although he was personally convinced of the importance of science, PWA funds were available only for construction. That was but the first of many rebuffs of the Science Advisory Board by Secretary Ickes or of conflicts between that Board and the National Planning Board and its variously named successors as they prepared reports with divergent views on programs dealing with the use of natural resources and science. In 1936, the Science Advisory Board was reduced to the status of part of the reorganized Division of Government Relations of the National Research Council. Undoubtedly, part of the friction had developed as the result of the Science Advisory Board's conscientious attempt to present an outside point of view by only rarely including Government scientists, even on subcommittees, whereas the National Resources Board/Committee relied to a great extent on Government experts and declared in a 1939 report that

> **Most well conceived Governmental action, if traced back to its source, will be found to spring from the work of one or many research workers, distributed among the Government offices and laboratories. They must supply the answers which are the tools and the material used in the formulation of sound policies.**

Scientists in the mid-1930's, despite the depression, were living in exciting times. Basic research had regained the standing that some had thought lost forever after World War I. Science in general had awakened to the fact that knowledge cannot be segregated into compartments but is continuous and that the most fruitful fields for research are often in the borderlands, the "no man's land" of science. Geology, which originated as a borderland science, had for some time been actively plowing its borderland fields of chemistry, physics, and biology, but a National Research Council poll in 1936 uncovered so many desirable lines of research that Remsen's statement of 1904 that "no matter in what direction we may look we are aware of great unexplored territories" and Walcott's 1901 statement that "the geologic Alexander will never lack worlds to conquer" were still palpably true. Even the mineral industry, more especially the oil industry, acknowledged that the future lay in "speculative geology" which required "more exact knowledge of geologic history, geologic processes, of stratigraphy and sedimentation."

Government geologists, as always, had basic obligations to the Nation in addition to the pursuit of knowledge. As tensions began to develop in Europe and the Far East, the lessons of World War I were once more reviewed. C. K. Leith and a small group of Washington scientists had kept the concept of strategic and critical minerals alive during the 1920's and 1930's. Leith, as a member of both the Science Advisory Board and the National Resources Board, tried to promote the adoption of a national minerals policy in 1934 and 1935 but without success. The need for a national mapping program was outlined by both the Science Advisory Board and the National Resources Board in 1934. In the mid-1930's, efforts were made to obtain funds for strategic-minerals studies, and Director Mendenhall somberly warned Congress that it was "futile to wait for an emergency and then expect sound and complete information." It was not until June 1939, however, that Congress passed the Strategic Materials Act and not until August 5, less than 1 month before the beginning of World War II in Europe, that Congress appropriated funds for strategic-mineral studies by the Geological Survey and the Bureau of Mines. With the beginning of the war, the third stage of conservation was once more interrupted and basic research projects were once more laid aside.

Chapter 2.
National Welfare and National Efficiency, 1904–1907

The idea that our natural resources were inexhaustible still obtained, and there was as yet no real knowledge of their extent and condition. The relation of the conservation of natural resources to the problems of National welfare and National efficiency had not yet dawned on the public mind.

—Theodore Roosevelt

As the U.S. Geological Survey's silver anniversary approached in 1904, the American Mining Congress, an organization of Western mining men who consistently supported the work of the Survey, was calling for the establishment of a cabinet-level department of mines. The editor of the *Engineering and Mining Journal* was equally enthusiastic about the accomplishments of the Survey in aiding the development of the mineral industry but called instead for greater scope for the Survey's economic geology program and "freedom from the encroachments of the wood and water departments." As it turned out, the editor's fear of the effect of "wood and water" on economic geology was well founded, although it was not the wood and water departments of the Survey that encroached on its economic geology program but the inauguration of a national conservation program with initial emphasis on forests and water.

The beginning of the national conservation program may well be dated by the transmittal to President Roosevelt in March 1904 of the report of the Second Public Lands Commission that dealt extensively with forests and water. Within a year, the management of the forest reserves was transferred from the Department of the Interior to the Department of Agriculture and the Survey yielded its examination of the forest reserves to the Forest Service. Theodore Roosevelt was deeply interested in the conservation movement and considered it one of the most important efforts of his administration, but some of the more conservative members of Congress did not share his enthusiasm. Although they had been persuaded to authorize the forest-reserves transfer, they did not respond to recommendations for water-related legislation and in fact showed their mistrust by two successive cuts in the Survey's appropriation for stream gaging.

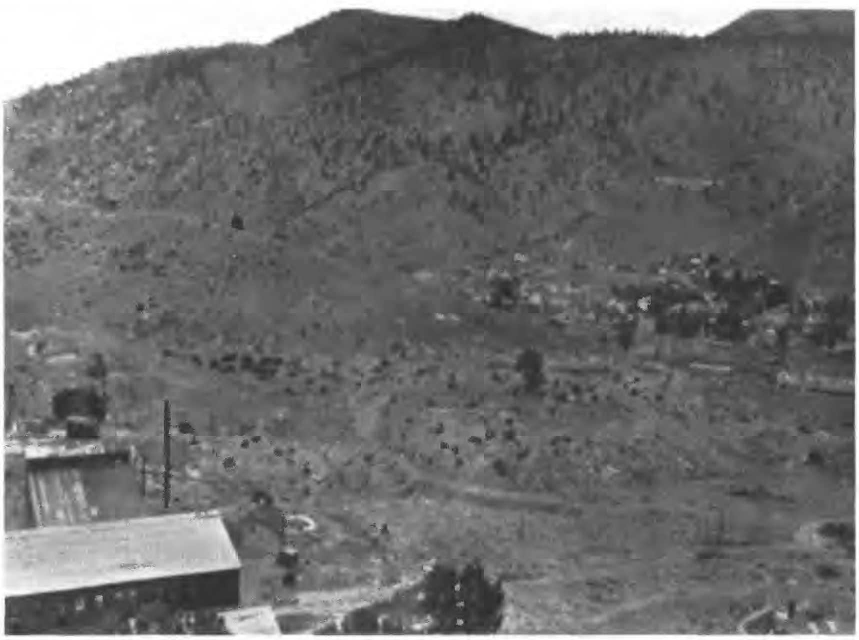
As long as the administration's conservation efforts were confined to forests and water, only the water-resources program of the Survey was vulnerable. In 1906, however, Roosevelt turned his attention to the mineral lands, and the withdrawal of millions of acres of supposed coal land in the West had an immediate impact on the Survey's geologic program. By that time, the mineral industry had begun to recruit economic geologists from the Survey so that the very success of economic geology was proving a handicap to its continued progress. Thus, in the spring of 1907, a new Secretary of the Interior, committed to the conservation movement, and a new Director, vitally interested in a business policy for the public domain, were able to set the Survey on a new course in which, for a time, practical geology outweighed research.

In 1904, no prophet foresaw this change. Scientists looked forward to new and challenging research objectives. C. R. Van Hise and George Becker, who assessed the "present problems" of geology and geophysics at the International Congress of Arts and Sciences in St. Louis that year, called for some very fundamental research. Van Hise defined geology as the science treating of the energy and substance of the Earth and its principal problem as the reduction of the science to order under the principles of physics and chemistry. Becker challenged physicists to undertake studies and enumerated a long list of problems that needed investigation. From the geological standpoint, the distribution of density within the Earth was one of the most important questions. Others were the age of the Earth and the solar system, the origin of the Moon, the outlines of ocean basins, the chief tectonic lines of the globe, seismology ("a vast subject in itself, but one almost totally lacking in theoretical foundation"), causes of earthquakes, origin and mechanism of volcanoes, the physics of magmatic solution, origin of petroleum and ore deposits, mathematics of erosion, geological climates and the origin of glaciation, and the polarity of lavas. Simon Newcomb, who regretted the establishment of the Carnegie Institution of Washington because its granting of funds might prejudice the selection of research projects, said

> **our nation needs the services of a body of men who shall be engaged in work of a distinctively different type from that carried on in our traditional institutions of learning, a work which belongs peculiarly to the present and future, because it was not possible in the past.**

As a Federal agency that depended on Congress for annual appropriations for its work, the Geological Survey had to devote most of its efforts to more practical "problems." Its work nonetheless encompassed a broad range of investigations from applied science and engineering to fundamental research and from paleontology to experimental physics.

The Geologic Branch, the oldest and largest of the three Survey's field branches, dominated the Survey in 1904. It was organized in four divisions: Geology and Paleontology, under C. W. Hayes; Alaskan Mineral Resources, under A. H. Brooks, who had begun his Survey career as Hayes' assistant; Mining and Mineral Resources, under David T. Day, who, like Hayes, had received a Ph.D. from Johns Hopkins in the 1880's; and Chemical and Physical Research, under G. F. Becker, who had been appointed to the Survey in July



Colorado, the leading mining State in the West, had been the scene of many mining-district studies in the Survey's first quarter-century, the most notable being S. F. Emmons' classic study of the Leadville district from which he had developed the idea of structural control of ore deposits and the replacement theory of ore genesis. In 1904, J. E. Spurr and G. H. Garrey began a study of a section at the northeast end of the great mineral belt that included the area where gold had been discovered in 1859, precipitating the second great rush of gold-seekers to the West. (The old placer diggings near the point where gold was discovered are shown in the foreground of the photograph.) Spurr and Garrey concluded that the greater portion of the gold, silver, and lead deposits of Colorado were of magmatic origin and that, in fact, magmatic processes were by far the most important mode of formation of ores. (From J. E. Spurr and G. H. Garrey, 1908.)

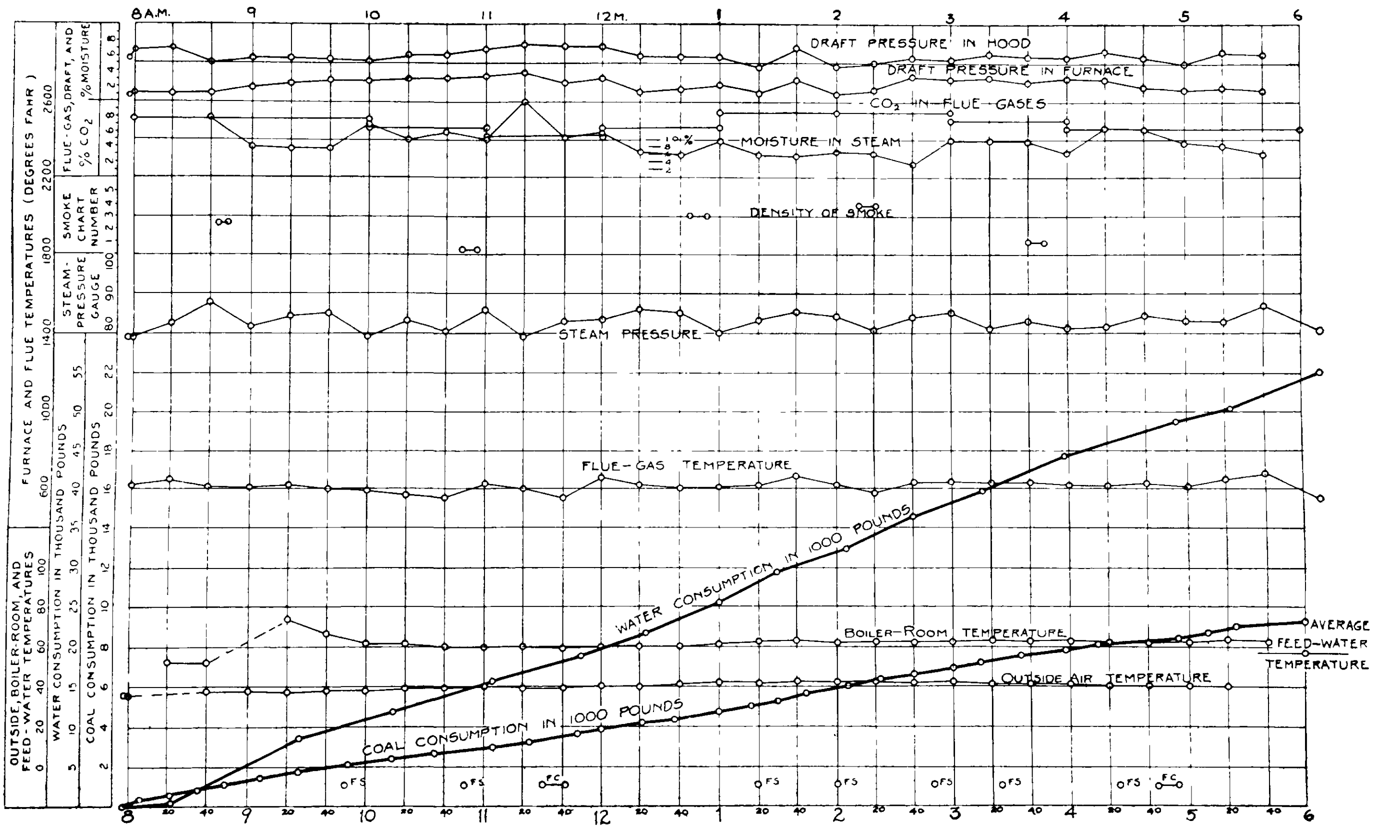
1879. Under the reorganization plan of 1900 as modified in 1902, the Division of Geology and Paleontology, the largest of the four, consisted of the Sections of Areal Geology, Precambrian and Metamorphic Geology, Pleistocene Geology, Paleontology, Economic Geology of Metalliferous Deposits, and Economic Geology of Nonmetalliferous Deposits, headed by Bailey Willis, C. R. Van Hise, T. C. Chamberlin, T. W. Stanton, S. F. Emmons, and Hayes. In the fall of 1903, Van Hise had become president of the University of Wisconsin, and as he was no longer able to spend long periods in Washington, the Section of Precambrian and Metamorphic Geology was discontinued as a formal organization. In the spring of 1904, the Section of Pleistocene Geology, which Chamberlin had headed in addition to his responsibilities at the University of Chicago, was replaced by a Section of Physiographic and Glacial Geology, under G. K. Gilbert, which would consider all natural agencies by which the surface of the Earth is modified rather than the single agency of ice. M. R. Campbell, who had also begun his Survey career in the field with Hayes, replaced Gilbert as Chairman of the Geologic Names Committee. In addition to these formal changes in organization, some of the young men who had shown a capacity for handling large problems and for coordinating the work of others were given supervisory authority over groups of parties based on natural classification of the work or geographic location. Thus, when Hayes found that his administrative duties as Geologist-in-charge of both the Division of Geology and the Nonmetals Section left him no time for field work, he delegated to E. C. Eckel responsibility for all nonmetals investigations except those in the geology of fuels.

The Metals Section was the most coveted assignment for Survey geologists in 1904 although its chief, S. F. Emmons, was probably the Survey's hardest taskmaster. Emmons had established as a basic principle that the general objective of the work was the determination of the laws that govern the formation of deposits of the useful minerals and of the rock formations in which they were most likely to be found. This was an objective that could be attained only by long and careful study of many and varied deposits, the most intensive of them in old districts where the mining development had been greatest. Of almost equal importance was the collection of accurate statistics of the Nation's mineral production and their analysis from the geologic standpoint. During the 1904 field season, Emmons himself completed a resurvey of the Leadville district in Colorado where he had done his first Survey work in 1879. Waldemar Lindgren, following the tradition begun by Clarence King and Emmons, prepared discussions of gold and silver production from the geologic standpoint for the annual Mineral Resources volume. J. E. Spurr, who had first worked with Emmons in 1894, directed two parties mapping areal and economic geology in Clear Creek and Gilpin Counties in Colorado and then made a reconnaissance of the newly important Tonopah and Goldfield districts in Nevada. W. H. Weed, who had been drawn into economic work in the mid-1890's, made a reconnaissance study of the copper deposits of the Appalachian region and also prepared a report on the copper deposits of the United States from the geologic standpoint. F. L. Ransome, who had joined the Metals Section in 1897, began the economic survey of the Coeur d'Alene district in Idaho. Ransome's contemporaries Arthur Spencer, after a year in Alaska, began a study of the zinc deposits of Sterling Hill and Franklin Furnace, New Jersey, and John D. Irving, who had defected part-time to Lehigh University, made economic investigations in the San Juan area of Colorado incidental to the areal mapping, aided by W. H. Emmons, the Metals Section's most recent acquisition. Of the still younger members of the section, J. M. Boutwell completed an investigation at Park City in Utah and began a study of the mineral deposits of that State, H. F. Bain continued his study of the lead and zinc deposits of the Mississippi Valley and prepared a report on the lead and zinc deposits of the United States. Another very recent acquisition, L. C. Graton, made a reconnaissance of the tin deposits of North and South Carolina under Lindgren's direction.

Investigations in the Section of Nonmetalliferous Deposits were for the most part carried on in conjunction with areal mapping. Hayes insisted on detail and accuracy in mapping, and maps prepared in the Nonmetals Section had already proved to be of value to both coal and oil operators in the Appalachian area, then the leading source of both commodities. M. R. Campbell, for example, had depicted the extent, position, and structure of coal beds so exactly in geologic folios that the operators were able to introduce more economical methods of mining. W. T. Griswold's determination of the underground structure on which the accumulation of oil and gas depended had been tested by drilling and found of value in the development of oil and gas fields. They continued such work in the Appalachian area in 1904; in addition, J. A. Taff worked in Indian Territory, where he divided his time between mapping coal fields and preparing detailed maps and descriptions for use of the Secretary of the Interior in selling the lands, thus classifying the lands in advance of disposition. Other oil-field investigations were made by F. C. Schrader, who began mapping the Independence quadrangle in Kansas, which included the southwestward extension of the Iola field, and by N. M. Fenneman, who reexamined the Gulf Coast oil fields where development had been especially active since the discovery of Spindletop in 1901. E. C. Eckel supervised investigations related to iron and structural materials, spending some time in northeast Texas in connection with a planned report on the iron industry of the United States, directed E. F. Burchard, a new geologic aid, in his study of iron deposits in Alabama, and continued work on the report on cement resources. Other work was undertaken by C. K. Leith, who made a reconnaissance of the iron deposits in the Rocky Mountain and Pacific States, and by T. N. Dale, who continued studies of slate, granite, and clay in the New England States.

Investigations of mineral resources in Alaska were expanded in the summer of 1904. In previous years, much of the Survey's attention had been devoted to investigations of gold placers, which were the largest producers of wealth in the territory. In 1904, C. W. Wright and F. E. Wright continued the reconnaissance investigations in southeastern Alaska begun by Arthur Spencer, L. M. Prindle and F. L. Hess examined the Fairbanks and Ramparts placers and made reconnaissance studies in the Yukon-Tanana region, and Fred Moffit investigated the gold placers of the Kenai Peninsula. In addition, the Survey began some fuels investigations in the territory. The gold discoveries of the late 1890's had stimulated interest in other mineral resources, and in 1900 Congress had extended the coal-land laws to Alaska. Little coal land was sold, however, for the coal-land laws provided for sales in governmental subdivisions and Alaska was still largely unsurveyed. In 1904, therefore, Congress provided for coal locations to be set off in rectangular tracts of 40, 80, or 160 acres, with north and south boundaries run according to true meridian and then described with reference to natural or permanent artificial monuments. As private interests were already claiming coal lands, the Survey sent George C. Martin to study the coal and oil fields of the Cook Inlet region and A. J. Collier to investigate the coal fields of the Cape Lisburne area in extreme northwestern Alaska north of the Arctic Circle. Topographic parties in the summer of 1904 mapped in the Yukon-Tanana region, the Cook Inlet region, and the Seward Peninsula in preparation for future geologic studies.

Chester Purington and Sidney Paige made a very practical investigation of the costs and methods of placer mining in Alaska for comparison with those in the Yukon Territory and British Columbia. They found that in Alaska operations requiring the installation of expensive plants were often undertaken



The study of nonmetalliferous deposits became more important around the turn of the century. In 1898, Director Walcott had urged that the coals and cokes of the United States be thoroughly studied by chemical investigations and determinations of calorific values, including practical tests, so that the fuels might be used with the greatest efficiency. Work was begun at the Louisiana Purchase Exposition in 1904, where the practical tests were spectacularly successful in demonstrating improvements in the use of solid fuels. The illustration shows the graphic log sheet of boiler tests of an Indian Territory coal. (From E. W. Parker, J. A. Holmes, and M. R. Campbell, 1906.)

before the ground had been adequately sampled, and although methods of mining and conveying the gold-bearing materials often left much to be desired from the standpoint of economy most were developing along favorable lines, but the gold-washing and gold-saving appliances in use were inexcusably crude and inefficient in many places. The most significant difference between the Canadian and Alaskan fields, however, was the complete lack of adequate means of transportation in Alaska in contrast to the exceptionally good roads in Canada. Purington and Paige concluded that much could be done to increase the output and lower the cost of mining in Alaska by the judicious building of good roads.

A. H. Brooks, the chief of the Alaskan division, was quick to point out that full development of all Alaskan resources depended on the improvement of transportation facilities. Construction of roads was important, but economical transportation for long distances could only be achieved by the construction of railroads. Several bills for construction of railroads in Alaska had already been filed in Congress but none had been acted on. Brooks suggested that the proper location of a railway should be determined by topography and the distribution of mineral resources, and that for an appropriation of about $200,000 the Survey could in 2 years make reconnaissance surveys of the suggested routes.

In addition to its usual field activities in economic geology, the Survey had agreed to organize the department of mining and metallurgy at the Louisiana Purchase Exposition in St. Louis, which celebrated the centennial of the Nation's first acquisition of western territory, and had appointed Joseph Austin Holmes, the State Geologist of North Carolina, to direct it. With the knowledge of what had proved most effective at earlier expositions, the Survey planned to use the exhibit as a sort of comprehensive publication showing the mineral products of the United States and the geologic conditions on which the minerals depended.

Originally, the Survey planned that its own contribution to the exposition would be a series of charts illustrating the origin of ore deposits, but then it was realized that the exhibit offered an opportunity to demonstrate the value of more comprehensive investigations of coal and coke, which it had been proposing for several years. A special appropriation of $60,000 was therefore requested "for continuing and enlarging the work of the Geological Survey in examining, analyzing, and testing of coals and lignites of the United States in order to determine their fuel values." The appropriation was proposed to the Senate by Senator Stephen B. Elkins of the Committee on the Geological Survey in January 1904, and in February 1904 Congress approved as part of the Urgent Deficiency bill an appropriation of $30,000 for analyzing and testing coals and lignites "to determine their fuel values and the most economic method for their utilization for different purposes" with the stipulation that all testing machinery and all coals and lignites to be tested be contributed without charge to the Government. Director Walcott immediately protested that $60,000 was the absolute minimum required to do the work, and another appropriation of $30,000 was included in the General Deficiency Act approved on April 27, 1904.

To direct the fuels-testing program, Walcott reverted to one of his favorite administrative procedures and named a committee of Edward W. Parker of the Division of Mining and Mineral Resources as chairman, M. R. Campbell of the Division of Geology, and J. A. Holmes. Campbell spent most of the summer visiting coal fields in Alabama, Arkansas, Kansas, Illinois, Missouri, North Dakota, New Mexico, and Texas, in connection with his duties as a member of the committee, incidentally gaining valuable information for use in planning future work, particularly in connection with the low-grade coals of the West, while Parker and Holmes dealt with the problems of setting up the plant.

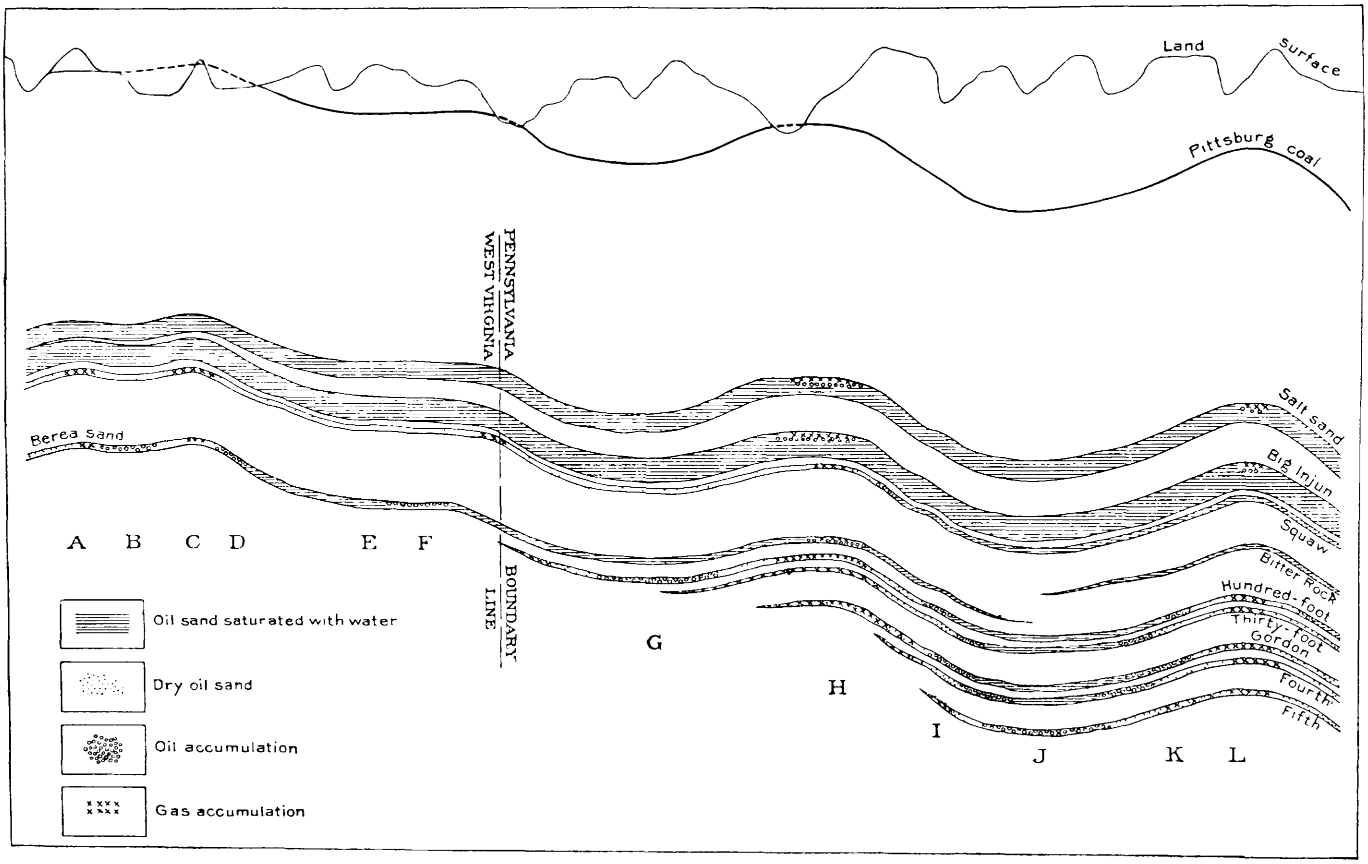
The coal-testing plant did not begin operations until the first of September 1904, delayed by the necessity of assembling and constructing the equipment that could be obtained free of charge as the law required and by the strike at the plant where some of the operating and conveying apparatus was purchased. Moreover, buildings had to be constructed—a boiler and engine house, a storage and washery building, and two buildings for briquetting machines and equipment—and a chemical laboratory installed in the Metal Pavilion, a short distance away.

The tests began to yield significant data almost immediately. In the steam-testing division under Professor L. P. Breckenridge of the University of Illinois, it was quickly learned that the steam-producing capacity of some coals could be improved by washing. In the gas-producer tests directed by Professor Robert H. Fernald of Washington University at St. Louis, it was learned that most American bituminous coals and lignites could be used as a source of power in a gas-producer plant and were in fact more efficient in a gas-producer plant than in a steam-boiler plant. Some of the lignites from North Dakota and Texas were found to have unexpectedly high power-producing qualities. The division headed by Dr. Joseph Hyde Pratt of the University of North Carolina found that some coals and the slack produced in mining could be briquetted on a commercial basis. The chemists under Professor N. W. Lord of Ohio State University analyzed the coals and lignites, using methods recommended by a committee of the American Chemical Society for correlation with other data in the hope of developing a classification of coal.

The annual *Contributions to Economic Geology*, inaugurated by Emmons and Hayes in 1903 to meet the growing demand from the mineral industry for prompt publication of Survey work, had in just 2 short years proved so successful that it was necessary to issue two volumes for 1904, one on the progress of investigations of mineral resources in Alaska, the other, of more than 600 pages, on investigations in the States and Territories. In addition, Survey and non-Survey economic geologists began making plans for a new journal that would publish papers dealing "with the application of the broad principles of geology to mineral deposits of economic value, with the scientific description of such deposits and particularly with the chemical, physical, and structural problems bearing on their genesis." In the first issue, published in 1905, the editors, among whom were J. D. Irving, Waldemar Lindgren, F. L. Ransome, M. R. Campbell, and C. K. Leith, pointed out that it was "inevitable" that some would "decry as mere luxuries of speculation all endeavors to solve the scientific problems which bear upon the practical difficulties of mining" although they thought, or more likely, hoped that their number was growing smaller.

The work of the remaining parts of the Geologic Branch was presumably less economically oriented although in fact the economic element turned up in unexpected places. In the Section of Paleontology, investigations literally ran the gamut from pure paleontology to economic geology, from W. H. Dall's studies of the marine Tertiary fauna of the Pacific Coast to R. S. Bassler's studies of the cement resources of the Valley of Virginia. Some paleontologists worked in the field with geologic parties: T. W. Stanton went to Alaska to aid George Martin in the study of coal and oil areas, and E. O. Ulrich assisted several geologists in their mapping projects in the Midcontinent region. Others worked independently on stratigraphic problems, as for example, David White in the Appalachian region. In the new Section of Physiographic and Glacial Geology, G. K. Gilbert continued his studies of glacial erosion and the terrace systems in the higher parts of the Sierra Nevada and also visited points on the shores of Lakes Huron, Michigan, and Superior in connection with a proposed investigation of modern earth movements in the Great Lakes region. W. C. Alden, Frank Leverett, and F. B. Taylor investigated glacial phenomena in Wisconsin and Michigan, while W. W. Atwood looked at the glacial phenomena in the Uinta Mountains. Areal geologic mapping was underway in all parts of the country. George Otis Smith was given general supervision over geologic surveys in New England and the crystalline belt of New Jersey, a field of responsibility last occupied by Raphael Pumpelly in 1892. In connection with his new assignment, Smith took up once more the study of critical areas in the Taconic and Green Mountains. To the south, Florence Bascom mapped in New Jersey, George Stose in West Virginia, and Arthur Keith and Laurence LaForge in the southern Appalachians. In the Western States, Whitman Cross continued mapping in the San Juan region of Colorado, and J. S. Diller spent most of the 1904 field season completing the study of the stratigraphy of the Taylorsville region, California, begun several years earlier with Alpheus Hyatt. C. R. Van Hise and C. K. Leith represented the Survey in a joint United States-Canadian commission to study the nomenclature and correlation of Precambrian formations in the Lake Superior region and spent 6 weeks in the field with Robert Bell and F. D. Adams of the Canadian Survey, A. C. Lane, the State Geologist of Michigan, and W. G. Miller, the Provincial Geologist of Ontario. The commission, with Lane dissenting in part, recommended that the Precambrian be divided into Keeweenawan, Huronian, Keewatin, and Laurentian, with an eruptive contact between the Keewatin and Laurentian and unconformities between the other divisions.

The Division of Physical and Chemical Research also had a wide range of investigations underway in addition to routine analyses. George Becker concentrated on investigations of elasticity, one of his "present problems" of geophysics, while A. L. Day and E. T. Allen extended their researches on the thermal properties of rock-forming minerals to the ferromagnesian silicates and prepared to make investigations in which artifical minerals could be dealt with under high pressure as well as high temperature. W. T. Schaller continued crystallographic studies of natural and artificial minerals and E. C. Sullivan his



No theory had yet been proposed that was considered adequate to account for the formation and movement of petroleum although the anticlinal theory of accumulation was widely accepted. However, W. T. Griswold and M. J. Munn concluded from a detailed study of part of the central Appalachian oil field, including preparation of a contour map of the oil sand by combining surface and subsurface data, that petroleum accumulated in anticlines if the rocks were porous and completely saturated but accumulated at the upper limit of the saturated area in rocks partly filled with water and at the bottom of synclines, or the lowest point in a porous medium, if the rocks were dry. (From W. T. Griswold and M. J. Munn, 1907.)

research on the secondary enrichment of copper ores. W. F. Hillebrand was called on to act as adviser in the investigation of coals and undertook a special investigation of his own on moisture in coals.

F. H. Newell directed the work of both the Hydrologic Branch, with its 46 employees, and the Reclamation Service, which had 187 employees. The Hydrographic Branch was organized in a Division of Hydrography subdivided into districts, and Divisions of Eastern Hydrology under M. L. Fuller, Western Hydrology under N. H. Darton, and Hydro-economics under M. O. Leighton. The work of the Hydrographic Branch proper ranged from pure geology to pure engineering, merging with the work of the Geologic Branch at one end and the Reclamation Service at the other. At the geologic end of the spectrum, the Division of Hydrology and the Division of Geology jointly supported inauguration of a plan devised by Arthur Veatch, for collecting and preserving well samples, in the Eastern Section of Hydrology. It was not possible to place observers at all wells, thus success depended on the cooperation of the drillers, and in general such cooperation could be expected only when the driller received some benefit. Veatch therefore made arrangements to answer any questions promptly and to interpret the records on request, in return for which the driller would furnish written records of his wells and samples of the materials penetrated. This simple plan proved both convenient and effective. Veatch himself prepared a report on the fluctuations of wells on Long Island, and Professor C. S. Slichter compiled the results of his field experiments on the rate of movement of underground waters and began preparation of a new and enlarged edition of "The Motions of Underground Waters" for which there was a continuing demand. Two useful publications were prepared in the Eastern Section: M. L. Fuller completed compilation of a bibliography and index of publications on underground waters and D. W. Johnson prepared the first comprehensive summary in the U.S. on the "Relation of the Law to

Underground Waters'' to meet the rapidly increasing demand for information and to assist efforts in several States to enact laws governing the use of such waters. In the Western Section of Hydrology, N. H. Darton, geologist-in-charge, was assisted by W. C. Mendenhall, C. A. Fisher, W. T. Lee, G. B. Richardson, and C. E. Siebenthal as well as several professors of geology who devoted part of their time to the work. Field work was underway in 10 States and Territories. Darton spent several weeks around Belle Fourche, South Dakota, where there was much interest in ground-water resources owing to the extensive settlement expected when the irrigation works of the Reclamation Service were put into operation, and continued work in the Bighorn Mountains of Wyoming and the Arkansas Valley in Colorado. Mendenhall had several investigations underway in southern California. Of the younger men, Lee studied the Colorado River valley from the mouth of the Grand Canyon to Yuma and also made a reconnaissance of Owens Valley, Fisher and Siebenthal carried on investigations in Colorado and Wyoming, and Richardson spent the summer of 1904 studying the ground-water resources of the Salt Lake Valley in Utah.

Investigations in the Division of Hydro-economics were partly scientific, partly practical, though somewhat weighted toward the latter. M. O. Leighton investigated the pollution of Lake Champlain, and R. B. Dole began a study of the character of the ground and surface waters of Minnesota, in cooperation with the Minnesota Board of Health, with special reference to their availability for use as municipal and industrial supplies. Scientists from the Survey and the Bureau of Forestry and the Bureau of Fisheries began an investigation of the drainage basin of the Potomac River that included a complete reconnaissance of the drainage area for sources of pollution, a hydrographic study of the amount of water flowing in the Potomac and its various tributaries, a study of the relation of soils and forest cover to quality and quantity of surface water in the basin, and a determination of the effect of some industrial waste on fishes. The Survey and the Bureau of Chemistry of the Department of Agriculture also carried on a joint investigation of the character of spring waters that had been placed on the market with considerable advertising fanfare.

Studies of nonmetalliferous deposits were extended to the geology of structural materials as new construction materials came into use. Slate was studied because both the geologic structure and mineralogical composition were of importance in its commercial use: the cost of production and strength depending on the structure, the durability and freedom from staining on the composition. Slate is so fine-grained, however, that it had to be studied in thin section under a microscope in order to distinguish the constituent particles. The illustration shows a thin section of a black roofing slate. (From T. N. Dale, 1906.)

At the engineering end of the spectrum, the Division of Hydrography made cooperative arrangements with eight States and increased the number of river stations to 754. N. C. Grover moved to Washington, replacing E. G. Paul as district engineer and also acting as Assistant Chief Hydrographer. H. K. Barrows succeeded Grover in the New England district and its headquarters were moved from Maine to Boston, Massachusetts. The Western Section of Hydrography was further subdivided so there were nine districts, seven of them coextensive with States, one comprising Colorado, Kansas, Nebraska, South Dakota, Wyoming and parts of New Mexico, Oklahoma, and Indian Territory, and one including the remaining parts of New Mexico, Oklahoma, and Indian Territory. The Reclamation Service was ready to move into the construction phase. The Board of Engineers had passed on all plans for the Shoshone project in Wyoming, and the Secretary of the Interior had set aside \$2¼ million for construction. Proposals for work were being received or advertisements for bids being prepared for several other projects. The Salt River project in Arizona, however, was running into special problems; the area was so inaccessible that freight rates were prohibitive and arrangements had to be made to manufacture bricks, lime, and cement on the site.

Unlike the Geologic and Hydrographic Branches, the Topographic Branch presented more of a dichotomy than a spectrum of work. The Branch had been reorganized in 1903 into two divisions, a Division of Topography and a Division of Geography and Forestry. The Division of Topography was further divided into Sections of Eastern Topography, Western Topography, Triangulation, and Inspection. The organization had been tentatively set up with R. U. Goode, one of Walcott's right-hand men, in charge of the Section of Western

Topography, and also chairman of the Topographic Committee, which was the administrative head of the Topographic Branch and of the Division of Topography, and Henry Gannett as head of the Division of Forestry and Geography. Goode was probably slated to become head of the Topographic Branch, but the plan became unworkable when Goode died suddenly. Instead, a rather involved organization was devised with two divisions, Eastern Topography under H. M. Wilson and Western Topography under E. M. Douglas, and three sections, Triangulation and Computing, Inspection of Topographic Surveying and Mapping, and Instruments and Topographic Records, which served both divisions. The Director again became Chairman of the Topographic Committee. The Eastern Division mapped in 22 of its 26 States a total of 18,121 square miles, more than 80 percent for publication at 1:62,500. More than half the mapping was done in the four States of New York, Pennsylvania, Ohio, and West Virginia, which had supplied $72,800 in cooperative funds. The Western Division mapped in 11 States and Territories a total of only 8,729 square miles, including 3,028 square miles in national forests at a scale of 1:125,000. Of the remaining area, a little more than 70 percent was mapped at the mile-to-the-inch scale. The record of mapping in the Eastern Division was comparable to that in 1903 but the area mapped in the Western Division was considerably less.

The year 1904 had been a highly successful one for President Roosevelt as well as the Geological Survey. The Panama Canal was finally underway; on February 29 he had appointed a 7-man commission to take charge of its construction and on May 4 the canal strip was legally transferred to the United States. On March 14, the Supreme Court had ruled in favor of the administration case in Northern Securities v. United States, the first of more than 30 antitrust actions begun by the administration, and the Sherman Antitrust Act had been revived. Then on November 8, Theodore Roosevelt was elected President in his own right. On December 6, when European powers threatened to intervene in the Caribbean to collect debts owed by the Dominican Republic, he asserted the right of the United States to exercise international police powers in the Western Hemisphere when forced to do so by international conflicts, extending the Monroe Doctrine from prohibition of intervention by European powers to the right of intervention by the United States. He followed that with an agreement between the United States and the Dominican Republic giving the United States charge of debt payments and customs finances of the Dominican Republic.

In his annual message to Congress in December, Roosevelt discussed the forest reserves at length and urged Congress to transfer their management to the Department of Agriculture. He recommended that Congress take several actions with regard to Alaska: to provide it with a delegate in Congress, to aid it in construction of needed roads, and to consider an Alaskan railway. He also spoke of economy:

> The enlargement of scope of the functions of the National Government required by our development as a nation involves, of course, increase of expense; and the period of prosperity through which this country is passing justifies expenditures for permanent improvements far greater than would be wise in hard times. Battleships and forts, public buildings, and improved waterways are investments which should be made when we have money; but abundant revenues and a large surplus always invite extravagance, and constant care should be taken to guard against unnecessary increase of the ordinary expenses of government.

The Survey's request for appropriations for the year beginning July 1, 1905, was prepared before the fuels-testing plant went into full operation and only two small increases were requested: $10,000 for skilled laborers and $25,000 for geological surveys to investigate iron ores and fuel resources and to extend mapping in mining regions. The total value of mineral production of the United States in 1904 had again exceeded $1 billion, but there had been a decline of more than 9 percent from the preceding year, almost all of it in the value of coal and iron on which industrial development was based. The fuel-testing plant had been thought of primarily as a demonstration of what could be done, but when the results proved so significant a deficiency appropriation of $25,000 was requested late in November to continue the work after the close of the exposition, and an additional item of $202,000 for fuel testing was added to the request for funds for the next fiscal year.

In bringing the request for the deficiency appropriation before the House in early December, the chairman of the Appropriations Committee, James Hemenway of Indiana, said

> **This work has developed so rapidly and it has been ascertained that it is of such great value to the Government that great pressure has been brought to bear to continue the work until March 4 next, and then, if Congress deems it wise, to continue it for another year. * * * Our coal interests over the country did not wake up to the fact that these tests were of such great importance until a short time ago, and now they are demanding more of this work than the gentlemen in charge have anticipated. It is claimed that discoveries as to lignites will save the country west of the Mississippi River large sums of money. I think on the whole it is one of the best pieces of work that the Government ever entered into.**

Support was bipartisan. Oscar Underwood of Alabama, well armed with technical facts, also spoke of the importance of the experiments, concluding, to great applause,

> **I think these experiments ought to be continued, and continued to the extent that all the coal fields in the United States that desire to have the benefit of the experiment may have it.**

The deficiency appropriation was passed very quickly by both House and Senate and approved by the President.

Another new item was added to the request for appropriations on December 27—$7,500 for structural-materials testing. The American Portland Cement Manufacturers had done some materials testing at the St. Louis exposition as part of its cement exhibit, using equipment and methods proposed by

Metals remained of prime interest in Alaska, but in the summer of 1904 a Survey geologist went north of the Arctic Circle to appraise the coal fields at Cape Lisburne as a possible source of coal for use at the Nome gold mines. The deposits had been known for many years and had been used by ships plying these northern waters, but they were accessible only by sea and only from July to October. (From A. J. Collier, 1906.)

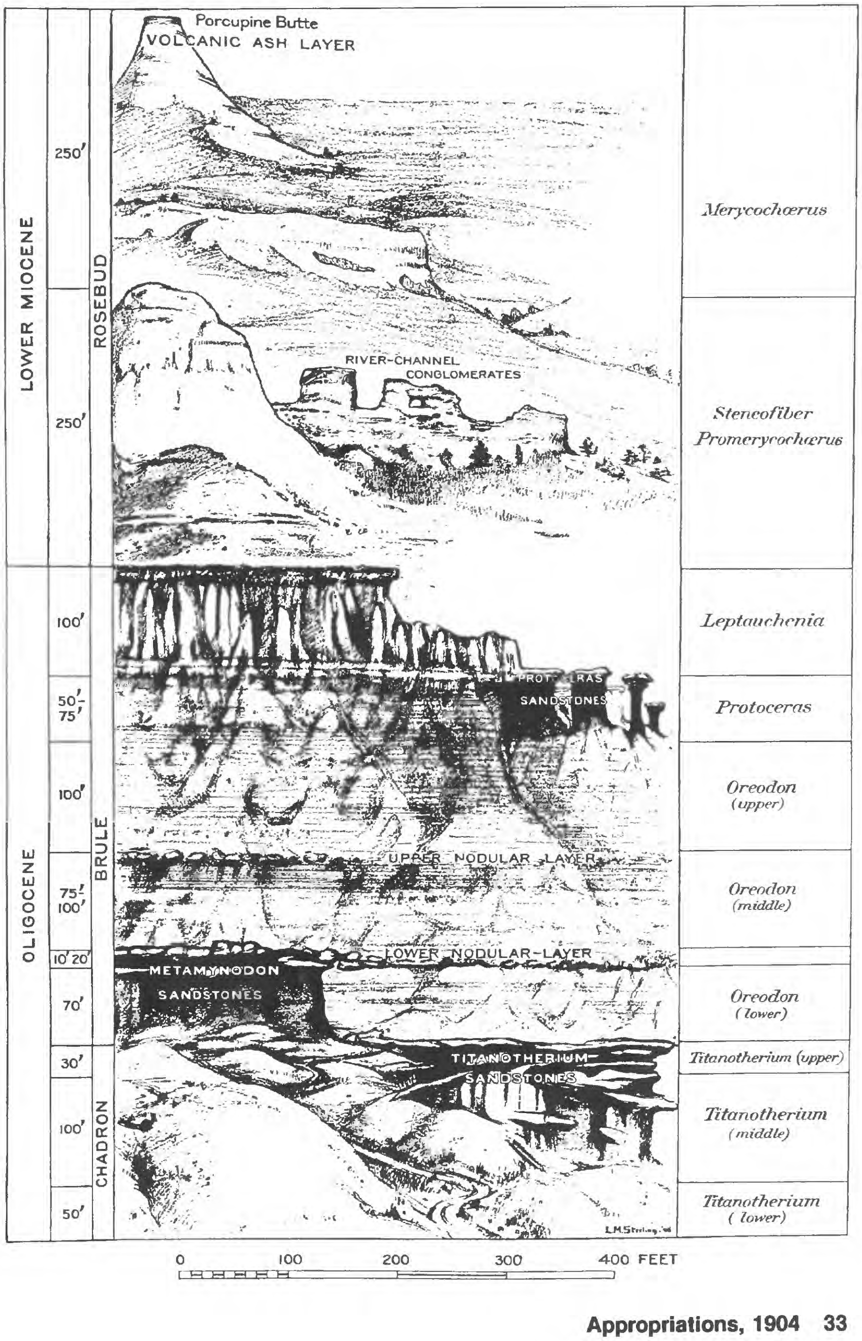
the special committee of the American Society of Civil Engineers. The exhibit building itself served as a working illustration of reinforced-concrete construction until it was completed in September, and for the remaining months of the exposition the laboratory showed the proper methods of testing cement and investigated the value of some sands, gravels, and broken stones in cement mortars and concrete used in some of the principal cities of the country. The valuable results obtained in the laboratory and the great need for more reliable information on structural materials suggested that such investigations should be continued. As Director Walcott pointed out in his request for funds

> **The large public works now being entered upon by the Government, especially the irrigation works of the West and the Panama Canal, call for the solution of new and important problems which relate not only to the use of these raw materials, but also to the most economical and efficient methods of utilizing additional manufactured products. And the solution of these problems is also a wider field, affecting, as it does, the use of building materials in all parts of the country.**

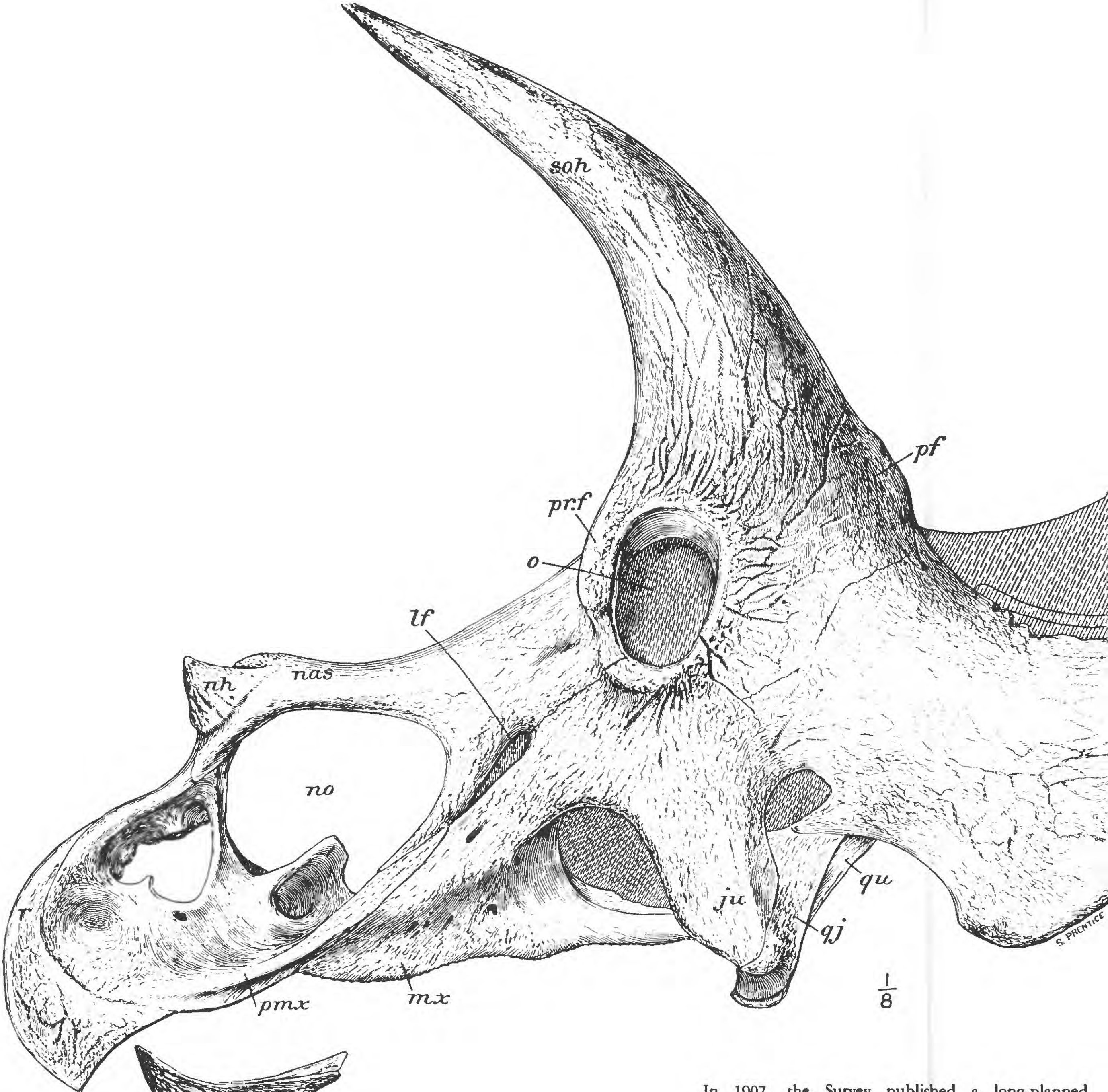
Walcott made it clear that there was no intent to make either the fuel testing or structural-materials testing a permanent part of the Survey. In particular, he said of the fuel testing "It is the purpose of the Survey to push this work to completion as rapidly as possible. But in view of the complexity of the problems to be solved and the magnitude of the financial interests involved, it is necessary that every part of the work be done with the greatest possible care. The estimate of expenses has been reduced to the lowest limit consistent with these conditions."

When the sundry civil expenses bill was passed, the Survey received not only the funds for the new programs but even more than it had asked for ongoing programs. The chief beneficiary was the Topographic Branch, whose appropriation was increased from $300,000 to $350,000. As soon as the clerk of the House finished reading "for topographic surveys, $300,000," William Adamson of Georgia proposed the increase to $350,000 and sent to the clerk's desk a memorial, in the form of a letter to the Speaker, from more than 20 State and Territorial geologists and other officials asking for increased support for topographic surveys, which could not be done so well by the States as by the Federal survey. The Secretary of the Interior and the Director, Adamson thought, had followed the President's request and had not asked for increased appropriations, but this demand came not from Washington but from the people. F. H. Gillett of Massachusetts, always wary of increasing Federal expenditures, suggested that rather than increase the Survey appropriation, the Survey demand money from the States. The chairman of the Appropriations Committee protested that the Democrats were always calling for economy, yet in 5 years the appropriation for the Geological Survey had been increased by $498,000, the Director had been given every dollar he asked for, and now the Democrats wanted to go him one better. The minority leader, John S. Williams of Mississippi, accepted the challenge and retorted that if the Republicans wanted to practice economy they could stop their "miserable oriental colonistic foolishness" and interfering in the affairs of Spanish-American republics; $498,000 was only one-tenth the price of a battleship and one-half the cost of keeping a regiment of soldiers on a war footing. The House then voted to increase the appropriation.

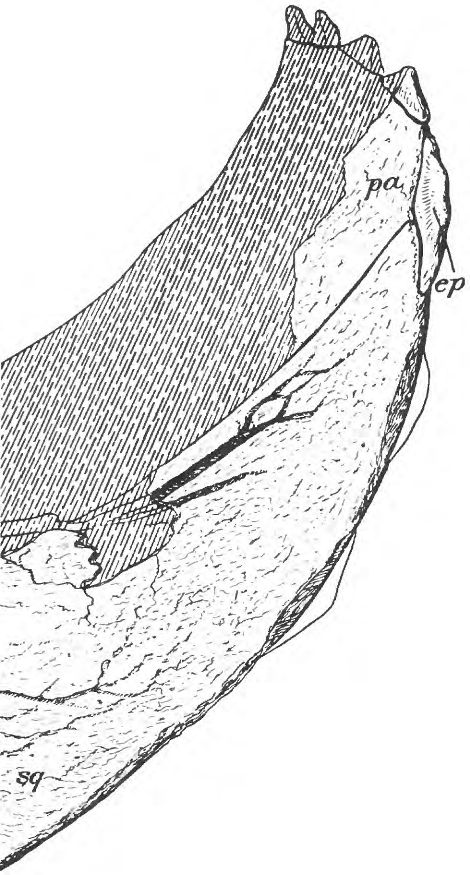
The Senate took up the cause of geologic surveys and voted to increase that appropriation to $200,000. Senator Patterson of Colorado called the geologic surveys "a more important work than which is not carried out by any department of the Government." Senator William Stewart of Nevada, once the Survey's nemesis but now a stalwart supporter, agreed: "I am not generally for extravagance in appropriations, but this is an important item." As others rose to endorse the increase, Senator William Allison, chairman of the Appropriations Committee, protested that he had as high an opinion of the Director of the Geological Survey as had other Senators but it just wasn't possible to appropriate all that public opinion demanded for the Survey. Senator Henry Cabot Lodge of Massachusetts remarked that the Director of the Geological Survey was the most skillful money-getter in Washington, but that only called forth another round of enthusiastic praise of the Survey and its Director. Senator Henry Teller of Colorado called it a discredit to the Nation that Congress had not extended the Survey's efforts to "every acre of American soil" and Senator John T. Morgan of Alabama who, along with Congressman Hilary Herbert, had been very critical of the Survey under Director Powell, held that the Survey had "contributed more within the last 10 years to the actual, present, and prospective wealth of the United States than any other institution we have ever had." In the final bill, approved on March 3, 1905, the total appropriation for the Survey was $1,785,000, an increase of 20 percent over the previous year's funds.



In a general study of the geology, stratigraphy, and paleontology of Western United States, H. F. Osborn found two natural divisions of geologic deposition and of animal and plant habitat similar to the existing natural divisions of plains and mountains. Moreover, the differences in mammalian life indicated differences in the mode of deposition of sediment in the two areas. According to a ruling of the International Geological Congress, the term "zone" could be used for faunistic levels that could be synchronized by the presence of certain distinctive animals, and hence in this "idealized bird's-eye view" of the Great Badlands of South Dakota, Osborn identified the *Titanotherium* sandstones, *Metamynodon* sandstones, and *Protoceras* sandstones as river-channel deposits. In official U.S. Geological Survey nomenclature, where paleontologic terms are not applied to lithologic units, these sandstones are parts of the Chadron Formation and Brule Clay. (From H. F. Osborn, 1909.)



In 1907, the Survey published a long-planned monograph on Ceratopsia, the horned dinosaurs. J. B. Hatcher reported that the skulls of ceratopsians were larger than those of any other known land animal, living or extinct (the skull of *Triceratops calicornis* Marsh shown in the illustration is more than 70 inches from tip to tip), but the brain case itself was relatively small. Hatcher believed that the broad, hood-like parietal crest and the horns were developed to provide increased protection and the dentition to be more efficient in procuring food, and that the Ceratopsia became extinct because, being highly specialized plant feeders, they had been unable to adapt to the changing environment caused by the diastrophism toward the end of the Cretaceous. (From J. B. Hatcher, 1907.)



The new programs brought about yet another modification of the organization of the Geologic Branch. J. A. Holmes agreed to stay on with the Survey to direct the fuel- and structural-materials testing programs, and Richard L. Humphrey, who had been in charge of the American Portland Cement Manufacturers' exhibit at the exposition, was appointed to take immediate charge of the structural-materials testing under Holmes' direction. Permission was obtained from the city of St. Louis, which had acquired the exposition buildings, to continue the work in Forest Park. The Director appointed a committee of Geologist-in-charge C. W. Hayes, M. R. Campbell, E. W. Parker, and Holmes to consider the best methods of exploiting the Nation's fuel resources and methods for their better utilization. Hayes, in turn, placed Campbell in charge of all geologic work on coal and retained for himself only the direction of the petroleum investigations. For the fuel- and structural-materials testing, most of which would be quite different from the Survey's normal work, the plan that had been successfully used in inaugurating the Reclamation Service was adopted: an advisory board was set up to which the scope of investigations and methods might be referred and from which a critical opinion of the results could be obtained.

Nearly half the increase in funds for geologic surveys was used for reconnaissance surveys of some of the western coal fields that had begun to attract the attention of coal operators and railroad men. Three experienced geologists, J. A. Taff, F. C. Schrader, and N. M. Fenneman, suspended their investigations in the Midcontinent and Gulf Coast areas, and several young men who had only recently joined the Survey worked with them: M. K. Shaler, who had been with Taff in 1904, H. S. Gale of the Metals Section, W. T. Lee, Arthur Veatch, George Richardson, C. A. Fisher, and newly appointed A. R. Schultz, a Leith protégé, all recruited from the Hydrographic Branch, and the State Geologist of North Dakota, A. G. Leonard. Surveys were made in New Mexico, Colorado, Utah, Wyoming, and North Dakota.

During the course of the summer of 1905, J. A. Taff, who was mapping in the Book Cliffs field of Colorado and Utah, was called on to aid the General Land Office by examining some contested coal lands near Coalville and Provo, Utah. The General Land Office, once the management of the forest reserves was transferred to the Department of Agriculture and the forest-lieu-land provision was repealed, was able to devote more time to investigating other public-land frauds and began an investigation of coal lands in Utah. The basic law for the disposal of coal lands was the Act of March 3, 1873, which limited the size of entry to 160 acres for an individual, or 320 acres for an association. This limitation made it impossible to develop some coal fields successfully and thus encouraged fraud in obtaining land by use of dummy entries or entries processed under the agricultural land laws.

Although the western coal program was the major effort in the Nonmetals Section, other fuels investigations were continued in western Pennsylvania, eastern Kentucky, and central Alabama, and Ralph Arnold took up George Eldridge's unfinished work in California. T. N. Dale continued his studies of structural materials, and F. L. Hess made a study of the magnesite resources of California. Most of the rest of the increase for geologic surveys was used to begin a systematic investigation of the iron ores of the country, the first to be made since the Tenth Census investigations of 1880. The investigation was placed under the direction of E. C. Eckel. Eckel himself and Charles Butts made field studies of iron deposits in Alabama and Virginia, and C. K. Leith examined most of the developed iron districts in the Western States. A. C. Spencer continued his detailed study of the iron, zinc, and manganese deposits in New Jersey and New York, concentrating especially on the deposits at Franklin, New Jersey, where Charles Palache was studying the mineralogy.

The metals program was somewhat smaller than usual as both H. F. Bain and J. E. Spurr had resigned, Bain to become State Geologist of Illinois and Spurr to begin his own consulting firm. Bain's work in the Mississippi Valley was suspended. The investigation of the newly discovered and unusually rich gold districts in Nevada, which Spurr had been expected to begin, was assigned instead to F. L. Ransome with the assistance of G. H. Garrey and W. H. Emmons, and the investigations in Arizona mining districts, which had been assigned to Ransome, were deferred, although S. F. Emmons spent some time in Arizona to keep in touch with developments. W. H. Weed was deeply involved in copper investigations, a review of the copper deposits of the United States, a reconnaissance of the copper deposits in the Appalachians, and further study of the veins at Butte. Lindgren began reconnaissance examinations of the mining districts in the Territory of New Mexico aided by L. C. Graton. Boutwell did no field work and instead spent his time working on the Park City report.

In 1905, even closer cooperation between the Division of Geology and the Division of Mining and Mineral Resources was effected. Lindgren was given responsibility for supervising the collection of statistics of the precious metals for the annual *Mineral Resources of the United States* as well as the discussion of the statistics such as he had prepared in 1904. The Division of Mining and Mineral Resources undertook a special study of the black sands of the Pacific Coast, an investigation that, it was thought, might lead to the development of an industry to utilize the black sands as a source of gold, platinum, iron, and some of the rare metals. The Division of Geology, in turn, began an investigation of a practical problem of long standing, the effect of hydraulic mining on agriculture in the Sacramento Valley of California, at the direct request of President Roosevelt. G. K. Gilbert was given responsibility for the investigation and in his typically thorough way went into the field in May to study the regimen of the Sacramento River and its tributaries with respect to the transportation of debris while a laboratory was set up at the University of California in Berkeley to study the laws that control the transportation of debris by streams.

There were nine parties in Alaska in the summer of 1905. In southeastern Alaska, paleontologist E. M. Kindle assisted the Wright brothers, who were giving special attention to gold and copper deposits. In the Yakutat Bay region, R. S. Tarr, assisted by B. S. Butler and Lawrence Martin, studied the occurrence of coal and gold but took time to study the glaciers and the remarkable deformation of the Earth's surface that occurred during the earthquake of September 1899. George Martin continued his investigations in the Controller Bay area and also made a reconnaissance of part of the Matanuska coal field. U. S. Grant, assisted by Sidney Paige, studied the geology and mineral resources of the Prince William Sound region, paying special attention to copper. In the Seward Peninsula area, Fred Moffit and F. L. Hess mapped an area of unusually intricate geology, and in the Yukon-Tanana region, L. M. Prindle continued his geologic reconnaissance with the assistance of young Adolph Knopf.

In addition to the areal mapping in various parts of the country, compilation of two large geologic maps was begun, one of the United States on a scale of 1:2,500,000 by George Stose, and one of North America on the scale of 1:5,000,000 by Bailey Willis. The latter map was compiled with the cooperation of the Governments of Canada and Mexico, and plans were made to issue a preliminary edition for the International Geological Congress to be held in Mexico City in September 1906.

Some of the most fundamental research being carried on in the Division of Physical and Chemical Research turned out to have very practical applications. In their study of eutectic series, A. L. Day and E. T. Allen took up two series of minerals, including a series ranging from pure lime to pure silica. As it happened, the melting of pure silica proved to be of immense technologic interest because quartz glass can be heated white hot without softening and while still hot can be plunged into water without breaking. Their basic research eventually led to the development of a commercial glass resistant to heat and chemicals.

The work of the Hydrographic Branch in 1905 continued along the lines previously developed except in the Division of Western Hydrology where field work was limited. The number of river measurement stations was increased to 817, the work of collecting well records and samples was extended to nearly every State and Territory, and a general investigation of the methods of deep drilling in the Eastern States and in Texas, Oklahoma, and Kansas was made. Field work in the study of ground waters was underway in 27 States and Territories, chiefly, however, in the Eastern Division where many part-time assistants were available. In the Western Division, field work was limited to California, North and South Dakota, Texas, Utah, and Wyoming. Quality-of-water investigations, underway in 16 States, included studies of the effect of sulfite pulp wastes on water and stream pollution, the best methods of purifying and recovering valuable ingredients in acid-iron wastes, dye wastes, or distillery slops, and a determination of the total amount of denudation in the Mississippi River system.

The two topographic divisions continued on their separate ways in 1905. The Eastern Division had cooperative arrangements with 12 States, which contributed more than $85,000, and mapped 18,042 square miles, about the same amount as in the preceding year. Better than 85 percent of the area was mapped at the mile-to-the-inch scale. The Western Division greatly increased the area mapped, from 8,729 to 22,671 square miles, but mapped only 2,783 square miles at the mile-to-the-inch scale. The remainder included mapping at various scales for the Reclamation Service, mapping in the forest reserves at 1:125,000, and mapping for the Geologic Branch at 1:250,000.

The work of examining the forest reserves, together with the men employed for it, was transferred during the spring of 1905 to the Forest Service. The Survey retained responsibility for compiling the special national-forest maps, and A. C. Roberts was placed in charge of the work, leaving Henry Gannett free to concentrate on geography and other assignments, which were not long in forthcoming. On June 2, the Committee on Departmental Methods, proposed by Gifford Pinchot and Secretary Garfield, was established to introduce modern business methods in the executive branch. Among the 70 experts assigned to assist the Commission was Henry Gannett, who participated in the investigation of the Bureau of Statistics of the Department of Agriculture and later in the investigation of the organizations carrying on scientific work. In addition, in January 1906 the Board of Geographic Names, of which Gannett was chairman, was extended by Executive order.

While Survey work was thus progressing smoothly and efficiently, politics once more entered the picture. In December 1905, the 59th Congress, elected in 1904, convened for its first session. The administration apparently had a large majority, as Republicans outnumbered the Democrats 250 to 136 in the House and 57 to 33 in the Senate, but both parties were divided into conservative and progressive elements, which were more important than party labels, and the conservatives held the reins of power. An attempt to change the rules in the House was defeated and Speaker Cannon passed over two Republicans of greater seniority but suspect politics to appoint James Tawney of Minnesota, with impeccable conservative credentials, chairman of the all-important Appropriations Committee. The President's annual message to Congress, however, was almost more progressive than the progressives and was labeled by one newspaper as an attempt to subvert the American tradition. The President asked for legislation on a variety of reforms, including strengthening of the Interstate Commerce Act to prevent imposition of unjust rates and make the services of the railroads available to all on an equal basis at reasonable and just rates. He called for "affirmative action" by the Federal Government in regulating the great corporations. He also repeated his previous recommendations for changes in public-land laws, for the Government to take control of the open range, for placing national parks under the Forest Service, and for admission of Oklahoma and Indian Territories as one State and Arizona and New Mexico Territories as another State.

There was no reference to coal in the annual message, but coal resources became politicized by being involved in several issues on which politicians disagreed. The House passed the bill for stricter regulation of the railroads on February 8, 1906. Four days later, Senator Benjamin Tillman of South Carolina, an outspoken opponent of the President, proposed a joint resolution authorizing the Interstate Commerce Commission to investigate railroad discriminations and monopolies, in particular whether the railroads had interests in coal and other products carried on their lines. Part of his plea for passage of the resolution was based on the need to return some initiative to Congress, because the public had been given the impression that this was solely the President's fight. Congress passed the resolution promptly but after the President signed it on March 7, in a bit of one-upmanship, he sent a message to Congress promising them preliminary reports on investigations of the anthracite and oil industries by the Commissioner of Corporations in the Department of Commerce and Labor before the end of the session. As it turned out, both the Commissioner of Corporations and the Interstate Commerce Commission in their separate investigations found that the railroads to a considerable degree controlled the coal companies.

The railroads' control of coal also came to light when the Senate received the bill passed by the House to provide for continuation and extension of the policy, inaugurated by Secretary Hitchcock, of leasing the segregated coal lands of the Choctaw and Chickasaw Indians in Indian Territory. When the Senate Committee on Indian Affairs proposed to amend the bill to provide instead for sale of the lands, Senator Robert M. LaFollette of Wisconsin, a close friend of C. R. Van Hise, was moved to consult the Secretary of the Interior and the Director of the Geological Survey; he found that bituminous coal of superior quality had been discovered on the segregated lands, that leases covering about a quarter of the area had been taken in the name of private coal-mining companies but were in reality controlled by railroads, that there was little or no competition in prices, and that rates for shipment were very high. LaFollette therefore proposed that the committee's amendment be amended to limit the amount of land that could be obtained by any one company and to include in the deeds a provision that the lands revert to the United States in trust for the Indians if acquired by a railroad. The Senate voted against the LaFollette amendment but the President himself told the Senator that he considered the matter important. LaFollette then suggested that the provision should, in fact, apply to all public coal lands; his colleague, Senator Francis Newlands, then filed a bill to reserve the coal and lignite underlying the public lands. When the Senate did not act on the Newlands bill, the President considered withdrawing the coal lands from entry by Executive order but the Attorney General expressed some doubt that he had the authority to do so.

Coal investigations provided a focal point for an attack on Survey appropriations, the first in several years. The request for appropriations submitted by the Survey did not include funds for continuation of the fuel- and structural-materials testing. On January 25, long before the House took up the appropriations bill, Senator James Hemenway, the former chairman of the House Appropriations Committee but now a Senator from Indiana, asked the Secretary of the Interior to send to the Senate a summary of the results obtained in the investigations at St. Louis and to give his opinion whether or not it was

In the Survey's first quarter-century, T. C. Chamberlin and other Survey geologists had made notable contributions to an understanding of continental glaciation. Comparatively few studies had been made of mountain glaciation before 1903 when W. W. Atwood began a study of glaciation in the Uinta and Wasatch Mountains. Clarence King, in his report on the Exploration of the Fortieth Parallel, had called attention to the evidence of mountain glaciation in those mountains and had speculated on the possibility of two periods of glaciation. Atwood found evidence of more than 50 glaciers and confirmed King's idea of two epochs of glaciation. Little Cottonwood Canyon, shown in the photograph, has the beautifully symmetrical U-shaped form characteristic of vigorously glaciated canyons. (From W. W. Atwood, 1909.)

desirable for the Government to continue them. Anticipating an affirmative answer, he also asked for an estimate of the necessary appropriation. On February 9, Secretary Hitchcock replied that in his own judgment the investigations should be continued and submitted a letter from the Director of the Geological Survey with an estimate of $200,000 for fuel testing, $100,000 for structural-materials testing, and $50,000 for removal of the plant and equipment.

Walcott cited many reasons, both scientific and practical, why the fuel investigations should be continued. For one thing

> **The carefully made analyses of these representative coals and lignites are giving to the engineers of the country data of great value, not only because this work is done with care, but also because the complete history of every such sample is indicated, and the record is authentic and reliable.**

Coal producers of the country, he noted, had been awakened to the value of a more careful study of their coals and of possible methods of improvement in quality, and manufacturers and other coal consumers had recognized the need to use their fuels more efficiently and to purchase them on a basis that indicated their true heating value rather than on some indefinite trade name or classification. Fuel supplies, he said, should be used without unnecessary waste and with the highest attainable efficiency. During 1905, more than $1.5 billion had been spent for fuels, but in the utilization of fuels for power, light, and heat the losses were so great that at most only 5 percent of the energy was available for actual work. Walcott listed 23 problems that needed investigation, most of them practical, but also some involving the physical and chemical properties of coal. First in importance was the prevention of accidents in coal mines by a study of the use of explosives in the presence of coal dust and coal gases in mines. He thought it desirable for the Government to continue the work begun by the Survey rather than turn it over to some other organization;

Both the accuracy and efficiency of topographic mapping had been improved, the amount of mapping completed each year had increased, and the cost of mapping decreased since C. D. Walcott became Director. Little change had been made, however, in methods of mapping. The illustration of the signal tower in the manual of topographic methods published in 1906 was the same as that in the 1893 manual. (From Henry Gannett, 1906.)

the work was being done effectively and there would be a loss in starting over. Moreover, the work pertained to the general welfare.

Walcott said less about structural-materials testing but made the point that engineers, architects, and builders in all parts of the country were demanding information because of the rapidity with which changes were being made in materials being used for construction purposes. He recommended not only continuing investigations already underway but extending them to field examinations and laboratory testing of other materials used in construction, such as sands, clays, cement and mortar, stone, steel, and other metals.

Apparently no problem was anticipated in obtaining the requested appropriations because in March 1906 a 39-member Advisory Board for the Investigation of Fuels and Structural Materials was formally organized and given Presidential appointments. Most of the members of the Advisory Board came from outside the Government, but because the Federal Government was at the time spending about $30 million a year for building and construction work, the Board included the Chief Engineer of the Isthmian Canal, the Chief Engineer of the Reclamation Service, the Supervising Architect of the Treasury Department, the Chief of the Army's Bureau of Ordnance, the Chief of the Navy's Bureau of Steam Engineering, and representatives of the Army's Corps of Engineers and the Navy's Bureau of Yards and Docks. The president of the Board was Charles B. Dudley, representing the American Society for Testing Materials. Dudley was also a member of the American Institute of Mining Engineers, twice its vice president and a member and former president of the American Chemical Society. He was not, however, an academic scientist but a chemist for the Pennsylvania Railroad, then under public scrutiny because of its coal interests. In that position, he had been responsible for revolutionary applications of chemistry in increasing the efficiency and safety of railroads.

When the House Committee on Appropriations filed its report on the sundry civil expenses bill on May 31, 1906, without any warning to the Secretary or to the Director that such an action was contemplated, it recommended reductions totaling $307,000 in the appropriations for fuel testing, stream gaging, topographic surveys, mapping forest reserves, and the report on mineral resources, and an appropriation for the Survey of only $1,138,320. That more than economy was involved became apparent as soon as the House debate on the Survey appropriation began on June 13. As soon as the clerk finished reading "For the general expenses of the Geological Survey, and the classification of the public lands, examination of the mineral resources and products of the national domain, continuation of the preparation of the geological map of the United States, gauging streams and determining water supply, and mapping forest reserves," and before he had a chance to read the amount, Edgar Crumpacker, Republican of Indiana, made a point of order: There was no authority in law for the Survey to make a map or gage streams except in the national domain. He thereby precipitated a 2-day debate on the merits of the Survey and the conduct of its work. Was "national domain" synonymous with public lands? Crumpacker thought the writers of the original legislation had used two different terms as a matter of literary style to avoid repetition and was promptly given several examples in which repetition was avoided without using two terms. The discussion then veered to House Rule XXI which prohibited a point of order against a public work in progress. Crumpacker held that a public work had to be tangible, such as a building; that assertion was countered with the observation that the boundary survey between Canada and Alaska, which was not tangible, had been ruled a public work in progress. Preparation of the geologic map had been included in the Survey appropriation since 1882, a map was patently a tangible object, and so Crumpacker withdrew his point of order against the geologic map. His colleague, James Watson of Indiana, who was in the chair at the time, then ruled that gaging streams was not a tangible object and could never be completed and therefore sustained that point of order. Before any more business could be taken up, friends of the Survey made a counter move. William Wiley, Republican of New Jersey, was given permission to insert in the *Congressional Record* several dozen letters and telegrams from prominent engineers and scientists praising the Survey. Wiley was an engineer, a graduate of Rensselaer and the Columbia School of Mines, and had been associated for many years with the publishing firm of John H. Wiley & Son founded by his grandfather.

The House then proceeded to consider appropriations for specific items. The first to be challenged was the appropriation for topographic surveys for which the committee had recommended $300,000; F. H. Gillett, Republican of Massachusetts, who in the preceding session had suggested that the Survey demand money from the States for topographic surveys, raised a point of order against the item, apparently under the impression that the topographic survey was part of stream gaging. He was quickly corrected and then William H. Stafford, Republican of Wisconsin, insisted that there was no connection between a topographic survey and a geologic map. There were several efforts to explain that relationship, but finally F. W. Mondell, Republican of Wyoming, said that a topographic survey was a necessary preliminary to a geologic map, which had been retained, and the Chair therefore ruled against the point of order. The topographic map could be finished, and was therefore properly considered a public work in progress.

An amendment to restore the appropriation for topographic surveys to $350,000 forced the chairman of the Appropriations Committee, James Tawney of Minnesota, to explain the committee's recommendation. "This is something more than a business proposition. It is a question of whether the Geological Survey shall fix the standard of expenditure in its bureau by determining the amount of its appropriations or whether Congress shall perform that function untrammeled by the influence the officers of the Survey can command by reason of the private, State, and municipal interests they serve." Congress had been deluged with letters and telegrams on behalf of the Survey, and Tawney thought the Survey had solicited them. He was particularly incensed by a letter signed by J. A. Holmes that invited the recipient to comment. This, said Tawney, was carrying lobbying far beyond anything ever before attempted. He had complained to the Secretary of the Interior and in return had received letters from Secretary Hitchcock and Director Walcott. Walcott said that so far as he could determine only two letters had been sent about appropriations, both by H. M. Wilson of the Topographic Committee to officials in Minnesota, and they had simply explained that because of the reduction in the appropriation for topographic surveys, certain work requested by those officials could not be done. The letter about which Tawney was most concerned, the Director assured him, had been sent to the Advisory Board. When he demanded more information on that advisory board, the Director told him that it was a board appointed by President Roosevelt and "respectfully suggested" that further information be sought from him. There were 39 members on that board, Tawney told the House, and they received $5 a day when they actually served! "When," he demanded, "are we going to call a halt in the ambitions of this Bureau, this man, the Director of the Geological Survey, for whom I entertain the highest respect? The Director of the Geological Survey is unquestionably the ablest man that has occupied the position, one of the best administrative officers of the government, but when he seeks to use the influence he acquires by virtue of the administration of his department for the purpose of increasing his appropriations I say it is time for this House to call a halt. While he is an eminent scientist, a good administrative officer, these are not his only accomplishments. He is also the smoothest and most scientific and accomplished lobbyist connected with the Government." To this Swagar Sherley, Democrat of Kentucky, retorted that it was lobbying with a difference when he went to the people to get an expression of opinion. Then Tawney, in a curious twist of logic, insisted that it was the duty of the Government to govern and it was the duty of the people to develop the country, but not at the expense of the Government. Topographic surveys should be made by States, and streams should be gaged by the corporations interested in water power. Moreover, cooperative surveys were illegal. The House overruled him; by a vote of 101 to 54, the appropriation for topographic surveys was increased to $350,000.

Questions were also raised about the appropriation for the report on mineral resources. Tawney wondered "Why is it so valuable? Who wants it?" Oscar Underwood of Alabama said he received more requests for that particular volume than he could fill. Tawney then questioned the amount; in 1891, the appropriation was only $10,000 and it hadn't been more than $50,000 until the year before, so why did the Survey need $75,000? Mondell suggested that the fact that there hadn't been an increase for several years was the best reason, but no increase was voted.

The committee had also recommended an appropriation of $100,000 for stream gaging but no appropriation was approved. When the item came up, Crumpacker made a point of order against it. Mondell argued against the point of order; the work was provided for by three distinct provisions of existing law: classification of public lands, examination of mineral resources ("It is a well known fact," he said, "that water is a mineral."), and the legislation of March 20, 1888. The Chair, however, sustained the previous ruling against gaging streams. Mondell then proposed an amendment to appropriate $100,000 to measure the capacity of streams in accordance with the Joint Resolution of March 20, 1888. Tawney accused Mondell of obtaining that amendment from the Survey, and Mondell admitted that much that he had told the House had come from the Survey; it was, he said, "sound and safe doctrine." A point of order against the amendment was sustained.

The appropriations for structural-materials testing and fuel testing, the newest items in the Survey budget, also came under attack. The committee had allowed the full amount for structural-materials testing, but when the item came up, John W. Weeks, Republican of Massachusetts, seeking to protect the Watertown Arsenal, insisted that the original appropriation did not contemplate a continuing work and therefore made a point of order against it. After considerable discussion, the Chair, regretfully, sustained the point of order but on the ground that it was contrary to existing law, which forbade the Survey to execute surveys or make examinations for private parties or corporations. Furthermore, it would go on forever and so was not a work in progress. George W. Norris, the Chairman of the Public Buildings Committee, thereupon offered an amendment to appropriate $100,000 for investigations of structural materials belonging to the United States. The Chair promptly ruled that the Norris amendment was in order and not subject to a point of order, and the appropriation as amended was quickly passed. The appropriation for

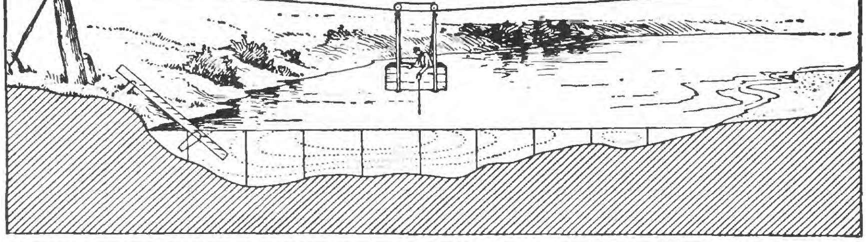
In 1904, the U.S. Geological Survey began an investigation, in cooperation with the Bureau of Forestry and the Bureau of Fisheries, of economic conditions that affected the utilization of the water resources of the Potomac River basin for industrial and recreational purposes and for the public water supply of the Nation's capital. H. N. Parker of the Survey, who investigated sources of pollution with particular reference to an undue prevalence of typhoid fever outbreaks in Washington, reported that typhoid outbreaks were caused almost entirely by contamination of the public water supply. The water had been obtained from the Potomac at Great Falls, 14 miles above the city, but passed through settlement reservoirs without any other purification until October 1905. Typhoid was most prevalent during times of low-river flow at Great Falls when contaminants were concentrated in the water. (From H. N. Parker, Bailey Willis, R. H. Bolster, W. W. Ashe, and M. C. Marsh, 1907.)

fuel testing also went out on a point of order and for the same reason, that the samples came from private parties or corporations, and then was reinstated as Franklin Brooks of Colorado, following Norris' lead, proposed an appropriation of $200,000, which was $100,000 more than recommended by the committee, for testing fuels belonging to the United States. Congressman Mondell then pointed out that the tests would help the Government to sell coal lands that would not otherwise be sold and to utilize coal that would otherwise go to waste. John Dalzell of Pennsylvania, one of the most powerful members of the House, then proposed an increase to $250,000 and that amendment was also passed.

The Senate Appropriations Committee made several revisions in the Survey portion of the bill. It restored "gauging streams and determining the water supply of the United States" to the general item and added a specific item of $200,000 for the work, increased the amount for the report on mineral resources to the requested $75,000, and for mapping forest reserves to $125,000. It also rephrased the item for testing structural materials to read: "For the investigation of the structural materials belong to and for the use of the United States," and neatly solved the several problems pertaining to fuel testing by adding a proviso "that in examinations, hereby authorized, for fuel materials for the use of the United States, or for the purpose of increasing the general efficiency or available supply of the fuel resources in the United States, the Director of the Geological Survey may have the necessary materials collected from any part of the United States where they represent extensive deposits; and it shall be the duty of the Director of the Geological Survey to have examined, without charge, the fuels required for use of the Government of the United States, and to give these examinations preference over other works. Provided, further, that in publishing the results of these investigations the materials examined shall not be credited to any private party or corporation, but shall be collected and described as representing such deposits." Part of the Senate proviso authorizing examinations "for the purpose of increasing the general efficiency or available supply" of fuel resources clearly extended the program from "testing" into more fundamental research.

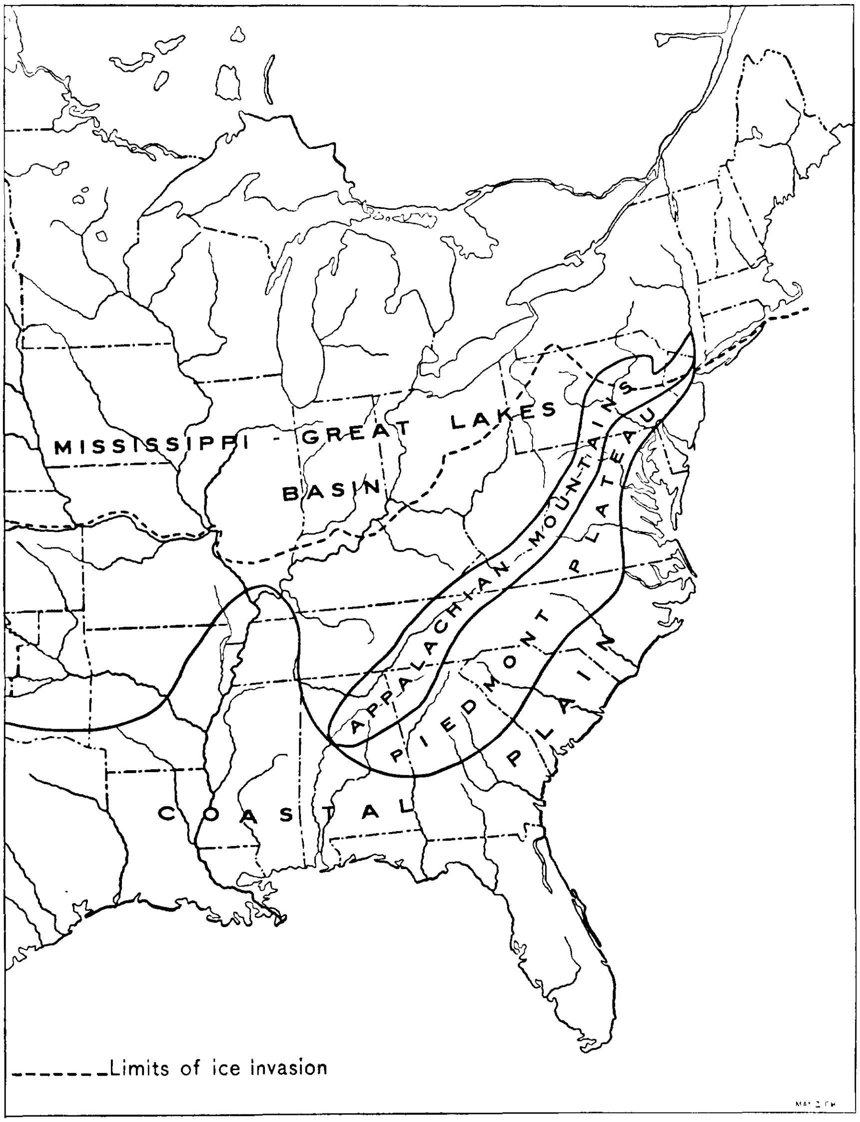
On June 20, just before the Senate itself took up the bill, Senator LaFollette proposed a concurrent resolution to authorize the Secretary of the Interior to have a thorough investigation made of the coal, lignite, and oil deposits of the United States and to report to Congress on their nature and extent and the best method of mining them, and to authorize the President to withdraw from entry and sale all public lands known to be underlain with coal, lignite, or oil, and all such lands, which in the judgment of the Director of the Geological Survey, contained deposits of coal, lignite, or oil, and that all such lands be withheld from entry or sale until such time as Congress determined otherwise. The resolution was tabled.

The Senate passed the appropriations bill on June 22 without any change in the committee's recommendations on the Survey appropriations. On June



The majority of water-resources investigations involved stream-flow measurements. Methods were, in general, simple. Stations were usually located at bridges from which the current meter could be easily manipulated and, as far as possible, where the stream channel was straight, there were no crosscurrents, and the stream bed was free of large projections. Soundings were taken at an arbitrary number of points laid off perpendicular to the thread of the stream and velocities were determined usually by holding the meter at 0.6 the stream depth. (From H. K. Barrows and J. C. Hoyt, 1905.)

In 1905, M. L. Fuller divided the Eastern United States, except New England and eastern New York, into four districts from the standpoint of ground-water supplies: the Coastal Plain, Piedmont Plateau, Appalachian Mountains, and the Mississippi and Great Lakes basin. New England and eastern New York he considered most nearly comparable to the Piedmont region. Ground water was related to geologic factors in each area: it occurred in sands and gravels in the northern Coastal Plain and in limestones farther south, was soft and of good quality in the north but often hard and charged with sulfur and iron in the south; it was relatively uncertain in the Piedmont, depending on joints and fissures; and it occurred in sandstones and some limestones in the Appalachian Mountains but it was seldom used as a source of supply. North of the limits of the ice invasion, glacial deposits were a good source of water. (From M. L. Fuller, 1905.)



27, the conference committee made its report, including a compromise figure of $150,000 for stream gaging, $100,000 (the House figure) for mapping forest reserves, and $75,000 (the Senate figure) for the report on mineral resources, and both Senate and House adopted the conference report. On the following day, however, the Senate reconsidered its vote and asked that the bill be returned. The conference report had eliminated "for the purpose of increasing the general efficiency and availability of supply of the fuel resources of the United States" in the appropriation for fuel testing, and the Senate had been persuaded that the wording should be retained. Eventually the House yielded, and the bill was finally passed on June 29, 1 day before adjournment, 2 days before the beginning of the new fiscal year.

On the day that the appropriations bill was passed, the President of the United States created a problem for the Survey by ordering the Secretary of the Interior "to report as soon as possible the coal lands where the Department deems the coal deposits of such value that we ought to withdraw the lands from entry." There simply was not enough information available in the Survey files to make any such report. On the basis of what information was available and some additional data from the Forest Service, Secretary Hitchcock on July 26 ordered the withdrawal from entry, filing, or selection of large areas of known or supposed coal lands in Utah, Wyoming, Colorado, New Mexico, North Dakota, Montana, Washington and Oregon. Additional withdrawal orders in the fall and early winter brought the total withdrawn acreage to 66,939,800 by December 13.

Investigation of the western coal fields thus became the most urgent program in the Geologic Branch in the summer of 1906. M. R. Campbell, who had been given responsibility for a new Section of the Geology of Fuels, established headquarters at Salt Lake City and personally supervised the work. George Richardson, M. K. Shaler, H. S. Gale, A. R. Schultz, A. C. Veatch, C. A. Fisher, and A. G. Leonard, all of whom had taken part in the reconnaissance of 1905, were assigned to develop information on coal fields in the Book Cliffs, Durango-Gallup, and Yampa fields of Utah, New Mexico, and Colorado, and the coal fields of Wyoming and Montana. Very little topographic work had been done in any of these areas, so the geologists had to prepare their own topographic bases. Special attention also had to be paid to determining land lines on the ground wherever possible so coal areas could be segregated with reference to land corners and plats made for transmittal to the General Land Office showing the classification of the land by legal subdivision. It was very different work from the Survey's ordinary geologic mapping. As a result of the season's work, nearly 38 million acres were restored to entry, almost 9 million classified as coal land, and the remainder found to contain no coal or coal of such low grade as to be worth only the minimum price.

An effort was made to continue as much as possible of the previously planned geologic program. George Ashley supervised the survey of coal areas in Pennsylvania, in cooperation with the State, as well as reconnaissance studies of the Elkhorn coal field of Kentucky and the Dickinson County coal field in Virginia. Frank DeWolf and N. M. Fenneman began areal and economic surveys in Illinois in cooperation with the State, Charles Butts broadened his work near Birmingham, Alabama, to include coal, and A. J. Collier made a general reconnaissance of the Carboniferous coal field of Arkansas. Petroleum investigations were limited to W. T. Griswold's survey of the Flushing quadrangle in Ohio and Ralph Arnold's surveys of the Santa Maria and Summerland districts in Santa Barbara County, California, in which he relied greatly on paleontologic evidence in determining stratigraphy and structure.

The investigations of iron ores being made under the supervision of E. C. Eckel were also continued. Eckel and E. F. Burchard made field studies in Alabama, Georgia, Tennessee, and Virginia. Other field studies were made by A. C. Spencer in Pennsylvania, C. K. Leith in southern Utah, and S. H. Ball in Wyoming. At the end of the field season, however, Eckel resigned to enter private industry.

The Metals Section did considerably less field work in 1906 than in previous years, in part because it continued to lose men to the private sector, among them this year its copper expert, W. H. Weed. Some of the youngest members of the section were given an opportunity to do independent work. Thus, L. C. Graton was given Weed's responsibility for copper statistics as well as a detailed study of the copper deposits of Shasta County, California; J. M. Boutwell replaced Bain in the analysis of lead and zinc statistics, and W. H. Emmons was sent to Montana to begin studies of the economic geology of the Philipsburg quadrangle. F. L. Ransome was finally free to begin the long planned work in Arizona but met with an accident after a preliminary reconnaissance of the Tombstone district and spent several months in the hospital. At the end of his field season in Montana, W. H. Emmons was sent to Nevada to make the observations needed to complete Ransome's report on the Bullfrog district. Lindgren continued to supervise the collection of precious metal statistics and also examined the tungsten resources of Boulder County, Colorado. H. S. Gale, a former member of the section, was diverted from the coal investigations long enough to examine some newly discovered deposits of carnotite in Rio Blanco County, Colorado.

Lindgren's major contribution of the year was his paper on the relation of ore deposition to physical conditions, presented at the 10th International Geological Congress in Mexico. Lindgren had taken the concept of depth zones, each characterized by its own mineral facies, as developed by Van Hise and others in the study of metamorphism, and by analogy applied it to the problems of ore deposition. Certain minerals or groups of minerals, he suggested, are characteristic of the temperature and pressure conditions under which they were formed, and consequently the genetic conditions under which a given ore deposit was formed are ascertainable. This was the key that opened the way to a genetic classification of ore deposits.

Fourteen parties went to Alaska in the summer of 1906, eight to make geologic investigations, three to make combined geologic and topographic surveys, two to make topographic surveys, and one to make stream measurements. Geologic investigations in southeastern Alaska, the Yakutat Bay region, and the Yukon-Tanana region were continued and the mapping of the accessible coal and oil fields of the Controller Bay region was completed. In the Seward Peninsula, F. H. Moffit, assisted by P. S. Smith, a Harvard University instructor, completed the areal mapping of the Nome and Grand Central quadrangles, the first attempt to make an exhaustive study of the geology of a placer district. Smith also made a reconnaissance of some of the other placer districts to gather data on the progress of mining and to familiarize himself with some of the larger problems of the province. J. C. Hoyt was detailed from the Hydrographic Branch to make stream measurements where cheaper methods of placer mining depended on an abundant supply of water.

Three volumes of *Contributions to Economic Geology* were published for 1906, a total of nearly 1,300 printed pages on gold, silver, copper, nickel, uranium, iron, manganese, limestone, gypsum, clays, building stones, feldspar, quartz, mica, graphite, mineral paints, abrasive materials, phosphates, sulfur, coal, lignite, and peat.

Geologic mapping and other investigations in addition to those in connection with economic studies were carried on in the Atlantic Coastal Plain, the Appalachian region, the Mississippi Valley, the San Juan Mountains of Colorado, and on the Pacific Coast. Members of the joint Canadian-U.S. committee on Precambrian nomenclature spent part of the summer in field work in the Adirondack Mountains of New York and then reached an agreement on uniform classification. G. K. Gilbert had been appointed to the special commission to investigate the San Francisco earthquake and spent much of the summer studying that part of Marin County near Bolinas and Tomales Bays that was traversed by the San Andreas fault. Under his direction, the experiments to determine the relation of detrital load to discharge of water, slope of stream bed, velocity, and other variables were continued in the Berkeley laboratory. Bailey Willis completed the geologic map of North America for presentation at the International Geological Congress, where some objections were raised because of his use of U.S. Geological Survey nomenclature. F. H. Knowlton, David White, T. W. Vaughan, and H. F. Osborn all made progress on paleontological monographs, and the monograph on ceratopsian dinosaurs begun by Marsh and continued by Hatcher was completed by R. S. Lull after Hatcher's death.

In the Division of Chemical and Physical Research, F. W. Clarke continued work on his monograph on geochemistry and after a conference with Sir John Murray obtained composite samples of materials from the *Challenger* Expedition for analysis in the Survey laboratories. W. F. Hillebrand prepared a new edition of his bulletin on rock analysis, and E. C. Sullivan prepared a bulletin on his researches on the chemistry of secondary enrichment. George

Becker continued to investigate problems in geophysics and C. E. Van Orstrand the study of the elastic properties of metals. A. L. Day and E. T. Allen continued their researches on the synthesis of minerals and made preparations to transfer the work to the Carnegie Institution of Washington. The Carnegie Institution had provided some support for their work, and when the Survey facilities were found to be unsuitable for the continuation of delicate experiments, the Trustees voted to purchase land and erect a suitable building.

The Hydrographic Branch had to cut back its program because of the unexpected reduction of 25 percent in the appropriation. It also acquired a new head and a new name. The Reclamation Service was by this time almost completely independent of the Survey and was preparing to move most of its force and archives to a nearby building for which Congress had appropriated additional funds. Newell therefore felt that he should relinquish direction of the branch, and at the beginning of the fiscal year, M. O. Leighton became Acting Chief Hydrographer. The decision was made that, rather than a uniform reduction in all lines of work, the needs of each part of the country should be studied and the work that seemed the least important in each region should be reduced or discontinued. However, measurements of stream flow were of the greatest importance in all areas of the country, and the suspension of measurements would make less valuable what had already been accomplished; thus, in the end, it was some of the research projects that had to be discontinued. The Hydrographic Branch was then reorganized into a single unit by abolishing the divisions. At the same time the name of the branch was changed to Water Resources Branch, as Leighton felt that the title was not only a more correct description of the work but was also more easily understood by the public. The reduced funds permitted only a few ground-water investigations, so N. H. Darton returned to the Geologic Branch and M. L. Fuller was given charge of all ground-water studies. Several brief investigations of ground water were made by various geologists as part of their work for the Geologic Branch, and others were made by two University of Chicago graduate students, O. E. Meinzer and S. R. Capps, who spent the summer with the Survey. Two quality-of-water investigations were continued in cooperation with the Massachusetts Institute of Technology and the Rhode Island State Board of Health.

The contrast between the two topographic divisions was even more marked in 1906. Both mapped somewhat smaller areas than in the preceding year, only 14,712 square miles in the Eastern Division and 19,360 square miles in the Western Division. In the Eastern Division, which had nearly $100,000 in cooperative funds from 10 States in addition to appropriated funds, nearly all the mapping was done for publication at 1:62,500. More than half the mapping was done in New York, already about 80 percent mapped, Ohio, Pennsylvania, West Virginia, already 99 percent mapped, and Illinois. In the Western Division, only 17.5 percent of the mapping was done at 1:62,500 or larger scales. About 7,500 square miles was mapped for publication at 1:125,000 and more than 8,600 square miles for publication at 1:250,000.

The coal investigations, as it turned out, not only upset the scientific program but were also used in the fall of 1906 as the takeoff point for an attack on the Survey administration that was carried on for several weeks in the pages of *Science*. Professor John C. Branner of Stanford University, who had taken to print in 1890 to chide the Survey for its lack of cooperation with the geologists of the country, took to print again on another "matter of far-reaching importance to the geologists and other scientific men of the country." In Professor Branner's view "The attitude of the survey toward the geologists of the country has come to be simply intolerable. No geologist has any rights that the survey feels bound to respect, unless indeed the geologist has political backing that makes it worth the survey's while to treat him with some sort of consideration."

Branner was upset because in January 1906, as the Survey was making plans to begin work in the Arkansas coal fields, he had received a letter suggesting that if he would turn over to the Survey the unpublished material on the coal fields of Arkansas, which he had mapped for the State survey in 1886 and 1887, both he and the Arkansas survey would be given full credit in the final publication; he asked instead that he be assigned to do the new mapping and was told that the Survey preferred that the mapping be done by full-time members of the staff. Branner then resigned his per-diem appointment, calling such a preference "an outrage and an unwarranted personal affront to which no self-respecting geologist can tamely submit." The resignation was held until October, in the hope that Branner would reconsider, when instead he wrote to Walcott and at the same time to *Science*. Branner accused the Survey of overriding local interests, of discrediting and driving State organizations out of existence, and even of invading the privacy of educational institutions to discredit them. His resignation was then accepted, and Walcott wrote to him that

> **The right of any geologist to restrict the operations of this survey in opposition to public interests can not be admitted.**

It was manifestly contrary to good policy, Walcott said, for any organization to duplicate the work of others where there was a prospect the results would be published, but 18 years was sufficient time to secure publication and so the interest of the public outweighed the fact that he had worked in the area.

Apparently inspired by Branner's action, Professor W. H. Hobbs of the University of Michigan also resigned his per-diem appointment and sent a copy of his letter to *Science*. Hobbs directed his attack at "the arbitrary and overbearing administration of the geologist in charge of geology." Hobbs' ire had been roused by the treatment accorded a manuscript on the crystalline rocks of Connecticut that he had submitted. The manuscript had been critically reviewed by G. K. Gilbert, who had not accepted Hobbs' conclusions and suggested that the work be reviewed in the field, by Bailey Willis, who suggested that the author's reputation would be better served by the omission of certain chapters, and by George Otis Smith, who condemned the manuscript as of no value except for material already published. The manuscript was then laid aside because Smith was then the head of the Section of Petrology and without his endorsement the manuscript could not be published. Hobbs complained that the Survey had become "the Great American Trust" and that Hayes was "a hustling business manager of the sledge-hammer type who has transformed the survey of Powell—which in a notable manner advanced the geological thought of the world and brought golden opinions from all sorts of people—into a great mining bureau with an auxiliary map establishment for 'coloring in' the national domain."

The dual attack prompted Walcott to send a letter to *Science* on the principles governing the Survey in its relations with other geological surveys and working geologists.

> **There is among scientists in general a rule of courtesy that denies to others the privilege of investigation in a direction which one has made his own by reason of his contributions to knowledge along that line. The rule is variously construed in different countries and by different men, but it is no part of my purpose to minimize its force. It has been recognized by the national survey since the days of Director King, and is now effective in relations with individuals and state surveys. It is, however, necessarily controlled by the progress of the general survey and the development of general plans, which sometimes require that work shall be done by the national organization notwithstanding meritorious individual claims. Moreover, professional courtesy on the part of a public official is subject to limitations imposed by his obligation to Congress and to the people to render prompt and efficient service.**

Long experience, Walcott suggested, had shown that men whose first obligation was to a university could not work as efficiently for the Survey as did its full-time employees. The Survey had not discontinued the employment of all university professors (the annual report for the year ending June 30, 1906 showed that 81 members of 51 educational institutions had been paid a total of more than $200,000 for their services during the year) but so many of the Survey staff by this time had become highly qualified scientists that it was no longer necessary to call on university men as often as it had been in earlier years.

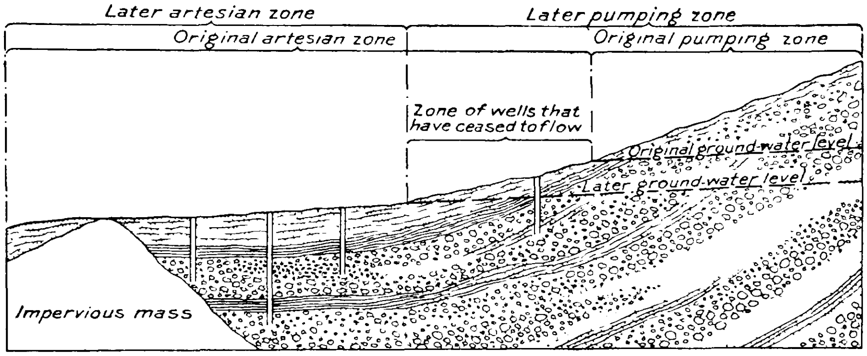
Branner was not mollified. In another letter to *Science* he modified slightly his statements about relations between the national and State surveys; his own experience (which had been in the late 1880's when Powell was Director) did not bear out Walcott's contention that relations were cordial and that cooperation was never forced upon a State organization. He had received a letter from the head of one State survey that had managed to survive who said that only by resort to the State's representatives in Congress had he been able to dislodge the U.S. Geological Survey from his State. (The more than faint echo of this charge during the debate on Survey appropriations a few months later suggests that he was referring to the Minnesota survey.) He was more concerned about the discrimination that the Director of the Survey was practicing against universities. Walcott's policy was in effect at the Geological Survey and the Carnegie Institution of Washington, and now Walcott was a candidate for Secretary of the Smithsonian Institution where he would undoubtedly pursue the same course "so the university professors of the sciences in this country and the universities themselves are face to face with a serious problem." By the time the letter was published, however, the Regents of the Smithsonian Institution had elected Henry Fairfield Osborn, President of the American Museum of Natural History, to the post of Secretary.

By this time Congress was back in session and coal was causing more trouble. The coal-land withdrawals had not greatly upset the coal industry, then largely based in the East and far more concerned with the Interstate Commerce Commission's investigation of eastern railroads and their ties to eastern coal mining. In his annual message to Congress on December 4, President Roosevelt alluded only briefly to the withdrawals, saying:

> **It is not wise that the Nation should alienate its remaining coal-lands. I have temporarily withdrawn from settlement all the lands which the Geological Survey had indicated as containing, or in all probability containing, coal. The question, however, can be properly settled only by legislation, which in my judgment should provide for the withdrawal of these lands from sale or from entry, save in certain special circumstances. The ownership would then remain in the United States, which should not, however, attempt to work them but permit them to be worked by private individuals under a royalty system, the Government keeping such control as to permit it to see that no excessive price was charged consumers.**

Although the coal industry had shown little interest in the withdrawals, Western Congressmen were concerned. On December 5, Congressman Mondell filed a resolution asking the Secretary of the Interior to supply a list of withdrawn lands, giving their current status and the reasons for the withdrawals. On December 15, Mondell saw the President, and on December 17, the withdrawal orders were modified to read withdrawn from coal entry only. Previously, lands outside the forest reserves that were officially reported by the Survey to contain coal had been withdrawn from all forms of entry while lands within the forest reserves and those outside the forest reserves not officially reported to contain coal had been withdrawn from coal entry only. On December 17 also, the President sent a special message to Congress stating that the coal-land law put a premium on fraud, that it was a scandal to maintain laws that made fraud the key to the development of natural resources, and sug-

One of the Survey's first ground-water investigations was made in southern Californa, where irrigation was necessary to mature the more valuable crops but was already so developed that any extension of areas of cultivation required an increase in water supply. When W. C. Mendenhall began his study in August 1903, low rainfall in the preceding decade and the constantly increasing drafts on stored water had already caused a decrease in the flow from artesian wells, a shrinkage of the artesian area, and a lowering of the water table outside the artesian area. Mendenhall pointed out that inasmuch as wells in the coastal plain were interdependent, users of ground water could choose to become rivals or to cooperate in preventing waste and conserving supplies. Realistically, he foresaw the possible necessity of State intervention to oversee the use of ground water. (From W. C. Mendenhall, 1905.)

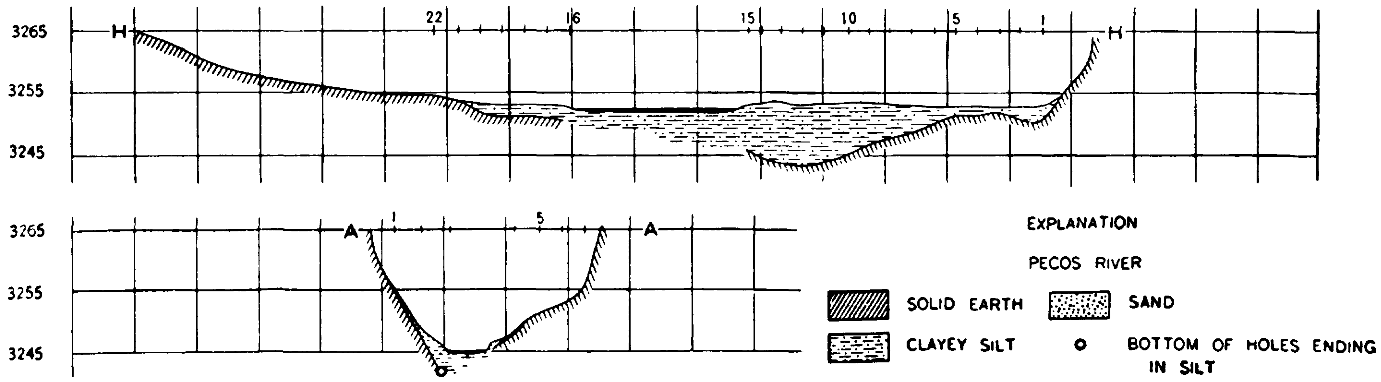


gesting that provision should be made for leasing coal, oil, and gas rights under proper restrictions. Senator Henry Hansbrough of North Dakota promptly filed bills to reserve the lands to the Government and to provide for leasing. Other bills were filed after the Christmas recess, but none was even reported out of committee before the session ended.

In the midst of all this turmoil, Secretary of the Interior Hitchcock was preparing to leave office. He had survived the rigors of the position longer than any of his predecessors, had obtained indictments against more than a thousand persons for land frauds, and had restored to the public domain more than 300,000 acres that had been misappropriated, but Secretary Hitchcock, already 72, was tired and eager to retire. On the opening day of the Congressional session in December, President Roosevelt had nominated James R. Garfield, the Commissioner of Corporations in the Department of Commerce and Labor and a member of the "tennis Cabinet," to be the new Secretary of the Interior.

In December 1906, Walcott submitted his resignation as Director of the Reclamation Service, but Secretary Hitchcock asked him to stay until the new Secretary assumed office. Within the Survey, Walcott was busy with a full-scale investigation of the Topographic Branch, precipitated by a complaint of discrimination by a member of the Eastern Division, and at the same time arranging a meeting of the State geologists of the Atlantic Coast States, who seemed not to share Professor Branner's distrust of the Survey, to plan a cooperative survey with special reference to the ground-water resources of the Atlantic Coastal Plain.

After Garfield's nomination to be Secretary of the Interior was confirmed on January 15, to take effect on March 4, the tempo of the public-land dispute began to pick up. As Commissioner of Corporations, Garfield had been a crusader, responsible for investigations of the meat-packing industry, which had resulted in several indictments and the passage of a law for a general system of meat inspection, and for investigations of the anthracite and petroleum industries. At the end of January, Senator Thomas Carter of Montana unleashed a scathing attack on Secretary Hitchcock, which very likely was meant as a warning to the new Secretary. Senator Carter complained that the publicity being given to charges of land frauds by the Interior Department "created the impression that the entire western population is, and has been, engaged in a veritable saturnalia of criminal conspiracy, fraud, and perjury over the whole broad surface of the public domain." Fraud, he said, was only a minor part of the public-land transactions. With specific reference to the coal lands, he pointed out that in the 33 years since the Coal Lands Law of 1873, only 407,000 acres of coal land had been entered, and at that rate it would take 5,000 or 6,000 years to enter the lands that had been withdrawn. A few days later, Congressman Mondell attacked the coal-land withdrawals in the House but first dissociated himself from the Senate criticism, saying he did not wish to impugn the motives of anyone or to appear as a captious critic or fault-finder. The withdrawals, however, were:



> **unauthorized by law and not warranted by any authority granted to executive officers either directly and specifically or by any possible construction of any statute, and which, if unchallenged, will undoubtedly be considered as establishing a precedent for the exercise of even further and more far-reaching executive power in the same direction * * *.**

In his opinion, the public lands could be reserved or withdrawn only pursuant to express legislative authority or by reason of a treaty, for the purpose of carrying out congressional grants, or for public purposes.

President Roosevelt countered with another message to Congress on February 13 on mineral-fuel lands and the public-land system. Again he recommended a leasing system for mineral-fuel lands and pointed out that it was not a wholly untried policy but one that had been used in Australia and in all the great coal-producing countries of Europe except Great Britain. He expressed "utter and complete dissent" with Senator Carter's view that there had been a minimum of fraud in the disposal of the public lands and pointed out that with regard to coal lands

> **the necessity for care in the future management of these fuel supplies is further illustrated by the rapid rate at which the use of such fuels is increasing in the United States. The amount of coal used in this country during the last ten years is practically equal to that used during the preceding 50 years of its history, and during each decade of this period the coal used was practically equal to the sum of that used during all the preceding decades. This remarkable development and the certain continuity of this prodigious growth compels us to recast all estimates as to the life of our "inexhaustible resources."**

Congress ignored the President's request for coal-land legislation, but it reacted strongly to his suggestion that legislation be enacted to provide for Government control of the public pasture lands of the West on the same general principles as applied to the control of the forest reserves by attacking the forest-reserve policy. Shortly after the management of the forest reserves was transferred from the Department of the Interior to the Department of Agriculture, Secretary Wilson instituted a system of leasing grazing lands within the forest reserves, to begin on January 1, 1906. The Secretary of the Interior and the Secretary of Agriculture entered into an agreement whereby the latter was given jurisdiction over applications for rights and privileges within the forest reserve, in effect placing the authority to issue permits in the hands of the Chief Forester, Gifford Pinchot. During the debate on the Agriculture appropriations bill, the Forest Service came under attack and the bill was amended to specify "That hereafter no forest reserve shall be created nor shall any additions be made to one heretofore created within the limits of the States of Oregon, Washington, Idaho, Montana, Colorado, or Wyoming except by Act of Congress." President Roosevelt thereupon issued Executive orders creating several additional forest reserves before he signed the appropriations bill.

On April 18, 1906, the coastal region of central California was shaken by an earthquake of unusual severity, causing many injuries or deaths and extensive property damage. The most disastrous effects were the outbreak of fires and the destruction of pipe systems carrying water to fight them, resulting in devastation such as that shown in the view looking west from Telegraph Hill toward Russian Hill in San Francisco. R. L. Humphreys of the Survey's Structural Materials Division was sent to California on April 19 to study the effects of the earthquake on buildings and construction, and G. K. Gilbert was a member of the Earthquake Investigations Commission, appointed by Governor George Pardee on April 21 but supported by funds from the Carnegie Institution of Washington, that made a thorough scientific study of the phenomena. (From G. K. Gilbert, R. L. Humphrey, J. S. Sewell, and Frank Soule, 1907.) ▶

The Survey began investigations of the quality of water, both chemical analyses and determinations of turbidity, or the amount of matter suspended in the water, at about the same time that it began the ground-water investigations. The amount of silt carried in suspension in streams was of special interest to the Reclamation Service, which had to contend with the problems of silt deposited in storage reservoirs. In a survey of Lake McMillan on the Pecos River in New Mexico, engineers discovered that about 42 percent of the storage capacity had been lost in 10 years. The unexpectedly rapid silting up of the reservoir was attributed to its small size. The illustration shows cross sections of test borings, A at the dam site and H about 8,000 feet back of the dam. (From W. M. Reed, 1905.)

The Geological Survey itself was in somewhat of a ferment by this time. Only 8 days after Garfield's nomination was confirmed, Walcott submitted his resignation as Director of the Geological Survey to the President. Osborn had declined the position of Secretary of the Smithsonian Institution, fearing that it would restrict his personal research. The Regents of the Smithsonian met on January 23 and elected Walcott Secretary; Walcott accepted immediately, tendering his resignation as Director of the Survey on the same day. President Roosevelt at first refused to accept Walcott's resignation but finally did so after winning Walcott's agreement to remain as Director of the Survey until Secretary Garfield gained some familiarity with the Department. Shortly thereafter, S. F. Emmons submitted his resignation as chief of the Metals Section, to take effect June 1.

The Survey appropriations had again been attacked in the House. The Survey had requested restoration of the $50,000 cut from the appropriation for water-resources investigations in the previous year but otherwise only the continuation of the previous year's funds. The House Committee on Appropriations, however, reduced that estimate by $675,000 to about 56 percent of the appropriation for the fiscal year ending June 30, 1907. The reduction was to be achieved by denying all funds for gaging streams, investigations of structural materials and investigations of fuels, and by reducing the appropriation for topographic surveys by $100,000, for geologic surveys by $50,000, and for engraving and printing maps by $25,000. The committee also revised the general item by omitting the authorizations for preparation of the geologic map of the United States and for gaging streams and determining the water supply of the United States. Another debate was precipitated, not so prolonged as in 1906 but much more blunt. For the most part the Democrats sat back and let the Republicans argue among themselves.

The debate began with a motion by the Chairman of the House Rules Committee, John Dalzell of Pennsylvania, to restore the phrases deleted by the Appropriations Committee from the general item, which was countered by a point of order from Chairman Tawney of the Appropriations Committee. Dalzell reminded Tawney that in the preceding session the Chair had ruled that the geologic map was a public work in progress so preparation of the geologic

map was reinstated. Tawney then tried to have it amended to "preparation of the geologic map of the national domain" but after another debate on the meaning of "national domain," the motion failed. Mondell then took up the argument to restore stream gaging. He insisted that water was a mineral, and this time quoted Dana's "Textbook on Mineralogy" to prove his point. If water was a mineral, then gaging streams was determining the amount of a mineral resource. Mondell convinced the House that water was a mineral but still lost the move to restore stream gaging to the general item when the House decided that as mineral resources were already covered in the general item, "gauging streams and determining the water supply" would be redundant.

The "national domain" debate was resumed when the appropriations for topographic surveys and geologic surveys were considered. For many years these had been described as "surveys in various parts of the United States" but the Appropriations Committee amended the items to read "surveys of the national domain." Marlin Olmsted, Republican of Pennsylvania, proposed an amendment to restore the previous wording for topographic surveys and a second amendment to increase the appropriation to $400,000. After considerable discussion, a compromise was reached: the wording was restored but the appropriation was increased only to $300,000. There was a similar argument about geologic surveys; for that item, both the earlier wording and the full amount requested were restored. During the debate on these items it became obvious that Tawney did not understand the nature of cooperative surveys. He believed that the Survey was contributing large sums of money from its appropriation to the States rather than that the States were furnishing money to the Survey. He accused the Director of seeking to undermine State geologists in order to "add them to his power and influence in the matter of increasing his appropriation" and reported that the State Geologist of his own State had withstood him and denied him the right to do any work in Minnesota. In turn, both Republican Dalzell, and Democrat Sherley, accused Tawney of lying.

The attempt to restore the appropriation for stream gaging failed. Mondell was back in the fray on this one, proposing an appropriation of $200,000 for examination of the water resources and products of the national domain, but Tawney made a point of order against it on the ground that water was included in mineral resources. William Englebright, Republican of California and a mining engineer by profession, then proposed an appropriation of $250,000 for investigation of the mineral resources of the national domain, in addition to the amount already appropriated, provided that not to exceed $150,000 be spent on water resources. That too met with a point of order. He tried again, omitting the proviso, and met with the same result.

The appropriation items for fuel- and structural-materials testing, however, were reinstated. The argument on structural materials revolved around duplication of work by the Survey, the Watertown Arsenal, the Supervising Architect's Office, and the Bureau of Standards. Congressman Wiley of New Jersey, who by this time had collected another sheaf of letters and telegrams endorsing the Survey work, assured the House that the Watertown testing machine was all right for tensile and compressive strength but could not determine vertical strain as the Survey equipment did, and the real duplication would be to appropriate money for the Watertown Arsenal to purchase similar equipment. No one was prepared to argue the point so the House voted to appropriate $100,000 for testing structural materials. The appropriation for fuel testing was also debated and finally, on Chairman Tawney's assurance (which was later found to be in error) that $50,000 of the current appropriation had been spent on equipment, the House voted to appropriate $200,000 to continue the fuel-testing program.

The Senate Appropriations Committee again revised the House bill. It restored "gauging streams and determining water supply" to the general item

The preservation of areas of scenic and scientific interest, a cause long espoused by geologists, was advanced by the enactment on June 8, 1906 of the American Antiquities Act, which authorized the President to declare historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest in the public lands to be national monuments. The first such designation, Devils Tower in Wyoming, was made on September 24, 1906. The photograph was taken by N. H. Darton who was studying the geology and water resources of the northern portion of the Black Hills and adjoining regions. (From N. H. Darton, 1909.)

and provided $150,000 for the work, raised the amount for fuel testing to $250,000 with the proviso it had added to the 1906 bill, which the House had omitted. The Senate passed the bill without comment on the Survey appropriation on February 26. Senate and House conferees agreed on the Senate appropriation for fuel testing but compromised on an appropriation of only $100,000 for stream gaging. Both houses accepted the conference report on March 2 over Mondell's protest that the "orders withdrawing practically all the national coal lands from entry have prevented all coal development in the West, and whatever good this Bureau may have done in the last year, if it had anything to do with proposing that policy and advocating it, or recommending it, it would have been infinitely better for the West had there been no Bureau of this sort or kind created."

James R. Garfield assumed the post of Secretary of the Interior on March 5, 1907, and within a few days there were changes in both the Department and the Survey. On March 9, F. H. Newell was appointed the second Director of the Reclamation Service, Arthur Powell Davis succeeded Newell as Chief Engineer of the Reclamation Service, and the Reclamation Service was separated from the Survey, becoming an independent bureau within the Interior Department. On March 19, the Topographic Branch was reorganized in accordance with a plan devised by a committee headed by Robert Marshall of the Western Division. The plan called for five divisions and the appointment of a chief geographer as administrative head of the branch. Pending the appointment of such an officer, which was left to the new Director, the chiefs of the five divisions, with H. M. Wilson as chairman, would act as the Topographic Committee. On April 2, a new branch, the Technologic Branch, was established, comprising two divisions corresponding to the appropriation items for fuel testing and structural-materials testing. Joseph A. Holmes was named "Expert-in-charge" of the Technologic Branch, although he himself preferred and used the term "Chief Technologist." On April 4, Secretary Garfield changed the title of the administrative head of the Geologic Branch, C. W. Hayes, from "Geologist-in-charge of Geology" to "Chief Geologist." The latter title had been used briefly by G. K. Gilbert while J. W. Powell was Director but when Survey funds had been slashed in 1892, many had complained about the existence of such an office, arguing that the Director of the Geological Survey should be its chief geologist. While Walcott was Director the title had not been used. No reason was given for its revival but it is reasonable to infer that the new Director was expected to be the Survey's principal administrative officer but not its chief scientist.

The selection of George Otis Smith as the fourth Director of the United States Geological Survey was announced on April 5, 1907. The choice was unexpected. Hayes was reported to be the favorite candidate of most Survey men. The press reported that C. R. Van Hise had declined the appointment, preferring to remain president of the University of Wisconsin, and that C. K. Leith, Van Hise's protégé, and W. B. Clark, the State Geologist of Maryland, had both been considered. Secretary Garfield, however, had chosen Smith because he had been impressed with Smith's administrative abilities as a member of one of the subcommittees of the Keep Commission during its investigation of the business operations of the Government. As the Senate was not in session, the appointment could not be confirmed, but on May 1, 1907, George Otis Smith became Acting Director of the U.S. Geological Survey. He was also Chairman of the Topographic Committee. On April 6, H. M. Wilson had transferred from the Topographic Branch to the Technologic Branch as its Chief Engineer, the Northeastern and Southeastern Divisions of the Topographic Branch had been consolidated as the Atlantic Division, and Smith had taken Wilson's place as Chairman of the Topographic Committee.

The organization of which Smith assumed charge was a vastly different one from the organization that Walcott had inherited from Powell in 1894. Walcott had become Director in inauspicious times, with the Survey under attack in Congress, and regarded with disfavor by segments of both the mining industry and the profession, and with the most serious economic depression of the 19th century underway. Superficially, the circumstances were similar in 1907; Survey appropriations were again under attack, some members of the profession were unhappy with the Survey, and there was a financial crisis. The most serious problems in 1892, however, were the lack of strong direction and internal dissensions that kept the Survey from functioning effectively as a unit. Walcott lost no time in assuming control of the work and within 3 years confidence in the organization was largely restored. Survey work expanded into new areas—investigations of water resources, Alaskan mineral resources, fuels and structural materials—all of them eminently practical in keeping with the times but never wholly applied science. At one and the same time, the Survey was actively involved in forest conservation and the reclamation of arid lands, and, at the opposite pole, theoretical and experimental research in geophysics and geochemistry. As the Survey's work expanded, Walcott continued to hold a tight rein on its conduct but relied more and more on committees or groups of scientists or engineers to develop a consensus of scientific opinion and to promulgate standards; from these committees he chose the best qualified persons to supervise individual programs. The Survey in 1907 was widely respected in Congress and in the profession; there was no question of its ability to survive difficult times, as there had been in 1892.

Walcott was accounted "the ideal administrator" by more than one of those who worked under his direction, but he was known to his contemporaries, according to legend, as "Snowshoes Charlie" because of his ability to get around without leaving tracks. Thus, although President Theodore Roosevelt said that "by his force, pertinacity, and tact, Walcott succeeded in putting the [Reclamation] act into effect in the best possible manner," most historians have overlooked his role in the passage of the act and his service as the first Director of the Reclamation Service. Most geologists when questioned identify him as a superb paleontologist, but few recognize how much of the modern Survey can be traced back to Walcott's administration. Shortly before he left the Survey, Walcott wrote to a young man who sought his advice on how to get ahead in the Government service.

> **I have always found it a good plan to consider the past as dead and gone, the present as an opportunity, and the future something to be looked forward to. Hence, my suggestion to you, in your dealings with all public officials, is to attend strictly to the business you have in hand each day, have a distinct plan for the future, and not to grumble or find fault with the past or with individuals with whom you have been in contact, or may be in contact.**

Chapter 3. Conservation: Not Prohibited by Law, 1907–1909

> **The Secretary of the Interior as the representative of the Executive in the care of the public lands and their resources often needs to take steps neither prohibited nor specifically provided for by law to prevent some great harm or to gain some great good for all the people.**
>
> **—James R. Garfield**

When George Otis Smith became Director of the Geological Survey on May 1, 1907, James R. Garfield had been Secretary of the Interior for less than 2 months. Both the Director and the Secretary were much younger than their predecessors, both came from politically oriented families, and both lacked experience in the administration of large or complex organizations. Garfield, the son of the Congressman from Ohio who became the 20th President, was 41. After graduating from Williams College and the Columbia Law School, he began practicing law with his brother Harry in 1888, concentrating on estate and corporation law. He had become active in Republican politics and was a member of the Ohio Senate from 1896 to 1899. He came to Washington in 1902 as a member of the Civil Service Commission and became a member of President Roosevelt's inner circle. A year later, Garfield became the first Commissioner of Corporations when the Department of Commerce and Labor was established. When he became Secretary of the Interior, the Department consisted of the General Land Office, the Indian Office, the Bureau of Pensions, the Patent Office, the Bureau of Education, the Geological Survey and its offspring, the Reclamation Service, along with various eleemosynary institutions, national parks, and monuments. He had little first-hand knowledge of conservation but readily absorbed the views of Gifford Pinchot. Perhaps Garfield's greatest value to the President in the post was his position on reform. Roosevelt regarded the Executive as subject only to the people and bound to take action if the Constitution did not explicitly forbid it, a view which he admitted most able lawyers past middle age did not take. Garfield was in complete accord with the President in this regard.

George Otis Smith, born in Hodgdon, Maine, in February 1871, was barely 36 when he was named Director. His father had founded a newspaper in Skowhegan in 1878 and served as its editor except for the 3-year period that he was Maine's Secretary of State, and when George Otis Smith entered Colby College in 1889, he was primarily interested in a career in journalism. At Colby he came under the influence of W. S. Bayley and at Bayley's suggestion went on to Johns Hopkins for graduate work in geology. In 1896, he received his Ph.D. from Hopkins, joined the U.S. Geological Survey, and married Grace Coburn of Skowhegan, a member of the widely known Maine family. Some of the Coburns had been identified with the railroad interests, especially the Maine Central Railroad, and others owned extensive tracts of timberland. Marriage brought to George Otis Smith responsibilities in helping to manage the Coburn estate. Smith's first assignment on the Survey had been as assistant to

George Otis Smith (1871–1944), Director of the U.S. Geological Survey, 1907–1930. Smith, only 36 when he became Director, considered the Survey to be a "bureau of information" with a "duty to assist in law enforcement," and his avowed greatest interest on becoming Director was the establishment of a business policy for the public domain. Throughout much of his directorate, he emphasized the practical aspects of the science, and he once remarked that "only as the utilitarian value of geology has become recognized has a use been found for geologists." (Courtesy of the Library of Congress.)

Bailey Willis in mapping in the State of Washington, and for several years Smith had continued to map in the Northwest. He had spent 1 year in the Metals Section, with G. W. Tower and S. F. Emmons mapping in the Tintic district in Utah, and then, in 1903, was assigned to investigations in Maine and New Hampshire. In 1905, Smith had been given supervisory responsibility for geologic investigations in New England; in 1906, he had been put in charge of a section of petrology and then detailed to the Keep Commission for introducing modern business methods into the Federal Government.

To assume the directorship following Walcott was a distinct challenge for a young man. To some, including the editors of *Economic Geology*, "however able his successor may prove to be it is doubtful whether he will meet with as great a measure of success in his administration of office." To others, who believed that the Survey had suffered both scientifically and financially by Walcott's efforts to develop such related interests as irrigation and forestry, the new Director had an opportunity to return to the less complicated days of the past or, as T. C. Chamberlin wrote in the *Journal of Geology*, "to show what can be done by an undivided devotion to the development of strictly geological work in the interest of industry, education, and science."

The policies the new Director would adopt could not be predicted, for when he was appointed George Otis Smith had not established a reputation as a brilliant scientist or as an administrator of science. In fact, the editor of the *Mining and Scientific Press*, trying to add a personal touch to the announcement of Smith's appointment, could only say that he was "reported to be a man of charming personality." A few years later, Smith reminisced that his greatest interest on becoming Director had been in establishing a business policy for the public domain and averred that the principal purposes for which the Survey had been established were practical, in the latter reflecting a view of Government science that was prevalent at the time. Certain it is that during his first years in office, Survey activities shifted from emphasis on research to emphasis on practical work and from a national orientation to stress on the public lands. The change coincided with a steady loss of personnel, as scientists left the Government service for higher salaried positions in the mineral industry, which lowered the Survey's professional standing.

The active interest of the Roosevelt administration in conservation quickly drew the Survey into the political arena. Western interests had been so thoroughly upset by the various withdrawals of public lands that a convention of protest met in Denver on June 19, 1907. Smith accompanied Secretary Garfield, Gifford Pinchot, and F. H. Newell to the convention where they were all given a thoroughly chilly reception. The convention vented most of its displeasure on the forest reserves but also asked that provision be made for filings on coal lands and that the leasing system for grazing lands be abolished, endorsed a liberal construction of the irrigation laws and State control of irrigation, and asked for the removal of restrictions on the settlement of Indian lands by whites. The convention did, however, go on record as approving the President's attempts to enforce the laws against land-fraud perpetrators.

The land frauds observed by Ralph Arnold, who was mapping in the Coalinga district in California, caused him to write to Director Smith suggesting that Secretary Garfield, who planned to visit Western regions after the convention, visit the Coalinga area, which contained the only vacant land in that part of the State that gave promise of producing oil. At that time, petroleum lands could be entered and patented only under the placer law, which required that a discovery be made before the land could be patented, so the oil companies could gain title only by development work such as drilling. When active

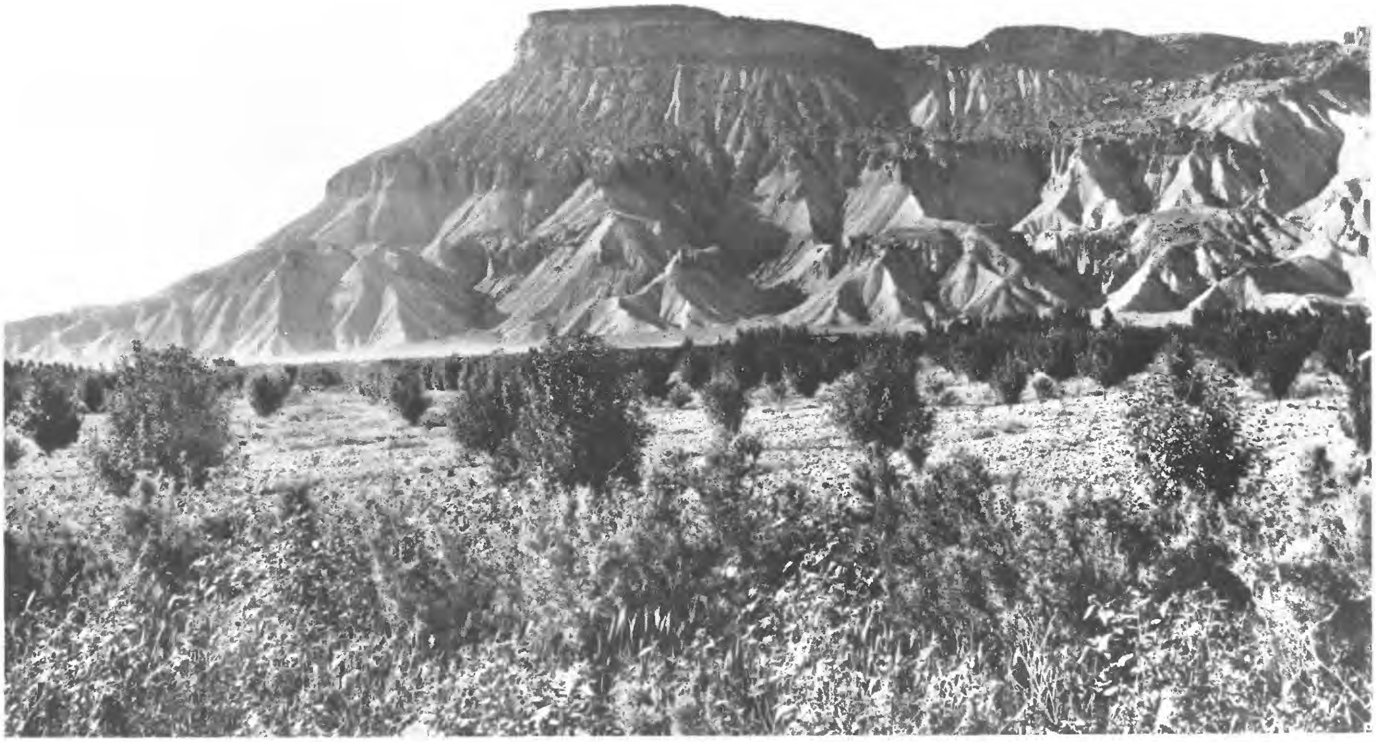
James R. Garfield (1865–1950), Secretary of the Interior 1907–1909. Garfield, son of the 20th President of the United States, was 42 when he became Secretary. Like the President he served, he tended to be a loose constructionist of the law. His Federal experience prior to becoming Secretary was a year as a member of the Civil Service Commission and 4 years as Commissioner of Corporations in which he gained a reputation as an investigator and reformer. As Secretary of the Interior, he worked closely with Gifford Pinchot and F. H. Newell in promoting the conservation of natural resources. (Courtesy of the Library of Congress.)

development began about 1900, the Land Office had withdrawn lands from agricultural filing so the drilling could go on unhampered. Some of the withdrawals, however, included agricultural land and the resultant hue and cry was so great that the lands had gradually been restored to entry. Now homestead entries were being made on land that was obviously not suited to agriculture in the hope of capitalizing on the oil companies' work. Arnold was able to convince Secretary Garfield of the need for action and on August 15 several thousand acres of presumed oil-bearing lands near Coalinga were withdrawn from homestead entry.

As a result of his Western visit, Secretary Garfield decided on a policy of local responsibility in the Interior Department. Land officials would be expected to familiarize themselves with the conditions in their districts and the needs of the homesteader and the farmer, so that Department officials in Washington would have information to judge the best interests of the people. In line with this objective, the Survey reopened offices in Denver and San Francisco.

Within the Survey there were other problems to be faced. In the fiscal year that began just 2 months after George Otis Smith became Director, the newest branch, the Technologic Branch, headed by Joseph A. Holmes, enjoyed most-favored-status. The Water Resources Branch had to discontinue nearly all research and even to decrease the number of stream measurements because of the reduction in its appropriation. The Topographic Branch had to cut back on field surveys because of the cut in its appropriation and a decline in cooperative funds. The Geologic Branch had the same funds as the year before but the extensive program of coal-land classification to which it was committed could only be carried out at the expense of other projects. The Technologic Branch, however, had the same funds and the same objectives as the year before.

Coal absorbed a large part of the attention of the Geologic Branch in the field and the Technologic Branch in the laboratory. The Geologic Branch planned to classify about 20,000 square miles of supposed coal land in the Rocky Mountain region, about one-fifth of the withdrawn area, on the basis of the first simple regulations for classification and valuation of coal lands approved by Secretary Garfield on April 8. Coal land was defined as land containing a coal bed at least 2 feet thick within 1,500 feet of the surface; its value depended on the number of such beds. M. R. Campbell was in charge of the work and 16 field parties were organized to carry it out. Only a few experienced men were available to head these parties so several young men were given responsibility and paleontologists T. W. Stanton and F. H. Knowlton were sent out to assist them in working out stratigraphic problems. A. G. Leonard and Carl Smith worked in the Sentinel Butte field of North Dakota and eastern Montana, A. J. Collier in the Miles City field in Montana, J. A. Taff in the Sheridan field in Wyoming, W. T. Lee in the Grand Mesa field of Colorado, Hoyt Gale in the Uinta Basin and George Richardson in southwestern Utah, and James H. Gardner, who had worked with M. K. Shaler in 1906, in the San Juan River coal basin of northwestern New Mexico and southwestern Colorado. In addition to these parties, C. A. Fisher supervised five parties led by inexperienced men in south-central Montana and north-central Wyoming, and Arthur Veatch supervised four such parties in south-central Wyoming in addition to inspecting contract surveys and resurveying an area near Rock Springs for the General Land Office. Near the end of the field season, Veatch was called in from the field and detailed to the White House, which then sent him to Australia and New Zealand to study their coal-land laws. Coal investigations in the Eastern States were still based on detailed mapping. George Ashley supervised the cooperative work in Pennsylvania and Frank DeWolf the work in Illinois. Together they made reconnaissance surveys of the Henderson field in



During the last 6 months of 1906, acting under orders of the President, the Secretary of the Interior withdrew from entry nearly 67 million acres of supposed coal lands in the Western States and Alaska. The classification and valuation of these lands, work that was very different from the Survey's earlier coal investigations, became a major effort of the Survey. Typical of the difficulties of classifying and placing a value on coal land were those in the Book Cliffs field, one of the most important coal reserves in the Rocky Mountain region. Coal-bearing rocks cropped out around the margin for more than 500 miles, but no single bed could be traced for more than a few miles and the thickness of the beds ranged from a mere film to 21 feet. At Mount Garfield, shown in the photograph, the coal occurs beneath the massive sandstone at the top. (From G. B. Richardson, 1909.)

Kentucky and the Evansville field in Indiana in anticipation of future cooperative work. Charles Butts continued to map in the Birmingham, Alabama, district. The Technologic Branch continued the fuel-testing program and also supported David White's research into the origin of coal.

The Survey's coal geologists were called together in January 1908 to establish a classification of coals for use in Survey publications because the coal testing program had not yet achieved one of its objectives, the development of a classification of coals based on their chemistry. The nomenclature and classification of coals, particularly the low-grade coals with which much of the western coal work was concerned, had long been a problem in the trade as well as in the Survey. The classification in general use, one proposed by Persifor Frazer in 1879, was based on the fuel ratio, defined as the quotient of the fixed carbon divided by the volatile matter as shown in a proximate analysis. The system was fairly satisfactory for high-grade coals but could not be used to separate lignite from bituminous coal. Although the coal-testing program had produced many ultimate analyses, as yet it had not yielded a method of classification. The geologists therefore agreed that six kinds of coal should be recognized: anthracite, semi-anthracite, semi-bituminous, bituminous, sub-bituminous, and lignite. They also agreed that the term "lignite" should be restricted to coals that were either actually woody in structure or closely approached wood in composition, and that "sub-bituminous" would designate coals next below the rank of bituminous but made no attempt to define the terms otherwise or to delimit the groups. One of the first uses of the classification system was on a map of the coal fields of the United States compiled by M. R. Campbell and R. W. Stone and published in the spring of 1908. The map showed the location and extent of the coal deposits, the character of the coal in each of the fields, and whether the coal was at workable depth. The area of the more accessible coal fields was estimated as about 327,000 square miles and the coal available as nearly 2,000 billion short tons.

The Technologic Branch, in addition to the fuel-testing program, also began investigations looking forward to an increase in mine safety. As part of his plan to reorganize the Interior Department, Secretary Garfield transferred to the bureaus some of the functions that had been carried on by the Secretary's Office. General supervision of the work of coal-mine inspectors in the Territories was transferred to the Survey at the beginning of the fiscal year with the suggestion that the nature and extent of mine accidents, particularly those resulting from explosions, be investigated. Such an investigation had also been high on Walcott's list of 23 fuels studies that should be undertaken. Rollin T. Chamberlin, son of T. C. Chamberlin, who had just received his Ph.D. from the University of Chicago for a thesis on gases in rocks, joined the Survey to investigate gases in coal. He and Clarence Hall visited several mines, where disasters had occurred, to collect samples and obtain data on conditions existing before the explosions and the manner in which the explosions were propagated.

The great effort being expended on coal and the continuing loss of economic geologists to private industry made it necessary for the Geologic Branch to curtail some field investigations. There were only two field projects in petroleum geology: Ralph Arnold's detailed survey of the Coalinga district in California and the structural investigation of Appalachian oil fields begun by W. T. Griswold and carried on after his resignation by M. J. Munn. Chief Geologist Hayes made a brief study of the bauxite deposits of the Southern Appalachians and the librarian, F. B. Weeks, made a reconnaissance of the western phosphate fields of Idaho, Wyoming, and Utah. The iron-resources investigations included work in Pennsylvania and Georgia by A. C. Spencer and W. T. Phalen and a reconnaissance of the principal manganese and manganiferous ore deposits of the United States by E. C. Harder, one of C. K. Leith's students who had assisted him in 1906. The Technologic Branch made most of the field investigations of structural materials and N. H. Darton was detailed to the Branch for that purpose. The metals program was much reduced. Waldemar Lindgren, who had succeeded S. F. Emmons as chief of the Metals Section, was too deeply involved in administrative duties to undertake any field work. S. F. Emmons was on leave to make a study of the Cananea copper mining district in Mexico and L. C. Graton and W. H. Emmons were with him, F. L. Ransome was occupied with reports, and only B. S. Butler, C. E. Siebenthal, and F. L. Hess were able to get into the field.

One of the largest projects in 1907 was the study of the geology and ground-water resources of the Atlantic Coastal Plain, a combined operation of the Geologic and Water Resources Branches in cooperation with several States. The project had been agreed upon at a meeting of State geologists in December 1906, and at that time a supervisory board had been established, with Professor W. B. Clark, State Geologist of Maryland, as chairman, and the State geologists of other cooperating States, the Chief Geologist, the Chief Hydrographer, the Chief of the Section of Paleontology, and the Chief of the Eastern Section of Hydrology as the other members. M. L. Fuller of the Water Resources Branch was put in overall charge of the project for the Survey, Clark supervised the geologic work from Massachusetts southward to and including North Carolina, and T. W. Vaughan supervised the work from the North Carolina-South Carolina border southward. During the 1907 field season, mapping and other field studies were carried out in New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida. Because of the concentration of work in the Coastal Plain, somewhat less areal geologic mapping was done in other States. Bailey Willis continued to work on the geologic map of North America, revising the material that had been incorporated in the map printed for the International Geological Congress in Mexico.

G. K. Gilbert resumed his studies of the principles of river hydraulics after the investigation of the San Francisco earthquake was completed. He maintained his interest in seismology, however, by serving as chairman of a 15-member Committee on Seismology of the American Association for the Advancement of Science and as a member of the Scientific Committee of the Seismological Society of America, which was established after the San Francisco earthquake.

In Alaska, W. W. Atwood and H. M. Eakin began a general study of the coal-bearing rocks of the territory, although its metals continued to be the principal interest. Fred Moffit examined the copper deposits of the Kasaan Peninsula and the valley of the Chitina River where there was a possibility that a railroad might be constructed. In the Seward Peninsula, P. S. Smith, F. J. Katz, and G. I. Findlay mapped the exceedingly intricate geology of an area that contained the only known quartz lode in western Alaska, Adolph Knopf investigated the tin deposits, and F. F. Henshaw continued the stream measurements with reference to placer mining. Because of the important mining developments and large gold production in the Fairbanks district, T. G. Gerdine and R. H. Sargent mapped at the mile-to-the-inch scale in preparation for future geologic work and C. C. Covert began hydrographic studies. Reconnaissance mapping was continued in the area between the international boundary and the Tanana and Yukon Rivers.

In the Division of Chemical and Physical Research, George Becker continued his investigations of geophysical problems and their application to geology, publishing three papers during the year on slaty cleavage, the age of a cooling globe, and the relations of radioactivity to geology and cosmogony. C. E. Van Orstrand continued in immediate charge of the work on elasticity. Early in July, A. L. Day and E. T. Allen left the Survey to inaugurate the newly built and equipped Geophysical Laboratory of the Carnegie Institution in a secluded area on the outskirts of Washington.

Oil-bearing lands near Coalinga, California, were withdrawn from homestead entry in August 1907 after Ralph Arnold of the Geological Survey pointed out that frauds were being perpetrated in the acquisition of land in the area. At the time, petroleum lands were patentable only under the Placer Act, which required discovery before the patent could be granted, and some who hoped to capitalize on the oil companies' exploration were filing homestead claims. Arnold's study indicated that petroleum occurred in five different formations and that the influence of structure on the accumulation of petroleum varied in different parts of the field, presumably because of the presence or absence of water below the oil "zones." (From Ralph Arnold and Robert Anderson, 1910.)

The Water Resources Branch had to cut back its work still further because of the second successive reduction in its appropriation. Only 630 river-measurement stations could be maintained, and 263 of them were maintained in cooperation with other organizations. State agencies provided funds for stream gaging in California and Nevada, but in other Western States the stream gaging was restricted to streams that were available for irrigation and there the Reclamation Service paid part of the expenses. The Secretary of Agriculture provided $6,000 for stream-flow measurements in the South Atlantic States where Congress had called for an investigation of the advisability of setting aside watersheds as forest reserves. Many of the stations in New England, New York, the Middle Atlantic States, and the Midwest were simply discontinued. The comprehensive investigation of the geology and ground water of the Atlantic Coastal Plain, being carried on in cooperation with several States and the Geologic Branch, was continued but little field work on ground-water projects could be done elsewhere. In the fall of 1907, when M. L. Fuller resigned to engage in private practice, responsibility for supervising the Coastal Plain project was transferred to the Geologic Branch. W. C. Mendenhall was called to Washington to supervise the remaining ground-water activities and his work in southern California was suspended. Investigations of the quality of water were confined to the few that could be carried on in cooperation with States or with the Sanitary Research Laboratory of the Massachusetts Institute of Technology.

The Topographic Branch was under new direction. Robert Marshall, who had chaired the reorganization committee in the spring of 1907, remained in Washington and was virtually in charge of the Branch after George Otis Smith became Director, although technically only Geographer-in-charge of the Pacific Division, until January 18, 1908, when he was promoted to Chief Geographer. Marshall was a Virginian, born in Amelia County in 1867 and educated in Richmond and at Columbian University in Washington. He was appointed to the Survey as a field assistant in 1889 and in 1890 was promoted to surveying duties in California. Frank Sutton, who became Geographer-in-charge of the Atlantic Division, had been with the Survey since 1886. Sutton graduated from Pennsylvania Military College in 1879 with a C.E. degree. W. H. Herron, Geographer-in-charge of the Central Division, a graduate of State Normal College of Eastern Illinois, joined the Survey in 1885. E. C. Barnard, Geographer-in-charge of the Rocky Mountain Division, had been with the Survey since graduating from Columbia University in 1884 with a degree in mechanical engineering. From 1903 to 1905, Barnard had been chief topographer of the U.S.-Canadian Boundary Survey. T. G. Gerdine of the Alaskan Division of Mineral Resources became Geographer-in-charge of the Pacific Division when Marshall became Chief Geographer. Gerdine was an 1891 graduate of the University of Georgia. He had been with the Survey since 1893 except for 2 years with the General Land Office. E. M. Douglas, who had headed the old Western Division, supervised the computing and instrument sections and was in general charge of office administration in the absence of the Chief Geographer.

The four topographic divisions completed 32,637 square miles of mapping, about 5 percent less than the Eastern and Western Divisions had accomplished in the preceding year. In the Atlantic Division, 11,200 square miles were mapped in 15 States, more than half of it at 1:62,500. The Central Division mapped only 4,715 square miles in 11 States, 75 percent of it at 1:62,500, but also made leveling surveys of the swamp areas in the ceded lands of the Chippewa Indians in Minnesota. The Rocky Mountain Division mapped 6,019 square miles, almost all at scales of 1:125,000 and 1:250,000. The Pacific Division mapped 10,703 square miles in 7 States and Territories at scales ranging from 1:31,680 in the Sacramento Valley of California to 1:250,000 in the Tonopah quadrangle in Nevada.

In the fall of 1907, Director Smith, Waldemar Lindgren and E. W. Parker of the Geologic Branch, and J. A. Holmes of the Technologic Branch attended the 10th American Mining Congress in Joplin, Missouri. The congress was still intent on gaining recognition in Washington for the mining industry by the establishment of a department of mines; it was better organized than it had ever been before and seeking the support of the eastern coal industry in its endeavors. The President of the Mining Congress, J. H. Richards of Boise, Idaho, reported that he had been in Washington and had seen the President of the United States, who said that he would recommend a bureau, but not a department, of mines in his next annual message to Congress and had also seen the new Secretary of the Interior who was at first opposed to the idea of a bureau of mines but then agreed to help.

The Director of the Geological Survey was lukewarm about the establishment of a bureau of mines. The Geological Survey, Smith said, was regarded both at home and abroad "as in reality performing the work of a mining bureau by reason of its activity in fostering the development of mineral resources of the country," and he asked for the Survey "a fair recognition for its part in the past of American mining." For the future, Smith promised an "even greater endeavor to increase its usefulness to your industry," subject of course to the limitations imposed by Congress through law and size of appropriations. In the lines along which he proposed to have the Survey increase its usefulness, however, he listed first "the fuller recognition of its duty in the matter of the classification of the mineral lands of the public domain" and after that, the rapid extension of systematic field study of all mineral resources so that geological exploration could keep ahead of economic development, the further development of the Survey as a source of authoritative and disinterested information for the benefit of the prospector or land owner, the broadening and improvement of the methods of collecting mineral statistics, the investigation of processes relating to the mining and later treatment of fuels, ores, and other mineral products, and the preparation of reports that would better meet the needs of the mining industry and their more prompt and effectual distribution.

Lindgren, who addressed the congress on its first interest, gold, was asked whether the economics of gold production were such as to lend support to the idea of a bureau of mines or whether the Government should interest itself in decreasing the cost of gold production by experiment stations. In a carefully phrased response, he said it would be desirable for the Government to investigate processes from a scientific standpoint. Political economists, as he had already pointed out, were not at all agreed that gold was necessary. Many believed that the increased production of gold during the preceding decade had brought about a depreciation in its value and thus an increase in wages and commodity prices. Depreciation in value was an automatic regulation of the gold output of the world because as gold became cheaper and more plentiful, the mining of low-grade ores was jeopardized.

Parker was more favorably inclined toward a bureau of mines. Coal consumption had been increased enormously by industrial development, and he predicted that if the current rate of production continued, the anthracite fields of Pennsylvania would be exhausted in 70 to 80 years. The bituminous fields would last for about 700 years, but improvements in methods of mining, preparation, and utilization of coal would prolong the usefulness of the best and most cheaply mined coals.

Holmes took his stand on the prevention of waste. The world, he said, recognized Americans as the most wasteful of all people in the utilization of their resources. Water, "in some respects the most valuable of all our mineral resources," was being wasted, by excessive use in many places, by not being used as a source of power in others. The waste of other mineral resources was an

In the Goldfield, Nevada, mining district, one of the most rapidly developing gold camps in the West, the ores were remarkably rich but also remarkably irregular and almost without exception associated with craggy outcrops of silicified volcanic rocks, such as those shown in the photograph. F. L. Ransome found that these ledges, as they were called by the miners, consisted of quartz, alunite, kaolinite, and pyrite, and concluded that the presence of alunite in association with the gold ores and the alteration of the rock indicated that the ores were deposited from solutions containing sulfuric acid. (From F. L. Ransome, 1909.)

even more serious matter because minerals were not renewed and when once exhausted were gone forever. Metallurgical processes were also wasteful; the large quantities of sulfur and arsenic vapors that poured out of the smelter chimney were economically and commercially valuable and at the same time destructive, killing nearby vegetation and thus permitting the rains to erode the land. The waste of fuel resources Holmes called appalling and said

> **every possible means should be adopted for reducing it to a minimum in order that our fuel resources may suffice for the future as well as for the present needs of the nation.**

Following the Mining Congress, Director Smith joined the Inland Waterways Commission on a trip down the Mississippi River. Where the idea for the Commission had come from, no one was quite sure. The President gave Pinchot the credit, but Pinchot was not certain whether he or W J McGee had thought of it. McGee had only recently returned to Washington after several years in St. Louis where he had become active in promoting the proposed Lakes-to-the-Gulf Waterway which would make it possible for ocean-going ships to come up the Mississippi to Chicago by way of the Illinois River. McGee, among others, saw that such a waterway could also be used for other purposes. The Army Engineers, however, were opposed to the idea, and in the Congressional session that ended on March 4, 1907, the House Rivers and Harbors Committee, under Chairman Theodore E. Burton of Ohio, disapproved an appropriation for such a waterway. Congressman Joseph Ransdell of Louisiana, who favored the waterway, thereupon demanded that the civil functions of the Engineer Corps be abolished and the work be put in the hands of a new Federal Department of Works. Instead, President Roosevelt on March 14 set up the Inland Waterways Commission with Congressman Burton as chairman and General Alexander Mackenzie, Chief of Engineers, as one of the members.

Others appointed to the commission were Senator Francis Newlands of Nevada, whose name was associated with the Reclamation Act, Senator William Warner of Missouri, Congressman John Bankhead of Alabama, Herbert Knox Smith, who had succeeded James R. Garfield as Commissioner of Corporations, the perennial duo of F. H. Newell and Gifford Pinchot, and W J McGee. In creating the Commission, Roosevelt stated that control of navigable waterways by the Federal Government carried with it corresponding responsibilities and obligations.

> **Our inland waterways as a whole have thus far received scant attention. It is becoming clear that our streams should be considered and conserved as great natural resources. Works designed to control our waterways have thus far usually been undertaken for a single purpose, such as the improvement of navigation, the development of power, the irrigation of arid lands, the protection of lowlands from floods, or to supply water for domestic and manufacturing purposes. While the rights of the people to these and similar uses of water must be respected, the time has come for merging local projects and uses of the inland waters in a comprehensive plan designed for the benefit of the entire country.**

The President also joined the trip down the Mississippi during which a plan was developed for a conference at the White House to dramatize the need for conservation.

In his annual message to Congress in December 1907, President Roosevelt, as he had promised the President of the Mining Congress, recommended the creation of a bureau of mines under the control and direction of the Secretary of the Interior "to have power to collect statistics and make investigations in all matters pertaining to mining and particularly to the accidents and dangers of the industry." If this could not be done immediately, at least additional appropriations should be given to the Department of the Interior "for the study

The continuing progress of the copper-mining industry in Alaska led to a demand for additional field investigations of the Prince William Sound area to supplement those by W. C. Mendenhall and F. C. Schrader in 1898 and by Schrader and A. C. Spencer in 1900. U. S. Grant and Sidney Paige, who studied the general geology as well as the mineral resources in three field seasons, noted that Prince William Sound is a highly eroded part of the surrounding Chugach Mountains, and that the fairly accordant tops of the mountains suggest an ancient peneplain that had been raised above sea level, warped, and highly eroded. In this view looking northward from Cordova, the mountains in the foreground are glaciated but the summits of those in the background are not. (From U. S. Grant and D. F. Higgins, 1910.)

of mining conditions, for the prevention of fraudulent mining schemes, for carrying on the work of mapping the mining districts, for studying methods for minimizing the accidents and dangers of the industry; in short, to aid in all proper ways the development of the mining industry."

The greatest emphasis, however, was given to the need for a comprehensive program for the "conservation of our natural resources and their proper use"; Roosevelt called it "the fundamental problem which underlies almost every other problem of our national life." He proposed that the National Government undertake the development of the great river systems as national water highways, first the Mississippi and its tributaries and then the Columbia. Other water uses should be part of the general plan for development of the waterways; Government dams, for example, should be used to produce power as well as to improve navigation, and the creation of deep waterways along the Mississippi could include the building of levees that, with control of the headwaters, would end the threat of floods in the delta region. Irrigation should be far more extensively developed, not only in the West but elsewhere, as in some of the South Atlantic and Gulf States where it would go hand in hand with the reclamation of swampland. The Federal Government should control the public grazing lands either by permit or lease. The Government should part with its title only to the actual homemaker, not the profitmaker, and its prime objective should be to secure the rights and guard the interests of the small-hold rancher.

Natural resources must not be wasted:

> **We are prone to speak of the resources of this country as inexhaustible; this is not so. The mineral wealth of the country, the coal, iron, oil, gas, and the like, does not reproduce itself, and therefore is certain to be exhausted ultimately; and wastefulness in dealing with it today means that our descendants will feel the exhaustion a generation or two before they otherwise would.**

He held that the Government should have the right to keep the fee of the coal, oil, and gas fields in its own possession and to lease the right to develop them under proper regulations, or, if Congress would not adopt this method, the coal deposits should be sold under limitations to conserve then as public utilities, the right to mine coals being separated from the title to the soil.

Much of the message dealt with the preservation or replacement of forests. Although the United States had made a beginning in forest preservation, the rate of exhaustion of timber was so great that the country was on the verge of a timber famine. About 20 percent of the forested territory was reserved in national forests, but these did not include the most valuable timberlands and the proportion was too small to do more than mitigate the trouble ahead. In particular, Roosevelt recommended that the Nation acquire all possible forest lands in the Appalachian and White Mountains.

The President's conservation program received a mixed but largely negative reaction from Congress, and indeed, in the months that followed, there seemed to be some confusion in the administration itself as to what constituted conservation. The Inland Waterways Commission report, sent to Congress in February 1908, defined the purpose of the conservation program as:

> **to carry out broad plans for the complete development of the resources of the country, and thus assure to the greatest number of people the greatest good for both the present and the future.**

In the past, the Commission pointed out, the great natural wealth of the country and the eagerness of Americans for immediate results regardless of future needs had led to extravagant consumption of natural resources and the encouragement of monopoly. These monopolistic tendencies in the past had been

Joseph Austin Holmes (1859–1915), Chief Technologist, U.S. Geological Survey, 1907–1910; first Director of the U.S. Bureau of Mines, 1910–1915. Holmes, a professor of geology at the University of North Carolina and State Geologist of North Carolina, was chosen to direct the department of mines and metallurgy at the Louisiana Purchase Exposition in 1904 and was a member of the committee overseeing the Survey's coal-testing program at the exposition. In 1905 he joined the Survey to supervise fuel testing and structural-materials testing under Survey auspices. He was active in the conservation movement but is remembered in particular for his pioneer work in promoting mine safety. (Courtesy of the Bureau of Mines.)

conspicuous with transportation agencies but were now opposing the best utilization of streams. The Commission therefore recommended that

> **hereafter plans for the improvement of navigation in inland waterways, or for any use of these waterways in connection with interstate commerce, shall take account of the purification of the waters, the development of power, the control of floods, the reclamation of lands by irrigation and drainage, and all other uses of the waters or benefits to be derived from their control.**

To attain the maximum benefits from these improvements and uses of water at a minimum cost, the Commission considered it desirable that there be an administrative agency with "large powers for the investigation and elaboration of projects under suitable legislative regulation."

The Inland Waterways Commission report was signed by all members of the Commission except General Mackenzie. Senator Newlands' bill to carry out the Commission's recommendations was so effectively opposed by the Corps of Engineers that it never came to a vote. One reason for the Engineers' opposition may have been the recommendations in the report by M. O. Leighton, the Survey's Chief Hydrographer, for preventing floods and maintaining navigable depths in streams by the establishment and maintenance of reservoirs in highland tributaries of great rivers, proposals that were notably different from the practices then in use for flood control, especially those of the Army Engineers, but which anticipated in many ways the Tennessee Valley Authority created by Congress a quarter of a century later. Leighton suggested that the logical way to control a river is to control the sources of its water supply, the logical way to prevent floods is to store and temporarily hold flood waters in reservoirs so they do not descend on the lower valleys in a large volume, and the proper way to maintain navigable depth of rivers at the low-water season is to provide for the intelligent use of stored water. In most places, levees and canalization were not the way to control the rivers. The first cost of his proposed system would be large but the ultimate cost would be nominal in comparison with the benefits, and, moreover, if a method could be devised by which the United States could realize a fair return on the additional water power created by the proposed storage system, the entire cost of the reservoirs would be returned to the Treasury.

Public vs. private control of water power sources had only recently become a matter of public interest as the electrical industry passed beyond the pioneer stage and transmission of power by electric lines made water power of value beyond the immediate vicinity of the source. Building dams in navigable streams had required express authorization by Congress and approval by the Chief of Engineers and the Secretary of War for more than a decade; in 1906, the number of applications for permits became so large that Congress passed a law to establish a uniform policy upon which approval would be given. One requirement was that construction begin within 1 year and be completed with 3 years. By an act of Congress in 1896, revised in 1901, the Secretary of the Interior had been authorized to grant rights-of-way through the public lands, forests, and reservations, where many of the best sources were located, "for electrical plants, poles, and lines for the generation and distribution of electrical power." After the management of the forest reserves was transferred from the Department of the Interior to the Department of Agriculture in 1905, the Forest Service began to charge for such permits within the reserves and to limit the length of the permits. In 1907, Secretary of the Interior Garfield, fresh from his crusading days as Commissioner of Corporations, charged that if the waters of the great mountain ranges of the West were acquired by private interests, "generations to come will pay tribute for use of water which should be preserved as a public utility, not a private privilege."

The dry dust of bituminous and lignitic coals had only recently been recognized as an explosive agent more insidious, threatening, and deadly to the miner than fire damp. Coal dust came mainly from breaking down coal at the face of the mine but was distributed through the mine in several ways, the finest dust being picked up by ventilating currents. A series of experiments at the Pittsburgh station, made with artificially prepared dust from a mine working the Pittsburgh seam that provided coal of uniform character and chemical composition, showed that dusts with about 10 percent of volatile combustible matter will explode; dusts with higher percentages of volatile combustible matter are more sensitive. The photograph shows an explosion at the Pittsburgh testing station. (From G. S. Rice, 1910.)

In the spring of 1908, the administration decided to take a stand on the issue when Congress passed a routine bill to extend the time for completion of water-power works on the Rainey River, a boundary stream between the State of Minnesota and the Dominion of Canada. Permission to build the dam had first been given in 1898 and at that time a limit of 3 years for completion had been set. The limit had been extended several times, and no difficulty was foreseen in obtaining another extension. On April 13, however, Roosevelt vetoed the bill with the conservationist manifesto that natural resources must not be granted and held in an undeveloped condition for speculative or other purposes. Unfortunately, after the bill was vetoed it was discovered that the administration did not have all the facts in the case, and the President had to request Congress to pass the bill over his veto. Secretary Garfield explained that the Rainey Company had spent time and money persuading railroads to come to the place of construction, that it took 7 years to get the consents of Canadian parliaments, and that work had to be suspended in 1907 because of the recession. Moreover, the Rainey River dam would improve navigation and maintain the Rainey Lake waters during the low-water period as well as furnish power.

Disposition of the mineral lands was a moot subject. Several bills were filed in the House and Senate—to reserve the coal lands, to dispose of the coal lands, or to reserve the mineral rights while providing for sale of surface rights—but none was ever reported out of committee. Ralph Arnold, meanwhile, had been pressing Director Smith for more action on California oil lands, and the Director had written to Secretary Garfield on February 23, 1908, recommending that "the filing of all claims to oil lands in the State of California be suspended in order that the Government might continue ownership of valuable supplies of liquid fuel in this region where all fuel is expensive." The superiority of liquid fuel for steamships and in particular for the Navy was becoming evident, and its adoption was primarily a matter of price. The rate at which the oil lands in California were being patented by private parties would bring public ownership to an end in a short time, and after that the Government would be obliged to repurchase the oil it had practically given away. Garfield, however, took no action on Smith's recommendation, and the House on April 22 passed a bill for sale of the oil lands filed by Congressman Sylvester Smith, Republican of California. In May 1908, the Department of the Interior endorsed the Mondell bill to provide for acquisition of the public phosphate lands under the placer law.

Bills to establish a bureau of mines, as recommended in Roosevelt's annual message, were filed in both the House and Senate. The Senate Committee on Mines and Mining did not report out any bill, and a joint resolution proposed by Senator Charles Dick of Ohio to provide for a Branch of Mining Technology in the Geological Survey was passed over more than a dozen times and never voted on. The House Committee on Mines and Mining, however, on April 6 recommended passage of a bill to establish a bureau in the Interior Department where it would be associated with the Geological Survey and would perform duties that would in no way duplicate those that the Survey was authorized to perform. In reporting out the bill, the committee noted that the mining industry added nearly $2 billion annually to the wealth of the country without receiving any promotion, help, or even attention from the Government but that its great growth had been attended with a disproportionate and appalling loss of life due to accidents and explosions in mines.

The President's recommendation in the annual message that funds be appropriated "for studying methods for minimizing the accidents and dangers" of the mining industry had been timely, for the year 1907 had been a disastrous one in the coal mines. During 1906, more than 2,000 miners had been killed but the toll in 1907 was even worse, and in December alone, the month in which Roosevelt made the recommendation, 700 were killed. On December 19, John McHenry of Pennsylvania filed a bill in the House for the purpose of supplying relief and alleviating suffering incident to accidents in coal mines, and both the Senate and the House talked about investigating mine disasters. Even before Congress convened, however, Clarence Hall and Walter Snelling of the Geological Survey's Technologic Branch had completed a report on coal-mine accidents, including a statement of methods used to prevent them in other countries and a suggested program of investigation. "In no other country in the world are the natural conditions so favorable for the safe extraction of coal as in the United States," they said, but "in spite of this fact the number of lives lost per 1,000 men employed is far higher than in any other coal-producing country, and the number of lives lost per million tons of coal produced is exceeded by only one other county."

The conservation of mineral resources, which were nonrenewable, had to be based on different premises than the conservation of forests or water. Scientists were concerned about the possibility of the exhaustion of oil and gas but their predictions of when it would occur were based on a limited knowledge of their occurrence. In the Gulf Coast area, for example, oil and gas were believed to occur in two ways, either concentrated in small areas near salt domes, or associated with favorable structures in certain geologic formations. Waste of these precious substances, such as gas in the well left burning for advertising purposes in the Caddo field in Louisiana, shown in the photograph, was totally unacceptable. (From G. D. Harris, 1910.)

On January 17, 1908, the Secretary of the Treasury forwarded to Congress an estimate for a supplemental appropriation of $200,000 .for the Survey, $120,000 to establish and equip a station for the investigation of methods of minimizing accidents and dangers in mines, $60,000 for investigation of mine accidents and their prevention and the improvement of mine conditions, and $20,000 for the investigation of methods of preventing waste in mining, extracting, and utilization of ores and mineral substances other than fuels. Approval of the full program would in effect set up a bureau of mines within the Geological Survey. An enthusiastic Senator Hemenway thought the appropriation should be made part of the urgent deficiency bill, then pending, but the House Committee on Appropriations instead attached it to the legislative, executive, and judiciary bill for the next fiscal year. Before reporting out the bill, the House committee amended the proposal to restrict the work to "such investigations in the Territories and the district of Alaska as will increase safety and efficiency in mining," reduced the appropriation to $195,000, and authorized the Secretary of the Interior to accept any site, buildings, equipment, or funds for use in the investigations that in his judgment it might be proper to accept. The House passed the bill with an appropriation of only $150,000 on the advice of Mr. Tawney that much of the first year would be taken up in acquiring buildings and equipment. When the bill came up on the floor of the Senate, Senator Philander Knox of Pennsylvania proposed an amendment to strike out the restriction of investigations to the Territories and Alaska and brought on a debate on States' rights in which Senator Henry Teller of Colorado was one of the most fervent objectors to Federal "interference" and Senator Eugene Hale of Maine a close second. When Senator Knox explained that the intent was to permit investigations to be made anywhere but that the Federal Government would apply the results only in the Territories and Alaska, the Senate passed the bill with the full amount of $195,000 on March 21. The bill then went to conference where it remained for the next two months.

The Conference of Governors, convened by President Roosevelt to dramatize the need for natural-resources management, met at the White House May 13–15, 1908. It was attended by a glittering array of dignitaries in addition to the Governors, including Justices of the Supreme Court, the Cabinet, Members of Congress, and representatives of leading scientific and technical organizations. Among the Federal representatives were, of course, Gifford Pinchot and F. H. Newell, and also George Otis Smith, M. O. Leighton, Henry Gannett, and Joseph A. Holmes of the Survey. In the opening address, the President called conservation the weightiest problem before the Nation and said that national power and prosperity depended on the energy and intelligence with which natural resources were used.

> **We have become great in a material sense because of the lavish use of our resources, and we have just reason to be proud of our growth. But the time has come to inquire seriously what will happen when our forests are gone, when the coal, the iron, the oil, and the gas are exhausted, when the soils have been still further impoverished and washed into the streams, polluting the rivers, denuding the fields, and obstructing navigation.**

The speakers at the conference assessed the problem of conservation from several points of view. Both Andrew Carnegie and T. C. Chamberlin stressed the need for research. According to Carnegie,

> **So far as our mineral wealth is concerned, the need of the day is prudent foresight, coupled with ceaseless research in order that new minerals may be discovered, new alloys produced, new compounds of common substances made available, new power-producing devices developed. The most careful inventory of the family patrimony should be made. I plead for economy, that the next generation and the next may be saved from want—but especially I urge research into and mastery over Nature.**

Chamberlin, who spoke in particular of soil conservation, said

> **The problem of soil management is a problem of proper balancings and adjustments, a problem to be solved by science and common sense.**

He suggested that as nature had been working on the complex problems of balance between soil formation, soil waste, surface slope, plant growth, and stream development for uncounted ages, nature's methods should be studied.

I. C. White and C. R. Van Hise, on the other hand, looked more to Government control. White spoke of the "awful waste" of fuel resources and called for legislation "to end the wild riot of destruction that has characterized the past." Van Hise, who spoke on fertilizers, considered the western phosphate deposits one of the most precious of the natural resources of the Nation and expressed the hope "that our wise and courageous President may find some legal way to preserve these deposits to the Nation, even as he has conserved the last great remnants of our forests."

Robert B. Marshall (1867–1949), Chief Geographer, U.S. Geological Survey, 1908–1919. Marshall first worked for the Survey as a field assistant in 1889 and a year later was assigned surveying duties as a topographer in California. Beginning in 1902, he was assigned to increasingly responsible administrative positions in the Pacific region. While serving as Chief Geographer, he was detailed for a year to the Secretary's Office to serve as superintendent of national parks and was on active duty as a member of the Engineer Officers Reserve Corps from June 1917 to March 1919. In 1919, he resigned from the Survey to devote full time to a project, which he had planned on the basis of information compiled during his 30 years with the Survey, to store flood waters, reclaim land, supply water to major cities, control floods, and ensure river navigation in California. The California Central Valley Project was partially realized before his death in 1949. (From the files of the U.S. Geological Survey.)

Holmes saw the problem as one of economics. "The right of the present generation to use efficiently of the [mineral] resources what it actually needs, carries with it a sacred obligation not to waste this precious heritage. The right to profit in the mining and subsequent use of our mineral resources does not carry with it the right to destroy the birthright of generations yet unborn in order that we of today may obtain more easily and more cheaply the products we need for present use."

He concluded that

> **It is therefore reasonable to expect that the users of mineral products will pay for them such higher prices as will make profitable their mining and preparation without serious waste. It is also reasonable to expect that the resulting increase in the first cost of the crude material will ensure their more efficient use, and that in turn will both help to keep down the ultimate cost of finished products and to conserve their resources.**

The Conference adopted a "declaration of views and recommendations" in which the Governors declared their "firm conviction that this conservation of our natural resources is a subject of transcendent importance," agreed "in the wisdom of future conferences between the President, Members of Congress, and the Governors of States," recommended the appointment by each State of a commission on the conservation of natural resources, and the enactment of laws looking to "the conservation of water resources for irrigation, water supply, power, and navigation, to the end that navigable and source streams may be brought under complete control and fully utilized for every purpose" and to "the prevention of waste in the mining and extraction of coal, oil, gas, and other minerals with a view to their wise conservation for the use of the People, and to the protection of human life in the mines." They expressed no opinion as to how conservation should be accomplished; that problem is still being debated.

The State Geologists assembled in Washington, 2 days before the Governors' Conference, at the invitation of the Director of the Geological Survey and before adjourning organized an Association of American State Geologists. One of their principal actions was the unanimous adoption of a resolution on topographic mapping to be presented to the President and the Governors at their meeting in the White House. The State Geologists went on record that a topographic map was necessary to the solution of serious problems relating to the "preservation" of our national resources and other "equally important" but unspecified problems, and therefore resolved "that we more earnestly ask of the State and Federal authorities in conference assembled their support in securing such a map, and, since the State and National interests are here so closely one, we most respectfully suggest: That State and Federal appropriations for topographic surveys be increased and that more immediately the Federal appropriation be increased for this work to meet the State appropriations now available."

While the White House Conference was underway, the Senate was debating the appropriations for the Survey for the fiscal year beginning July 1, 1908. The appropriation requested was $1,612,870, or $167,850 more than the year that began July 1, 1907. The House Committee on Appropriations had recommended an appropriation of only $1,085,520 in its report filed on April 10, but the House itself had increased the appropriation to $1,420,000 by amending the committee's recommendations with regard to stream gaging, fuel testing, and structural-materials testing. The committee had allowed no funds for stream gaging but inadvertently had used the old wording for the introductory item, including "gauging streams and determining the water supply" in marking up the bill. When the debate began on May 10, James Needham of California proposed an amendment to add $200,000 for investigations of water resources. He was told that he was out of order, that only whole paragraphs could be amended. After some discussion, which included consideration of the finer points of punctuation, the Chair ruled that paragraphs ended with dollars, therefore individual items were paragraphs, and Mr. Needham's amendment was in order as a separate paragraph. Mr. Tawney then made his usual point of order against stream gaging and the Chair sustained it. Needham bided his time until after the appropriations for several specific items had been passed, but as soon as the appropriation for the report on mineral resources was approved he proposed an amendment to appropriate $200,000 for mineral resources, which, he said, was clearly covered by existing legislation. Tawney promptly made a point of order against the amendment on the ground that the item for preparation of the report on mineral resources had already been passed. Needham blandly replied that his amendment was a separate paragraph, providing for the examination of mineral resources not the preparation of the report, and the Chair overruled Tawney's point of order. Needham then suggested that inasmuch as water was a mineral, the Director could use the $200,000 for water-resources investigations if he wished, and Tawney delivered himself of the opinion that water might be a mineral but it was not a mineral resource of the United States. He was flatly contradicted by F. W. Mondell, who insisted that water was one of the most valuable and perhaps the most valuable of the country's mineral resources. Tawney thought there was ample money under the irrigation law to pay for stream gaging and was again contradicted by Mondell, who pointed out that under the reclamation law stream gaging could be done only in connection with irrigation projects. At this point, Swagar Sherley suggested an appropriation of $100,000 and the Tawney forces yielded. If the money is to be used for stream gaging, let it be appropriated for stream gaging said Walter I. Smith of Iowa as he offered an amendment to appropriate $100,000 for stream gaging and determining the water supply of the United States. The amendment was promptly passed. Appropriations for fuel testing and structural-materials testing were also discussed at some length, but in the end the House voted the same amounts as had been appropriated for fiscal year 1908, thus doubling the committee's recommendations for testing structural materials and increasing that for fuel testing from $100,000 to $250,000. Tawney thought there was entirely too much duplication in the various testing programs in the Government but was nonetheless incensed when John Small of North Carolina read a letter from the Chief of Ordnance saying that the Army and the Geological Survey had made an agreement about which structural materials each organization should test, and that inasmuch as the Watertown Arsenal did not test fuels and the Survey did not test metals, there was no duplication. Such an agreement, Tawney expostulated, destroyed the legislative function of deciding on programs.

Survey topographic parties spent two seasons resurveying and marking with stone monuments part of the boundary line between Idaho and Washington that had become obliterated. The 60th Congress had made a special appropriation for this work. Boundary lines are of two kinds: those defined by some natural feature; and those defined by imaginary lines traced on the Earth's surface by astronomic or mathematical processes, which had to be perpetuated by marks of some kind. The Idaho-Washington boundary included both, defined in part by the channel of the Snake River and in part by the meridian passing through the junction of the Snake and Clearwater Rivers. The illustration shows one of the stone markers. (From R. B. Marshall, 1911.)

The Committee on Appropriations had also attempted to exert control over the Survey's method of operation by attaching a proviso to the appropriation for structural-materials testing that no part of the appropriation could be paid as "compensation or emolument" to any person not regularly and continuously employed by or whose entire time was not devoted to the service of the United States. Although aimed primarily at the Advisory Board, such a proviso would also eliminate the employment of part-time or per-diem employees. The House, however, struck out the proviso after Oscar Underwood announced that the amount spent on those college professors was "a mere bagatelle."

The House passed without discussion, however, a requirement the committee had inserted in the bill that the National Academy of Sciences at its next meeting "take into consideration the methods and expenses of conducting all surveys of a scientific character and all chemical, testing, and experimental laboratories and to report to Congress as soon thereafter as may be practicable a plan for consolidating such surveys, chemical, testing, and experimental laboratories so as to effectively prevent duplication of work and reduce expenditures without detriment to the public service.'' Tawney said the purpose of the study was to investigate the whole subject of governmental scientific work and to report to Congress on a plan for consolidating the work ''whereby the scientific research work of the Government will be carried on in one Department, in one bureau, and in one only, and when the final result is obtained the people of the United States and the world will know where they can obtain the final result of these original scientific investigations. In that way we will also stop the duplication of scientific work that is now going on in all the Departments of the Government.'' The proposed law further required that anyone employed by the United States Government, or by any scientific bureau or institution that was required to report to Congress, should refrain from participation in the deliberations of the National Academy of Sciences on the subject and from voting on or joining in the recommendations. The requirement seemed to be aimed at Charles D. Walcott, Chairman of the Committee on the Organization of the Scientific Work of the Government appointed by President Roosevelt in 1903 and still in existence.

Marshall Ora Leighton (1874–1958), Chief Hydrographer of the U.S. Geological Survey, 1906–1913. Leighton, a graduate of the Massachusetts Institute of Technology in 1896, was first employed by the Survey as a consulting engineer in 1901. He joined the Survey full time in 1902 and became the first head of the Hydro-economics Division of the Hydrographic Branch in 1903. He succeeded F. H. Newell as Chief Hydrographer in 1906 at a difficult time in branch history as Congress was cutting its appropriation, but during his tenure he expanded the surface-water work, encouraged and developed ground-water work, and defined the scope of quality-of-water work. His plan for prevention of floods and maintenance of navigable depth in streams in conjunction with water-power development, prepared for the Inland Waterways Commission, in many ways anticipated the Tennessee Valley Authority. Leighton left the Survey in 1913 for a career as a consulting engineer. (Courtesy of the Massachusetts Institute of Technology.)

The Senate made only one change in the Survey appropriation, an increase for geologic surveys to $300,000; the House conferees refused to yield, however, and only $200,000 was appropriated. The House conferees also succeeded in attaching a proviso to the appropriation for fuel testing that all investigations be completed on or prior to July 1, 1909, and that all investigations already in progress be completed and reported on before the close of the fiscal year.

In the days immediately following the Governors' Conference, the House and Senate finally reached agreement on the legislative, executive, and judiciary bill that contained the funds for mine-accidents investigations. (The long delay was caused by the Senate's 365 amendments of the House bill.) For the mine-accidents legislation, the House figure for the amount of the appropriation and the Senate's purpose of the investigations were accepted. Roosevelt signed the bill on May 22, 1908, making immediately available $195,000 for investigations ''for the protection of the lives of miners in the Territories and in the district of Alaska, and for conducting investigations as to the causes of mine explosions with a view to increasing safety in mining.'' A Division of Mine Accidents was immediately set up in the Technologic Branch of the Survey.

On May 21, the House took up the bill to establish a bureau of mines and found Mr. Tawney one of the most vocal objectors to its passage. The mining-safety legislation had been passed, he said, and inasmuch as the Geological Survey had been given money to investigate the cause of mine accidents, that took care of the man in the mines, and this proposed bureau would only help corporations. The House nonetheless passed the bill by an overwhelming majority and sent it to the Senate. The session adjourned, however, on May 30 before the Senate could take it up.

The net result of the various appropriations acts was that at least for the fiscal year beginning July 1, 1908, the Technologic Branch would have more funds than before and the regular Survey program would have somewhat less. Funds for the Technologic Branch were in fact more than the funds appropriated for the Topographic, Geologic, or Water Resources Branch alone and more than 60 percent as much as all three combined. With the Geologic Branch already committed to the coal-land classification and the Water Resources Branch necessarily devoting most of its energy to stream gaging, much of the Survey's potential for innovative research was in the hands of Joseph Austin Holmes.

Then on June 8, 1908, Holmes was appointed Secretary of the Section on Mineral Resources of the National Conservation Commission, which President

Roosevelt had established under the chairmanship of Gifford Pinchot. The Commission was organized in four sections—water resources, forest resources, resources of the land, and mineral resources—and to each of these sections President Roosevelt appointed, as he had to the Inland Waterways Commission, both Members of Congress and members of the profession. The Inland Waterways Commission was in fact reconstituted as the Section on Water Resources. The Section on Mineral Resources included Congressman John Dalzell of Pennsylvania, who so consistently supported the fuel-testing programs, as chairman, Senators Joseph M. Dixon of Montana, Frank P. Flint of California, and Lee S. Overman of North Carolina, Representatives Philo Hall of South Dakota and James L. Slayden of Texas, Andrew Carnegie, C. R. Van Hise, John Mitchell, head of the United Mine Workers, John Hayes Hammond, and Professor I. C. White, as well as Holmes, as members. Henry Gannett was appointed Geographer to the Commission.

The Executive Committee of the National Conservation Commission met on June 19 and outlined a plan for making an inventory of the natural resources of the United States so that work could begin on July 1 with the cooperation of the various Federal bureaus, State authorities, and national organizations. Several men from the Geologic, Water Resources, and Technologic Branches were asked to prepare reports in connection with this inventory, and Henry Gannett was given general supervision of the compilation of material.

Within the Survey, Holmes began to consolidate the operations of the Technologic Branch and to look forward to the establishment of a bureau of mines. Wasting no time once the Mine Accidents Division was set up, he obtained authority from the Secretary of War to use part of the old arsenal tract in Pittsburgh for an explosives experiment station, and then decided to concentrate, as far as possible, the various projects of the branch in that city. The fuel-testing equipment that had been used at Norfolk, Virginia, to test naval supplies was moved to Pittsburgh, chemical investigations carried on in laboratories at several universities were also transferred to Pittsburgh, and a physical laboratory was set up. Structural-materials investigations were not easily consolidated, and only the chemical laboratories and testing equipment for investigations of clay and clay products were set up in Pittsburgh. Other special investigations were continued at St. Louis, Missouri, Atlantic City, New Jersey, and Northampton, Pennsylvania.

To initiate the mine-accidents program, plans were made for Survey engineers to visit the coal-mining regions in Europe to learn from their experience, and an invitation was extended to the Governments of Great Britain, Belgium, and Germany to send their most experienced mine-safety officers to advise the Survey on plans for investigations. Victor Watteyne, Inspector-General of Mines in Belgium, Carl Meissner, Councillor of Mines in Germany, and Arthur Desborough, H. M. Inspector of Explosives in England, arrived about the end of August, examined the plans and equipment of the mines-experiment station that was being established in Pittsburgh, and then visited some of the coal fields. As rapidly as the means became available, the Mine Accidents Division plunged into a series of investigations of explosives used in coal mining, of the occurrence of explosive gases and inflammable or explosive dust, of the so-called safety lamps and of mine rescue apparatus for use in mines filled with poisonous and explosive gases, and of the use of electricity in coal mines where either gas or inflammable dust was abundant.

The report of the visiting mine-safety officers to the Secretary of the Interior dealt primarily with mining safety, but it also pinpointed a special problem in the conservation of mineral resources. The experts reported that they were "greatly impressed" with the loss of coal in mining operations in many parts of the United States, which they termed a serious, permanent, and national loss.

> **It seems to be a natural outcome of the ease with which coal has been mined in the United States and the enormously rapid growth of the industry. The active competition among the operators and the constant resulting effort to produce cheaper coal has often naturally led to the mining of only that part of the coal which could be brought to the surface most easily and cheaply, leaving underground, in such condition as to be permanently lost, a considerable percentage of the total possible product. Certainly much of this loss can be prevented through the introduction of more efficient mining methods.**

They discreetly avoided any discussion of the conditions under which the more efficient methods might be introduced.

The Technologic Branch in addition to its fuel testing continued to support David White's research into the origin of coal, and White, in a paper distilling a dozen years' study of coal into a statement on its formation, demonstrated why research was needed. Much had been learned about coal since geologists first began studying it, and it was no longer necessary to argue that coal was "a stratified carbonaceous deposit of first-hand organic debris in which the vegetal elements greatly predominate, at least optically." In the genesis of coal, however, the conditions of growth and accumulation of the organic matter, the kinds of organisms and the proportions of each, the conditions and duration of the initial process of organic decomposition, and the nature and energy of the dynamic forces bringing about the subsequent alteration of the organic residue were all facts that had to be considered. After more than a century of discussion, whether the coal-forming vegetation grew in place or was brought in was still a matter of dispute, and the difficulties of investigating the kinds and proportions of the organic matter contributing to the formation of the various kinds of coal and the determination of the resulting special qualities seemed almost insurmountable. The essential feature in the coalification of the organic debris, according to White, was the deoxygenation and dehydrogenation of the vegetal matter, the first step of which was accomplished by fermentation through the activity of microorganisms. The nature and relative amounts of the resultant hydrocarbon compounds depended on the extent to which the decomposition had progressed, and that in turn was governed by a complex of factors, the principal one the amount of oxygen available. The weight of field observations tended to confirm the conclusions of some of the earlier paleobotanists that the anthracites and bituminous coals were metamorphosed peats and lignites. White believed, however, that in the progressive devolatilization and consequent improvement of the coal as the result of dynamic influences, the essential cause was not folding or faulting but the deeper-seated horizontal thrust movements to which the folds and faults were the local means of relief, although gravity pressure or loading was also influential. Research, he concluded, was necessary on the point at which the biochemical process ended and the dynamochemical one began.

The great variety of work underway in the Technologic Branch, which ranged from research to service, was in fact comparable to that of an independent bureau with the exception of the ties to the Geologic Branch for studies of fuels and structural materials. Holmes' activities as head of the branch were much more in the nature of a director of a bureau than a subordinate chief, which made for a somewhat unusual relationship with the Director of the Geological Survey.

In the Geologic Branch, investigations of the economic geology of substances other than coal were few in number. J. A. Taff returned to the Mid-continent to resume investigations of its oil fields, and Ralph Arnold and M. J. Munn continued work in southern California and in the Appalachian fields. Very little work was done on iron ores although A. C. Spencer, who had been put in charge of mapping in central Texas, examined iron ores there. The metals program was severely curtailed. S. F. Emmons and Waldemar Lindgren were occupied with reports. F. L. Ransome completed field work in the Goldfield district of Nevada, and he and W. H. Emmons made reconnaissance investigations of the mining regions in northwestern and north-central Nevada. In the fall, Ransome started a field study of the Breckenridge district in Colorado. B. S. Butler mapped the Frisco, Utah, district. J. M. Boutwell resigned to become a consulting geologist and L. C. Graton to become Secretary of the Copper Producers Association.

Mapping projects and stratigraphic studies were continued in the Coastal Plain, the Appalachian Mountains, the Mississippi Valley, and various parts of the West. Arthur Keith, who replaced Bailey Willis in charge of the Section of Areal and Structural Geology, spent considerable time in Massachusetts and Vermont in an effort to correlate the work of the several geologists who had worked in New England. In the Mississippi Valley, Chief Geologist Hayes, Professor A. H. Purdue, the State Geologist of Arkansas, E. O. Ulrich, and J. A. Taff made a field review of the stratigraphic and faunal relations of Paleozoic rocks in the Ouachita uplift. Bailey Willis with the aid of several colleagues compiled paleogeographic maps of North America at 15 different periods for exhibit at the Symposium on Correlation at the meetings of the American Association for the Advancement of Science and the Geological Society of America. Ralph Arnold, W. H. Dall, G. H. Girty, F. H. Knowlton, T. W. Stanton, and David White were among those presenting papers at the symposium. The Section of Physiographic and Glacial Geology was suspended by default. Gilbert was busy with his study of river hydraulics, Leverett spent most of the year in Europe at his own expense, and Alden made field studies in Wisconsin under the supervision of T. C. Chamberlin or worked on reports in conjunction with water-resources investigations.

The Division of Alaskan Mineral Resources, which operated under a separate appropriation, was able to maintain a full and varied field season. There were 17 separate investigations, most of them concerned with metal mining regions. W. W. Atwood and H. M. Eakin spent another season in a general study of coal fields. P. S. Smith and E. M. Kindle made detailed stratigraphic studies in the Seward Peninsula, and C. C. Covert continued and extended the investigations of the water resources of the Yukon-Tanana region and the stream gaging in the Circle, Fairbanks, and Baker regions. Topographic surveys were made of more than 4,000 square miles in southeastern and southwestern Alaska, the Copper River Basin, and the Yukon Basin.

The Division of Physical and Chemical Research lost two chemists, first E. C. Sullivan, who left to become director of research for the Corning Glass Works, and then W. F. Hillebrand, to become Chief Chemist of the National Bureau of Standards. Two months before Hillebrand left the Survey, he and Whitman Cross of the Division of Geology had been elected to membership in the National Academy of Sciences. The two men had begun their Survey careers together, appointed in 1880 and assigned to work with S. F. Emmons in the mining geology investigations in the Rocky Mountain region, and they had collaborated on several papers on minerals of the region. After the mid-1880's, however, when Hillebrand was transferred to Washington, their careers had diverged; Hillebrand was increasingly concerned with analytical chemistry and Cross with petrography. F. W. Clarke, who became the Survey's senior chemist, completed the first edition of the "Data of Geochemistry," which was termed "an important service to science" by the *American Journal of Science*.

The Water Resources Branch was able to increase the number of gaging stations, even though its appropriation had not been increased, as the result of cooperative agreements with States and repayments from other Federal agencies. Research, however, had to be limited. In fact, the total allotment for ground-water investigations was insufficient to maintain the regular staff, continue the investigations by university experts, and continue the Coastal Plain study, so arrangements were made to assign H. R. Johnson to the Geologic Branch for half the year and for the State of Utah to pay O. E. Meinzer's field expenses while he was studying the ground-water resources of Juab, Millard, and Iron Counties. Johnson studied the occurrence, distribution, and quantity of underground waters in Antelope Valley and adjacent parts of the Mojave Desert in California, and G. A. Waring began a systematic study of the springs of California, especially those reputed to have medicinal properties.

A fundamental change was made in the topographic mapping program. On the advice of Secretary Garfield, the Survey accepted only $100,000 in cooperative funds, although more than $160,000 was offered. Consequently, more mapping was done in the public-land States and more mapping was done at small scales than in the previous years. Two-thirds of the mapping was done in the Rocky Mountain and Pacific Divisions, but about 82 percent of the area was mapped at scales of 2 to 4 miles to the inch. In the Atlantic and Central Divisions, 83 percent of the area was mapped at the mile-to-the-inch scale. In all four divisions, however, a significant amount of mapping for the first time was done at the scale of 2 inches to the mile.

Several members of the Survey prepared reports for the National Conservation Commission's inventory of natural resources. Chief Geologist Hayes prepared the report on iron resources, carefully labelling it "a first approximation." He concluded that at the existing rate of increase in production, the high-grade ores would not last more than 30 years and that by 1940 large use

By 1907, the Survey was making extensive use of multiple-point methods in studying stream flow, in particular the 0.2- and 0.8-depth method shown in the illustration. In this method, observations of depth and velocity are made at several points in a section perpendicular to the mean direction of the current, which divide the total cross section of the stream into elementary strips. The current meter is held successively at 0.2 and 0.8 depth and the mean of the velocities at these points is taken as the mean velocity for that vertical. The discharge of any elementary strip is the product of the average depth, the mean velocity, and the width of the strip, and the sum of the discharges of the elementary strips is the total discharge of the stream. (From H. K. Barrows and R. H. Bolster, 1910.)

would have to be made of low-grade ores. F. B. Van Horn, who had succeeded Eckel as Hayes' assistant, estimated the total available tonnage of phosphate as 221,500,000 tons, acknowledging that the estimate was based on very incomplete data. At the rate of increase in production that had prevailed for the preceding 25 years, he estimated that available rock phosphate would be exhausted in 25 years, and pointed out that much of the phosphate, in fact about 40 percent of it in 1907, was not being used to aid American farms but was being exported. Waldemar Lindgren prepared reports on gold, silver, copper, lead, and zinc. He concluded that the resources, though large, were not measurable with any accuracy, but if the existing rate of increase in production continued, the known reserves, workable under 1908 conditions, would be exhausted before the middle of the 20th century. However, he pointed out, there was no way of knowing that the development of the world would continue along the same lines, that metals would continue to have the same value, that the same metals would be used for the same purposes, and without that knowledge the prediction meant little. M. R. Campbell and E. W. Parker estimated that 0.3 percent of the original total supply of coal, or 0.7 percent of the easily accessible and available coal had been exhausted by 1907 but that all available coal would be exhausted early in the 21st century and all coal by the middle of that century. David T. Day estimated that the known supply of petroleum was 15 to 24 billion barrels. Petroleum would last for 90 years at the then current rate of production but would be exhausted by 1943 if production continued to double each 9 years as it had since 1860. Day called attention to the enormous waste of natural gas—as much as a billion cubic feet a day—that accompanied petroleum production and urged that radical measures be taken to suppress such waste.

A. H. Brooks devoted much attention to the coal resources of Alaska in his report. Ores and other minerals mined to the close of 1907 included gold, silver, copper, lead, tin, coal, petroleum, gypsum, marble, and mineral waters, but quantitative data were not available because 84 percent of the territory was geologically almost unknown and less than 1 percent had been mapped in detail. More data were available for coal than for other resources; it was known to underlie some 1,200 square miles and believed to underlie more than 12,000 square miles. The estimated tonnage was more than 15 billion tons but could easily be ten to a hundred times as much. The deposits easily accessible from the Pacific Coast were already being exploited but in the central province there were still large areas unprospected, and northern Alaska was not only undeveloped but likely to remain so until the accessible coal approached exhaustion.

M. O. Leighton, W. C. Mendenhall, R. B. Dole, Herman Stabler, and Henry Gannett all prepared papers on the conservation of water resources for the National Conservation Commission report. Gannett's paper was essentially a description of a map of mean annual precipitation in the United States based on data from 4,000 stations. Gannett's map radically revised John Wesley Powell's map of 1878. The 20-inch isohyetal line, east of which all areas received 20 inches or more a year, was considerably to the west of Powell's, extending in a southwesterly direction from roughly the 98th meridian at the Canadian border to the 103d meridian at the Mexican border. Within the arid region west of that line, there were many areas within which rainfall exceeded 20 or even 30 inches a year. Gannett also prepared a map showing the percentage of annual precipitation during the months from April to September, which was more important for agriculture than the mean annual precipitation. On that map, the Great Plains region was shown as receiving more than 70 percent of its annual precipitation during the growing season.

Leighton contributed papers on floods and water-power development. A review of river-discharge records had indicated unmistakably that floods were increasing. Climate, topography, geology, surface vegetation, and artificial agencies such as storage, reservoirs, and drainage all affected the flow of streams, but Leighton concluded that the increase in flood tendency was due by and large to the denudation of forest areas. Storage of flood waters in reservoirs would alleviate the danger of floods and under proper management would increase water-power possibilities in some areas and provide water for reclamation of many millions of acres of land in the arid West. A special census had shown that at the time 5,365,680 horsepower was developed in the United States, more than half of it in the North Atlantic region and the drainage basin of the St. Lawrence River. Leighton calculated that a total power installation of at least 200 million horsepower was possible. The greatest water-power possibilities were in the northern Pacific region, essentially the basins of the Columbia and Sacramento Rivers. F. H. Newell of the Reclamation Service, in the same Conservation Commission report, estimated that a total of between 40 and 50 million acres, including the area then under ditch, could be reclaimed. If all the runoff waters could be conserved and used in irrigation, the total area might be nearly 60 million acres, but large areas existed where there was no irrigable land on which the water could be brought at a reasonable cost.

Dole and Stabler estimated that the surface of the United States was being removed at the rate of 0.0013 inches a year. The amount was small but represented more than 270 million tons of dissolved matter and 513 million tons of suspended matter transported to tidewater every year by the streams of the United States. To make their figures easily comprehended they pointed out that "If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about seventy-three days."

Mendenhall's paper on ground-water resources was more philosophical than the others. Ground water, he pointed out, sustained crops and forests and was used in irrigation, in industry, in transportation, and in many activities of life, but the total quantity could not be closely determined because the determination involved such factors as the percentage of pore space in deeply buried and inaccessible material that were not directly measurable. A determination of total quantity, however, was not important as only a very small proportion of the water was accessible and utilizable. It was important that of the relatively small amount that was within reach, "only that proportion that, if withdrawn, will be restored annually can be utilized, because, obviously, withdrawals in excess of this mean reduction of the principal and eventual bankruptcy." He noted that already there were a few small districts where the ground water was being extracted faster than it was being renewed, other areas in which the ground water was being contaminated by careless discharge of industrial waste or sewage or brines from deep wells, and still other areas in which the stripping of natural cover was causing a material reduction in the annual accession to the supply. "These conditions," he said, "must be met and remedied; then nature, through her annual rainfall, will repair the harm, as yet slight, that has been done."

The National Conservation Commission completed its report by December 1, 1908, and it was endorsed 10 days later by a joint conference of Governors, State conservation commissions, and delegates and representatives of State and national organizations dealing with natural resources. In just the few short months since the White House Conference had met, 33 States and Territories had established conservation commissions and 41 national organizations were also participating in conservation activities.

The Commission divided natural resources into three categories. Although natural resources are interrelated, it said, they are unlike, and each class required distinct treatment. Moreover, the treatment applied to each class should be adapted to its own fullest development and best utilization and to those of the other classes of resources. Lands and forests were classified as improvable resources; the land could not be increased but its productivity and availability for use might be augmented, and forests could be protected and improved in such a way as to meet human necessities. Water was classed as a naturally renewable resource; man may do nothing to increase it but may do much in the way of conservation and better utilization. Minerals, however, are "limited in quantity and can not be increased or improved by anything which man may do." In an unfortunate choice of terminology that suggested profligracy was permissible, the Commission classified minerals as expendable resources.

The Commission stressed that waste of natural resources was not to be tolerated. The most reprehensible waste was that of destruction, as in forest fires, uncontrolled flow of gas and oil, soil wash, and abandonment of coal in mines. Nearly as reprehensible was misuse, as the consumption of fuel in furnaces and engines of low efficiency, the loss of water in floods, the use of ill-adapted structural materials, and the growing of ill-chosen crops. Waste arising from nonuse was less reprehensible and sometimes unavoidable.

For the conservation of mineral resources, the Commission proposed that metals should be so used as to reduce to a minimum the loss by rust, electrolytic

The joint study of the Atlantic Coastal Plain by the Geologic and Water Resources Branches of the Survey included stratigraphic and paleontologic investigations to determine the lithologic units worthy of recognition as formations or members. The paleontologic studies provided more definite information on the character and boundaries of the units but no major changes were made in the divisions recognized by earlier investigators. L. W. Stephenson, however, suggested a "readjustment" of nomenclature in order to retain the name "Tombigbee," first proposed by E. W. Hilgard in 1867, as a subdivision of the Eutaw. The photograph is of the Tombigbee Sand Member of the Eutaw Formation along the Chattahoochee River below Columbus, Georgia. (From L. W. Stephenson, 1914.)

action, and other wastes; the National Government should exercise such control of the mineral fuels and phosphate rocks then in its possession as to check waste and prolong the supply; preventive measures to reduce mine accidents should be adopted. The Commission concluded that

> **While the distribution and quantity of most of our important mineral substances are known in a general way, there is imperative need for further surveys and investigations and for researches concerning the less-known minerals.**

Water supply, the Commission emphasized, should be considered the paramount use of water, and next should come navigation in the humid regions and irrigation in the arid regions. The development of power on navigable and source streams should be coordinated with the primary and secondary uses of the waters but should be encouraged, other things being equal, because it would reduce the drain on other resources and because properly designed reservoirs and power plants would retard the runoff and so aid in the control of streams for navigation and other uses. The Commission urged that broad plans be adopted to provide for a system of water improvement extending to all uses of the waters and benefits to be derived from their control, and that

> **To promote and perfect these plans, surveys and measurements should be continued and extended, especially the more accurate determination of rainfall and evaporation, the investigation and measurement of ground water, the gauging of streams and determination of sediment, the topographic surveys of catchment areas and sites available for control of the waters for navigation and related purposes.**

"Good business sense," according to the Commission, demanded the formulation of a definite land policy. The existing public-land laws did not serve the best interests of the Nation and should be modified. Public lands should be devoted to the use which would best serve the interests of all the people. Classification of all the public lands was therefore necessary. The timber, minerals, and the surface of the public lands should be disposed of separately. Public lands more valuable for conserving water supply, timber, and natural beauties or wonders than for agriculture should be held for the enjoyment of all people except from mineral entry. Title to the surface of the remaining non-mineral public lands should be granted only to actual homemakers.

Secretary of the Interior Garfield reacted quickly and positively to what he perceived to be these needs, even when it meant reversing a stand previously taken or alienating powerful interests. Although the Department had in May 1908 endorsed the Mondell bill for disposing of the phosphate lands, in the light of the Van Horn, Van Hise, and Conservation Commission recommendations, the Secretary on December 9, instructed the Commissioner of the General Land Office to withdraw from all forms of disposal the unpatented lands in tracts covering 4,699,160 acres in Wyoming, Idaho, and Utah supposed to contain phosphate "in aid of proposed legislation affecting the disposal of the phosphate lands" and then recommended to Congress that the phosphate lands be segregated from agricultural lands and leased. On December 15, the Secretary ordered public lands in the area of the Caddo oil field in Louisiana withdrawn from settlement, entry, or other form of appropriation, pending investigation by the Geological Survey, to prevent waste of natural gas. Chief Geologist Hayes and David T. Day had reported that when they visited the field in October, they had found gas escaping from four wells and a well burning with a flame 70 to 100 feet high as an advertising spectacle. Hayes estimated that at least 75 million cubic feet of gas were being wasted every day, and Hayes believed steps should be taken to prevent such waste.

The philosophy behind these actions, Secretary Garfield explained in his annual report to Congress:

> **It is the duty of the Executive to take such action as will protect the interests of all the people of the United States in their property rights, and, if the occasion requires and the facts warrant, it is the duty of the Executive to prevent the acquisition of the public domain by private interests if such acquisition be detrimental to the public welfare. If there be no power to affirmatively provide for the ultimate use or disposition of the public domain in accordance with the needs of the public welfare, it is the duty of the Executive to temporarily prevent its acquisition until Congress may have an opportunity to consider the question and adopt appropriate legislation.**

With the development of this philosophy in the Department, the Survey made plans to systematize the classification program to ensure uniformity of treatment consistent with Department policy and to provide control of the increasing mass of records. On December 18, 1908, a Land Classification Board was established in the Division of Geology of the Geologic Branch with Arthur Veatch as Chairman. The Board consisted of a general advisory section—the Chairman, the Chief Geologist, and the chiefs of the Fuels and Metals Sections—to consider questions of policy and approve standards, and four classification sections to deal with the particular classes of lands. C. A. Fisher and G. C. Martin formed the first Coal Classification Section; Ralph Arnold and J. A. Taff, the Oil Classification Section; F. B. Van Horn and E. O. Ulrich, the Phosphate Section; and H. C. McCaskey and F. L. Ransome, the Section on Metalliferous Deposits. Most of the members were young men—the average age of the members of the classification sections was less than 40 and the Chairman of the Board was only 30—and all were active field geologists.

President Roosevelt said little about conservation in his last annual message to Congress, which was delivered before the joint conference met and approved the National Conservation Commission report. What he did say pertained only to forests, inland waterways, and national parks, which he said should be adjacent to national forests and under the Department of Agriculture. In November, his handpicked successor, William Howard Taft, had been elected President and confident that his program would be carried forward, he was making plans to leave on a trip to hunt big game in Africa when his term was over.

On January 22, 1909, he sent the report of the National Conservation Commission to Congress with a special message again urging that the plan for the development of waterways be put into effect, that provision be made for the protection and more rapid development of the national forests, that changes be made in the public-land laws, including separation of surface and mineral rights and the withdrawal from entry of all coal, oil, gas, and mineral lands still remaining with the Government, and that a bureau of mines be established. He also asked for an appropriation of at least $50,000 to cover the expenses of the National Conservation Commission.

Congress clearly wanted little if any part of the conservation program. It authorized publication of the Conservation Commission report but otherwise almost completely ignored it and the President's recommendations with regard to it. No appropriation was made for the work of the Commission, and to make sure that there would be no more such reports, Tawney personally attached an amendment to the sundry civil expenses bill forbidding the detail of any Federal employee for service with any such commission, or the payment of any money for salary or expenses to anyone working on such a commission. The Senate debated the bureau of mines bill that had been passed by the House in the preceding session but decided that there were already too many bureaus and commissions and did not vote on it. Only a minor change was made in the mineral-land laws. Persons who had entered or selected lands under the

In February 1909, Congress authorized 320-acre homesteads in nine Western States if the land was designated by the Survey as not susceptible of successful irrigation at a reasonable cost from any known source of water supply. The designation of areas suitable for these enlarged homesteads was not a simple matter. The high plains of eastern Colorado, which consisted of "grass, sunshine, and solitude" according to N. H. Darton, appeared to be suitable only for grazing lands, but Darton, who had recently completed a study of the geology and ground water in the Arkansas Valley, reported that several formations were known to be water bearing, but artesian flows were available only in the lower lands, in places the supply was inadequate, and in some places too saline or alkaline for use in irrigation. (From N. H. Darton, 1906.)

nonmineral-land laws that were subsequently classified, claimed, or reported as valuable for coal would be permitted to elect to receive patent to their lands by reserving to the United States the coal deposits and the right to prospect for and mine them. The House Committee on Public Lands, on the other hand, ignored the administration bill and recommended passage of the Mondell bill to make the phosphate lands available under the Placer Act. Leasing proposed by the Secretary of the Interior, the committee concluded, was "a radical and questionable departure from the long-established public-land policy of the country, and one calculated to hamper development." Moreover, in the committee's opinion, there was "no necessity for alarm that the phosphate deposits of the country will be soon depleted or that there will ever be a phosphate famine or shortage." What locators in the western areas needed, they said, was "encouragement and an opportunity to develop their industry." Rather than follow the administration's lead on the grazing lands, the House and Senate came to an agreement in mid-February and passed the Enlarged Homestead Act, authorizing 320-acre homesteads on nonirrigable, nonmineral lands having nonmerchantable timber in nine Western States, with a proviso that no lands would be subject to entry under the act until the Secretary of the Interior designated them as not being susceptible of successful irrigation at a reasonable cost from any known source of water supply. Congress by that time may have begun to suspect that the new administration would not be a carbon copy of the Roosevelt administation. Taft had sought no advice from Roosevelt on the selection of the Cabinet but instead had relied heavily on Senator Philander Knox of Pennsylvania, who had served as Attorney General from 1897 to 1904 and whom Taft had chosen as his Secretary of State. As the appointments were announced, it became evident that the Cabinet would be weighted with lawyers, all but one of them over 50 and politically a bit to the right of center. Only two members of the Roosevelt Cabinet were retained, one of them James Wilson of the Department of Agriculture. Garfield had expected to be retained, and Pinchot wanted him retained, but in mid-January, the President-elect had announced that Richard A. Ballinger, who had served briefly under Garfield as Commissioner of the General Land Office, would be his Secretary of the Interior.

When the first request for segregation of land under the Enlarged Homestead Act was received in the Department of the Interior in late February 1909, it was referred to the Reclamation Service, but Newell, who was busy at the time with selection of water-power sites, told Secretary Garfield that the Survey had had experience in classification, had data in its files, and was the agency best equipped to do the work. Privately, Newell, who thought the bill a bad one, advised George Otis Smith to have nothing to do with it, but the Director, who believed the bill was a good one, was eager to oblige when Secretary Garfield turned to the Survey and so responded promptly. The Land Classification Board was expanded, Chief Hydrographer M. O. Leighton was added to the advisory board, and a section on nonirrigable land was set up with W. C. Mendenhall and J. C. Hoyt as members. On his last day in office, Garfield made the first designation of land under the Enlarged Homestead Act.

Newell's preoccupation with the selection of water-power sites at that time resulted from a decision by Pinchot, Newell, and Garfield, when it became evident that there would be no new legislation on water-power sites before Congress adjourned. With only days remaining before the change of administration, Newell selected and Garfield withdrew from all forms of entry some 3,928,780 acres along the courses of 16 rivers in 7 Western States. The last withdrawal was made on March 2, 1909.

The appropriations bills were passed hastily as the Congressional session was drawing to a close. The scenario differed only in detail from the one that had been followed since Tawney became Chairman of the House Appropriations Committee. The committee slashed the Survey's budget, this time by $800,000, eliminating all funds for fuel testing and halving the funds for structural-materials testing. During the House debate, John Dalzell proposed $200,000 for fuel testing, Tawney made a point of order against the proposal on the basis of the previous year's proviso that the investigations be completed by July 1, 1909, and the House compromised on an appropriation of $100,000. George Norris made a motion to increase the appropriation for structural-materials testing to $100,000, and the House agreed. The appropriation for the investigation of mine explosions, which the committee had cut to $100,000, was increased to $150,000. The Senate Appropriations Committee recommended increases in the appropriations for topographic surveys, geologic surveys including paleontology, Alaskan mineral resources, and stream gaging; the Senate accepted all recommendations and voted a total appropriation for the Survey of $1,592,390. The conference committee agreed to the Senate figure of $350,000 for topographic surveys and $90,000 for Alaskan mineral resources, compromised on $225,000 for geologic surveys including paleontology, and accepted the House figure of $100,000 for stream gaging. The appropriation for the year beginning July 1, 1909, although somewhat less than that for the year underway, actually provided more funds for old-line Survey functions such as topographic and geologic surveys; the major cuts were in activities identified with conservation—stream gaging, mapping forest reserves, fuel testing, and structural-materials testing.

The report of the National Academy of Sciences on the scientific work of the Government, requested in the previous year's bill, had been "not much use," as Tawney grumbled, to a committee that was trying to control or curtail the scientific work of the Government. The Academy had appointed a committee of R. S. Woodward, director of the Carnegie Institution of Washington, W. W. Campbell, director of the Lick Observatory, Edward L. Nichols, Professor of Physics at Cornell, Arthur A. Noyes, acting president of the Massachusetts Institute of Technology, and C. R. Van Hise, president of the University of Wisconsin. The committee was given access to the reports and data collected by the Walcott committee in 1903 and based most of its conclusions on that material. The amount of actual duplication of work, it found, was unimportant although the duplication of organizations and plants for conduct of work was great enough as to need careful attention from Congress. It made no recommendations, however, as to possible consolidations as each would require careful study. The committee was troubled most by the lack of rational correlation of work in allied fields or interrelated planning of the scientific work of the Government. The committee therefore recommended the establishment of a permanent board, composed of the heads of the scientific bureaus, two delegates from each House of Congress, and five to seven eminent men of science not connected with the Government, to meet at stated intervals and consider questions of the inauguration, continuation, and interrelation of the various branches of Government scientific work. That board, the committee felt, should also select men for the more important new projects or to fill vacancies in the more important positions in the agencies. What the Academy seemed to be telling Congress was that scientists, not politicians, should decide on the scientific work of the Government. A few months later, it gave further evidence of its distaste for the mixing of science and politics by rejecting for the third time the nomination of Gifford Pinchot to membership.

When the new Secretary of the Interior was sworn into office in March 1909, George Otis Smith had been Director of the Geological Survey for 22 months. In that short time there had been a great change in the organization he had taken over from Charles D. Walcott, but not in the way T. C. Chamberlin had hoped. Geology, topography, and hydrography had been the main subjects in Walcott's last annual report. For George Otis Smith in 1909, the special features of the work were progress in land classification, organization of the Land Classification Board, the investigation of water resources, topographic surveys, mine accidents, and technologic investigations. The "development of strictly geological work" received far less than "undivided devotion."

Chapter 4.
Conservation: Within the Limitation of Authority, 1909–1911

One of the propositions that I adhere to is that it is a very dangerous method of upholding reform to violate the law in so doing; even on the ground of high moral principle, or of saving the public. Congress has the power to dispose of land; not the executive. It is the business of the executive to protect the public lands within the limitation of his authority.

—William Howard Taft

As soon as William Howard Taft was inaugurated as President of the United States on March 4, 1909, Theodore Roosevelt tactfully left to hunt big game in Africa, expecting Taft to continue the program of progressive reform that he had begun. Taft was an excellent administrator, but he was not another Roosevelt. He did not share Roosevelt's conviction that the President was responsible only to the people but was more inclined to the view that the President was responsible to the legislature. He tended to move cautiously and to be scrupulous over constitutional issues. He believed his role in conservation was to give the Roosevelt program the force of law. Taft, however, was almost totally lacking in the political sensitivity that had been one of Roosevelt's strong points. Within a very short time his administration faced serious political problems, and the Geological Survey under its young Director became embroiled in some of them.

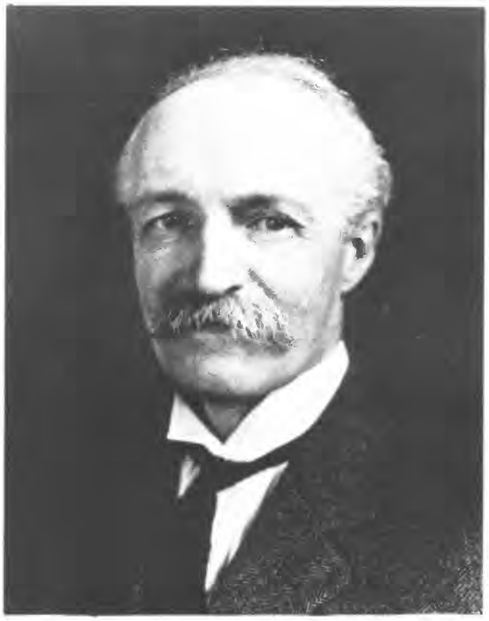
The long-brewing confrontation between progressive and conservative elements in Congress became a skirmish in the House, where the issue was Speaker Joseph G. Cannon's exercise of power, in the special session that convened on March 15, 1909. A battle was averted when the President supported the reelection of Cannon as a means of ensuring passage of his tariff legislation but in the spring of 1910, progressives in the House, led by George W. Norris, successfully revolted against the Speaker and voted to elect the Rules Committee and to exclude the Speaker from membership on the committee. The conservation movement provided a setting for another battle between progressives and conservatives, between Gifford Pinchot, the Chief Forester and Roosevelt's chief adviser on conservation, and Richard A. Ballinger, the new Secretary of the Interior, who, like President Taft, was a strict constructionist of the law. Theodore Roosevelt returned from Africa and Europe in the summer of 1910, and espoused the cause of the progressives. In the November 1910 elections, the Democrats captured control of the House of Representatives for the first time since 1895. The Senate remained nominally Republican but was actually dominated by insurgents whom Taft labeled "assistant Democrats."

In the view of George Otis Smith, who staunchly supported Ballinger, "the whole conservation movement is now linked up with Mr. Pinchot's views on the subject, so that orthodoxy in the cause means agreement with Mr. Pinchot. * * * Any issue is to be raised that can be made against Secretary Ballinger, not because of the issue, but because Secretary Ballinger is to be overthrown because he opposes Pinchot's way of conserving." The controversy led to the President's dismissal of Pinchot as Chief Forester and a congressional investigation of the Department of the Interior and the Forest Service. The majority of the investigating committee exonerated Secretary Ballinger, the division strictly on party lines. Public opinion, however, convicted him and by the spring of 1911 President Taft was convinced he must accept Ballinger's resignation in order to prevent further deterioration of his own political future.

Administration recommendations on the revision of public-land law and on conservation were largely sidetracked during the investigation. There was no clear progressive-conservative division on these issues at the beginning of the investigation, for both progressives and conservatives in Congress recognized that the differences between Roosevelt-Garfield-Pinchot and Taft-Ballinger views were not of conservation itself but of concepts of executive power. In fact, when Roosevelt and Taft spoke at the Conservation Congress in September 1910, the chief difference that the press detected in their views on conservation was a difference in the style of delivering speeches. Scientists spoke out in vain that conservation was a scientific and technical matter. In the public mind, Roosevelt, Pinchot, and Garfield were progressives and conservationists, Taft was a conservative but he had fired Pinchot, hence he must be anticonservation.

The Survey during these years continued the concentration on public lands and practical work begun under Secretary Garfield and worked in close cooperation with the General Land Office, even to the extent of taking over

William Howard Taft (1857–1930), President of the United States, 1909–1913. Taft was a conservative, with some progressive leanings, who was elected President in an era that was very reform minded. He had come into national prominence as president of a commission to establish civil government in the Philippine Islands after the Spanish-American War and the first civil governor of the islands from 1901 to 1904. He then became Theodore Roosevelt's Secretary of War and also his troubleshooter and closest adviser. Taft was in full sympathy with the objectives of the Roosevelt conservation program but believed they should be attained by legislative rather than executive action. He gradually allied himself more and more with the conservative wing of the Republican party and alienated the progressives, particularly by his dismissal of Gifford Pinchot as Chief Forester, and was defeated for reelection in 1912. (Courtesy of the Library of Congress.)



Gifford Pinchot (1865–1946), one of the principal architects of Theodore Roosevelt's conservation program. Pinchot began the first systematic forestry work in the United States in 1892 at the Vanderbilt Forest in North Carolina. In 1896, he was appointed a member of the National Forest Commission of the National Academy of Sciences, although not a member of the Academy; in 1897, he became adviser on forest reserves to the Secretary of the Interior. In 1898, he became Chief of the Division of Forestry of the Department of Agriculture, which later became the Bureau of Forestry and then the Forest Service. Pinchot was also a member of the Second Public Lands Commission in 1903, the Inland Waterways Commission in 1907, and chairman of the National Conservation Commission in 1908. He was dismissed as Chief Forester by President Taft in 1910 for defying an Executive order forbidding executive-branch employees to deal directly with Congress. (Courtesy of the Library of Congress.)

some of its work. Perhaps as a consequence, problems within the Survey increased. The loss of personnel was great; in the first year after the change of administration, although the Director insisted there was no connection, 13 geologists resigned from the Survey. By the summer of 1910, a rebellion against the emphasis on practical work began in the Geologic Branch where geologists thought a little research might improve the process of classification of the public lands. To a lesser degree, the Water Resources Branch followed suit. Later in the year, a discussion of the future of economic geology instigated by an editorial by J. D. Irving, long-time associate of S. F. Emmons, was carried on in the pages of *Economic Geology*.

In the field season of 1909, 18 of the 76 full-time geologists in the Geologic Branch were assigned to the classification and evaluation of western coal lands and 2, Hoyt Gale and R. W. Richards, were transferred from coal-land to phosphate-land classification. Ten geologists resigned from the staff, including George Ashley to become State Geologist of Tennessee, Frank DeWolf to become State Geologist of Illinois, Ralph Arnold to become a consulting geologist, and J. A. Taff to be geologist for Southern Pacific. Paleobotanist David White took over Ashley's supervision of the quadrangle mapping in cooperation with the State of Pennsylvania but supervision of the cooperative mapping in Illinois was transferred to the State. Young Robert Anderson, only 3 years out of Stanford, continued Arnold's investigations in California and succeeded him in the Oil Classification Section of the Land Classification Board, but Taff's work in the Midcontinent areas was suspended for lack of a replacement. M. J. Munn replaced Taff in the Oil Classification Section of the Land Classification Board while continuing the studies of Appalachian oil fields he had begun as Griswold's assistant. Anderson attempted to push the work in California even farther beyond the limits of actual production to outline areas of possible productive territory but was also called on to examine possible oil fields in Utah and in the Bighorn Basin in Wyoming. Wyoming was then the focus of considerable interest as a potential oil region, and C. H. Wegemann, R. W. Howell, and E. C. Woodruff were all diverted for a short time from coal-land classification to examine oil fields in the State.

Coal-land examinations were made in Montana, Wyoming, North and South Dakota, Colorado, New Mexico, and Utah and in the Coos Bay and Eckley coal fields of Oregon. Phosphate-land examinations were made in Idaho and northeastern Utah. Assistant geologists A. R. Schultz and W. R. Calvert, who had succeeded C. A. Fisher and George C. Martin as the Coal Classification Section of the Land Classification Board, classified or reclassified about 18.7 million acres of supposed coal land, and about 11 million acres were restored to entry as noncoal land. Under the new regulations, which had been approved by Secretary Ballinger in April 1909, they placed a value of almost $381 million on 5.6 million acres of coal land, about $293 million more than the value at the minimum price. Another 20.4 million acres of land in Montana, Wyoming, Utah, and Arizona were withdrawn for classification. The Phosphate Section of the Land Classification Board set no values but restored to entry 2.3 million acres that field work had shown were not valuable for phosphate and withdrew an additional 402,000 acres of new phosphate territory found during the field examinations.

At this time, the Metals Section was entering a new phase of its work. Waldemar Lindgren, the chief of the section, who had been elected to the National Academy of Sciences in April 1909, held that the first descriptive period of the science of economic geology was drawing to a close, that it was now necessary to turn to physical chemistry for the solution of some of the remaining problems, and the economic geologist should turn to the critical examination of mineral deposits over wide areas. Lindgren suggested, for example, that the principal epochs of the segregation of metals had been different in the eastern and western parts of North America. In the eastern part of the continent, the principal metallogenetic epochs were associated with the Precambrian, the Paleozoic intrusive rocks, sedimentary iron ores, Triassic trap rocks, Cretaceous, and Tertiary or later epochs of zinc and lead concentration. In the western part, the principal epochs had been the Precambrian, Early Mesozoic, Late Mesozoic, Early Tertiary, Post-Pliocene, and the Cretaceous or later epochs of copper concentration in sedimentary rocks. (In 1870, Clarence King had recognized seven longitudinal zones of mineral deposits but he believed that only two periods of mountain-making, one culminating in the Jurassic and the other in the Tertiary, had favored the formation of metalliferous deposits.) Mining district studies were still important, however, and S. F. Emmons was pressed into service again to supervise such work. The mining interests in the Breckenridge district of Colorado, which Emmons had examined in 1895, had petitioned the Secretary for a survey so Emmons made a preliminary inspection after which F. L. Ransome began the field work aided by E. S. Bastin. Emmons also made a preliminary inspection of the Ducktown, Tennessee, copper deposits before W. H. Emmons began work there, and spent some time inspecting new developments at Globe, Arizona, as a result of which it was decided that Ransome would prepare a supplementary report as soon as he had time. Emmons also supervised A. C. Spencer's mapping of the Ely quadrangle, Nevada, with its huge deposits of disseminated copper ore. H. D. McCaskey began a detailed study of the quicksilver deposits of the Terlingua region in Texas.

In the chemical laboratories, R. C. Wells, who had received a Ph.D. from Harvard in 1904, succeeded Hillebrand and began studies of minerals containing elements that recent technical developments had made important—tungsten, vanadium, molybdenum, uranium, titanium, columbium, thorium, and the rare earths—in conjunction with Schaller's mineralogical and crystallographic studies. Chase Palmer, who had taught for 25 years after receiving his doctorate from Johns Hopkins, continued the work begun by E. C. Sullivan.

Most of the Geologic Branch's noneconomic projects were continued in 1909; geologic mapping and stratigraphic and paleontologic studies were underway in all parts of the country. Bailey Willis completed the revision of the geologic map of North America and preparation for printing was begun. W. W. Atwood completed a classification of the physiogaphic features shown on the Survey's topographic maps as an aid to teaching.

In other areas of research, F. W. Clarke, who had also been elected to the National Academy of Sciences in April 1909, completed his recalculation of atomic weights and a preliminary study of the chemical denudation of the earth. Becker used the latter as a basis for calculating the age of the ocean as between 46 and 74 million years, and then, taking Walcott's dating of the base of the Cambrian as 27,640,000 years and the magnitude of the Precambrian as about the same, the age of the Earth was 50 to 65 million years. Becker noted that three methods of determining the age of the Earth—on the basis of refrigeration so dealt with as to exclude tidal instability, on the basis of Hayford's level of isostatic compensation, and on the basis of the age of the ocean—were converging on an age of the Earth of 65 to 55 million years, between two and three times the age King had calculated in 1893.

The Technologic Branch was forced to give up research in 1909. The reduction in the appropriation for fuel testing fully taxed the division's energies just to keep up with routine analyses and tests of coal purchased by the Government; the various experiments to increase the efficiency of fuels had to be curtailed. In the Structural Materials Division, a change in the phraseology of the legislation provided an additional complication. The Comptroller

General ruled that the work authorized by the appropriation was limited to investigations of such materials as were actually the property of the United States and to be used by the United States, and therefore test of samples submitted by contractors for acceptance by the United States, such as the cement being purchased by the Isthmian Canal Commission, could not be charged to the appropriation. The division continued to test the materials but had to obtain reimbursement from the Government bureaus that submitted the material, a procedure that necessarily increased administrative costs. The Structural Materials Division was also called on to investigate the quantity, quality, and location of structural materials available for use in localities where public buildings had been authorized by Congress. Holmes himself participated in this work along with several geologists of the Geologic Branch, including E. F. Burchard, N. H. Darton, and T. Nelson Dale.

The engineers of the Mine Accidents Division visited the scenes of mine fires and explosions and investigated the conditions of the mines to determine the cause of the disasters; they also aided State officials at 14 mine explosions and 7 mine fires. Tests of safety lamps and rescue apparatus were continued, and on each Saturday throughout the year demonstrations were given at the Pittsburgh testing station of the use of explosives in the presence of explosive mixtures of mine gas, coal dust, and air in proportions similar to those in mines. In March 1910, a Mine Explosion and Mine Rescue Station was established at Urbana, Illinois, in cooperation with the State Survey and the University of Illinois, to interest mine operators and inspectors in the economic value of safety equipment and to train mine workers and others in the use of resuscitation apparatus. In January 1910, the manufacturers of explosives used in coal mines were invited to submit explosives for testing, and on May 15, 1910, the Survey issued Explosive Circular No. 1 listing those that had been found satisfactory.

Richard A. Ballinger (1858–1922), Secretary of the Interior 1909–1911. Ballinger, like the President he served, was a strict constructionist of the law; his appointment caused concern among the followers of James Garfield and Gifford Pinchot who feared that it meant Taft, through Ballinger, intended to scuttle the Roosevelt conservation program. Ballinger recommended many changes in public-land law that were enacted by later Congresses but his effectiveness as Secretary of the Interior was destroyed by charges that he had mishandled land claims, which touched off a Congressional investigation. Although the investigating committee exonerated him, he resigned in 1911 because of public mistrust. (Courtesy of the Library of Congress.)

The emphasis on the public lands was a special hardship for the Water Resources Branch with its limited funds. When he took office, Secretary Ballinger questioned the legality of Secretary Garfield's last-minute withdrawals of water-power sites and believed that the Reclamation Service had grossly exceeded its legal authority by committing itself to plans for work, the cost of which far exceeded existing funds. Within a few days, he found that the President agreed with him on the power-site withdrawals and therefore restored the power sites to the public domain. Ballinger then directed the Geological Survey to make an investigation of water-power sites and to recommend withdrawals necessary to protect them pending enactment of legislation. By the end of June, new power-site withdrawals had supplanted the Garfield withdrawals.

With the aid of cooperative funds from 12 States and funds from other Federal agencies, the branch was able to maintain 878 gaging stations and to undertake a few ground-water studies. Field studies and analyses of the quality of water, however, were discontinued except for the completion of the study of the surface waters of Washington. Herman Stabler transferred to the Reclamation Service, W. D. Collins to the Department of Agriculture, and H. N. Parker resigned.

A special effort was made to raise the standard of the progress report on stream measurements by revising the methods of computation to insure greater accuracy and by indicating the probable error of the monthly estimate. To facilitate the use of Government reports relating to water supply and climate, the Survey and the Weather Bureau agreed to divide the United States into 12 areas, and the progress report was then divided into 12 parts, each covering one

In the spring of 1909, Secretary Ballinger restored to entry water-power sites that had been hastily withdrawn during the waning days of the Roosevelt administration on the recommendation of the Forest Service and the Reclamation Service. He then asked the Geological Survey to recommend sites. Among those chosen by the Survey were several along the Deschutes River in Oregon. The Deschutes had a remarkably constant natural flow, and its headwaters afforded reservoir sites sufficiently large and so distributed that the total flow could be utilized for both irrigation and power, the upper part of the river furnishing water for irrigation of lands in the upper part of the basin and the lower part, which flowed in a deep canyon, affording opportunities for power development. The photograph shows Benham Falls, near Bend, Oregon, where a reservoir was proposed to regulate the flow for power development. (From F. F. Henshaw, J. H. Lewis, and E. J. McCaustland, 1914.)

of the agreed-upon areas. Instruments for determining stream flow were improved, and a new automatic gage, which gave a printed record of the time and stage of the river every 15 minutes, was developed by Gurley Co. from preliminary plans and suggestions of branch engineers.

The allotment for ground-water investigations was only a few hundred dollars more than in the preceding year, but that was enough for Waring to continue the investigation of the springs of California and for Meinzer to study ground-water conditions in parts of New Mexico and Utah. H. E. Gregory studied the ground-water conditions in the Moko and Navajo reservations in Arizona with funds supplied by the Bureau of Indian Affairs.

The topographic mapping program was still further skewed in favor of the public lands during the field season of 1909. Director Smith ruled that until Congress appropriated money specifically for cooperative surveys, first consideration must be given to the public-land States where the Federal interest was paramount and second consideration to the progress of the topographic map of the United States. A maximum of $20,000 was set for cooperative work in States of which less than 35 percent had been surveyed, $15,000 for those of which 35 to 70 percent had been surveyed, and only $10,000 for States of which more than 70 percent had been surveyed. Cooperative money offered by States amounted to $250,000 but less than $150,000 was accepted from 19 States. Nearly three-fourths of the 36,539 square miles mapped in 1909 were in the Rocky Mountain and Pacific Divisions, which included most of the public-land States. Mapping was also begun in the Territory of Hawaii. Under a cooperative agreement with the Superintendent of Public Works of the Territory, which stipulated that the entire expense of the work be borne by the Territorial Government, the Survey detailed topographers and loaned instruments to begin the survey of the island of Kauai. C. H. Birdseye and eight other topographers were despatched to Hawaii to begin the work. A disagreement with the Forest Service about control of the work led the Survey to discontinue the preparation of the atlas of national forests. Folios of 36 forests had been completed; four partly finished folios, on Director Smith's orders, were turned over to the Forest Service.

President Taft's political problems were already well developed by the end of the 1909 field season. He had called the 60th Congress into special session on

In the summer of 1909, O. E. Meinzer combined an examination of the rapidly growing Estancia Valley in central New Mexico for the purpose of classifying lands under the Enlarged Homestead Act with a study of ground water to meet an urgent demand for information on the feasibility of irrigation by ground water in the area. Meinzer concluded that despite the high cost of fuel, pumping for irrigation could be profitable if the water was pumped in an economical way and widely used but that the underground supply was too small to irrigate more than a small part of the valley and in the central part of the valley the presence of alkali might impair the quality of the water or prohibit its use. The illustration shows a well being tested. (From O. E. Meinzer, 1911.)

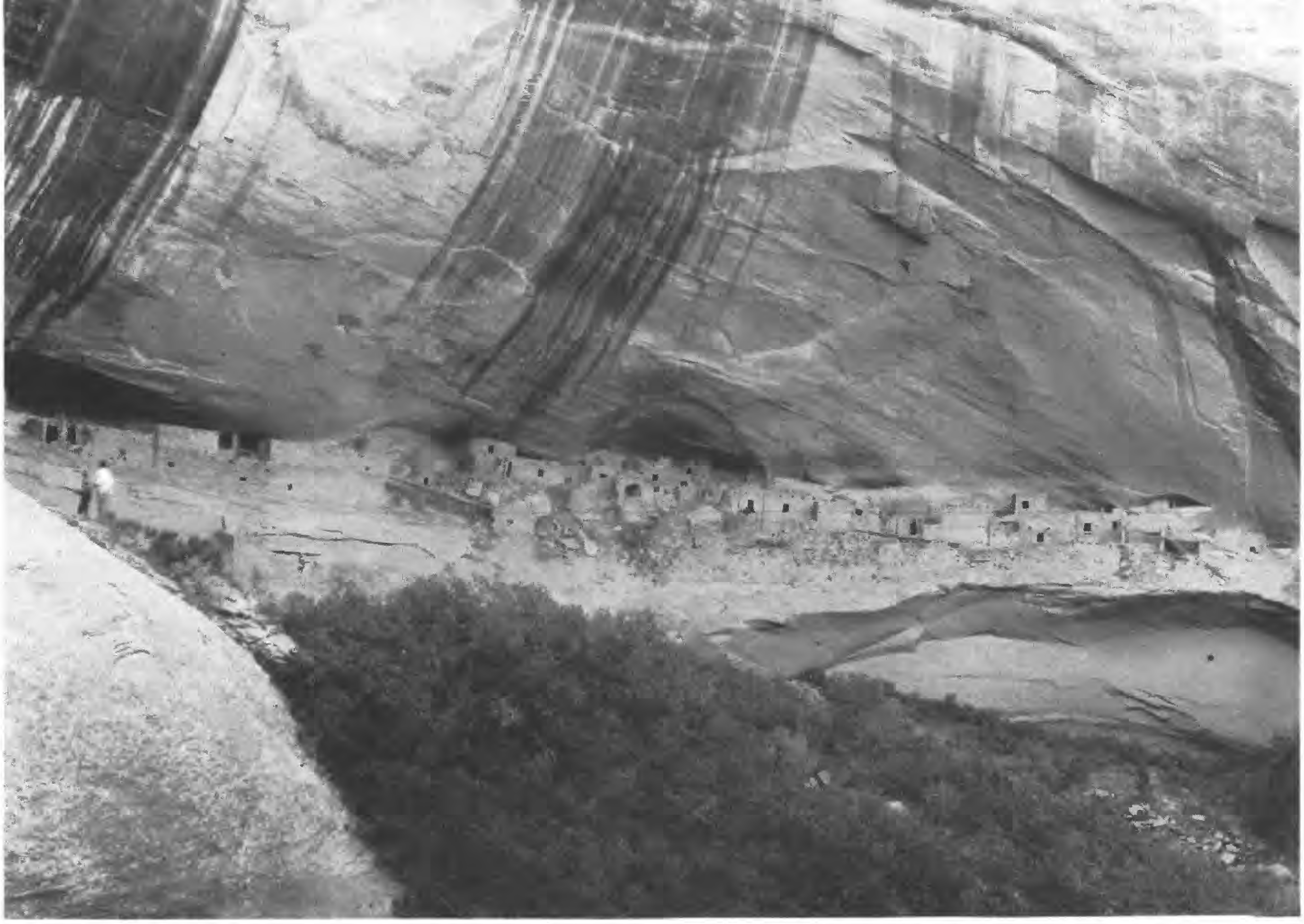
March 15 to prepare a new tariff law. Theodore Roosevelt, who had been wary of the protective tariff, had remarked in his annual message to Congress in 1907 that although the country was committed to the protective system and it was "probably desirable that every dozen years or so, the tariff laws be carefully scrutinized," the subject could not "with wisdom be dealt with in a year preceding a Presidential election, because as a matter of fact experience has conclusively shown that at such a time it is impossible to get men to treat it from the standpoint of the public good. In my judgment the wise time to deal with the matter is immediately after such election." Taft evidently had accepted that judgment, and he did not anticipate any serious problems for there was a strong Republican majority in each house.

Discontent, however, had been growing both in Congress and throughout the country with the manner in which and the purposes for which the powers of the Speaker were being exercised by Joseph G. Cannon. As President-elect, Taft had encouraged a move to replace him as Speaker and to change the House rules, but when he was warned that if the Speaker was defeated for reelection or if the rules were changed, his plan for tariff revision would be in peril, he threw his support to Cannon. Cannon was reelected Speaker and the move to change the rules was defeated but a substantial number of Republicans voted with the minority. The House then passed the tariff bill so promptly that the Senate Committee was able to introduce a revised bill, containing more than 800 amendments of the House bill, on April 12. But there the bill remained for more than 3 months as a group of Midwestern Senators organized in opposition and prolonged the debate while the House waited for the Senate to act.

Opposition to Roosevelt conservation was increasing by the summer of 1909. The West was once more in a rebellious mood; the National Domain League had been formed in Colorado to restore the rights of farmers, stockmen, and miners in the national domain, which the League claimed had been usurped by the Forest Service, and the Western Conservation League was founded in Spokane, Washington, to oppose Federal control of natural resources. The Western Conservation League numbered among its founders close political friends of the Secretary of the Interior. Meanwhile, the more ardent proponents of Roosevelt conservation had been outspokenly critical of Congress and its failure to enact the Roosevelt conservation measures. An article by C. R. Van Hise on the subject in *World's Work* attracted the attention of James Tawney, Chairman of the House Appropriations Committee, and he retaliated with a blistering attack on Van Hise in the House, pointing out that Van Hise had for many years drawn a salary from the Geological Survey. Tawney then inserted in the Congressional Record an article of his own defending Congress, which *World's Work* had refused to publish.

Pinchot, of course, was suspicious of Secretary Ballinger, who had replaced his friend James Garfield. On July 23, 1909, Ballinger revoked the cooperative agreement approved by Garfield whereby the Forest Service supervised timber cutting and fire protection of forest lands in Indian reservations, having been advised by the Solicitor that such an agreement was illegal. When George Otis Smith stopped in to see Pinchot later that day, he was accused of being a turncoat and a renegade and told that if there was any more criticism of Garfield, he, Pinchot, would himself lead the fight against Ballinger.

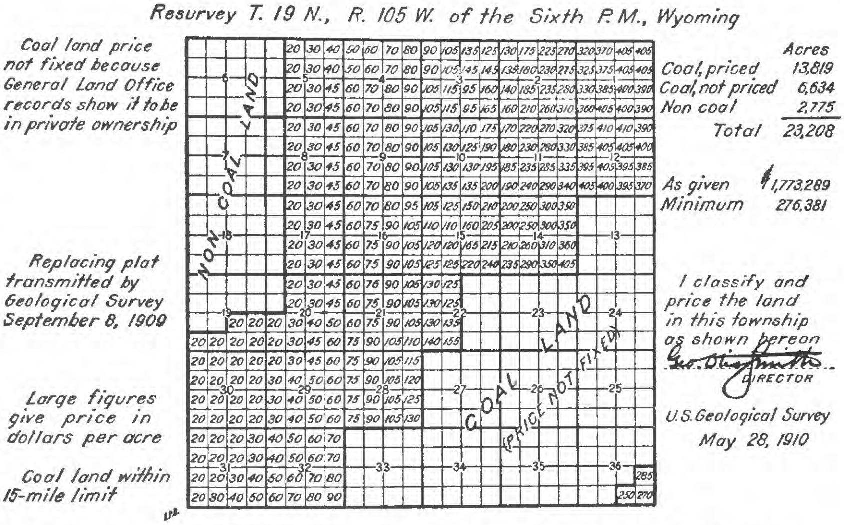
At the Irrigation Congress in Spokane, August 9–14, 1909, which Ballinger, Smith, and Pinchot all attended, Pinchot made good on that promise. The first day of the meeting was uneventful except for George Otis Smith's policy statement on the classification of the public lands and the Survey's role therein. On the second day, however, former Governor George Pardee of California attacked Secretary Ballinger for his action on the water-power sites, citing newspaper reports that 15,868 acres of choice water-power sites in Montana had been claimed after Ballinger reversed the Garfield withdrawals. The



Funds supplied by the Office of Indian Affairs enabled Yale Professor H. E. Gregory, who supervised the Survey's ground-water studies in Connecticut, to begin a reconnaissance of the scenic region bordering the Colorado canyons between the Little Colorado and San Juan Rivers southward to the line of the AT&SF Railway. The area of about 25,000 square miles in Arizona, New Mexico, and Utah was home to more than 32,000 Indians assigned to six vaguely defined reservations but only 500 others. Gregory's investigation was aimed at determining ways in which the country could be fully utilized and, as the region is arid, designed chiefly to obtain information about water supply. The illustration shows the cliff dwellings of some of the long vanished people who once inhabited the land. (From H. E. Gregory, 1916.)

next morning George Otis Smith claimed the podium to announce that the 15,868 acres had shrunk to 158.68 acres, and he allowed as how "the water-power entryman who can make these four forties shoestring six miles of the Missouri River deserves to become an Indiana politician." Secretary Ballinger then left the congress to continue on an inspection trip with F. H. Newell, leaving George Otis Smith behind on "department watch service," but there were no further incidents at the Irrigation Congress.

Behind the scenes, however, new charges against Ballinger were being developed. Louis Glavis, an examiner for the General Land Office, in mid-July requested the assistance of the Forest Service in investigating certain coal-land claims in the Chugach National Forest in Alaska, and in a second message several days later had hinted darkly that the Secretary of the Interior and the Commissioner of the General Land Office were involved in illegal actions. The claims in question had been obtained in 1903 by Clarence Cunningham of Seattle on behalf of an association but were not valid under the law at that time, which required public surveys. After the 1904 law was passed authorizing private surveys, surveys were made and an application to patent was submitted. The local land office cleared most of the claims in 1907, and an approach was made to the Morgan-Guggenheim syndicate to obtain railroad facilities for shipping the coal. In December 1907, Ballinger, then Commissioner of the General Land Office, ordered the claims clear-listed but reversed his decision after Secretary Garfield told him that Glavis had raised the possibility of a conspiracy to evade the law and put Glavis in full charge of the investigation. During the year that Ballinger was in private practice between being Commissioner of the General Land Office and becoming Secretary of the Interior, he had prepared a brief on behalf of Cunningham. In May 1909, 2 months after returning to Washington, Ballinger had ordered Glavis removed from the investigation on the grounds that he was working too slowly and an immediate hearing on the claims was ordered. In response to Glavis' request in July,



The end product of the Survey's work of classifying and evaluating coal lands was a township map such as that shown in the illustration. The intrinsic value of the coal was determined by its character and heat-giving quality, but the workability of the deposit depended on its thickness and depth as well as its accessibility and other conditions that affected the cost of extraction. The coal was considered workable if the value exceeded the cost of extraction. Regulations established the price per ton for coal of a certain quality, thickness, and depth and provided for variations from these standard conditions. (From George Otis Smith and others, 1913.)

Pinchot assigned one of his assistants in the Forest Service to aid Glavis in preparing charges against the Secretary, which Glavis then submitted to President Taft. Pinchot fully expected Taft to dismiss the Secretary. Taft, however, informed Ballinger of the charges, the Secretary submitted an explanation, and on September 13, the President ruled in Ballinger's favor, and Glavis was dismissed.

President Taft was then on a cross-country speaking tour. He had approved the Payne-Aldrich Tariff Act on August 5, 1909, saying that it was not "a perfect bill, or a complete compliance with the promises made, strictly interpreted," but it represented "a sincere effort on the part of the Republican party to make a downward revision." Public reaction, however, had been adverse, especially in the West. The President was ill-prepared for the trip, having procrastinated in the preparation of speeches because of his distress over Mrs. Taft's illness, and he made several statements that exacerbated rather than alleviated public indignation over the bill. Taft began by commending Senator Aldrich in glowing terms, then, on September 17, in Winona, Minnesota, near the heart of progressive country, he made a speech in support of Congressman James A. Tawney in which he defended the tariff as the best that the Republican party had ever passed. Until that time he had escaped personal criticism, but the honeymoon ended with the Winona speech.

On September 17, George Otis Smith renewed his plea for the retention of public oil lands in Government ownership. Secretary Ballinger, unlike his predecessor, endorsed the request and sent a letter to Taft recommending that the oil lands be withdrawn from entry and urging legislative action to assure the conservation of an adequate supply of petroleum for the Government's own needs. The Secretary's recommendation regarding the oil lands reached the President en route, and on September 26, Ballinger and Smith met with Taft at Salt Lake City. The President approved the recommendation and telegrams were immediately despatched to the Acting Secretary and to the Chairman of the Land Classification Board of the Survey. On September 27, Temporary Petroleum Withdrawal No. 5 was ordered, barring all forms of location and entry on 3,041,000 acres in California and Wyoming. The withdrawal of the California and Wyoming oil lands in late September was followed within a few weeks by additional withdrawals in Utah, Colorado, Arizona, New Mexico, and California.

On September 28, 1909, President Taft spoke on conservation at Spokane, Washington. His views on conservation did not depart from Roosevelt's, but he placed the responsibility for further action squarely on Congress. He believed that the forest lands should be retained and protected and only the forest products sold. Power sites should be sold under restrictions as to their use. Surface rights to coal, oil, and phosphate lands should be separated from mineral rights. The minerals, Taft said, should be valued by quantity and quality, rather than acreage, and the lands either retained and leased on a royalty basis or sold subject to restrictions designed to prevent monopoly. The *Mining and Scientific Press* commented that "if any faith is to be put in political bargains, Congress should give him what he asks in return for his defense of the tariff bill. Congress, however, has a way of its own, and is influenced mainly by what its leaders estimate to be insistent public opinion. Many will find reason to oppose the policy the President has outlined."

Both George Otis Smith and J. A. Holmes attended the American Mining Congress, which met at Goldfield, Nevada, during the week of September 27, and both spoke on aspects of conservation. Holmes told the Mining Congress that the function of the Federal Government in connection with mine operations was one of inquiry and research with two fundamental purposes: greater safety for the lives of miners, and conservation of mineral resources. Smith spoke on the Survey's role in classifying the public lands to fulfill the requirements of existing law and to provide Congress with data on which to base new legislation. The Mining Congress adopted several resolutions at its final session favoring some aspects of the conservation program. It asked that a national bureau of mines be established, that the Geological Survey assist Mining Congress committees in developing safety programs in mines, and endorsed the movement for the development of inland waterways. It urged State and county authorities to develop and safeguard desert water supplies, and requested that the Survey be authorized to cooperate in the work, especially with regard to desert water supplies on the public domain. It also asked for a national commission, elected from the mining communities, to prepare a revised code of mineral-land laws and recommended changes in the Alaska coal-land laws and enactment of laws for the development of oil lands in Alaska.

Chief Geologist Willard Hayes issued a public statement explaining that the withdrawals of oil lands were made because only a radical revision of American mining law would remedy the unsatisfactory conditions for entry of public oil lands. When the placer mining law was enacted, he pointed out, no one had any idea that it would ever be made to cover mineral deposits so far removed in every essential characteristic from gold-bearing gravels as are oil and gas. A law for disposition of the public oil lands must recognize the fundamental difference between oil and gas and other minerals, namely, mobility.

> These elusive products can be drawn from a distance underground across boundary lines, and exclusive title to the product is acquired only after it reaches the surface. It follows, therefore, that oil can be disposed of by the Government or other owner of the land in which it occurs only as a commodity, and not in terms of acres like coal or other minerals occupying fixed locations. This difference is so well recognized that it has determined the leasing system which is practically universal in all the oilfields where the land is in private ownership. The Government cannot do better than to adopt the plan which has been worked out through long experience, and, where the holdings are sufficiently large, has been found thoroughly satisfactory, both to the oil operator and to the private land owner.

Hayes went on to say that "Any ideal or practical law must further recognize the fact that actual discovery involves heavy expenditure and considerable time, and that the prospector must be adequately protected in his investment before as well as after the discovery is made. The area to which he is given a preferred right must therefore be sufficiently large to justify his initial heavy investment and in such compact shape as to protect his discovery from encroachment by drilling on subsequent entries. A well considered leasing law will give certain incidental advantages of great importance both to the Government and to the oil operator. It will constitute the most effective means for the conservation of the oil and gas resources of the country by enabling the Government to regulate developments so as to prevent much of the criminal waste now prevalent."

The origin and accumulation of petroleum was then a live subject, on which there was no unanimity of opinion in the Geological Survey. Chief Geologist Hayes subscribed to the formation of petroleum from organic materials; he and William Kennedy, for example, in their bulletin on the oil fields of the Texas-Louisiana Gulf Coastal Plain, had suggested that the oil of the Gulf Coastal Plain was the result of the action of decomposing organic matter, both animal and vegetable but chiefly the latter, on gypsum. Others, however, were inclined toward an inorganic origin, at least for some deposits. Becker believed some oil deposits could have originated from iron or other metallic carbides formed by the action of volcanic emanations on water; David T. Day considered it possible that metallic carbides had existed in the Earth during its early history and that the hydrocarbons might have been formed by decomposition of these carbides by water. Structure was held to be important in the trapping or accumulation of oil, but W. T. Griswold's careful mapping had shown that an anticline or flexure in the rocks was only one of the necessary conditions, the others being porosity of the reservoir rocks and movement as the result of differences in gravity of oil and water or the direct action of gravity in oil sands that contained no water. M. J. Munn, from his work in the Appalachian fields, concluded that the most important or controlling factor in the accumulation of oil and gas was not structure but rather moving water under either hydraulic or capillary pressure. Survey research in these and related subjects declined during fiscal year 1910 because of the loss of personnel and the necessary concentration of work on classification of the public mineral lands.

President Taft's first annual message to Congress in December 1909 contained no recommendations on conservation or public-land legislation, on which he promised a special message, other than the admission of Arizona and New Mexico as States and a new form of government for Alaska. Secretary Ballinger, however, in his annual report that accompanied the message, called for remedial legislation "if material progress is to be made in securing the best use of our remaining public lands." He noted that

> **while development is the keynote, the best thought of the day is not that development shall be by national agencies, but that wise utilization shall be secured through private enterprise under national supervision and control.**

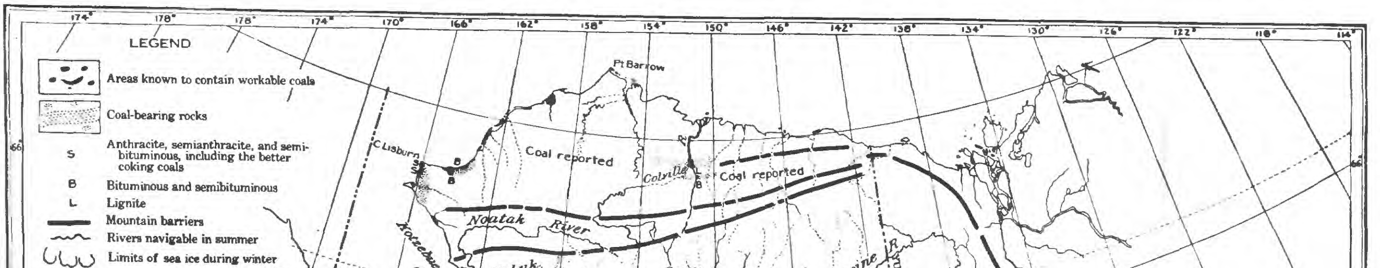
Many of Secretary Ballinger's recommendations clearly involved the Geological Survey. He asked, for example, that specific legislative authority be given the Department to classify and segregate public lands into well defined divisions according to their greatest apparent use, stating that the Survey had undertaken such classification through the general authority given in its Organic Act, but that full legal effect should be given to such classification so as to prevent the entry of lands belonging to one class under laws applicable to another class. He recommended that the coal-land laws be supplanted by an act separating the right to mine from the title to the soil, the objective being to conserve the coal deposits as a public utility. Disposition of the coal might then be accomplished through leasing or sale of deposits with restrictions on mining and use to control the output. Ballinger recommended that similar legislation be enacted with regard to lands containing oil and gas, repeating Hayes' statement that the nature of those deposits required that their disposition be in terms of quantity extracted rather than acreage. He also recommended that Congress authorize the Executive to reserve certain areas of the withdrawn oil lands for the purpose of affording a supply of fuel oil for the future use of the Navy. The phosphate lands should not be disposed of as either placer or lode mineral claims but should be leased or sold in limited areas and on conditions preventing monopoly and insuring domestic use. Ballinger's other recommendations included repeal of the Timber and Stone Act, modification of the Carey Act, an appropriation for surveying railroad lands in national forests, and enactment of a measure to authorize classification of all lands capable of being used for water-power development and disposal of such lands under conditions reserving title to the Federal Government and easement for limited periods.

The disposition of the public lands that had prevailed until the administrations of Secretaries Hitchcock and Garfield, Ballinger said, had "naturally provoked the feeling that the public domain was legitimate prey for the unscrupulous and that it was no crime to violate or circumvent the land laws. It is to be regretted that we, as a nation, were so tardy to realize the importance of preventing so large a measure of our natural resources passing into the hands of land pirates and speculators, with no view to development looking to the national welfare." In conclusion, he asked that Congress give specific authority to make temporary withdrawals of public lands because "the legal authority of the Secretary of the Interior to make even temporary withdrawals of public lands for the purpose of submitting to Congress what may appear to the Secretary as an exigency requiring new legislation applicable to their proper use and disposition has been questioned."

When Congress convened in December 1909, the public's curiosity about Secretary Ballinger had been aroused but not because of his recommendations on public-land legislation. The November 6 issue of *Collier's Magazine* had contained a severely critical editorial on Ballinger's handling of the Cunningham claims, and the November 13 issue included an article by Louis Glavis, which the magazine advertised as "Are the Guggenheims in charge of the Department of the Interior?" In response, Secretary Ballinger had threatened to file suit for libel. On the opening day of the session, Congressman G. M. Hitchcock of Nebraska proposed that a committee investigate the General Land Office with relation to coal lands and to public lands in general in Alaska, and the Senate asked that President Taft send it the documents in the Glavis case. On December 21, Senator Wesley Jones of Washington, one of Secretary Ballinger's political friends, read a letter from the Secretary to the Senate, asking that any investigation by Congress of the Interior Department "be sufficiently broad and far-reaching to put at rest the suspicions, criticisms, and representations of corrupt or improper practices" charged against his administration. He also asked that such an investigation include the Forest Service as he had reason to believe that the "pernicious activity of certain of its officers" had been the source of inspiration for these charges. After the Christmas recess, Senator Jones introduced a joint resolution to authorize an investigation of the Interior Department and the Bureau of Forestry by a special committee of the Senate and House of Representatives. For several months, he said, the press of the country had been filled with charges against Secretary Ballinger, ranging from petty insinuations and innuendos to direct charges of malfeasance and misconduct in office. If Ballinger had used his office to advance special interests or for personal gain, that should be shown, but if he had been unjustly accused, that too should be shown, not only for his own sake but also that public confidence in the honesty and integrity of Government officials be restored. In discussing the proposed resolution, Senator Jones admitted that he did not agree with all of Ballinger's policies and proposals, but he commended the Secretary for providing specific recommendations when for several years there had been only "glittering generalities" and "platitude upon platitude." Senator Francis Newlands stated that he did not support all of Ballinger's recommendations either but thought they were "thorough, comprehensive, and wise" and "likely to reach the evils that are feared and to effect the reforms which are desired." There were no great differences between the Garfield-Pinchot and the Ballinger views of conservation, Newlands pointed out. Rather, their differences were in concepts of executive power: Garfield and Pinchot believed that executive power included all that was not forbidden by law whereas Ballinger held that executive power was limited to what was expressly authorized by law.

Senator Newlands expressed the hope that the proposed investigation would not delay needed legislative action. Many bills for reform of the land laws and for reforms called for by conservation policy had been introduced, but Congress was always slow to undertake reform unless driven by public opinion. Such opinion was only then being formulated to drive Congress into action. Senator Jonathan Dolliver then read a letter from Pinchot defending the Forest Service for forcing publicity on the Cunningham claims. The letter was in defiance of an Executive order of November 26, 1909, prohibiting subordinate officers of the Government from dealing directly with Congress, and therefore President Taft promptly dismissed Pinchot. Public attention was thus focused on the investigation; the public might not understand the intricacies of public-land law, but it assumed that in dismissing Pinchot, the symbol of Roosevelt conservation, Taft was arraigning himself on the side of the "Old Guard."

The joint resolution authorizing the investigation was passed by both Houses of Congress and approved on January 19, 1910. The investigation began on January 26 and continued intermittently thereafter until May 20, a total of 46 days being used for testimony by the 33 witnesses. The investigation was supposed to be a general look at the administration of the Forest Service and the Interior Department, but attention was soon concentrated on Alaska and the Cunningham claims, some of which were in or near the Chugach National Forest. The Forest Service's expert, sent to appraise the claims, reported



Alaska had large deposits of coal but the amount of coal mined was insignificant even from the two most important fields— Bering River and Matanuska. Production from these fields had been held back in part by the development of the California oil districts but also by the coal-land laws pertaining to Alaska, which did not recognize that the development of a coal field is quite different from the mining of placer gold. Geographic and climatic conditions were controlling factors in the utilization of Alaska's mineral fuel in 1910 according to A. H. Brooks. Only the coals of the Pacific slope were then important, although coals of the central and northern provinces might in time be used for local consumption. The Bering River and Matanuska felds could supply high-grade fuel for use in Alaska, by the Navy, and by Pacific Coast industries if a railway were constructed to bring the coals to tidewater. (From A. H. Brooks, 1910.)

there was no coal in the area. The General Land Office expert reported there were at least 22 "veins" of coal but not enough timber to make mining possible. C. A. Fisher of the Survey, sent to arbitrate the conflicting reports, said there were at least 28 distinct coal beds, and that less than one-third of the area of the Cunningham claims was within the forest reservations. When Pinchot was called as a witness, he presented a written statement charging that Ballinger had been unfaithful to the public and to the President, that he was in fact a dangerous enemy to conservation. The statement aroused great expectations in the public mind, but in cross-examination Pinchot admitted that the statement contained errors, that he had no direct knowledge to support some of his allegations, and that much of his criticism of Ballinger was based on differences in matters of policy or legal interpretation.

From the Survey, both A. H. Brooks and George Otis Smith were called to testify before the investigating committee. Brooks' testimony was largely technical, on Alaska coal and its mining and marketing. When asked about the best way to conserve coal on the public lands, he suggested that waste in coal mining had been due, at least in part, to unrestricted competition by a large number of operators whereas economical development called for large-scale operations. The dilemma for conservationists was that monopolistic ownership tended to result in high prices and conservation of coal whereas unrestricted competition meant lower prices but waste of coal. He suggested that in Alaska the law should give a man the choice of a leasehold or freehold but should control the price so that the deposits would be developed rather than held for speculative purposes. George Otis Smith, however, went on record as favoring leasing. Smith was also questioned on many aspects of Department policy and proved to be one of Ballinger's strongest supporters. In the course of the questioning, Smith drew a careful distinction between himself and Pinchot:

> I think Mr. Pinchot and I differ on one fundamental principle, and that is that the end justifies the means. I do not believe that it does.

During the closing arguments by legal counsel, little attention was given to the technical aspects of the claims and much was made of the fact that a document by the Attorney General, which seemed to be the basis for Taft's decision to retain Ballinger in office after the Glavis charges reached him in August 1909, had been predated and appeared to be based on a memorandum prepared in the Interior Department. The session adjourned before the Joint Committee completed its consideration of the testimony and prepared a report.

The hint of scandal had not diverted all attention from Secretary Ballinger's recommendations on public-land law and conservation. On December 20, 1909, without waiting for Taft's promised special message, Congressman F. W. Mondell, who had been one of the first to question the legality of the coal-land withdrawals in 1906, delivered a wideranging speech, which he began by castigating the Forest Service and its chief as well as the Department of the Interior on water-power development. "With due respect to the very able and efficient Secretary," he said, the Federal Government "had no constitutional right to in any way control the use or disposition of waters flowing in non-navigable streams within the States," and the Secretary of the Interior, being a good lawyer, knew it. From water power, Mondell moved to consideration of irrigation and finally to mineral resources, coming out strongly on the side of those who opposed Federal control. Eight Western States and two Territories, he claimed, could supply the entire Nation with coal, at the existing rate of consumption, for more than 3,722 years, and after that North Dakota lignites and Alaska coal could be used. No one knew or could possibly estimate the ultimate oil and gas supply. Federal control was completely unnecessary.

President Taft's special message on conservation was, to a great extent, merely "an epitome of the recommendations of the Secretary of the Interior."

In the fall of 1909, President Taft authorized the withdrawal from all forms of entry of more than 3 million acres of potential oil land in California and Wyoming, which had only recently become the focus of considerable interest as a potential oil region. C. H. Wegemann, who examined the Salt Creek field in Natrona County, Wyoming, in the field season of 1909, reported that there were two domes in the area—Salt Creek and Teapot. The Salt Creek Dome had first produced oil in 1889 but its development had been slow. Teapot Dome had not been tested but Wegemann believed structural conditions were favorable for the accumulation of oil. The illustration shows the Shannon sandstone lentil that outlined the Salt Creek anticline and furnished the oil in the discovery wells. (From C. H. Wegemann, 1911.)

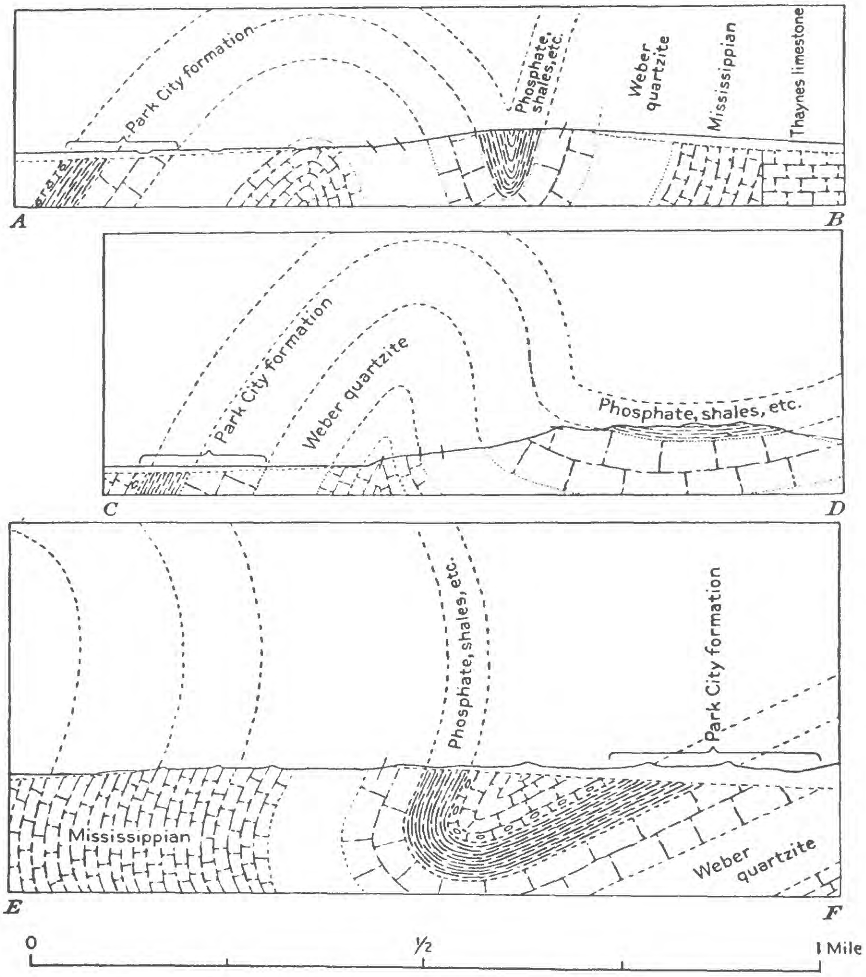
Taft added an endorsement of the reforestation of sources of navigable streams and proposed improvements in inland waterways, and urged Congress to act on the proposed measures promptly as the results of the Joint Committee's investigation were not needed to determine the value and necessity of the recommended legislation. Few of the recommendations were enacted into law, however, for the session proved to be a stormy one. On March 17, 1910, the revolt against the Speaker broke out anew. On that day, George Norris of Nebraska offered what he called a privileged resolution calling for election of the House Committee on Rules. For 2 days, the House debated the nature of the resolution; on March 19, Speaker Cannon ruled that the motion was not privileged, citing as precedent a ruling by Speaker Randall in December 1878 on a similar motion. The House then voted not to accept the Speaker's ruling and then adopted a resolution that called for the election of a 10-man Committee on Rules, 6 from the majority, 4 from the minority, and specifically denied the Speaker a place on the committee. Taft, it is believed, secretly approved the action and made no move to aid the Speaker. The public concluded, however, that as Taft did not encourage the insurgents he was on Cannon's side. The misunderstanding led to a complete break between the administration and the insurgents, who then opposed Taft's proposals; he, in turn, began a campaign to destroy the insurgents and build up the conservative wing of the Republican Party.

Among the bills Congress passed were those for New Mexico and Arizona statehood, authorization of Presidential withdrawal from entry of public lands, provision for agricultural entries on coal lands, and the establishment of a Bureau of Mines. The Pickett Act as originally submitted authorized the President to withdraw lands "for public use, for examination and classification to aid in administering existing law; to conserve the public domain pending legislative action when in the judgment of the President public interest requires." As finally passed and approved by the President on June 25, 1910, the law provided that

> **the President may, at any time in his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the United States, and the District of Alaska, and reserve the same for water-power sites, irrigation, classification of lands, or other public purposes to be specified in the orders of withdrawals, and such withdrawals or reservations shall remain in force until revoked by him or by act of Congress.**

The law also provided that the lands would be open under the mining laws for "minerals other than coal, oil, or gas and phosphates" and that any bona fide occupant or claimant of oil or gas-bearing lands on the date of the withdrawal order "in diligent prosecution of work leading to discovery" would not be affected by the withdrawal. Another act, approved on June 22, 1910, provided that the withdrawn or classified coal lands were subject to entry under the homestead laws, the desert-land law, the Carey Act, or withdrawal under the Reclamation Act, with a reservation to the United States of the coal and the right to prospect for, mine, and remove it.

The House passed the bill to establish the Bureau of Mines before the Ballinger-Pinchot hearings got underway. The House bill was identical, except for minor changes in wording, to the bill passed by the House during the second session of the 66th Congress, and only a few negative votes were recorded despite the eloquent efforts of the economy-minded Mr. Tawney who said there were already too many bureaus, that another one would cost money, and



In December 1908, Secretary Garfield withdrew from entry more than 4 million acres of supposed phosphate lands in Idaho, Wyoming, and Utah. Disposition of these lands posed a problem because rock-phosphate deposits had not been previously considered in mining law. Placer locations had been used for phosphate deposits in the Southeastern States, but the most valuable part of the Florida and South Carolina deposits were true placers. The rock-phosphate deposits of the Western States, however, were more analogous to coal than to placers. These diagrammatic structure sections of the Beckwith Hills area, Wyoming, show the nature of the deposits, most of which were in the middle member of the Park City Formation. (From H. S. Gale and R. W. Richards, 1910.)

besides the Geological Survey was already doing the work effectively. The Senate Committee on Mines and Mining amended the bill before reporting it favorably in March 1910. To make it clear that the Bureau was intended to be a scientific organization, the Senate bill required the Director to be thoroughly equipped for the duties of his office by technical education and experience and omitted the phrase in the House bill that would have the Bureau "foster, promote, and develop the mining industries of the United States."

The pros and cons of a Bureau of Mines were thoroughly aired in the technical press in the spring of 1910. Opponents of the bill argued that such an organization was unnecessary because the Geological Survey was already doing the work, that the Bureau might duplicate the work of the Survey and thereby cause friction, that it would be impossible to obtain competent engineers for the salaries paid by the Government, and that the Bureau would be bound to come under political influence. Those who favored establishment of the Bureau countered that the Survey should be enabled to concentrate its efforts on the investigations for which it had been established, and that the Survey was living proof that a Federal bureau could attract competent men, produce outstanding results, and remain free of political influence. The *Engineering and Mining Journal* in New York and the *Mining and Scientific Press* in San Francisco were on opposite sides of the fence, the *Journal* opposed, the *Press* in favor. The Survey itself was divided, with Holmes working tirelessly for establishment of the Bureau while George Otis Smith opposed it.

The bill finally passed by Congress and approved by President Taft on May 16, 1910, called for a Bureau of Mines in the Department of the Interior "to make diligent investigation of the methods of mining, especially in relation to the safety of miners, and the appliances best adapted to prevent accidents, the possible improvement of conditions under which mining operations are carried on, the treatment of ores and other mineral substances, the use of explosives and electricity, the prevention of accidents, and other inquiries and technologic investigations pertinent to said industries, and from time to time make such public reports of the work, investigations, and information obtained as the Secretary of said department may direct, with the recommendation of such bureau."

The act approved on May 16 called for transfer of the entire Technologic Branch of the Geological Survey to the Bureau of Mines. The House Committee on Appropriations, however, made no provision for structural-materials testing by either the Bureau or the Survey and recommended instead an appropriation of $50,000 for such work by the Bureau of Standards. In the discussion of Bureau of Mines funding on June 2, Congressman Mondell pointed out that the investigations of structural materials in the field were geologic and properly the work of the Geological Survey, but that testing was properly the work of the Bureau of Standards, which could legally perform tests for private parties. An attempt was made on the floor of the House to appropriate funds for the Bureau of Mines to do the work but failed. The Senate approved such an appropriation but yielded to the House in conference, so the structural-materials testing was transferred from the Survey to the Bureau of Standards. The total appropriation for the Bureau of Mines in its first year was $502,200.

The Sundry Civil Expenses Act provided a total appropriation for the Geological Survey of $1,175,015, including increases of $75,000 for geologic surveys and $50,000 for water-resources investigations, both designed to accelerate the work of public-land classification. Appropriations were also made to the General Land Office to complete the examination and classification of lands in Montana and Idaho within the Northern Pacific Railroad grant and to begin public-land surveys in Alaska. Both appropriations were later transferred to the Survey.

Other measures of interest to the Survey passed by the Congress included the establishment of Glacier National Park. The bill to establish that park had first been filed in the 60th Congress and endorsed by Secretary Garfield. When it came up again in February 1910, Senator Joseph M. Dixon of Montana "eschewed" a speech for "7 feet of a better or more eloquent speech, taken with a camera by Mr. Walcott, formerly Director of the Geological Survey, or merely one corner of this wonderful country," and the bill was quickly passed. President Taft approved the bill on May 11.

A new building for the Survey, the Bureau of Indian Affairs, the Reclamation Service, General Land Office, and Bureau of Mines was authorized in the Public Buildings Act approved on June 25, 1910. The Survey had been quartered in the Hooe Building at 1330 F Street Northwest since 1884 but had been seeking a building of its own for almost as long. By 1910, the space in the Hooe Building was both inadequate and unsuitable, not only for laboratory space but on all counts. As the Survey grew, wings and extensions had been added to the original building, but the floor space was increased at the expense of proper lighting. F Street had become one of the busiest streets in town; the traffic vibrations prevented the use of sensitive instruments, and the street noises made it difficult or impossible to hear when the windows were open on the street side. To add to the general confusion, the alleys on the sides of the building gave access to a theater, two newspaper offices, a hotel, and several saloons, with their attendant noises. The bill passed in 1910, strictly speaking, authorized only the preparation of designs and estimates for a building to cost not more than $2.5 million to occupy the entire square bounded by E, F, Eighteenth, and Nineteenth Streets Northwest with the funds left over from purchase of the land (which amounted to $96,506.20).

By the time the appropriations were approved, a contest had developed over the directorship of the Bureau of Mines. Holmes was the obvious choice, and in fact had been endorsed by many. Holmes, however, had had a long and close association with Pinchot, going back to his days as State Geologist of North Carolina, and although he had carefully refrained from taking sides in the Ballinger-Pinchot controversy, he was not acceptable to the Secretary. He was also not acceptable to some of the ruling clique in the House, especially Mr. Tawney who felt that Holmes' active lobbying had forced his hand on appropriations. Even in the Geological Survey there were those who feared that Holmes' skill in obtaining appropriations might work to the detriment of the older bureau. Within 10 days of the enactment of the law, George Otis Smith launched an all-out effort to secure the position for Edward Parker, the Chief of the Survey's Division of Mineral Resources, instead of Holmes. By early June, the mining journals were reporting the contest as another Ballinger-Pinchot confrontation. In mid-June, President Taft was reported as leaning toward appointing Parker but Senate confirmation seemed all but impossible inasmuch as 67 Senators had signed a petition supporting Holmes' appointment. Taft therefore postponed the decision, and on July 1, 1910, appointed George Otis Smith as Acting Director of the Bureau of Mines as well as Director of the Geological Survey.

Smith's appointment did not set well with the mining fraternity, or at least with that segment that had supported a separate Bureau of Mines. In a lead editorial, the *Mining and Scientific Press* proclaimed "Bunkoed was the widespread comment through the West." The *Press* roundly criticized the President for waiting until Congress had adjourned and then appointing Smith, and added "We fear that the Director of the Geological Survey has precipitated what we are sure he was most anxious to avoid, a contest between the Survey and the Bureau of Mines. He may temporarily control the situation, but in the nature of things such a condition can not last and the reaction is likely to be more severe than would have been the original action had the latter been met helpfully rather than in a spirit of antagonism."

At the start of the new fiscal year, the Geological Survey also became even more closely involved in the work of the General Land Office. Survey topographers began the public-land surveys in Alaska for which Congress had made a special appropriation, and Survey geologists began the work of examining and classifying the lands of the Northern Pacific Railroad grant. The Survey was also given greater responsibility in the validation of coal-land entries, and it was agreed that the Land Office would undertake no field examinations until it was determined that Survey data were insufficient, and it would submit copies of reports of field examinations to the Survey for advice before taking action.

The examination, classification, and valuation of mineral lands continued to be the largest single element in the Geologic Branch program during the field season of 1910, but the additional funds appropriated for geologic surveys made it possible not only to resume projects that had been suspended when the public-land surveys began but even to start a few new ones. In particular, a concerted effort was made to complete areal geologic maps and reports, even to the extent of assigning geologists to complete the work begun by others.

Research also became a part of the public-lands work. Half the 20 geologists assigned to field examinations for the classification and valuation of coal lands had little or no experience; the more experienced, however, combined long-range research with their examinations. W. T. Lee undertook stratigraphic studies along the eastern front of the Rocky Mountains, C. T. Lupton, a study of the Cretaceous coal-bearing rocks along the south flank of the Uinta Mountains, Max Ball, a reconnaissance of the coal geology of the Parowan Range in Utah, and E. C. Woodruff, a study of the coal resources of the Gunnison Valley in Colorado.

The phosphate program remained one of only examination and classification. Hoyt Gale was detached from the program to supervise the work on the Northern Pacific grant, and direction of the phosphate program was turned over to R. W. Richards. Richards, Professor G. R. Mansfield of Northwestern University, and J. H. Bridges made a detailed examination of about 500 square miles in southeastern Idaho which, they estimated, contained more than a billion tons of high-grade phosphate rock. C. L. Breger and Professor Eliot Blackwelder made a reconnaissance in northwestern Wyoming and eastern Idaho to determine the extent and character of the phosphate deposits northeast of Bear Lake. Phosphate lands in Florida were also examined by George Matson of the Coastal Plain project as a temporary employee of the General Land Office.

In a pioneer study of the ore deposits of a large geographic unit to obtain information about little known districts for mineral statistics and, at the same time, to study a large area systematically for data on the location and origin of ore deposits, Waldemar Lindgren and L. C. Graton found that the mining districts of New Mexico form a belt trending south-southwest through the mountainous section of the Territory. They recognized three periods of ore deposition, each characterized by distinct types of deposits which, according to Lindgren's recently proposed concept, corresponded to different physical conditions. In the Magdalena district in Socorro County, the chief zinc-producing district in New Mexico, shown in the photograph, the ores are contact-metamorphic deposits associated with early Tertiary intrusions and formed under moderately high pressure and temperature. (From Waldemar Lindgren, L. C. Graton, and C. H. Gordon, 1910.)

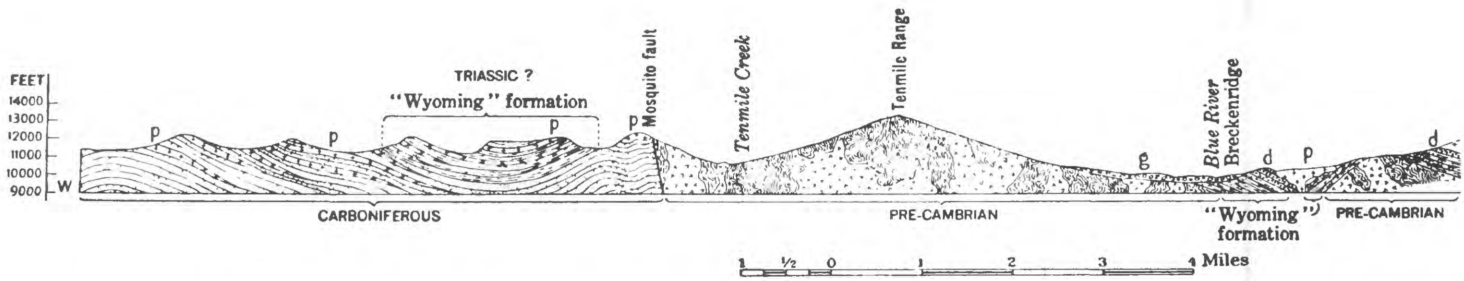
Fuels investigations in the Eastern States included coal-field mapping in Alabama, Tennessee, Illinois, and Missouri, and oil-and-gas studies in Alabama, Kentucky, and Tennessee. C. D. Smith was assigned to complete the quadrangle mapping in Oklahoma left unfinished when Taff resigned. David White continued his microscopic investigation of coals to ascertain the relation of the kinds and state of preservation of the plant materials to the chemical qualities and economic value of coals.

In the Metals Section several geologists began to study the mineral deposits of large geographic areas on which Lindgren placed such emphasis: Frank Schrader in Nevada, B. S. Butler in Utah, J. B. Umpleby in Idaho, A. N. Winchell in Montana, and Howland Bancroft in northeastern Washington. Mining district studies were continued, especially those of copper districts such as the Miami-Ray district in Arizona by F. L. Ransome, the Ely district of Nevada by A. C. Spencer, Shasta County, California, by L. C. Graton, and Ducktown, Tennessee, by W. H. Emmons and F. B. Laney. E. S. Bastin and J. M. Hill mapped the areal and underground geology in the Central City district in Colorado, F. L. Hess completed field work in the Randsburg quadrangle, California, Sidney Paige mapped the Silver City quadrangle in New Mexico, and C. E. Siebenthal did additional work in the Joplin lead-zinc district.

The economic development of Alaska was again the basis of the Survey's work there in 1910. Reconnaissance topographic surveys were made of 13,815 square miles and reconnaissance geologic surveys of 8,635 square miles in the Copper River and Susitna regions, the upper Yukon Basin, the Innoko-Iditarod region, and northwestern Alaska. Adolph Knopf completed the detailed study of the mineral resources of the Eagle River region in southeastern Alaska, and G. C. Martin, assisted by F. J. Katz and Theodore Chapin, made a detailed geologic survey of part of the Matanuska coal field. C. E. Ellsworth and G. L. Parker continued the study of the water resources of the Yukon-Tanana region begun at Fairbanks in 1907 and extended it into the Birch Creek and Fortymile districts. Parker also spent a month in the Seward Peninsula collecting gaging-station measurements made by the mine operators and making additional measurements.

The increase in the appropriation for water-resources investigations made it possible to undertake additional research in 1910 although most of the branch's work remained stream gaging and nearly all of it was done west of the 100th meridian. With the aid of cooperative funds from 13 States and funds from other Federal agencies, the total number of gaging stations was increased to 1,105. Old-time records of stations maintained by the War Department and the Weather Bureau were also investigated, and by comparisons of measurements and adjustments, it was possible to obtain several long-time records of daily discharge. These it was hoped would throw light on the relation of runoff to precipitation and the effect of deforestation on river discharge.

The Division of Underground Water was enlarged to include newly resumed studies of the quality of water and Herman Stabler came back to the Survey from the Reclamation Service. Major projects were undertaken in California and Arizona. In California, R. B. Dole began a study of the composition of underground water in the San Joaquin Valley, and Stabler studied irrigation by the use of pumping plants in the San Joaquin and San Jacinto Valleys to supplement Mendenhall's geological and statistical studies of the development of ground water in those areas. C. H. Lee began an investigation of the relation of ground-water supplies to runoff and loss through evaporation and other forms of drainage in Owens Valley in cooperation with the City of Los Angeles. In Arizona, O. E. Meinzer began an investigation in Sulphur Spring Valley, in part in cooperation with the Arizona Experiment Station,



In 1909, F. L. Ransome mapped the Breckenridge district, some 60 miles west-southwest of Denver, Colorado, to link Spurr's work at Georgetown with that of Emmons at Leadville. Ransome found that the thick series of Paleozoic rocks, including the limestone that was so productive at Leadville, is not present at Breckenridge. In the section east of the Tenmile Range, he identified the oldest sedimentary rocks, resting directly on the Precambrian, as the Wyoming (Triassic?) or the Dakota (Cretaceous) and found that these units, and to some extent the Precambrian, had been intruded by monzonitic porphyries, mainly as sills. Ransome thought the ores had been deposited from thermal waters and gases given off from the solidifying monzonitic magma, perhaps in cooperation with meteoric water, but he was uncertain whether the metals came from the magma or from the rocks invaded by it. (From F. L. Ransome, 1911.)

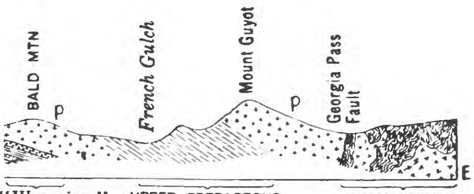
which involved reconnaissance topographic surveys and careful studies of ground-water levels, the costs of recovery by pumping, the chemical character of the ground waters and soils, and other factors bearing on the problem of irrigation by ground water.

The Topographic Branch continued to concentrate on the public-land States but only 65 percent of the total area mapped during the field season of 1910 was in the Rocky Mountain and Pacific Divisions, somewhat less than in the preceding season. Sledge Tatum became head of the Rocky Mountain Division on June 1 when E. C. Barnard was detailed to the State Department for work on the United States-Canada Boundary Survey. S. S. Gannett was the boundary expert in Eastern United States, appointed by the Supreme Court to resurvey and mark the western boundary of Maryland and designated by Director Smith, at the request of the Attorney General of North Carolina, to find the line marked by blazed trees in 1821 along the disputed part of the North Carolina-Tennessee boundary line.

The political situation continued to engage public attention throughout the summer of 1910. Theodore Roosevelt returned from his long trip abroad in mid-June. From the moment he emerged from the jungle he had been besieged by leaders of both sides of the Republican argument; Pinchot went abroad to consult him and Taft sent him a handwritten letter. Roosevelt at first vowed to remain silent but the silence was short-lived. He then decided to tour the country in an attempt to reunite the party. But in one primary after another, the progressives were winning and the standpat Republicans losing, so Roosevelt rather soon alined himself with the progressives.

On August 31, Roosevelt spoke at the dedication of the State Park at Osawatomie, Kansas, and with him on the platform were Pinchot, Garfield, and the leaders of the Kansas insurgents. The speech is known as the one that defined his "New Nationalism," which "maintains that every man holds his property subject to the general right of the community to regulate its use to whatever degree the public welfare may require it." He also said that "words count for nothing except in so far as they represent acts. This is true everywhere; but, O my friends, it should be truest of all in political life. A broken promise is bad enough in private life. It is worse in the field of politics. No man is worth his salt in public life who makes on the stump a pledge which he does not keep after election; and, if he makes such a pledge and does not keep it, hunt him out of public life."

President Taft was in the Summer White House in Beverly, Massachusetts, but the telephone and telegraph promptly brought him news of Roosevelt's remarks. On that same day he came to a decision about the Bureau of Mines and wrote to Director Smith: "I have concluded that I ought to appoint Mr. Holmes Director of the Bureau of Mines. The truth is that in searching for a competent man I do not find any one whom I am willing to appoint and take responsibility of turning down a man who comes to me recommended by both the labor organizations and mine owners and superintendents. * * * [Parker] is a good man, but not so well adapted to the work as Holmes. I thank you for the work you have done in the preliminary organization of the Bureau."



Smith was then in Stockholm, with G. F. Becker, Whitman Cross, S. F. Emmons, Arnold Hague, and Waldemar Lindgren, attending the sessions of the 11th International Geological Congress. Economic geology was one of the principal subjects of discussion, and C. R. Van Hise gave one of the opening addresses on the influence of applied geology and the mining industry on the economic development of the world. Van Hise pointed out that iron, coal, and copper had been of paramount importance in industrial development. He made a plea for the utmost economy in the use of metals so they would remain available for generations to come, and he predicted that within a few hundred years many nations would be obliged to turn to other sources of power than coal. In the future, he said, countries with large quantities of water power would be the rising nations industrially.

Professor J. F. Kemp of Columbia University had been delegated to present the United States' part of the planned review of the world's resources of iron ore. Kemp pointed out that the future of the iron industry was a function of several variables, some which neutralized each other: the increase in annual production, decrease in then known sources of supply, discovery of new sources of supply, gradual decline in average percent of iron in ores used, increase in expense of production, improvements in existing processes, supply of fuel, introduction of new methods of smelting, and the substitution of other materials for iron and steel. On the whole, however, he concluded that the iron industry would continue without any very fundamental changes for many years to come.

Professor Joseph W. Richards of Lehigh University argued that the energy source to reduce the iron ore was more important than the ore itself. Metallurgists were continually improving their methods, and the improvements in time would make it possible to work poorer ore. Richards predicted that in 20 years it would be possible to make pig iron from 40 percent ore as cheaply as it was then being made from 50 percent ore. He urged the International Geological Congress to make a careful inventory of the actual and potential coal reserves of the world, and the Congress decided to do so at its next session in 1913.

The U.S. Geological Survey officially proposed to the International Congress the preparation of a 1:1,000,000-scale geological map of the world with a system of colors suggested by Bailey Willis but was rebuffed. The Commission on the Geologic Map of Europe unanimously agreed that such a map was impossible of realization at the time and that in any event the color system accepted at Bologna in 1881 should be used. The Commission, however, did recommend publication of a geologic map of the world at a suitable scale, and a committee, including George Otis Smith as one of the members, was appointed to bring in a proposal at the next Congress.

Joseph A. Holmes took over direction of the Bureau of Mines from George Otis Smith on September 10, and a few days later attended the Conservation Congress in Minneapolis at which both President Taft and former President Roosevelt spoke. Both Taft and Roosevelt advocated Government control of the acquisition and use of natural resources; Taft defined conservation as "the preservation of our natural resources for economical use so as to secure the greatest good to the greatest number." Scientific men, Taft said, had always been aware of the danger of wasting natural resources, but the formation of public opinion was a task that had been assumed by Theodore Roosevelt. He had inherited Roosevelt's policy and rejoiced in that heritage.

Both Chief Geologist Hayes and Professor T. C. Chamberlin, in the fall of 1910, pointed out that conservation and ownership were separate issues. "Most good causes," Chamberlin said, "as they come into popular favor, suffer diversions, if not perversions, in the interest of other causes," and conservation was then being used to promote an unrelated issue.

The protection of natural values against wastage is one thing, the possession of these values quite another thing. The best conservation may not be correlated with the best ownership, all things considered. Ownership, desirable on other accounts, may be an obstacle to conservation, and ownership, otherwise undesirable, may be tributary to conservation. This is so because, in their fundamental nature, the problems of conservation and the problems of possession are distinct questions, each to be solved in its own way and on its own basis. They center in separate fields. The conservation of natural resources centers in the scientific and technical; the right of ownership and the most desirable distribution of ownership center in the political and the sociological.

Conservation was not at issue in the November elections. The elections, however, were disastrous from the politically conservative point of view. The Democrats elected a group of reform-minded leaders, most of whom were not attached to William Jennings Bryan, and regained control of the House for the first time since 1895. The balance of power in the Republican Party shifted to the progressives. In the Senate, the Republicans had a nominal majority of 10, but 8 or 9 Republican Senators were progressives.

In his annual report transmitted to the final session of the 61st Congress, Secretary Ballinger repeated some of his earlier recommendations for changes in public-land laws. But first, with obvious reference to the problems of the year past, he "ventured the opinion" that when the Department of Commerce and Labor was established "it would have been more logical to have consolidated the Interior Department and the Department of Agriculture" and transferred from them certain functions to the Department of Commerce and Labor and other departments, as, for example, the Patent Office from Interior to the Department of Commerce and Labor and the Pension Office from Interior to the Departments of War and the Navy. As it was, there was duplication of effort and divided jurisdiction, between Interior and Agriculture with regard to forest reserves, and between Interior and Commerce and Labor because of the Bureau of Mines and the Bureau of Standards.

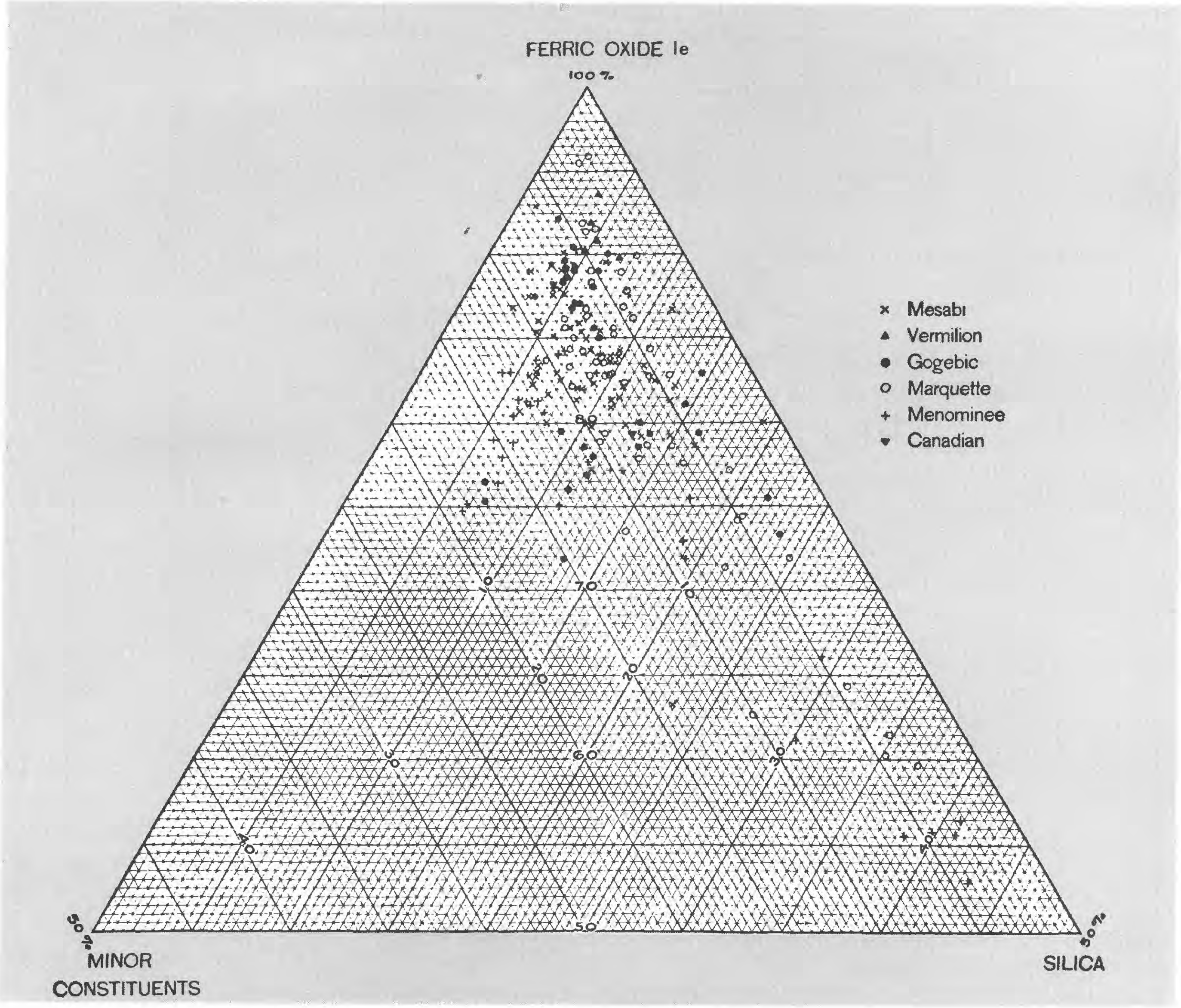
In his 1910 report, Ballinger favored sale of coal lands rather than leasing, repeating the statement he had made in 1907 as Commissioner of the General Land Office that the Government would thus avoid the necessity of supervising operations and employing a large staff to collect rents and account for them. He continued to favor leasing of oil lands, which had been successful with the lands of the Five Civilized Tribes, but suggested that the law should recognize the right of prior bona fide locators of oil lands. He made a special plea for a liberal policy in opening up the California oil lands because of the enormous cost of coal for fuel in California. Search of the Patent Office records had disclosed several patents for stoves for domestic heating that would burn crude oil, and he pointed out that consumers would benefit by burning oil, at 85¢ a barrel, rather than coal, at $11 to $15 a ton. He also asked for adoption of some form of legislation that would retain the fee title to water-power sites in the people and vest the power of regulation and control in either the State or the Federal Government in such a way as not to limit prompt and economical development or permit monopolization or extortion.

President Taft, in the State-of-the-Union Message, was more explicit in his recommendations. He conceded the force of Secretary Ballinger's arguments regarding the coal lands but went on record as favoring leasing through competitive bids for terms not exceeding 50 years. He recommended that surface and mineral rights for phosphate lands be separated, as had been done for coal lands, and that the phosphate lands be leased with an added condition to enable the Government to regulate, and if need be prohibit, the export to foreign countries. Taft recommended that the law allow a prospector for oil and gas the right to prospect for 2 years over a certain tract of Government land by license and that a lease be granted on discovery. Water-power sites, he recom-

In 1911, C. R. Van Hise and C. K. Leith presented the results of a study of the geology of the Lake Superior region, with special reference to the iron and copper-bearing formations, begun by R. D. Irving in 1880 and completed by them after his death. The iron-bearing formations consist of interbanded layers, in widely varying proportions of iron oxide, silica, and combinations of the two, that are remarkably similar in lithology even though they occur in three different groups separated by great unconformities and are unique among most of the sediments of the world. The rocks become ore by local enrichment, largely by the leaching out of silica, and to a lesser extent by the introduction of iron oxide, so there are complete gradations between rocks and ores. To show the chemical composition of the iron ores, Van Hise and Leith plotted individual analyses in a triangular diagram in which each point represents a unique combination of ferric oxide, silica, and minor constituents. (From C. R. Van Hise and C. K. Leith, 1911.)

mended, should be directly leased by the Federal Government for terms not exceeding 50 years or that the site be patented to the State in which it was situated on condition that the State dispose of it under similar terms. He asked also that the limitation on reservation of forest lands in Oregon, Washington, Idaho, Montana, Colorado, and Wyoming be repealed but stated that there was no need for radical reform in the methods of disposing of agricultural land for "the present laws have worked well. The enlarged homestead law has encouraged the successful farming of lands in the semiarid regions." Finally Taft asked, but with no sense of urgency, for a bureau for the care and control of the national parks and also that the Grand Canyon of the Colorado and surrounding territory be included in another national park.

President Taft and Secretary Ballinger agreed on the necessity for some action with regard to Alaska coal lands. Ballinger pointed out that extensive industrial progress in Alaska would be impossible without cheap fuel and improved transportation, "the latter depending largely upon a supply of the former. The importance of opening the vast coal fields of Alaska to development under some plan which will prevent waste and monopoly cannot be overestimated." Taft recommended passage of a law permitting the leasing of



Government coal lands in Alaska after public competition. He was reluctant to recommend home rule for Alaska but did favor the appointment of a commission for the government of the territory, which he thought would "lead to an improvement in Alaska and the development of her resources that is likely to surprise the country."

Shortly after Congress convened in December 1910, the Joint Committee on the Investigation of the Interior Department and the Forest Service submitted a report divided on party lines. The seven Republican members of the committee concluded that the charges against Secretary Ballinger appeared "to have had their origin in a strong feeling of animosity created by a supposed difference in policy respecting the conservation of natural resources. The accusers evidently had this policy very deeply at heart and were evidently disposed to take a most unfavorable view of the character and motives of anyone whom they supposed to be opposed to their views. They thus came to regard the most natural and innocent acts occurring in the ordinary course of department administration as furnishing evidence of some sinister purpose. * * * The evidence has wholly failed to make out a case. Neither any fact proved nor all the facts put together exhibit Mr. Ballinger as being anything but a competent and honorable gentleman, honestly and faithfully performing the duties of his high office with an eye single to the public interest." The majority suggested, however, that the Alaska coal-lands claims cases be heard before a U.S. Court and that the Government lease, rather than sell, the coal lands. The four Democratic members of the committee concluded that the Secretary had not been "true to the trust imposed in him as Secretary of the Interior, was not deserving of public confidence, and should be requested to resign." The lone insurgent, Congressman James Madison of Kansas, declined to associate with either party and presented a third report saying that the Glavis and Pinchot charges "should be sustained."

Although the majority of the committee had cleared Secretary Ballinger, public opinion had convicted him, and for that reason administration programs lost support. Bills were filed to accomplish most of the public-land and conservation measures recommended in Taft's State-of-the-Union Message, but few were even called up. Discussion of a bill to permit exploration and leasing of coal lands in Alaska led to a violent altercation between progressive and conservative on the floor of the House. Chairman of the Public Lands Committee F. W. Mondell called the bill "the result of a very earnest, careful, and painstaking effort to meet in a fair way, and a way we believe is in harmony with the best public sentiment, the coal situation in the District of Alaska." Congressman Madison, the insurgent from Kansas, called the bill a "mockery," and James Wickersham, the delegate from Alaska, charged that while there had been much talk about conservation and a leasing bill for Alaska, the local land office in Alaska had been issuing patents on coal claims as fast as they could and there was little left to lease. Mondell and Wickersham questioned each other's veracity, then, as the Congressional Record reported, "menacing actions took place," and the Sergeant at Arms was called to restore order. The House then voted against the bill.

The Weeks Forest Purchase Act, which had been discussed for several years, was passed during the closing days of the congressional session. The act authorized the Forest Service to acquire and manage forests on the watersheds of interstate rivers with the consent of the State in which the land lay. The Secretary of Agriculture was to propose a selection, the Geological Survey to demonstrate its suitability, and a National Forest Reservation Commission, composed of the Secretaries of War, Interior, and Agriculture, and two members of each House of Congress, were then to approve the acquisition.

Secretary Ballinger had become a liability to the administration but President Taft continued to support him. Some time earlier, Taft had told one critic

The "unaltered" Precambrian sedimentary rocks of the Grand Canyon, first recognized by John Wesley Powell and more carefully studied by C. D. Walcott at intervals between 1883 and 1895, were reinvestigated after topographic maps on a scale of 1:48,000 were published between 1906 and 1908. Walcott had divided these rocks into two terranes, the Unkar and Chuar, separated by a slight erosional unconformity. L. F. Noble described the Unkar terrane in the Shinumo quadrangle as a wedge-shaped mass inset into the underlying Vishnu schist and composed of a great number of small tilted fault blocks. He divided the Unkar into five formations. The photograph shows a less common structure in the Unkar, a sharp monoclinal flexure, known as the Wheeler fold, in Bass Canyon. (From L. F. Noble, 1914.)

"If I were to turn Ballinger out, in view of his innocence and in view of the conspiracy against him, I should be a white-livered skunk. I don't care how it affects my administration and how it affects the administration before the people; if the people are so unjust as this I don't propose to be one of them." In mid-January 1911, Senator William Purcell, a Democrat of North Dakota appointed to fill a vacancy, introduced a resolution that Ballinger not be retained in office. Duncan Fletcher, freshman Senator from Georgia who had been president of the Gulf Coast Inland Waterways Association, said that the people did not require that an official be infallible but that they were "not satisfied to have him simply keep on the windy side of the law and pursue a course neglectful of and unfaithful to their interests to the point just inside the line of criminal guilt." Secretary Ballinger submitted his resignation, which the President again refused to accept. The Purcell resolution, debated in a half-hearted way over the course of a few days, never came to a vote.

While Secretary Ballinger was facing an increasingly hostile Congress and public, George Otis Smith faced increasingly irksome problems within the Geological Survey. Private industry was making heavy inroads on the Survey's geologic staff. The work of the Land Classification Board was increasing in volume, but not in variety, as a result of the various cooperative agreements and Secretarial orders, and as the paper work increased, the opportunity for field work decreased, a state of affairs to which most geologists are congenitally averse. The rank-and-file reaction to the emphasis on the public lands came out in the annual Pick and Hammer show. To the recurring refrain of "The L.C.B. is the biggest thing you'll see; it's just a little bigger than the whole G.B." the playwrights proclaimed:

Oh the Survey, the Survey, it don't amount to much
Since Congress has no money for geology as such:
The L.C.B * * *
There's coal land, oil land, power sites, and sich,
And when we get them classified you can't tell which is which;
The L.C.B * * *
Oh, the G.L.O. used to think it wasn't slow,
But since we got to going we have taken it in tow:
The L.C.B. * * *

There had already been a large turnover in staff when on December 1, 1910, the Chairman of the Land Classification Board, Arthur Veatch, applied for and was granted leave of absence to engage in exploration for oil abroad for private interests. Although the Board was a section in the Geologic Branch, on January 1, 1911, W. C. Mendenhall of the Water Resources Branch was named Chairman of the Board, its advisory committee, and, ex officio, chairman of each of the classification sections. N. C. Grover, who had left the Survey in 1907, returned on March 1, 1911, to become Chief Engineer of the Board, and A. H. Brooks, Chief of the Alaskan Section, was added to the advisory committee. The membership of all sections was increased, and the section of hydrographic classification was divided into units dealing with water power and irrigable lands.

The emphasis on nonmetalliferous deposits led to some restiveness among the metals men. J. D. Irving, in an editorial in the October-November 1910 issue of *Economic Geology* called on Federal and State surveys to investigate special problems in economic geology, claiming that in the United States economic geology had been studied almost exclusively on a geographic basis and reports were failing to provide information on general laws of the occurrence of ores. Letters poured in in response to the editorial, and most of the writers seemed to think that, although State surveys had been mentioned, the editorial was directed at the Federal Survey.

The first reply to be published was that of Waldemar Lindgren, who said that there were actually three methods of investigation: the monographic, which Irving had called descriptive geographic; the true geographic, or the comparative study of all mineral deposits in a given large area to ascertain geologic relationships and genesis; and the study of special problems. The economic work of the Survey had begun with the monographic method, at Leadville and the Comstock, although Becker's quicksilver investigations and gold-belt study showed that the geographic method had not been neglected. The emphasis was now on the true geographic method; it was necessary in order to take a census of metallic resources, and it was the safest way to obtain reliable

In the summer of 1910, M. R. Campbell took time off from coal-land classification to visit the newly established Glacier National Park in Montana and prepare a popular guide to its geology and scenery. The former Director of the Survey, C. D. Walcott, had been an advocate of the new park and the bill to establish it had first been filed by Secretary Garfield. The scenic features of the park are alpine, and many small glaciers are perched along the range in protected places. Swiftcurrent Valley, shown in the photograph by T. W. Stanton, was the principal route for transporting supplies into the mountains during the height of the mining excitement in the area; the beauty of its scenery and its accessibility had drawn many visitors before the creation of the park. (From M. R. Campbell, 1914.)

conclusions on the genesis of ores. The Survey could undertake few studies of special problems because of the small size of its staff. In making the distinction between the monographic and "true" geographic methods, Lindgren seemed unaware that Clarence King's plan for mining-geology investigations did not call for monographic treatments exclusively but for studies of mining districts in geologic units and the census of mineral deposits in geographic units. Lindgren's true geographic method was a modification of the original plan.

Charles D. Walcott, the third Director of the Survey, agreed with Irving. In earlier times, Walcott wrote, many broad generalizations had been drawn and reputations won as the result of reconnaissance work. Then it was realized that detailed work in selected areas must be done before another series of correlations and broad deductions could be "ventured upon." However, as such work had been going on for 20 years, the time had come to specialize, and the best men should be given the opportunity. He added, significantly in the light of past history, that in the nature of things some men would have to be pushed into new work, some would do it if encouraged, and the best would do it anyway, even in the face of administrative opposition.

There were no comments from S. F. Emmons, but in view of the long and close association between Emmons and Irving, it may be assumed that Emmons had approved Irving's editorial if indeed he had not instigated it, for Emmons during his more than 30 years in the Survey had never been one to remain passive when he disapproved a course of action. The whole discussion, which continued for several months in the pages of *Economic Geology*, was pointed up poignantly by Emmons' sudden death in March 1911 on the eve of his 70th birthday. Tributes were many and varied. The *Mining and Scientific Press* said that "In certain ways Emmons was the most influential geologist America ever produced. With the possible exception of his chief, Clarence King, to whom he was always devoted, he came closest to mining engineers and mine operators of any of the men which have served the nation through work on the Geological Survey." The *Engineering and Mining Journal* for once agreed with the *Press*: "Emmons' death has deprived science not only of an eminent geologist, but of the pioneer in economic work in this country. For the last 30 years he has indeed been the most prominent figure in that field in America, if not in the world." T. W. Rickard said "What Lyell did for geology, Emmons did for economic geology," adding that his greatest contribution, painstaking detail in working out structure, had become so commonplace that his origination of the method had been forgotten. The volume on the origin of ore deposits which Emmons had been editing for the American Institute of Mining Engineers was dedicated to him and became known as the "Emmons Volume." Contributions from many friends and coworkers were used to establish the Emmons Fellowship at Columbia University, which had the oldest school of mines in the country.

By early spring of 1911, advisers had convinced President Taft that he must accept Secretary Ballinger's resignation. In a highly publicized letter on March 7, in which he reaffirmed his support of the Secretary and condemned the conspiracy that led to his removal, he accepted the resignation. Six days later, Walter L. Fisher of Chicago became Secretary of the Interior. Fisher was known as a successful reformer. He had been active in Chicago politics for several years, and as president of the Municipal Voters League, he had conducted such a vigorous campaign against corrupt aldermen, whom he called "gray wolves," that two-thirds of the members of the city council were elected on pledges drawn up by the League. He had also served as traction counsel for the city and prepared a plan for municipal purchase of street railways that was accepted by the city council and approved by the voters in a referendum. But Fisher was also an ardent conservationist, and it was this that qualified him for the Interior position. He had been president of the Conservation League of America in 1908–09 and with Gifford Pinchot had drawn up the declaration of principles for the National Conservation Association in 1909. Taft's appointment of Fisher satisfied members of the progressive wing of the Republican Party. Theodore Roosevelt was especially pleased with the appointment and wrote to former Secretary Garfield "If two years ago he [Taft] had done some of the things he has done now, he would probably have saved himself from nine tenths of the blunders he has made and is making."

Ballinger returned to Seattle where he died a few years later, broken in spirit. Thirty years later, Secretary of the Interior Harold L. Ickes, who as a young man had supported Pinchot in the controversy, declared after examination of Department records that Ballinger was not guilty. Long before that time, most of the public-land legislation that he had recommended had been enacted into law.

The Geological Survey was not affected by the change at Department level. When it came time to begin field work under the Weeks Forest Purchase Act, however, George Otis Smith deemed it politic to begin the work himself by making a preliminary examination of two proposed forest tracts in Georgia and Tennessee aided by Arthur Spencer of the Geologic Branch. Heeding T. C. Chamberlin's strictures on the role of geologists in conservation, Smith also ruled that the Survey's report would be a statement of fact without recommendations.

Chapter 5. The Furor for Practical Results, 1911–1914

There is, however, grave danger that, carried away by the present furor for practical results, we may lose sight of our scientific ideals. Applied geology can only maintain its present high position of usefulness by continuing the researches which advance the knowledge of basic principles. Future progress in applied geology depends on progress in pure geology.

—A. H. Brooks

During the years between the appointment of Walter L. Fisher as Secretary of the Interior in the spring of 1911 and the outbreak of World War I in Europe in 1914, George Otis Smith served as Director of the U.S. Geological Survey under both a Republican and a Democratic administration. Within the Survey there were three Chief Geologists, and two heads of the Water Resources Branch, one called a Chief Hydrographer, the other a Chief Hydraulic Engineer. The two Secretaries of the Interior did not differ greatly in their public-land policies, and both supported the scientific and mapping programs of the Survey. Within the Survey, however, two different trends developed, one epitomized by the change in title of the head of the Water Resources Branch. The Water Resources and Topographic Branches were primarily concerned with practical work, for the most part in the public-land States. Both branches received increasing amounts of cooperative funds that enabled them to expand their programs, but usually for the acquisition of data or the production of maps and not for research. The Geologic Branch, on the other hand, increasingly stressed the research aspects of its program in both Eastern and Western States. The Survey's responsibilities for mineral-land classification were altered by Secretarial orders and agreements with the General Land Office, and on May 1, 1912, the Land Classification Board was separated from the Geologic Branch and given status as an independent branch of equal rank. Thereafter, geologic investigations in the public-land States became primarily geologic investigations in which classification might be one but not the sole objective.

During the summer of 1911, however, the Geologic Branch continued to be deeply involved in public-land problems. The Land Classification Board, under its new Chairman, W. C. Mendenhall, simplified and systematized its work so a large and more accurate output could be obtained without increasing the staff. Form letters were adopted to answer the simpler inquiries, and maps were prepared for each of the public-land States on which areas known or suspected to contain mineral deposits, reservoir sites, or lands valuable for power sites were colored in accordance with a definite plan so the remaining uncolored areas could then be clear-listed without special search of the records or literature. A study of the methods of evaluating coal land was already underway when Congressman F. W. Mondell wrote to Secretary Fisher on June 24 that the Survey's valuations placed on coal lands were "so beyond all reason and justification" that he found it difficult to discuss the subject "in an entirely dispassionate and respectful way." His complaint was not directed at the policy of selling at a price to discourage speculation, he said, but at a price that discouraged all sales. In fact, sales of coal land had been substantially greater since the adoption of the classification program, but the Survey sought a better method of valuation based on its greater knowledge of western coal.

Classification of coal and oil lands was continued under the supervision of M. R. Campbell, aided by E. G. Woodruff and W. R. Calvert. Nineteen other geologists were engaged in field work. The phosphate-land classification was continued under the direction of R. W. Richards. Field studies were made by G. R. Mansfield, A. R. Schultz, and Eliot Blackwelder, as well as Richards, and large areas that had originally been included in the phosphate reserves on the basis of mapping by the Hayden Survey in 1877 were eliminated. Field work for classification of the lands in the Northern Pacific Railroad grant, begun under the direction of Hoyt Gale in 1910, was completed by F. C. Calkins, J. T. Pardee, and R. W. Stone. Gale had been given yet another pioneering assignment, this time supervision of the search for potash.

A search for potash became part of the Survey's geologic program as a byproduct of the phosphate conservation program. The world's sole known source of the potash needed for fertilizer was at that time Germany, and the German potash trust, in retaliation for the withholding of phosphate by the United States, had an export duty placed on potash and prorated the amount to be mined so that exports to the United States were decreased and the price of fertilizer had doubled. An appropriation of $12,500 "for exploration and investigation within the United States to determine a possible source of supply of potash, nitrates, and other fertilizers" had been included in the Agriculture Appropriations Act over the objections of Congressman Mondell, who contended that the Geological Survey was the proper agency to conduct the work. When the Survey appropriations came up for discussion later, Mondell proposed an amendment to add $20,000 to the appropriation for chemical and physical research for "research on geological conditions favorable to the presence of potash salts," and that amendment was also approved. Despite the wording of the amendment, it was clear from the discussion that Congress ex-

Walter L. Fisher (1862–1935), Secretary of the Interior, 1911–1913. Fisher was a Chicago attorney who had been active in the reform of municipal politics and was also a leader in the conservation movement. He was president of the Conservation League of America in 1908–09 and with Gifford Pinchot drew up the declaration of principles of the National Conservation Association organized in 1909 after Congress refused to fund conservation programs. Fisher was more successful than Ballinger in promoting Alaskan interests, and Alaska was formally established as a Territory and a commission appointed to plan a railroad into the interior in August 1912. He was no more successful than Ballinger, however, in achieving a revision of public-land law. (Courtesy of the Library of Congress.)

pected the Survey to conduct a physical exploration. The mining journals took it for granted that the Survey would succeed but had questions as to what would happen next. If potash were discovered on the public lands, would the Government develop and mine the deposits? Or would it sell them, and if so, how? Or would it lease them? The assumption of success had as many pitfalls for the Survey as the questions about disposal of the land.

The search for potash was begun in the Quaternary lake beds of the Great Basin. Potash in its soluble or most useful form was known to be almost universally associated with other soluble salts, so attention was first directed to natural saline residues and to natural or artificial brines and bitterns. Both the Quaternary lake beds and the Permo-Triassic red beds of the Rocky Mountain States, Kansas, Oklahoma, and Texas were thought to be more likely than others to contain potash salts in commercial quantities. The area to be explored was large and the funds were limited, so the lake beds were chosen for the first drilling tests because the centers of desiccation could be more accurately determined, locations for drilling better selected, and adequate testing done with fewer drill holes.

Alaska and its development had become the subject of so much interest that the Survey temporarily suspended its work in southeastern Alaska that had been carried on for a decade in order to begin investigations in other parts of the territory. Extensive topographic mapping was done in the Copper River region, in the Kenai Peninsula, and in the Yukon Basin. J. W. Bagley made a detailed topographic survey of part of the Port Valdez mining district and the Moose Pass region to test the methods and instruments for use of photography in topographic mapping. Geologic studies were made in the Copper River region, the Kenai Peninsula, and the Yukon Basin, where the topographers were working, and in the Susitna Basin. Two explorations were carried north of the Arctic Circle. A. G. Maddren was attached to the party surveying the border between the United States and Canada north of the Porcupine River and mapped the geology of 400 square miles on topographic maps prepared by the boundary surveyors. In northwestern Alaska, P. S. Smith and C. E. Giffin mapped the topography of about 10,000 square miles and the principal geologic features of about 8,000 square miles, traveling up the Alatna River, then crossing the divide to the Noatak, and down the Noatak to Kotzebue Sound.

In the programs not specifically oriented toward the public lands, the Metals Section played a more prominent part. Several studies of the ore deposits of large geographic units were underway in Arizona, Utah, Idaho, Nevada, and Montana. In addition, mining district studies were begun in the Tintic district of Utah by Lindgren and in the Creede district in Colorado by E. S. Bastin and J. M. Hill; J. D. Irving took over the task of completing S. F. Emmons' report on the Leadville district. C. E. Siebenthal continued his work on the zinc and lead deposits of northeastern Oklahoma and southwestern Missouri, E. F. Burchard continued his study of the red iron ore deposits of the southern Appalachians, and Frank Hess began a reconnaissance of the vanadium deposits of the United States. Fuel investigations in the Eastern and Central States included David White's continuing study of the regional variations of Appalachian coals, coal-field mapping in Illinois, Iowa, and Missouri, and M. J. Munn's examination of oil and gas developments in Tennessee and Kentucky.

Geologic mapping for the atlas was continued in all parts of the country and the field work connected with the geologic survey of the Atlantic and Gulf Coastal Plain was completed as planned except in a few small regions. T. W. Vaughan spent about a month in the Canal Zone to correlate geologic formations there with those of the Gulf Coastal Plain and also visited in the Bahamas and Florida Keys as part of his study of the geology and geologic processes in southern Florida.

In the Division of Physical and Chemical Research, the physical studies were all basic research. Becker was busy with a variety of projects: a study of the effect of radioactivity on the cooling of the Earth, methods of determining the viscosity of liquids, the effect of electrolytic action due to differences in sulfide potential on the decomposition of ores, and the application of "imaginary geometry" to the study of strain in rocks. Van Orstrand's experiments on diffusion in solids were extended to include a study of the variation of diffusion with pressure and temperature. F. W. Clarke was supervising publication of a new edition of his "Data of Geochemistry," but most of the other chemists were engaged in making routine analyses.

At the end of the field season, on October 15, 1911, Chief Geologist Hayes joined the exodus of geologists leaving the Survey for higher paying positions in private industry, resigning to become vice president and general manager of the Compañía Méxicana de Petróleo El Águila. Hayes had joined the Survey as a field geologist in 1887 after receiving his Ph.D. in chemistry from Johns Hopkins. He was quickly recognized for the standards of accuracy and precision that he applied to his field measurements, much greater than those in general use at the time, and for his patient accumulation of data. His first published paper in 1891 on the overthrust faults of the southern Appalachians was epoch-making. He had also made significant discoveries about the ancient landforms in the southern Appalachians, had provided geologic information useful in the construction of large engineering works, mining coal, and drilling for petroleum, and had been one of the first to make useful quantitative estimates of mineral resources. In 1900, he had become the first Chief of the Section of Nonmetalliferous Deposits, in 1902, Geologist-in-charge of Geology, and in 1907, when George Otis Smith became Director, he had been named Chief Geologist. His "Handbook for Field Geologists," first published in 1908, was a standard reference for many years. Hayes took no public role in the conservation movement beyond supervising preparation of the report on the mineral reserves of the United States for the National Conservation Commission and the 1910 paper in the *Mining and Scientific Press*. In fact, he had little patience with the extremists on both sides. T. C. Chamberlin once remarked that perhaps Hayes' most important contribution to the conservation movement was the conservation of common sense.

Hayes had been held responsible by some for the trend toward applied geology in the Survey. He had, of course, believed that geologic research should be useful—that people had a right to expect geologists, especially those in Government organizations, to help in solving the problems of everyday life—but such research is not necessarily a commercialization of science. As a matter of fact, the tendency toward applied science was not confined to one organization, or even to one science, as A. H. Brooks pointed out in his presidential address to the Geological Society of Washington in December 1911. The trend toward applied science he attributed to "the evils of relative over-population and depletion of nature's wealth." There was no danger in the trend if applied geology rested on a broad basis of scientific research, but he warned that

> **If the spring of pure science is cut off, the stream of applied geology must soon run dry.**

Professor Hobbs of Michigan, who had been one of Hayes' sharpest critics, saw in the Brooks paper "an apology for and a glorification of the almost exclusion of pure science from the later work of the Geological Survey" although he conceded that "the concluding sentence of the address, if taken alone, might indeed seem to contradict the earlier statements of the report."

The position of Chief Geologist was first offered to Brooks, who preferred to remain Chief of the Alaskan Division, and then to Waldemar Lindgren.

Lindgren, like Hayes, had begun his Survey career when John Wesley Powell was Director, had spent several years mapping quadrangles, and had turned to economic geology when that work began to expand after 1893. Lindgren had learned from Hayes' experience. He accepted the position of Chief Geologist on condition that he be relieved of all possible administrative routine, be allowed to retain direction of the Metals Section, and have an opportunity to continue his own research.

Lindgren's appointment was favorably received. The *Engineering and Mining Journal* reported happily that it was "of more than passing significance in the mining profession, since for the first time in 30 years it places as the actual operative head of the Government's work in geology a man who by training, experience, and sympathy is allied primarily with the mining industry." Lindgren, however, was more than a mining geologist; in addition to his "essentially European mastery of detail and breadth of thoroughness of training," the *Journal* said, he had had "a remarkably rich fund of geologic experience" and was "regarded as one of the strongest all-around geologists of the time."

The Water Resources Branch was even more involved in public-lands work than the Geologic Branch in 1911 and also struggling against odds because of reduced funds and personnel. Some 83.5 percent of the direct appropriation and most of the cooperative and repay funds were used for work in the public-lands States, so comparatively little work could be done elsewhere. In an effort to meet the demands being made on the branch, Chief Hydrographer Leighton spent as much time as he could spare from other duties with E. C. Murphy and E. C. LaRue in the field examination of water-power withdrawals, rights-of-way, Carey Act segregations, and designations under the Enlarged Homestead Act. When the Assistant Secretary called on the Survey to examine water supplies in Mesa Verde National Park for the use of park officials and tourists, W. C. Mendenhall himself took the assignment rather than recess any of the ground-water projects. The bulk of the branch's work continued to be stream gaging, but C. H. Lee studied the effect of the absorption of flood waters on ground-water supplies in southern California, O. E. Meinzer examined the problems of irrigation with ground water in the Tularosa Basin of New Mexico and the development of supplies for range stock on the plateaus, and Everett Carpenter investigated the ground-water resources of Boxelder and part of Tooele County in Utah. A. J. Ellis began one of the most detailed studies of ground water yet undertaken in the East, a study of the ground-water resources of Connecticut under the supervision of Professor H. E. Gregory of Yale.

In 1911, Survey geologists began a congressionally mandated search for potash, concentrating at first on the desert-basin area where, from the work of G. K. Gilbert and I. C. Russell on ancient Lakes Bonneville and Lahontan, they believed that potash salts might occur in association with other desiccated saline and alkaline-water deposits. One of the first areas tested, Silver Peak Marsh in Nevada, proved disappointing; salt deposits were found but no potash-bearing salts occurred within the uppermost 50 feet tested by hand-drilling. C. D. Walcott's photograph shows part of Salt Creek Marsh and "Alcatraz Island," a hill of Cambrian limestone nearly submerged by the playa deposits that bears a striking resemblance to an oceanic island. (Photograph from the files of the U.S. Geological Survey.)

Topographic mapping was carried on in 36 States and the Territory of Hawaii, and a total of 33,140 square miles was mapped. The public-lands States were still given preference, and nearly 65 percent of the area mapped was in the Rocky Mountain and Pacific Divisions. However, 20 States provided an additional $177,853 in cooperative funds, and Director Smith abandoned his requirement that the amount accepted be in relation to the rate of progress toward completion of the topographic map of the United States. The largest sum, $25,000, came from the State of Ohio, which was 70 percent mapped at the beginning of the fiscal year, and $12,000 was accepted from West Virginia, which had been completely mapped, for remapping at a larger scale. In addition to the topographic mapping, 1,261 linear miles of river surveys were run, some paid for by the States and some done in connection with investigations of the Water Resources Branch, but all in relation to water-power development.

By 1911, coal-land classification was being combined with more complete studies of the geology of an area. A. L. Beekly, for example, began mapping the North Park area in Colorado, where both the Hayden and King surveys had mapped in the 1870's. Beekly noted that although the report by Arnold Hague of the King survey on the area was brief and admittedly based on a hasty reconnaissance, he was "impressed with the pioneer geologist's remarkable grasp of the leading geologic features." Some of the most important coal beds in the region were in the widely distributed Coalmont Formation, shown as scenically eroded remnants in the photograph. (From A. L. Beekly, 1915.)

In the late summer of 1911, Secretary Fisher made an inspection trip to Alaska, accompanied by the Governor of Alaska and various Department officials, including A. H. Brooks of the Survey and J. A. Holmes of the Bureau of Mines. On his return, Fisher said the visit had demonstrated the necessity of establishing some policy on Alaska; the Morgan-Guggenheim interests had at least proposed some development, but everything had since come to a standstill. In an address to the American Mining Congress on September 27, he suggested that the Federal Government should construct a railroad from tidewater to Tanana and the Yukon, that a leasing law for minerals be enacted, and a territorial government should be established. These recommendations were included in his annual report to the President.

George Otis Smith continued to press for changes in public-land laws but took care to emphasize that the Geological Survey's role in public-land administration was a scientific one. In his annual report submitted to the Secretary of the Interior in the fall of 1911, he pointed out that Federal geologists had observed the working of public-land laws in nearly all the important mining districts of the country for more than 30 years and that the Survey engineers had been in touch with irrigation and power developments for almost as long, and had developed an opinion on public-land laws based on both field conditions and administrative experience. It was his belief that

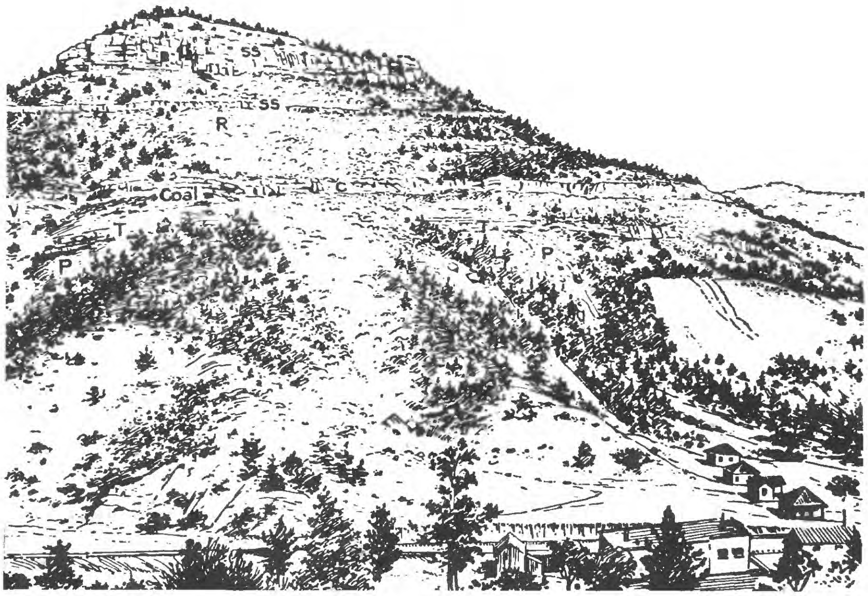
> **The objects to be sought by amendment of the public-land laws are first, purposeful and economical development of resources for which there is present demand, with retention of such control as may insure against unnecessary waste or excessive charges to the consumer, and second, the reservation of title in the people of all resources the utilization of which is conjectural or the need of which is not immediate.**

To attain these objectives, it was essential that the public lands be classified, that surface and mineral rights be separated, and that the land be disposed of on terms that would secure their highest use, enforce development, and protect the public interest.

Under the Pickett Act, classification of the public lands in advance of disposition was possible, and disposition could be postponed to await legislation, but there were loopholes. No withdrawal was effective against location or appropriation for minerals other than coal, oil, gas, and phosphate. The apparent intent was to promote the exploration and discovery of metalliferous minerals, but the wording made no provision for such minerals as potash and nitrates, of no less vital concern than phosphates to the agricultural interests. It also permitted attempts to claim sand and gravel as minerals in order to secure control of power sites and entering claims for commercially worthless land in order to set up a claim for title to land of great prospective value for oil.

Smith suggested that legislation to permit the separation of surface and mineral rights, wherever the two had values that could be separately utilized, should be the first step in amending the land laws. Such separation, already applied to coal deposits, should be extended to oil, gas, and phosphate lands. Similar legislation should reserve to the Government the exclusive right to grant easements for the future development of water resources, for either power or irrigation, and at the same time make provision for grants of surface patents for agricultural use of the land or of mineral patents where mining would not interfere with water-power development.

To Smith, the coal-land law was the most satisfactory of the existing mineral-land laws in that it made possible placing an adequate valuation on the



As coal investigations progressed into new areas, questions were raised about the correlation of the coal-bearing formations. W. T. Lee's detailed study in 1910 and 1911, including careful measurements of sections at short distances, showed that the coal-bearing rocks of the Raton Mesa region in Colorado and New Mexico, long considered the equivalent of the typical Laramie of the Denver Basin, actually constituted two distinct formations, neither of them equivalent to the Laramie, separated by an unconformity. The lower, which Lee named the Vermejo (V on the sketch of a mesa near Koehler, New Mexico), contained a Montana-age flora and was older than the Laramie and more closely related to the Mesaverde of New Mexico; the upper, which he named the Raton (R on the sketch), contained a flora similar to that of the post-Laramie formations of the Denver Basin and of the Eocene Wilcox group of the Gulf Coast. (From W. T. Lee, 1917.)

deposits, which permitted purchase for immediate development and prevented, or at least discouraged, purchase for long-time investment or monopolization. As the ideal valuation was well-nigh impossible, however, leasing would have advantages because it would relieve operators from the large capital outlay necessary for acquisition of the large acreage necessary for a modern mine, and that in turn should lower the cost of operation and the price of coal to the consumer. Moreover, better control would be possible, despite the cost of Federal management and the possibility of inefficient administration or even maladministration. If a leasing law were not enacted, however, the existing law should be amended to allow holding a unit large enough to permit opening and equipping a modern mine.

Smith felt the most urgent need was for legislation for disposition of oil and gas lands. The placer law was wholly inadequate, and an altogether new measure was needed, one especially adapted to provide for the sane and equitable development of the industry. Such a law should authorize the issue of exploratory permits, granting the exclusive privilege of occupation, and should provide that upon discovery the permit holder would be given a leasehold title with a royalty varied to meet local and actual conditions. As for the phosphate lands, neither the placer nor the lode law was applicable, and a leasing law should be enacted.

Smith also suggested that the mining laws of the United States be revised. The law of the apex had proved more productive of expensive litigation than of economical mining, and in many mining districts it had been made inoperative either by common agreement or by compromise between adjoining owners. Discovery of ore in place should not universally be made a prerequisite to the location of a mining claim, for in many regions deposits underground could be definitely surmised even though no surface evidence existed. The law should provide for acquisition of metalliferous land classified as such on the basis of adequate geologic evidence. The mining law should also provide for enforced development by requiring actual use as a condition of occupancy, or, alternatively, the existing evil of idle mining property could be remedied by the adoption of leasehold, under which the Government could enforce operation.

Finally, Smith indicated that both the Survey and the Department of Agriculture agreed on water-power legislation: lands valuable for water-power development should be leased for a fixed term, not to exceed 50 years, with moderate charges for use and occupancy of land, revocable only upon breach of condition or if consumers were charged excessive rates.

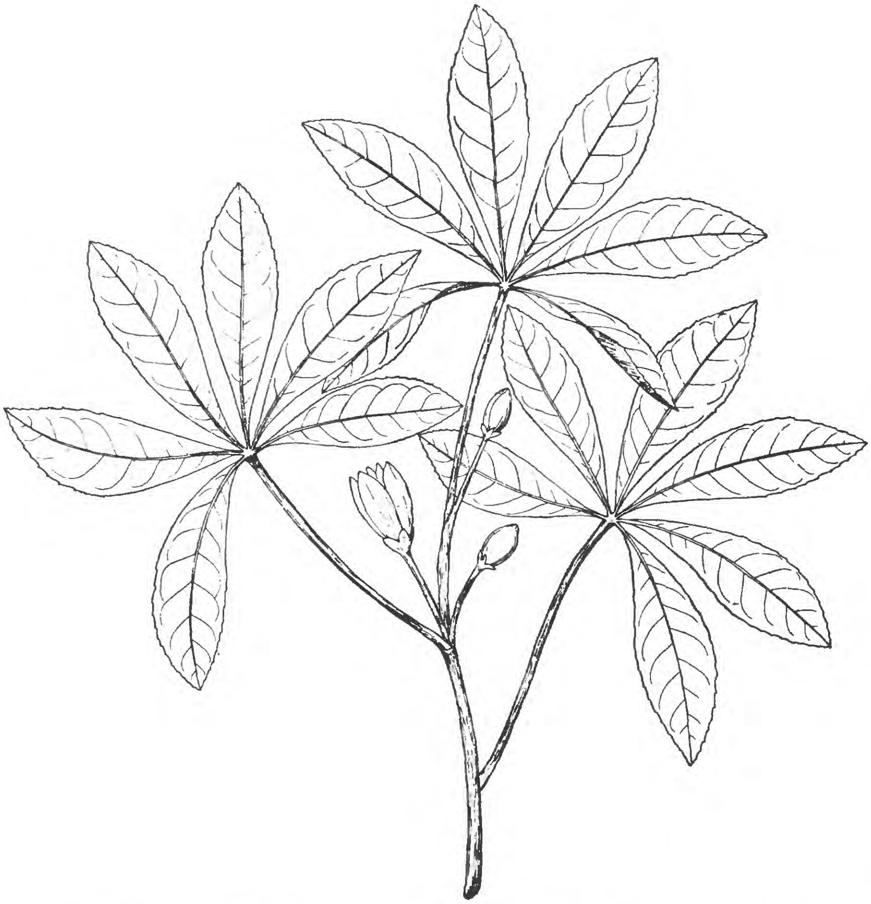
Secretary Fisher included all these recommendations in his own annual report to the President. He also approved the Survey's request for significant increases of $150,000 each for geologic surveys and water-resources investigations in the budget estimate submitted to Congress in the fall of 1911 to help meet the heavy demand for classification of public lands.

Secretary Fisher, like his immediate predecessors, believed that the Department of the Interior was badly organized and proposed some changes. The Department's real function, he wrote in his annual report, was "the administration and disposition of the land and natural resources held directly or in trust by the Nation" and the Department would "more effectively and economically carry on this tremendously important function if it is given all of the distinctively administrative duties relating to it." It should also be relieved of certain functions, and, as one change, he proposed the transfer of the Patent Office to the Department of Commerce and Labor. He also called for an expansion of the work of the Bureau of Mines by an extension of its accident-prevention work to metals mines, quarries, and metallurgical plants, and by the addition of investigations into various branches of the mining industry with a view to lessening the waste of essential resources.

Exploitation of low-grade disseminated copper deposits became practicable when cheap and efficient mining and metallurgical practices were developed about 1907. In the Ray and Miami districts of Arizona, the ore was mined, with one exception, by caving systems of stoping, as shown in the photograph of the surface above the Miami mine, concentrated by flotation and running water, and then the concentrates were smelted locally. F. L. Ransome found that the ore was formed in two stages: solutions associated with monzonite-porphyry intrusions deposited disseminated sulfides which were then enriched by downward percolating atmospheric water. The ore bodies were undulating, flat-lying masses of irregular shape and thickness in the marginal portions of the porphyries and in the adjacent schists. The shape and size of the ore bodies to a large extent depended on the lower limit set for the percentage of copper in material classified as ore. (From F. L. Ransome, 1919.)

Although Fisher had largely quelled the turmoil in the Department, President Taft's troubles had multiplied. In January 1911, a group of insurgent Republicans under the leadership of Senator Robert M. LaFollette founded the National Progressive Republican League, which sought to gain control of the Republican organization. In January also, President Taft proposed a reciprocal reduction of tariffs between the United States and Canada to lower trade barriers between the two nations, but the 61st Congress adjourned on March 4 without acting on the proposal. The 62d Congress, elected in November 1910, was then called into special session on April 4, 1911, to consider the reciprocity agreement. The Democrats, after 14 years as the minority party, again controlled the House of Representatives and elected as Speaker Champ Clark, one of the leaders in the revolt against Speaker Cannon. Sensing victory in 1912, the Democrats were in no mood to cooperate with the administration unless in doing so they could contribute to Republican difficulties. Thus, despite Republican opposition to the reciprocity agreement, the House approved it promptly. While the Senate debated the measure, the Democrats began numerous investigations, and joined insurgent Republicans in passing several low tariff bills, all of which the President vetoed. The reciprocity agreement was finally approved on July 22, but Taft's hopes for a free trade area were shattered when the Canadian Parliament failed to come to an agreement and in the general elections that followed the Conservative Party raised the specter of American annexation of Canada and defeated the Liberal Party.

Taft was a firm believer in the competitive system and, in fact, that there was no intermediate point between true competition and socialism. Coupled with his strong commitment to law enforcement, this belief produced a vigorous antitrust campaign by the Justice Department. While Congress was in session, the Supreme Court, on May 15, 1911, ordered the Standard Oil Company of New Jersey dissolved on the ground that it engaged in unreasonable restraint of trade. Two weeks later, on May 29, the Court found the American Tobacco Company in violation of the Sherman Antitrust Act. By these decisions, the Supreme Court in effect changed the nature of the Sherman Antitrust Act by asserting the Court's power to decide whether a business was guilty of violating the Sherman Act, and thereby produced a crisis in the Republican Party. After the Supreme Court decisions, Taft intensified his antitrust activities and thus alienated the more conservative members of his party and the



Coastal Plain investigations included paleobotanist E. W. Berry's study of the fossil plants of the Southern Coastal Plain to carry the correlation of Tertiary formations, which had a "checkered nomenclatorial history," from Alabama across the Mississippi Embayment. The earlier Eocene (Midway and Wilcox) in the Mississippi Embayment lacked the succession of marine faunas that were present in the type locality along the Alabama River in Wilcox County, Alabama. The Midway was found to be a typical marine series but the Wilcox was composed of littoral or estuarine sediments over wide areas and contained one of the most abundant and varied fossil floras known to science. The illustration shows a restoration of a branch from the Eocene tree *Bombacites formosus* Berry. (From E. W. Berry, 1916.)

business community. The decision in October 1911 to institute action against United States Steel alienated Theodore Roosevelt, for one of the main points of evidence against the steel corporation was its acquisition of the Tennessee Coal and Iron Company in 1907, which Roosevelt had tacitly, if not actually, approved.

In December 1911, President Taft devoted the entire State-of-the-Union Message to the trust question and sent special messages on other issues. In a special message on the Interior Department, he said:

> **There is no branch of the Federal jurisdiction which calls more imperatively for immediate legislation than that which concerns the public domain, and especially the part of that domain which is in Alaska.**

He endorsed Secretary Fisher's recommendations for classification of the public lands, for leasing of mineral lands, for Federal construction of Alaska Railways, but stopped short of the Secretary's recommendation on self-government for Alaska. He also called for Federal control of water-power sites and establishment of a "Bureau of Federal Parks."

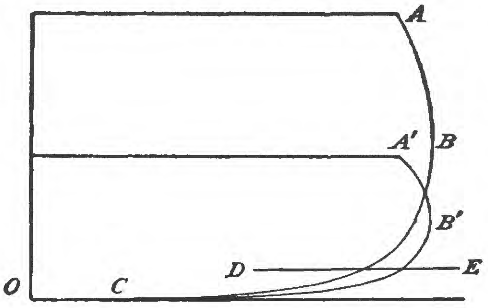
Congress paid scant heed to the President's recommendations. The second session of the 62d Congress, which convened on December 4, 1911 and remained in session until August 24, 1912, was no more tractable than the first had been. Campaign politics created additional problems. On the Republican side, Taft wanted to be nominated for a second term, Senator LaFollette also had presidential ambitions, and Theodore Roosevelt was clearly in the running although he did not formally declare his "availability" until February 1912. The Speaker of the House, Champ Clark, and Congressman Oscar Underwood of Alabama were active candidates for the Democratic nomination, as was Governor Woodrow Wilson of New Jersey.

The House went beyond Taft's recommendations with reference to Alaska and on April 24, 1912, passed a bill to create a legislative assembly in the district of Alaska. The Senate passed the bill on July 24, and when the President finally approved it a month later, the territory acquired by the U.S. in 1867 finally became the Territory of Alaska. Section 18 of the act created a railroad commission to conduct an examination into the transportation question, to examine railroad routes from the seaboard to the coal fields and to interior and navigable waters, to secure surveys and other information with respect to railroads, including the cost of construction and operation, and to obtain information on the coal fields and their proximity to railroad routes. The act specified that the commission be composed of "an officer of the Engineer Corps of the U.S. Army, a geologist in charge of Alaska surveys, an officer in the Engineer Corps of the U.S. Navy, and a civil engineer who has had practical experience in railroad construction and has not been connected with any practical railroad enterprise in Alaska." When the commission was organized, the Survey's A. H. Brooks became its vice chairman.

Congress took no action on the President's recommendations for leasing of mineral lands, Federal control of water-power sites, or establishment of a national parks bureau. It did, however, make two small changes in public-land laws; it closed the loophole in the Pickett Act, and it enacted a law to separate surface and mineral rights on oil land.

During this session, the political organization of the West was completed. New Mexico was admitted to statehood on January 6, 1912. Arizona, which had been part of New Mexico Territory, became a State on February 14. In August 1911, President Taft had vetoed the Congressional resolution admitting Arizona to statehood because its State constitution contained a clause providing for recall of judges by popular vote. Arizona was admitted as a State once the clause was removed and then promptly reinserted the offending clause in its constitution. Arizona's first Representative was Carl Hayden, sheriff of Maricopa County, whose Congressional career lasted until May 1968 when he reluctantly retired at the age of 90. During his long years in Congress, which included many as Chairman of the Senate Appropriations Committee, Hayden became quite knowledgeable about the Geological Survey's work and exercised a strong influence in promoting congressional understanding of its capabilities.

As part of an investigation of the problems caused by the overloading of some California rivers with waste from hydraulic mines, geologist G. K. Gilbert and hydraulic engineer E. C. Murphy collaborated in a series of laboratory experiments on the transportation of debris by running water. Gilbert concluded, however, that the empirical formulas could not be directly applied to natural rivers. The primary cause of stream traction, or the movement of coarser debris, was the bed velocity but bed velocity could not be satisfactorily defined because the direction of motion and velocity are constantly changing at any given point and bed velocity is not independent of depth. In the diagram, DE is the upper limit of the zone of saltation or stream traction, and ABC and A'B'C are the vertical velocity curves for the same mean velocity but two different depths of current. (From G. K. Gilbert, 1914.)



When Congress finally adjourned on August 24, 1912, there were three major candidates for election to the presidency. The Republican convention had been controlled by the conservative elements of the party who managed to exclude most of Roosevelt's supporters by ruling against contested delegations, and it had nominated President Taft for a second term. Roosevelt's followers then met, declared the Taft nomination fraudulent, and called upon Roosevelt to head a third party. In due time, the Progressive Party met and nominated Roosevelt for President. The Democratic National Convention had nominated Governor Woodrow Wilson of New Jersey for President on the 46th ballot.

Conservation was not an issue in the 1912 campaign; both the Republican and Democratic platforms endorsed it. Both party platforms also supported a corrupt practices act and favored banking reform but differed in traditional fashion on the tariff. Both Republican and Progressive Party platforms called for control of monopolies while the Democratic platform called for their virtual abolition. Much of the debate, however, centered around a distinction drawn by Louis Brandeis, known as "the people's attorney" because of his advocacy of public causes, who said the issue before the people was regulation of competition vs. regulation of monopoly.

Conservation was injected into the trust issue at the Progressive Party convention in August when Theodore Roosevelt read to the assembled delegates passages from C. R. Van Hise's new book "Concentration and Control; A Solution to the Trust Problem in the United States." Van Hise, viewing the matter as a scientist, pointed out that monopoly alone, or size alone, did not inevitably result in abuse. In fact, to some degree economic concentration resulted in increased efficiency which in turn could produce lower prices or better service. Strict enforcement of the antitrust laws would hamper conservation, for conservation of natural resources required cooperation among the firms of the Nation's primary industries. Methods of mining that produced immediate profits, for example, were not the methods to insure maximum production over the longest time; operators chose them because of the pressure of competition. The solution, according to Van Hise, was to set up general codes of fair business practices to which all companies, large or small, would be expected to conform.

During the summer of 1912, Van Hise also struck a raw nerve in the Geological Survey when he remarked casually, in discussing his concept of a national university, that "When the United States Geological Survey was originated there were drawn to Washington the most brilliant group of geologists in the country. This survey for a number of years was the center of the world for the advancement of the science of geology; but in recent years, while the organization is vastly larger, having appropriations of millions where it had in early days appropriations of hundreds of thousands, it is almost exclusively a department of practical geology. It is not contributing in any large way to the advancement of science."

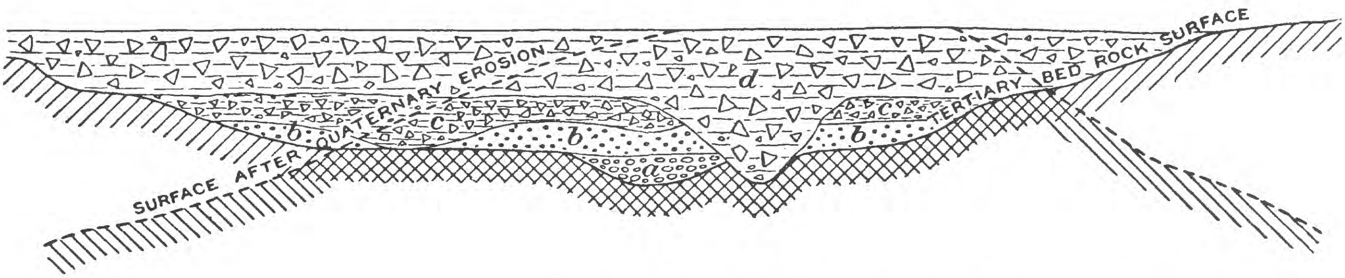
This time Director George Otis Smith reacted personally and vigorously, stating

> **That the United States Geological Survey concerns itself with the practical side is true now as it has always been in the past; whether its work is more or less devoted to practical geology than formerly can be decided according to one's taste or prejudices; but that is is almost exclusively a department of practical geology must be denied.**

Moreover, he said, "the recognition of the applicability of geologic data collected by government scientists to the administration of the public lands is in itself * * * a large contribution to the advancement of science," for thereby the "field of science" was "broadened" and "the standing of science" was "dignified." He concluded that "whenever this bureau becomes exclusively 'practical' or exclusively 'scientific' it will cease to deserve either recognition or support."

During the winter and spring of 1912, the Survey had already taken steps to separate the public-lands and research aspects of its program and to give greater emphasis to the latter. On May 1, 1912, the duties of public-land administration were removed from the Geologic Branch, leaving it wholly a scientific organization. The Land Classification Board became, by Director's order, an independent branch, equal in rank to the Geologic, Topographic, and Water Resources Branches. The organization of the Geologic Branch itself was modified at the start of the fiscal year. The two largest sections, Geology of Fuels and Areal and Structural Geology, were divided into two at the 100th meridian, thus effectively separating the work in the public-lands States from that in other States. The Section of Glacial Geology was revived, and the investigations of the geology of the Coastal Plain and investigations in petrography were given greater prominence as subsections under Eastern and Western Areal Geology respectively. In another move to improve administration and at the same time to relieve the burden on the Chief Geologist, a new position of Administrative Geologist was established in the Director's Office shortly after the start of the fiscal year. The Administrative Geologist was in effect an assistant director, being given charge of certain functions and designated to serve as Acting Director in the absence of the Director, an assignment that had hitherto been delegated to the Chief Geologist.

Waldemar Lindgren (1860–1939), Chief Geologist of the U.S. Geological Survey, 1911–1912. Lindgren, born in Sweden and a graduate of the Royal Mining Academy in Freiberg in 1882, joined the U.S. Geological Survey in 1884 and succeeded S. F. Emmons as head of the Metals Section in 1907. Lindgren had a broader general training than most mining geologists, being soundly trained in chemistry, well versed in all phases of geology, and skilled in both field and laboratory methods. He was also well acquainted with statistics and resource evaluations for a quantitative perspective. During his years with the Survey, Lindgren made fundamental contributions on metasomatic processes in veins, contact-metamorphic deposits, and control by physical conditions. Lindgren achieved the final step in genetic classification of mineral deposits in a volume published shortly after he left the Survey to become William B. Rogers Professor of Geology at the Massachusetts Institute of Technology. (Courtesy of the Library of Congress.)

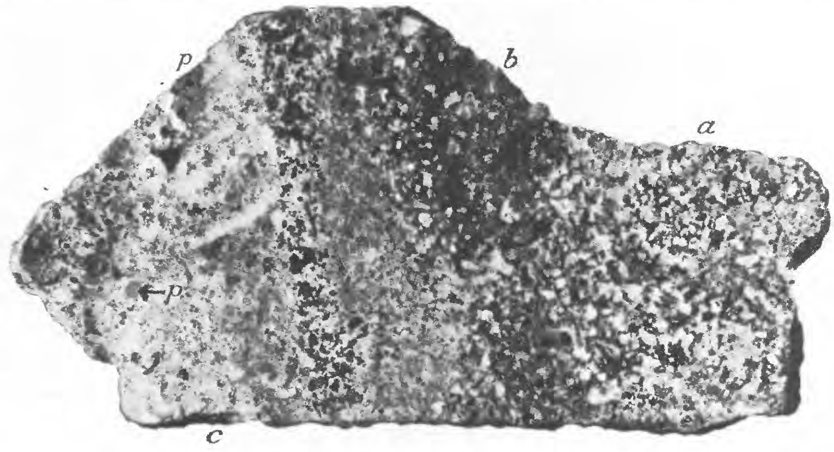


In Lindgren's report summarizing 15 years of Survey work in the California gold belt, he linked the origin and distribution of the gold deposits to the geologic history of the Sierra Nevada. Gold-bearing quartz was deposited in veins toward the end of the Mesozoic when the Sierra first became a mountain range, gold from the veins was then accumulated in stream beds during long periods of erosion in the early Tertiary, the gold-bearing gravels were then covered and sealed in by volcanic flows, and finally, after the range was again elevated, new streams rapidly eroded canyons until the old gravels were exposed. Gold from both the destroyed portions of the old channels and from the veins accumulated in the modern canyons. The diagram is a schematic representation of relations among the deep gravels (a) deposited in young streams, bench gravels (b) deposited by more mature streams, rhyolitic (c) and andesitic (d) tuffs, the Tertiary bedrock surface, intervolcanic channels, and the surface after Quaternary erosion. (From Waldemar Lindgren, 1911.)

The duties of the new Land Classification Branch were described as "the consideration of questions of Survey policy in matters relating to land classification and the preparation of reports thereon for the Director, and the receiving from the other branches and recording of all data valuable in the administration of the public lands." In the months preceding the establishment of the Land Classification Branch, steps had been taken to systematize the process of land classification in the Department to make use of the scientific data available in the Survey. In January 1912, the Secretary issued orders requiring the General Land Office to submit all entries and selections of public lands, other than those specifically excepted from reservation under the Pickett Act and those under which a vested right had accrued, to the Survey for a report on their mineral or power values. On March 5, the Survey and the General Land Office came to an agreement on procedures. If the Survey reported the land to be without value for mineral, power, or reservoir resources, the Land Office would clear-list the case. If the Survey reported the land to have any of these values, the Land Office would give the applicant an opportunity to disprove the classification, and if he were unable to do so would proceed in accordance with the Survey's report. Where the Survey's information was too meager for a definite report, the Survey would give the Land Office such information as it had for use by the Land Office's field service. The Land Classification Branch would have no field duties, nor would it have an independent appropriation; instead its work would be supported by allotments from the funds appropriated for geologic surveys, topographic surveys, and gaging streams. It was thus more of a staff function than an operating branch.

The new branch was divided into two divisions, Mineral Classification, which in turn was divided into four sections, and Hydrographic Classification, which was divided into two sections. The total staff consisted of 30 permanent employees: 12 professional, 4 technical, and 14 clerical and subclerical. Walter C. Mendenhall continued as its head and N. C. Grover as the Chief Engineer.

George Ashley, head of the Coal Classification Section of the Land Classification Branch, became the Survey's first Administrative Geologist.



In a study of part of the Central City quadrangle, Colorado, immediately north of the Georgetown quadrangle mapped by Spurr and Garrey (see page 22), E. S. Bastin and J. M. Hill found that most ores occurred as veins which were in part fissure fillings and in part replacements of various rocks along zones of fracturing. Downward enrichment was confined mainly to the gold-silver deposits, which were the main economic resources of the district, and could be related to ground-water level. The photograph of the polished surface of ore from the Alice Mine shows, from right to left, almost all stages in the conversion of quartz monzonite porphyry into typical ore. The porphyritic texture is preserved at *a* but largely obliterated at *c* where all original minerals except apatite have been altered and pyrite, *p*, occurs in more abundant and larger crystals than in the less altered parts. (From E. S. Bastin and J. M. Hill, 1917.)

Ashley, a graduate of Cornell in 1889, had received his doctorate from Stanford in 1894. He had had experience with both the Arkansas and Indiana State Surveys before joining the U.S. Geological Survey in 1901, and had served as State Geologist of Tennessee from 1910 to 1912.

The reorganization of the Geologic Branch brought men with recognized research abilities to administrative positions. David White, who became Chief of the Eastern Section of Fuels, had been elected to the National Academy of Sciences in April. White, F. L. Ransome, who became Chief of Western Areal Geology, and T. Wayland Vaughan, Chief of the Coastal Plain Subsection, had all been starred in the 1910 edition of *American Men of Science* as three of the thousand American scientists whose work was considered most important. The other new chiefs were W. C. Alden in the Section of Glacial Geology, and E. S. Larsen, Jr., in the Subsection of Petrography. Alden, who received his Ph.D. from the University of Chicago in 1903, had been with the Survey since 1896. Larsen, a graduate of the University of California in 1906, had joined the Survey in 1909, after a year as instructor at the University of California and 2 years at the Carnegie Institution's Geophysical Laboratory.

The Geologic Branch had no additional funds for research. The Survey had, in fact, begun its 33d year on July 1, 1912, without an appropriation. The new Chairman of the Appropriations Committee, succeeding Congressman Tawney who had not been reelected in 1910, was John J. Fitzgerald of Brooklyn, New York, a man described by one of his colleagues as having an instinctive antagonism toward the members of the executive branch who came before the Appropriations Committee. He reported out the sundry civil expenses bill on June 3, 1912, with a recommended total appropriation of $109.6

On June 6, 1912, Mount Katmai, a 7,500-foot peak near the eastern end of the Alaska Peninsula erupted so violently that within a few hours the surrounding area and the west half of Kodiak Island were covered with ash, and dust fell as far away as the Ketchikan Valley in southeastern Alaska. Katmai was one of the least-known Alaskan volcanoes and had been dormant so long that there were not even legends of earlier outbreaks. Survey funds were not available for an investigation of the volcano, but the National Geographic Society sent Survey geologist George C. Martin to Alaska. Martin arrived just 4 weeks after the eruption began and spent several weeks documenting its effects. The photograph, taken by Martin on July 14, shows beach grass already growing through cracks in 11 inches of ash at Douglas Village, some 60 miles northeast of the volcano. (From G. C. Martin, 1913.)

million, which was $42.4 million less than the estimate submitted by the executive branch and $32.1 million less than the appropriation for the fiscal year ending June 30. Although the Survey had hoped for the $385,000 increase approved by the Secretary, it counted itself fortunate, under the circumstances that its appropriation was cut only $10,000, or less than 1 percent. The entire cut was made in the appropriation for Alaskan mineral resources, which had in previous years been included in the Urgent Deficiency Appropriations Act so an early start could be made, and the cut was made on the theory that it was too late in the year to spend the full amount. The Sundry Civil Expenses Act was enacted on the last day of the session, August 24, and the House Committee figures held.

Research is not always deterred by lack of funds, and the Geologic Branch found several ways to expand its research in 1912. When Katmai, one of the least known Alaskan volcanoes, and one that had been so long dormant that there were not even local legends of former outbreaks, erupted so violently on June 6, 1912 that the sound of the first explosion was heard 750 miles away at Juneau, the Survey had no funds for an investigation and Congress had not yet appropriated funds for the fiscal year beginning July 1. The Research Committee of the National Geographic Society made plans for an investigation and chose George C. Martin of the Survey as principal investigator because he had made a cruise along this little known coast in 1904 and was therefore somewhat familiar with its geography. Martin spent a month examining the effects of the eruption and then began a study of the metalliferous deposits of Kodiak Island. A. G. Maddren continued his geologic investigations along the Alaskan-Canadian boundary north of Porcupine through the courtesy of the Boundary Commissioner. Most of the Alaskan Division geologists and topographers, however, had to postpone the start of field work.

In the Division of Geology, 26 geologists were assigned to the mapping and classification of coal lands. Classification, however, now required a more exact knowledge of the character of the coals, and so C. E. Lesher spent some time in the field testing apparatus devised to determine the ash and moisture content of coals. W. T. Lee's study of the stratigraphy of the coal-bearing formations of the southern part of the Rocky Mountain region had provided so much valuable information on the age and correlation of formations and the physical conditions under which they were deposited that it was extended northward to the Yampa field. Mapping was done in greater detail than in previous years, in some places for quadrangle publication. Similarly, the examination and classification of phosphate lands was continued and the work refined to include quadrangle mapping for the geologic atlas. Quadrangle mapping had for some time been the rule in the oil-field investigations in California.

The geologic knowledge already acquired in California was used to designate the first naval petroleum reserves. On June 25, 1912, the Secretary of the Navy asked the cooperation of the Secretary of the Interior in securing the reservation for the Navy of oil-bearing public lands in California sufficient to ensure a supply of 500 million barrels. The Geological Survey recommended two areas, one in the Elk Hills of Kern County, where no discoveries of oil had yet been made, and the second in the Buena Vista Hills, south of the Elk Hills, where oil had already been discovered. These areas became Naval Petroleum Reserves No. 1 and No. 2 in Executive orders dated September 2 and December 12, 1912. Within the boundaries of both reserves, large tracts appeared to have been legally patented to private owners and only part remained in the hands of the Government. Most of the private land at the time the reserves were established was owned by the Southern Pacific Railroad Company, the ownership based on grants made under the Act of July 26, 1866, of alternate sections of nonmineral land in aid of railroad construction. The Federal Government filed suits to reclaim title to some of these sections, claiming that the Southern Pacific had misrepresented them as nonmineral.

The search for potash, the most practical of all Geologic Branch projects, was continued in 1912 without marked success, although two promising areas were withdrawn from entry as potash reserves, one in Nevada and the other near Searles Lake in California. By adding two chemists, W. B. Hicks and R. K. Bailey, to the staff of the chemical laboratory to perform the routine analyses for potash, some of the other chemists were freed for research investigations. George Steiger began a study of heavy metals in deep-sea deposits, R. C. Wells began a study of the application of physicochemical methods to geologic problems, and Chase Palmer carried forward E. C. Sullivan's work on the interaction between minerals and water solutions in collaboration with E. S. Bastin of the Metals Section.

Palmer reported to the American Institute of Mining Engineers that preliminary results of their experiments indicated that sulfides, arsenides, and sulfarsenides of some metals precipitated metallic silver very efficiently from dilute solutions of silver sulfate and that nearly all the sulfides and arsenides common in ore deposits were capable of reducing gold from a solution of its chloride. As the waters descending through the upper portion of most sulfide ore bodies were sulfate waters and carried chlorides, Palmer and Bastin suggested that similar precipitative action could occur under natural conditions, and that such reactions might be of importance in the secondary enrichment of ore bodies.

The Metals Section continued its studies of the geology and mineral resources of large geographic units in the West and of several mining districts.

David White (1862–1935), Chief Geologist of the U.S. Geological Survey, 1912–1922, Chairman of the Division of Geology and Geography of the National Research Council, 1924–1927. White joined the Survey as a paleontologic draftsman in 1886, after graduating from Cornell University, and remained with the Survey until his death. Primarily a paleobotanist, he became an authority on Paleozoic stratigraphy and on the formation of peat and coal; he was also author of a theory of oil distribution used for many years by the oil industry as a basis for exploration. White's interests, however, were broad and he contributed notably to studies of Precambrian life, ancient climates, and gravity anomalies. So many Survey geologists who worked under his direction were recruited by oil companies after World War I that a notable proportion of the leading oil geologists of the world on company payrolls in the 1930's were former members of the U.S.G.S. (From the files of the U.S. Geological Survey.)

David White's most comprehensive paper on the origin of coal was published in 1913, shortly after he became Chief Geologist. He followed that analysis with a paper showing that resins actually did occur in coals of higher rank, which many scientists had believed owed their differences in rank to differences in the types of plants from which they were formed. The surface of the specimen shown is strewn with small pieces of wood flattened and converted to mineral charcoal; needle-like resinous casts cross the specimen parallel to the grain. (From David White, 1914.)

W. H. Emmons, who had resigned from the Survey to join the faculty of the University of Minnesota, returned on a part-time basis to continue the detailed study of the Creede district in Colorado begun by Bastin. East of the 100th meridian, C. E. Siebenthal continued his investigation of the lead-zinc ores in Missouri and E. F. Burchard his study of the red iron ores of the southern Appalachians.

David White broadened the program of the Eastern Section of Fuels. C. A. Davis began a study of the peat bogs of eastern Massachusetts, mapping of coal fields was continued in cooperation with the States of Illinois and Missouri, and a detailed remapping of the coal fields in southwestern Virginia that set new standards for precision and detail was begun in cooperation with that State. The great Cushing field, one of the most phenomenal producers in history, was brought in in March 1912, causing intense interest in oil in Oklahoma. At the request of the State Geologist, M. J. Munn was diverted for a time from his work on the Appalachian areas to examine a geologically little known area in southwestern Oklahoma where the residents were interested in the possible occurrence of oil or natural gas. Munn concluded that the structure in at least part of the area along the Red River offered some encouragement for wildcat prospecting. An investigation was also begun to test the theory, proposed by some geologists, that the rate of downward increase of temperature was more rapid in rocks containing petroleum and gas than in barren rocks. Becker and Van Orstrand designed apparatus for measurement of temperatures in deep wells and supervised its construction; measurements were then made in Ohio, Pennsylvania, and West Virginia in cooperation with the Geophysical Laboratory of the Carnegie Institution.

In other parts of the Geologic Branch, geologists of the Subsection of Coastal Plain investigations under T. W. Vaughan cooperated with several non-Survey scientists and organizations to correlate formations on the Atlantic coast with those on the Pacific coast and to work out the geologic history of the Gulf Coastal Plain and the Central American and Antillean regions. The Glacial Geology Section expanded its program of Pleistocene geology by mapping in the Blackfeet Indian Reservation, Montana, in connection with which a reconnaissance trip was made to southern Alberta, and by beginning a project in cooperation with the Minnesota State Survey to map the Pleistocene deposits in the northern part of that State.

The work of both the Water Resources and Topographic Branches in 1912, by contrast, continued to be largely confined to the public-lands States and to be almost wholly concerned with practical objectives. In the Water Resources Branch, the problems of hydrographic classification had reached a desperate stage. Many of the power-site withdrawals were still unexamined; many applications for rights-of-way had been pending for more than 2 years; applications for power permits and for segregations of land under the Carey Act were acted on without field examination although such examination was highly desirable; applications for designation under the Enlarged Homestead Act, which required field examinations, were piling up; and the examination and classification of land valuable for power sites in Arizona and New Mexico, required by Congress in the acts admitting them to statehood, had not been made. During part of the field season, W. B. Heroy and W. N. White were detailed from the Land Classification Branch to aid E. C. LaRue and E. C. Murphy, who did the greater part of the field work, but personnel and funds were simply insufficient to meet the demands.

The total allotment for investigations of ground water and quality of water was only $16,870, but it was made to cover a variety of investigations. O. E. Meinzer, who had become acting chief of the division when the Land Classification Branch was established, undertook two special investigations in Montana,

As part of his investigation of the origin of petroleum, David White took an active part in the study of the Green River Formation of northwestern Colorado and northeastern Utah, which contained shales that would produce oil when subjected to destructive distillation. The Survey considered this shale as a great reserve or undeveloped resource that would be developed as soon as the demand for petroleum greatly exceeded the supply. In anticipation of that day, a study of the Green River Formation was begun in 1913 and continued in succeeding years. The work indicated that gas and ammonium sulfate (fertilizer) might also be obtained from these rocks. In the photograph of about 600 feet of oil shale northeast of Watson, Utah, the darker layers are the richer beds. (From D. E. Winchester, 1916.)

one in the vicinity of Butte where underground water was in demand for milling operations and for irrigation of truck farms, and the other on the Flathead reclamation project, where the settlers were having difficulty in obtaining domestic water supplies. Meinzer then continued his investigation of the Tularosa Basin in New Mexico in cooperation with the State Agricultural Experiment Station. C. H. Lee continued the investigations of the percolation of flood waters to the underground reservoir in southern California. Kirk Bryan and W. O. Clark began surveys of the Sacramento and Santa Clara Valleys in California, and Everett Carpenter, a study of the ground-water resources of southeastern Nevada. Walton Van Winkle investigated the quality of water in Oregon. In the Eastern States, A. J. Ellis continued to study the ground-water resources of Connecticut, and R. B. Dole investigated the quality of water in Georgia, Florida, Arkansas, and Texas as part of the Coastal Plain project.

The Topographic Branch had mapping underway in 29 of the 48 States, the District of Columbia, and the Territory of Hawaii, but its major effort was still in the States west of the 100th meridian. On July 1, 1912, a new division was established in that area by separating Washington, Oregon, and Idaho from the Pacific Division as the Northwestern Division under T. G. Gerdine. George R. Davis, who succeeded Gerdine as Geographer-in-charge of the Pacific Division, was a Californian who had joined the Survey as a recorder in October 1898 and became an assistant topographer in November 1903. The principal mapping scales east and west of the 100th meridian were different, in part as a result of cooperative agreements with 18 States, 12 of them in the Atlantic and Central Divisions, and the Territory of Hawaii. East of the 100th meridian, all mapping was done at the mile-to-the-inch or larger scales, and all mapping in Hawaii was done at 2 inches to the mile. West of the 100th meridian, about 75 percent of the mapping was done at scales of 1:125,000 and 1:250,000.

In November 1912, Woodrow Wilson was elected President, the first Democrat to hold the office since Grover Cleveland. Although the campaign had begun as a three-way race among Wilson, Roosevelt, and Taft, it soon developed into one between Wilson and Roosevelt and their different concepts of progressivism. Wilson's "New Freedom" and Roosevelt's "New Nationalism" sounded very much alike although a careful analysis indicated some differences, especially how goals were to be achieved. Roosevelt was very popular, but the two-term tradition was still strong. Wilson received more than 6 million votes, less than half of the total popular vote, but Wilson and

Roosevelt between them received nearly 10 1/2 million votes to Taft's 3 1/2 million, showing that the country had become dominantly progressive. Wilson recognized this in his inaugural address on March 4, 1913, when he said that the Nation wished to use the Democratic Party to interpret a change in its plans and point of view.

In anticipation of the change in administration and new priorities, the Survey published a bulletin entitled "The Classification of the Public Lands" in January 1913, to present "a full statement of the policy of land classification and a detailed description of the procedure and methods so far found necessary to carry out that policy in the stage of development already reached." The culmination of several years' experience, it was designed "to be of value both to students of government and to geologists and engineers interested in the application of scientific investigation to practical business."

New coal-land regulations, developed.after more than a year's study, were approved by Secretary Fisher on February 20, 1913. In earlier regulations, coal had been divided into four classes and prices and depth limits had been fixed without any provision for graduated changes, but in the new regulations, depth limits were determined in accordance with the quality and thickness of the coal on the basis that the depth at which any coal can be commercially mined is dependent on the profit that may be derived, and prices were determined in accordance with the heat value of the coal expressed in British thermal units. The general effect was to increase the area classified as coal land underlain by beds of the best quality and to decrease the area classified as coal land underlain by poorer coals. At the same time, values were increased for land where the coal beds were more than 15 feet thick and decreased materially for land underlain by beds 2 to 5 feet thick. The effect of the latter change was a much greater acreage valued at the minimum. The new regulations were not only more realistic; in large measure, they met Congressman Mondell's objections.

The 62d Congress, in the session that ended on March 4, 1913, amended the Organic Act of the Bureau of Mines. Section 2 of the revised act defined the general province of the Bureau as "inquiries and scientific and technologic investigations concerning mining, the preparation, treatment, and utilization of mineral substances with a view to improving health conditions and increasing safety, efficiency, economic development, and prevention of waste in the mining, quarrying, metallurgical, and other mineral industries." The committees involved made it clear that the change was not meant to extend the work of the Bureau but to define its scope more clearly, and emphasized that the investigations were to be fundamental scientific investigations, the results of which would be widely and generally useful.

Congress also appropriated funds for construction of the new building for the Survey and other Interior agencies that it had authorized in 1910, and President Taft signed the bill as one of the last acts of his administration. During the Senate debate on the public buildings bill, a fire broke out at 7:15 a.m. on February 26 at 1320 F Street Northwest, only 12 feet from the Annex which housed the Survey's printing plant. George Otis Smith seized the opportunity to have a letter delivered to Senator Miles Poindexter before Congress met that day depicting the perils of housing the Survey in its existing quarters and the monetary loss to the Government if the Annex had been destroyed. The Survey itself, however, was left without funds for the coming year when President Taft vetoed the sundry civil expenses bill because of a provision for enforcement of the antitrust law which he called class legislation of the most vicious kind. However, President Wilson called the 63d session into special session on April 7, and the bill was again passed before the fiscal year began.

When the Wilson administration took office in March 1913, few of the Cabinet officers were familiar with the departments they would head or with national politics. One of the few who knew the Washington scene well was Franklin K. Lane, the new Secretary of the Interior. Lane was a California lawyer who had been appointed to the Interstate Commerce Commission by Theodore Roosevelt in 1906. Wilson wanted Lane in the Cabinet and had originally selected him for the War Department but then turned to him when he had difficulty in filling the admittedly difficult post at Interior. Lane was a westerner but at the same time enough of a conservationist to avoid rousing the wrath of the very vocal conservationists of the East. The new Secretary of Agriculture, succeeding James Wilson who had filled that post since 1897, was David F. Houston. Houston was a classical economist, with a graduate degree from Harvard University, who had been an advisor to Wilson on the tariff. When appointed to the Cabinet, he was chancellor of Washington University in St. Louis. Under Houston's guidance, the Department of Agriculture added research on economic and social problems to its research on agricultural production that had flourished under Wilson. The Department of Commerce and Labor was divided into two departments. Unlike the Secretaries of Commerce and Labor, who had all been lawyers, the new Secretary of Commerce, William C. Redfield, was a steel manufacturer and exporter. Relations among the Departments of the Interior, Agriculture, and Commerce would therefore be on a different basis than they had been during the Roosevelt and Taft administrations.

New appointments within the Geological Survey brought about more changes than were imposed by the change of administration. Lindgren resigned as Chief Geologist on November 16, 1912, after only a year in office, to become Rogers Professor of Economic Geology in the Massachusetts Institute of Technology, and David White, who had been with the Survey since 1886 but a section chief only since July 1912, was appointed Chief Geologist. White's appointment further emphasized the research nature of the Survey's geologic work, for White was widely regarded as one of the leading paleontologists of this country if not the world, and his career had been devoted almost entirely to research of seemingly the most esoteric kind, Paleozoic paleobotany. Unlikely as it might have seemed to the nonscientist, however, paleobotany was essential to a full understanding of the geology of fuels, and White's work had long been directed toward the ultimate solution of economic problems as well as the advancement of science.

The Water Resources Branch, on the other hand, became even more oriented toward practical problems and data gathering. On June 3, 1913, M. O. Leighton resigned as Chief Hydrographer to engage in private practice. N. C. Grover, who had been Chief Engineer of the Land Classification Board, was appointed to fill the vacancy. At the same time, the title was changed from "Chief Hydrographer" to "Chief Hydraulic Engineer," officially because the latter title was "more closely in accord with the designation used in commercial organizations for men engaged in similar work and * * * also better descriptive of the qualifications for and duties of the office, as well as more distinctive, inasmuch as the Hydrographic Office of the Navy Department has a better claim to the title of hydrographer." Whatever the semantics, the Water Resources Branch seemed to have accepted the emphasis on applied science more readily than had the Geologic Branch.

David White's administration of the Geologic Branch proved unlike that of either of his predecessors. His life, according to W. C. Mendenhall, had two leading motives—enthusiastic devotion to science and an equally absorbing interest in humanity. White possessed "charm of manner that made him a delightful companion, at home, in the office, or in the field;" he also had a strong instinct to be helpful and an innate sense of fairness in dealing with others. A Pick and Hammer Club song described other attributes that contributed to his success:

Now Geologs all, whoe'er you may be
If you want to rise to the top of the tree,
Just study and read, forget your pay,
And do your durndest every day;
And - learn to talk interminablee
And perhaps you'll all be ruler of the whole G. B.

White from the very beginning showed a certain disregard for formal organization, and as M. R. Campbell said when White retired as Chief Geologist in 1922, he made the Geologic Branch one family. In 1913, the Coastal Plain investigations were completely separated from Eastern Areal Geology and raised to the status of a full section to give greater prominence to the work of T. Wayland Vaughan on marine deposition in the Florida region, while at the same time the Section of Glacial Geology extended its study of glacial and interglacial deposits to contemporary deposits of the bordering regions and the geologic history of the continent during the Pleistocene epoch. Thus the work of the two sections was closely related and, in fact, geologists of both sections worked in Missouri, Arkansas, and Louisiana. Frank Leverett of the Glacial Geology Section studied the history of Caddo Lake, Louisiana, while E. W. Shaw of the Coastal Plain Section attempted to correlate the Pleistocene deposits of the lower Mississippi Valley with those of the glaciated regions to the north. (Shaw's study also included the sediment being deposited in the delta of the Mississippi River and some of his work took him offshore, thus bringing Senator Lodge's somewhat facetious prediction of 1900—that the Survey would go offshore and obtain a navy—from the realm of the improbable to the possible.)

Much of the fuels program in 1913 dovetailed with the geologic atlas program. Quadrangle mapping continued in the California oil fields and in coal and oil-and-gas areas east of the 100th meridian in cooperation with the State surveys of Pennsylvania, Virginia, Illinois, Missouri, and Oklahoma, and an even greater proportion of the mapping for classification and evaluation of coal- or oil-bearing lands of the public domain or Indian lands was done in sufficient detail for folio publication. In addition, the search for new oil-and-gas areas was continued in California, in Wyoming, and in the new and exciting areas of Oklahoma where several new fields had been discovered and hundreds of successful wells drilled. C. H. Wegemann examined the Healdton and Loco fields and then with A. E. Fath and R. W. Howell mapped the area along the Red River east of that examined by M. J. Munn in 1912. Despite the new discoveries, the Survey anticipated that the day would come when the oil and gas resources of the United States would be depleted, and so E. G. Woodruff began an investigation of the oil shales of the Uinta Basin in western Colorado and northeastern Utah, combining mapping and stratigraphic studies with practical distillation tests in the field.

In the Nonmetals Section, now under Hoyt Gale, the examination of phosphate withdrawals was also closely related to the geologic mapping program. The search for potash was less easily combined with a geologic mapping program, but N. H. Darton made a reconnaissance examination of about 1,800 square miles in central New Mexico to study the stratigraphy and conditions of sedimentation and chemical deposition in the red beds that were thought to be the second most likely source of the elusive element; that work eventually led to a geologic map of the State. An earlier interest in structural materials was revived with the employment of Professor F. F. Grout to study clay deposits and a granite area in Minnesota in connection with a report on building and ornamental stones.

F. L. Ransome succeeded Lindgren as Chief of the Metals Section, with J. B. Umpleby as assistant, but also retained his position as head of Western Areal Geology, again merging to a degree an economic program with the basic geologic mapping program. Much of the work of the Metals Section was a continuation of that begun under Lindgren, particularly the reconnaissance examinations of mining districts over large geographic units. The section also became involved in the search for a declining resource. The gold products of the United States had begun to fall off as new territory was not being developed to compensate for the failing supply in old and large producing districts. The results of several short investigations of reported occurrences and potential sources were reported in the annual *Contributions to Economic Geology*, along with reports of investigations of other mining districts.

The Survey's Alaskan program was again curtailed in 1913 because of the late appropriation. Extensive work had been planned for the Matanuska area, but because of the delay in starting, the geologists were able to make only a reconnaissance to determine the general distribution of the coal. However, J. W. Bagley was able to spend about 6 weeks making topographic surveys using the panoramic camera and phototopographic methods in the Broad Pass region and to map some 2,500 square miles for publication on a scale of 4 miles to the inch with 200-foot contours. C. E. Ellsworth and R. W. Davenport made a preliminary study of the possibilities of developing water power in the Prince William Sound region and adjacent portions of the Copper River and Bering River areas.

Scientists in the Division of Physical and Chemical Research divided their time between practical and basic research. The physicists continued investigations of the elasticity of metals and also designed and constructed special apparatus for determining temperatures in deep wells. Chemists alternated between routine analyses and research on physicochemical problems. Becker himself was drawn into a very practical problem. Since 1910, construction of the Panama Canal had been hampered by frequent earth slides. Chief

In 1911, the Survey began a series of local investigations of ground-water resources in cooperation with the State of Connecticut to supplement its 1909 report, which was not sufficiently detailed for local or quantitative studies. The chief water-bearing formations of Connecticut were the unconsolidated glacial materials that cover the bedrock. The efficiency of glacial drift in storing water depended on the rate of underground drainage, which in turn varied with the porosity and the topography of the underlying bedrock. For example, the dune sands of the Connecticut River Valley, shown in the photograph, were among the most porous beds and absorbed water rapidly, but they also allowed the water to circulate most freely and were therefore rapidly drained. (From H. E. Gregory and A. J. Ellis, 1916.)

Geologist Hayes had been called into consultation, and in 1911 D. F. MacDonald had been assigned to the Isthmian Canal Commission as geologist. Becker spent a good part of the year investigating the mechanics of earth slides after inspection of the various slides in the field.

To draw attention to the basic scientific research in the Geologic Branch, arrangements were made to publish some papers similar to those that had previously been sent to scientific journals in an annual publication called *Shorter Contributions to General Geology*. The first paper was H. S. Gale's "The Origin of Colemanite Deposits," published in the late summer of 1913. It was followed shortly by E. W. Shaw's paper on "The Mud Lumps at the Mouths of the Mississippi" and G. K. Gilbert's paper on "Interpretation of Anomalies of Gravity."

The 12th International Geological Congress, which met in Toronto, Canada, in 1913, was concerned with both applied and fundamental geology. The review of the coal resources of the world proposed at the 1910 Congress produced enough material for publication of three quarto volumes and an atlas. Total world reserves were estimated as 7,397,533 million tons (7.4 trillion tons) of which nearly 4 trillion were bituminous coals, nearly 3 trillion brown coals, and nearly 0.5 trillion anthracite. China had the greatest reserves of anthracite; North America, of the bituminous and brown coals. A proposal was made to consider world resources of phosphoric acid, so necessary for agriculture, at the 13th Congress, but the final decision was left to the Belgian geologists who would host the next Congress. Other sessions were concerned with differentiation in igneous magmas, the influence of depth on the character of metalliferous deposits, the Precambrian, interglacial periods, and Paleozoic seas and their relation to diastrophism and time divisions. The Committee on the International Geological Map appointed at the 1910 Congress proposed preparation of geological maps of continents at a scale of 1:5 million, each with a distinct center of projection, using the map of North America as a model. The proposal was adopted and the committee was enlarged to include, among other new members, Bailey Willis, who had compiled the geological map of North America.

While the Geologic Branch moved to strengthen its research potential in 1913, the Water Resources Branch placed even more emphasis on the eminently practical work of stream gaging. Its new Chief Hydraulic Engineer, N. C. Grover, said that

> **The Survey has always taken pride in the practical value of the data collected and published under its auspices. The engineers must therefore have an appreciation of the practical. They must not only understand how to do stream-gaging work and everything connected therewith, but also be able actually to do these things.**

During his first year in office, the number of gaging stations, exclusive of those in Alaska, increased to 1,371. Two new hydrographic districts were established: Arizona and New Mexico under G. A. Gray, and Washington under G. L. Parker. The old Southern Pacific district then became the California district, and the old Northern Pacific district, the Oregon district. The Ground Water Division continued to devote some effort to research. However, most of the investigations were made west of the 100th meridian, and most were concerned with ground-water supplies for irrigation. The only major investigation east of the 100th meridian was A. J. Ellis' continuing study of ground water in Connecticut. The division also participated in E. W. Shaw's Gulf Coast investigations by analyzing 60 samples of water from the mouth of the Mississippi River.

For the first time in several years, the Topographic Branch mapping in 1913, in terms of areas covered, was not predominantly in the public-lands States. Fourteen States east of the 100th meridian contributed well over

$100,000 in cooperative funds, much of it for resurveying at larger scales. Nearly 60 percent of the mapping was for publication at 1:62,500, and less than 5 percent, nearly all in national forests, at 1:250,000.

As a Survey contribution to the national park movement, J. H. Renshawe of the Topographic Branch spent a considerable part of his time preparing colored relief maps of the various parks for the Secretary's Office. Secretary Lane was keenly interested in national parks and gave A. C. Miller, a fellow Californian and Chairman of the Department of Economics at the University of California who was serving as Assistant to the Secretary, special responsibility for development of a unified administration of the ten national parks for which the Department was then responsible. Miller, in turn, delegated much of this responsibility to another Californian, young Horace Albright, a law student at the University of California, who was his clerk and who eventually became the second Director of the National Park Service.

Having accomplished many of its major objectives in tariff and banking reform in the special session of Congress that met from April 7 to December 1, 1913, the administration turned to other matters in the fall of 1913. Secretary Lane's first annual report in November 1913 was devoted almost entirely to public-land policy. The "old" policy he characterized as land is land save when it contains minerals and let's dispose of it as quickly as possible. The "new" policy called for the land to be used for the purpose to which it was best fitted and to be disposed of with respect to that use. The West had accepted the necessity of the new policy; it did, however, ask action so that the lands could be used. Lane recommended leasing of the Western mineral lands, and that the search for oil be stimulated, with a plan to protect the prospector. For the development of Alaska's resources he suggested that a new piece of governmental machinery, a board or commission, be appointed. Alaska had the potential of a State and should be regarded as such and not as a storehouse for the rest of the Nation. The Government should undertake construction and operation of a system of railroads and the Alaska coal lands should be leased. The *Portland Oregonian* called Lane's report a state paper that might become the "basis of a new charter of liberty" for the West. The policy had the approval of President Wilson, who would use his influence to embody it in law; as the potency of the Wilson influence had been shown in the first session of Congress by the new tariff and banking laws, the *Oregonian* expected that the second session would open a new era of development in Alaska and the West.

Wilson did endorse Federal construction of a system of railways in Alaska in his State-of-the-Union Message and promised other messages on the development of Alaska's resources as part of a general plan of conservation.

> **We have a freer hand in working out the problem in Alaska than in the States of the Union, and yet the principle and object are the same, wherever we touch it. We must use the resources of the country, not lock them up. * * * The resources in question must be used, but not destroyed or wasted; used, but not monopolized upon any narrow idea of individual rights as against the abiding interests of communities.**

Congress passed the bill to authorize construction of railroads in Alaska and President Wilson approved it on March 12, 1914. The bill to provide for leasing of coal lands in Alaska took longer, but it was finally passed and approved on October 20, 1914. The Coal-land Leasing Act required the Secretary of the Interior to have surveyed lands known to be valuable for coal, with preference to be given first to the Bering River, Matanuska, and Nenana fields. The President was ordered to designate and reserve from use, location, sale, lease, or disposition, a maximum of 5,120 acres of coalbearing land in the Bering River field, 7,680 acres in the Matanuska field, and half the acreage in other Alaskan coal fields with the provision that such coal could be mined if the supply of coal at a reasonable price was insufficient for Government works. Leases were authorized of 40 acres or multiples thereof, with a maximum of 2,560 acres in one block. The leases were to be subject to competitive bidding, with royalties specified but not less than 2 cents a ton, plus an annual rental.

Administration bills were also filed to provide for exploration and disposition of coal, oil, and gas on public lands in the 48 States and for the development of water power and related use of public lands. The House Public Lands Committee held full hearings on the mineral-lands bill and reported out a new bill on May 12 providing for leasing of mineral-fuels and mineral-fertilizer lands on a royalty basis. Except for coal, the bill applied to the public lands of Alaska as well as those of the 48 States. The water-power bill, however, remained in committee.

In its report on the general leasing bill, the Public Lands Committee complained that

> **With all this enormous wealth decreed to us by nature and by purchase, with all the mineral deposits slumbering in the ground yet untouched, the Government, with all its patriotism, with all its wisdom, has as yet no well-defined, well-digested, rational policy for the development of the mineral resources contained in its public lands.**

The laws were "crude, irreconcilable, inefficient, without uniformity, confusing to the brain of the miner, impossible of interpretation by the layman." In fact, they were not laws, but "a jargon of Executive orders, rulings, interpretations and decisions made by different bureau chiefs and clerks in the ramifications of the various bureaus of the Interior Department." The leasing plan would "insure a proper development and an intelligent utilization of our

In 1912, O. E. Meinzer began a thorough survey of the geology and hydrology of the Tularosa Basin of New Mexico in cooperation with the New Mexico Agricultural Experiment Station. Settlers who followed the railroad into the area had expected to use dry-farming methods, ordinary supplies of water having already been appropriated, and when dry-farming failed, some were considering the feasibility of developing new supplies for irrigation by storing flood waters or sinking wells. Meinzer found that sufficient ground water for domestic use and for raising stock could be obtained almost everywhere in the area of valley fill, although water of sufficiently good quality was difficult to find in some parts. He also noted that much of the water added to the underground reservoir each year was added below soil unsuitable for agriculture. One of the remarkable features of the basin was its gypsum sands, such as those shown in the photograph, part of which became the White Sands National Monument in 1933. (From O. E. Meinzer and R. F. Hare, 1915.)

mineral resources, without waste and without permitting monopoly or injustice to be pressed down upon those who would develop the West, or upon the interests of the public, who are entitled to reap the benefits." Congressman Edward Taylor, Democrat of Colorado, presented a minority report to express his opposition "to having the resources of the West withheld from private ownership and put into a general Federal leasing system"; he considered the bill "in violation of the moral, legal, and constitutional rights of the Western States." The House, after lengthy debate, passed the bill on September 23 and sent it to the Senate, which did not act on it before adjournment.

The Geological Survey was subject to some Congressional scrutiny during the session because of its public-lands activities. The concentration of topographic and hydrographic work in the public-lands States had inevitably caused some dissatisfaction in the other States even as John Wesley Powell's insistence on general geology before economic geology had caused problems for the Survey a quarter of a century earlier. Early in the second session, Congressman James P. Buchanan of Texas filed two bills "to provide for a more equitable means of distribution of topographic and hydrographic surveys and other work of the U.S. Geological Survey among the several States, and to make such work more effective and serviceable to the several States in the work of improvement and development." One bill was referred to the Committee on Mines and Mining, the other to the Committee on Expenditures in the Interior Department; neither was reported out. On June 22, when the House began consideration of the Survey appropriations, Congressman Patrick H. Kelley of Michigan offered an amendment, which he said was endorsed by the State Geologist of Michigan, to provide for an equitable distribution of expenditures for topographic and hydrographic surveys among the several States. The formula proposed was complicated, based on several factors such as the ratio of State to national population and of unmapped areas in the State to those in the Nation. The amendment was rejected, on a point of order, and the Chairman of the Appropriations Committee, John J. Fitzgerald, stated that 60 percent of the Survey apporpriation was spent in the public-land States, but he for one believed that the entire appropriation should be spent there.

Congressman Scott Ferris of Oklahoma, Chairman of the Public Lands Committee, then proposed that the appropriation for geologic surveys be increased to $400,000 because of the public-lands work, and Fitzgerald countered with "I desire to compel the Director of the Geological Survey to spend this money where the law contemplated that it should be spent, spent on the public domain, and not upon private property for the benefit of individuals." Ferris replied that his amendment was designed solely to aid the work of classification. It was poor economy, he said, to keep the homesteader waiting until the Geological Survey could get enough money to go out and make the necessary investigations. The Public Lands Committee was under constant pressure—there was a constant stream of complaints from chambers of commerce, from homestead settlers' organizations, and from individuals asking the committee to do something—but the Public Lands Committee had no power to appropriate money. The only way the Survey had to secure the funds was to suggest to the Interior Department the propriety of estimating for the money needed; the Survey had in fact requested and the Department had approved an estimate of $400,000, but the Committee on Appropriations had allowed no increase. The Ferris amendment was then approved, despite repeated objections by Fitzgerald, by a vote of 60 to 45. Congressman Charles Curry, Republican of California, then offered another amendment, to insert "of the public lands" after "geologic surveys." Ferris immediately made a point of order against the amendment as new legislation, but the Chair did not sustain the point and the amendment to restrict the Survey's geologic work to the public lands was passed without discussion.

In 1913, the Survey made a reconnaissance of potential water-power sites in south-central Alaska. The region tributary to the Copper River, Prince William Sound, and the Susitna was one of the richest mineral districts in Alaska, contained arable lands, and was thought to afford many opportunities for water-power development. Moreover, the Copper River and Susitna valleys, which had tidewater terminuses at Cordova and Port Valdez (shown in the photograph), were important potential routes for the railroad into the interior. The preliminary report on water-power potential, however, was pessimistic; the sites were not as abundant as had been assumed, and any power development would have to compete with the mineral fuels available in the area. (From C. E. Ellsworth and R. W. Davenport, 1915.)

When the appropriation for stream gaging came up for consideration, Ferris proposed another amendment, presumably also meant to aid the work of classification, to increase that appropriation to $200,000. Floor discussion degenerated at this point to a discussion of the merits of the Appropriations Committee rather than the merit of the amendment, and the amendment was rejected on a tie vote of 55 to 55.

The sundry civil expenses bill was passed by the House on June 25 without any further amendment of the Survey appropriation. The Senate declined to go along with the restriction of geologic surveys to the public lands, and the amendment was dropped in the first conference. The increase in the appropriation, however, was approved, and the total appropriated for the Survey was $1,405,520.

By the time the appropriations bill was finally passed on August 14, 1914, World War I had begun in Europe. Almost immediately the Survey began to receive inquiries concerning possible sources of various mineral products. The combination of the increased demand for information on mineral resources and the near miss on restriction of the Survey's work to the public lands brought about a changed perspective on its mission. In the fall of 1914, George Otis Smith, retreating not a whit from his insistence on the importance of the Survey's function in public-land administration, discovered anew the wisdom of the Survey's first director regarding its national role in mineral-resource investigations. "So far as the development of the mineral resources of the country is concerned," Smith wrote, "it is as important to know the resources of privately owned land as of Government-owned land. Director King, in the first annual report of the Survey, in illustrating the need for Federal investigation, selected iron as a mineral resource of large importance and stated that with the wide distribution and variety of occurrence of iron ores, neither corporations nor individual States could adequately investigate the subject, and he added that only for a few exceptional minerals could private or State enterprise successfully prosecute such work. If it is remembered that in this same report Director King prophesied for the United States a future annual output of mineral products having a value of a billion dollars, and that the present production is two and a half times that amount, it must be conceded that the desirableness of the Federal scientific investigation of these national resources is even greater now than in 1880." If Federal geologists were restricted to the public lands, Smith warned, they would have no opportunity to advance the study of ore deposits, and the same principle, in fact, held for all geologic investigations. Property lines and State boundaries must be overlooked when attempting to solve a geologic problem.

Chapter 6.
National Efficiency and Security, 1914–1917

What we are seeking now, what in my mind is the single thought of the message, is national efficiency and security.

—Woodrow Wilson

The beginning of World War I in August 1914 caught the United States by surprise. Fighting had been going on in eastern Europe off and on for some time and in June Greece and Turkey had almost gone to war again, but when the Archduke Franz Ferdinand, heir to the Austrian throne, and his wife were assassinated by Serbian nationals on June 18, few Americans realized that a world war would follow. During the spring and early summer of 1914, Americans had been far more concerned about the possibility of war in the Western Hemisphere for relations between Mexico and the United States had been so strained that in April Mexico had severed diplomatic relations and Congress had authorized President Wilson to use force to uphold U.S. rights and secure redress of grievances. That crisis seemed to have been averted when Wilson and President Huerta of Mexico accepted the offer of Argentina, Brazil, and Chile to arbitrate the dispute, but then Mexico rejected the arbitration proposal agreed to by the ABC powers on June 24. Huerta resigned on July 15, thus alleviating the tension somewhat, Carranza installed a new government in August, and in late November the U.S. forces that had occupied Vera Cruz since late April were withdrawn. Relations between the two countries, however, remained uneasy.

Austria's declaration of war on Serbia on July 28 was followed in rapid succession by Germany's declaration of war on Russia on August 1, and then on France on August 3. Germany then invaded Belgium and on August 4, Great Britain declared war against Germany. President Wilson issued a proclamation of U. S. neutrality in the Russo-German conflict on August 4 and on the next day broadened the proclamation to include the Anglo-German war. Two weeks later, as Belgian fortifications were crumbling and British troops were landing at LeHavre, Wilson asked Americans to be neutral in thought as well as action. Americans, however, did not all remain neutral. Within a month after the outbreak of war they were divided, some neutral, some pro-German, some pro-Allies.

Even though the United States was officially neutral in the European war, its outbreak posed problems because it disrupted normal trade relations, made it difficult for the United States to obtain the goods normally imported from Europe, and halted the European demand for American luxury goods. Very soon, however, there developed an urgent need in Europe for American agricultural products, and then a still more urgent need for American steel, copper, and explosives. Within 2 years the United States became the principal supplier of metals and munitions to Europe. Petroleum exports during this same interval increased by 17 percent. The United States then produced nearly two-thirds of the world's supply of petroleum and was exporting more than 20 percent of its production.

In 1914, when it was almost universally believed that the war would be a brief one, the ability of the United States to rely on its own mineral reserves and remain industrially independent was viewed with some optimism. When President Wilson proposed a plan in December 1915, for national efficiency and security—which most people called preparedness—he included the safeguarding and intelligent use of natural resources as one of the measures, placing natural resources in the same framework as had Theodore Roosevelt a decade earlier when he called attention to the relation of natural resources to national efficiency and welfare. Congress debated the disposition of the withdrawn mineral lands and the various waterpower bills but reached no decision.

Within 2 years after the war began, however, some mineral raw materials were difficult to obtain; by 1917 it was clear that for more than a dozen essential minerals American reserves were insufficient for American needs. The problems of mineral supply brought about changes in the program of the Survey's Geologic Branch, and renewed emphasis on economic geology. The metals investigations thereafter laid the groundwork for development of the strategic-minerals concept; the research program in the geology of fuels made the Survey prime recruiting ground for the oil companies within a few years.

For most of the time between the outbreak of war in Europe and the U.S. entry into the war in 1917, the programs of the Topographic, Water Resources, and Land Classification Branches were not affected by the war. Within the Department of the Interior, the Survey, primarily through its Topographic and Water Resources Branches, cooperated with other agencies in the successful effort to establish the National Park Service and worked with the Reclamation Service in beginning a long-range plan to control the Colorado River.

Questions were raised about the effect of the war on mineral supplies needed by American industry almost as soon as war began in 1914; on August 16, Interior Secretary Lane held a public conference to outline the expected developments, and early in September the Survey published George Otis Smith's "Our Mineral Reserves—How to Make American Industrially Independent." Director Smith, in general, took an optimistic view. The United States was not only the world's greatest producer of mineral wealth, it possessed greater reserves of most of the essential minerals than any other nation. The only essential minerals of first rank of which the Nation had no known supply at all commensurate with its needs were nitrates, potash salts, tin, nickel, and platinum. Problems might develop with some minor minerals, such as antimony, pyrite, arsenic, magnesite, graphite, strontium, and barite, for which the United States had been largely dependent on foreign sources. Increased prices might result in an attempt to work American deposits of antimony, although they would not last long, but substitutes might also be found for some of the uses of antimony. Pyrite had been used in the manufacture of sulfuric acid, then the basis of much of the industrial chemistry, but a great potential existed for production of sulfuric acid as a byproduct of the smelter industry, and the production of sulfur itself had increased as the result of the successful operation of the Frasch process. Some arsenic had been produced as a byproduct of smelters but more could be saved. Magnesite deposits were known in California, and once the Panama Canal opened it might become profitable to develop them and transport the ore to eastern markets. Only the crucible industry would be affected by cutting off the foreign supply of graphite but adequate resources of crucible graphite might yet be found in this country. Strontium was known to exist in several places in the United States although none had been mined in 1913, and a good supply of barite would undoubtedly be found for the looking.

At the other end of the scale, the Director stated that in its reserves of mineral fuels the United States held an "impregnable position," and its iron-ore reserves were so enormous that increased demands for ore could be readily

Woodrow Wilson (1856–1924), President of the United States, 1913–1921. Wilson, a graduate of the College of New Jersey (now Princeton University), was a contemporary of David T. Day and C. Willard Hayes in the Johns Hopkins graduate school. He was elected president of Princeton in 1902 and elected Governor of New Jersey in the Democratic sweep of 1910. In his inaugural address, Wilson called for action on the tariff, conservation, banking, and regulation of economic interests. He had less success with conservation than with other progressive reforms although the Park Service was established in 1916 and the Mineral Leasing and Water Power Acts were passed in 1920. His second term was dominated by World War I and the attempt to achieve a just peace settlement. One of the lasting monuments of his administration is the National Research Council, which he established as a permanent body by Executive order in May 1918. (Courtesy of the Library of Congress.)

met. Smith expected no problems with supplies of cement, fluorspar, or phosphate, but he felt that difficulties of one sort or another might occur in some segments of the mineral industry. Among the major metals, the copper industry would probably feel the effects of war more seriously than any other metal industry with the possible exception of the silver industry. A material curtailment of copper production seemed inevitable; for the preceding 5 years approximately half the copper from American refineries had been exported almost entirely to countries now engaged in the war. Aluminum, on the other hand, had been imported in considerable quantity from Europe and the war should therefore stimulate the search for domestic deposits and promote larger-scale working of the bauxite deposits of the Southern Appalachian States. The war's effect on the lead industry was uncertain although it seemed probable that ultimately the price of lead would increase. Smith believed the zinc industry might profit from the war. Domestic smelter capacity and spelter production had increased faster than consumption, but as most of the zinc smelting centers of continental Europe were in the active war zone, the United States might be able to develop a business of smelting foreign zinc in bond and establish foreign markets for United States zinc. Among the minor metals, manganese might present a problem, for domestic production of manganese had been relatively small and imports large. Shutting off the supply of ferromanganese from steel manufacturers would mean that much more ferromanganese might have to be manufactured domestically, but Smith said it was "cheering to know that the United States possesses within easy reach of manufacturing centers abundant reserves of such ores."

Of the five essential minerals of which the United States lacked sufficient supplies in 1914, the Survey was actively seeking only one, potash. The United States was the world's greatest user of tin but most of it was imported from the Far East, the major portion through England and Holland, and minor amounts of stream tin in Alaska were the only known domestic supplies. Nickel was less of a problem as most of it came from the great deposit at Sudbury, Ontario, and was refined at Bayonne, New Jersey. Russia was the world's greatest producer of platinum; in 1913 the United States had imported 49,000 troy ounces of crude ore and nearly 70,000 ounces of unmanufactured platinum. The deposits in Oregon and California yielded only 570 ounces of crude ore. Nitrates, needed for explosives and fertilizers, were nearly all imported from Chile. Hoyt Gale had concluded, in a Survey bulletin published in 1912, that "few, if any, of the known [U.S.] deposits at present warrant much outlay for development as a source of commercial nitrate salts."

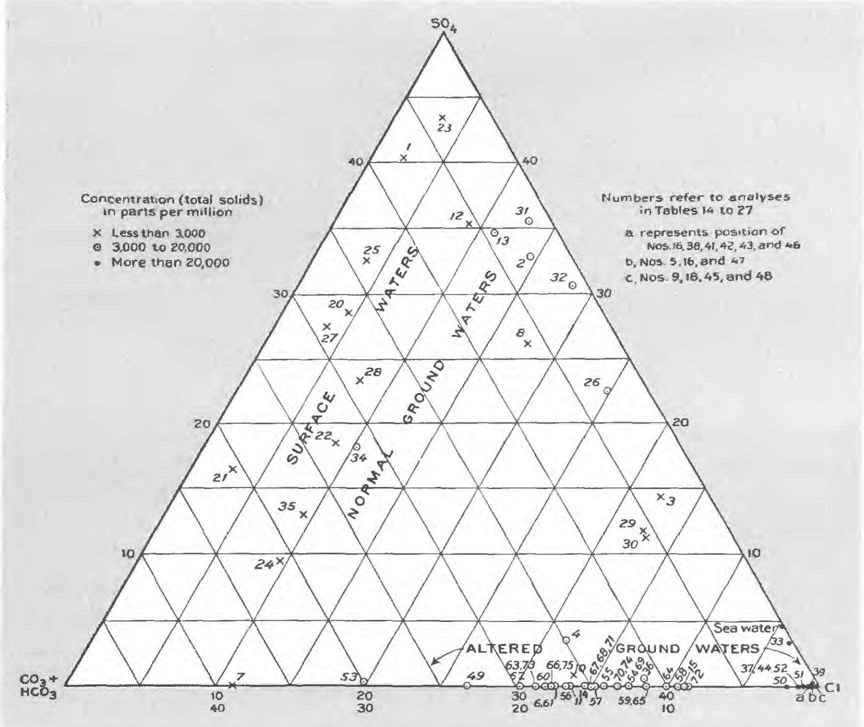
In 1914, the Survey continued its search for potash, but the well drilled in the Black Rock Desert of Nevada was unsuccessful. Hopes were raised for the discovery of supplies in the red beds when laboratory analyses of Permo-Triassic samples from the west-central and Panhandle regions of Texas disclosed indications of potash. The studies of the red beds were then extended from New Mexico into Arizona, Colorado, and Wyoming to define as nearly as possible the sedimentary basins in Permo-Triassic time. Although Director Smith's bulletin stated that the United States had an impregnable position in regard to mineral fuels, the statement was more applicable to coal than oil even though petroleum production had reached a record high in 1913 of more than 248 million barrels. The demand for petroleum was increasing so rapidly (the number of registered motor vehicles, for example, passed the million mark in 1913) that the Navy was giving thought to producing oil from the naval reserves to meet its own needs.

Franklin K. Lane (1864–1921), Secretary of the Interior, 1913–1920. After a career in journalism, law, and politics in California, Lane entered the Federal service as a member of the Interstate Commerce Commission in 1906 and was quickly recognized as one of the ablest members of the commission. As Secretary of the Interior, Lane walked a tightrope on conservation policy matters, keeping both the West and the Pinchot school of conservationists reasonably satisfied. He actively and successfully supported the effort to establish the National Park Service and persuaded Stephen Mather to be its first director. Lane was enthusiastic about public service and endeavored to kindle the same enthusiasm in the Interior Department employees and to foster a spirit of teamwork within the Department. (Courtesy of the Library of Congress.)

In 1914, the Survey increased its geologic mapping to aid the discovery of new oil fields or extension of known fields, with mapping underway in Oklahoma, northwestern Louisiana, Mississippi, California, Wyoming, and in the Porcupine dome area north of Forsyth, Montana. Field studies of the oil shales of the Green River Formation were also continued by D. E. Winchester after E. C. Woodruff resigned. Structure was still the prime criterion for locating oil pools, but in the older fields in Ohio, where production was coming from deeper sands, operators had begun to question the validity of the anticlinal theory. D. Dale Condit mapped in detail the structure of the oil sands as well as the relation of the oil pools to the general geologic structure and to the character of the sands in the Summerfield and Woodsfield quadrangles. Condit found that the depth of the Berea Sandstone below near-surface sands varied and that oil and gas might not be found even in structurally favorable locations because of the trend, extent, texture, or degree of saturation or salt water of the pay sand.

Several investigations were undertaken in cooperation with the Bureau of Mines where Van H. Manning, Survey alumnus, had been Acting Director for some months because of the prolonged illness of Joseph A. Holmes. The Bureau set up a Petroleum Division at the start of the fiscal year, and David T. Day promptly moved from the Survey to the Bureau to continue his studies on the fundamental nature of petroleum. Then David White of the Survey and C. A. Davis of the Bureau also joined forces to study the origin and composition of oil shale. Several California oilfields had been severely damaged by the inflow of water that made it impossible to extract large quantities of oil. The exclusion of water from the well was a technologic problem, which the Bureau investigated; determining the source of the water and tracing its migration was a geologic problem, which G. S. Rogers began to study for the Survey.

David White told the Washington Academy of Sciences at its December 1914 meeting that the organic matter of oil shales was, in general, regionally altered by dynamic agencies in a process parallel to the alteration of coals. A study of the distribution of petroleums and their salient features indicated that



In 1914 the Geological Survey and the Bureau of Mines began a joint investigation in the Sunset-Midway oil field in California where production had declined as the oil sands were invaded by water. In the early years of development of this field, and of geologically similar fields elsewhere, it was believed that the water and oil co-existed in the same sand and its appearance in the wells was regarded as inevitable. Later investigations had shown that the water was extraneous and its invasion related to the decline in gas pressure as the result of production. The joint Survey-Bureau mission was to locate the source and natural circulation of the water and develop means to exclude it. The Survey's G. S. Rogers found that the waters in and near the oil measures were very different in character from normal ground water, as the triangular diagram shows, and suggested that water analyses might be used to determine the productive horizon in a general way and in wildcatting as an indication of the presence or absence of oil and gas. (From G. S. Rogers, 1919.)

no commercial pools of oil were to be found where the coals in or above the oil-bearing formations had reached the stage of carbonization at which the fixed carbon exceeded 70 percent of the pure coal. Further, the oils of pools in regions of relatively high fixed carbon were, in general, highest in saturated hydrocarbons. In zones of lesser alteration of the organic debris, the oils were less refined, and the lowest grades of oil were found in formations in which the solid fuels were lignitic. In other words, as the carbonaceous residues in rocks became more distinctly carbonized, the liquid hydrocarbon distillates became more fully hydrogenized. White concluded that the limitation of commercial oil pools to regions of not too advanced alteration of the buried carbonaceous deposits bore unfavorably on the inorganic theory of the origin of petroleum. Within a relatively short time, his carbon-ratio theory became an important factor in the search for new oil fields.

Coal-field investigations were continued in Illinois, Missouri, Pennsylvania, Virginia, and Tennessee in cooperation with the States, and in Indiana, Iowa, Kansas, and West Virginia under Survey auspices alone. Many of these studies were undertaken in preparation for a general discussion of the coal fields of the United States in much greater detail than in the abbreviated account presented to the International Geological Congress in 1913. The Survey and the Bureau of Mines worked together in a study of Tennessee coals; F. R. Clark of the Survey examined and sampled all coal mines producing coal on a commercial basis and the Bureau made the coal analyses. West of the 100th meridian, classification and mapping of coal lands, as well as phosphate lands, was continued but smaller areas were covered than in previous years, in large part because of the greater detail in mapping.

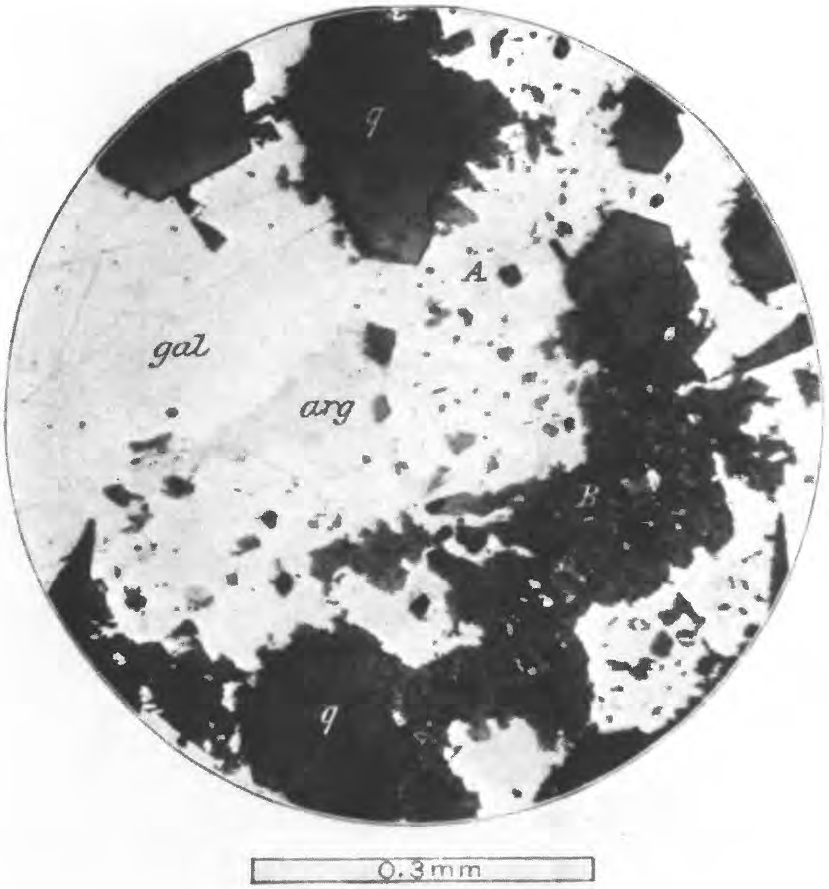
The Metals Section also had investigations underway in cooperation with the Bureau of Mines. In a comprehensive study of the placer deposits of the United States, J. M. Hill of the Survey studied the character, geologic occurrence, and origin of placer deposits and Charles Janin of the Bureau investigated methods and costs of placer mining. In a general investigation of the application of geologic features to the problem of mining and engineering construction, D. F. MacDonald, back from a stint at the Panama Canal, studied mining methods at Santa Rita, New Mexico, where A. C. Spencer was directing the study of the copper deposits. The Bureau also helped support F. B. Laney's metallographic studies as they promised to aid in the separation and reduction of ores as well as a determination of the origin of ores.

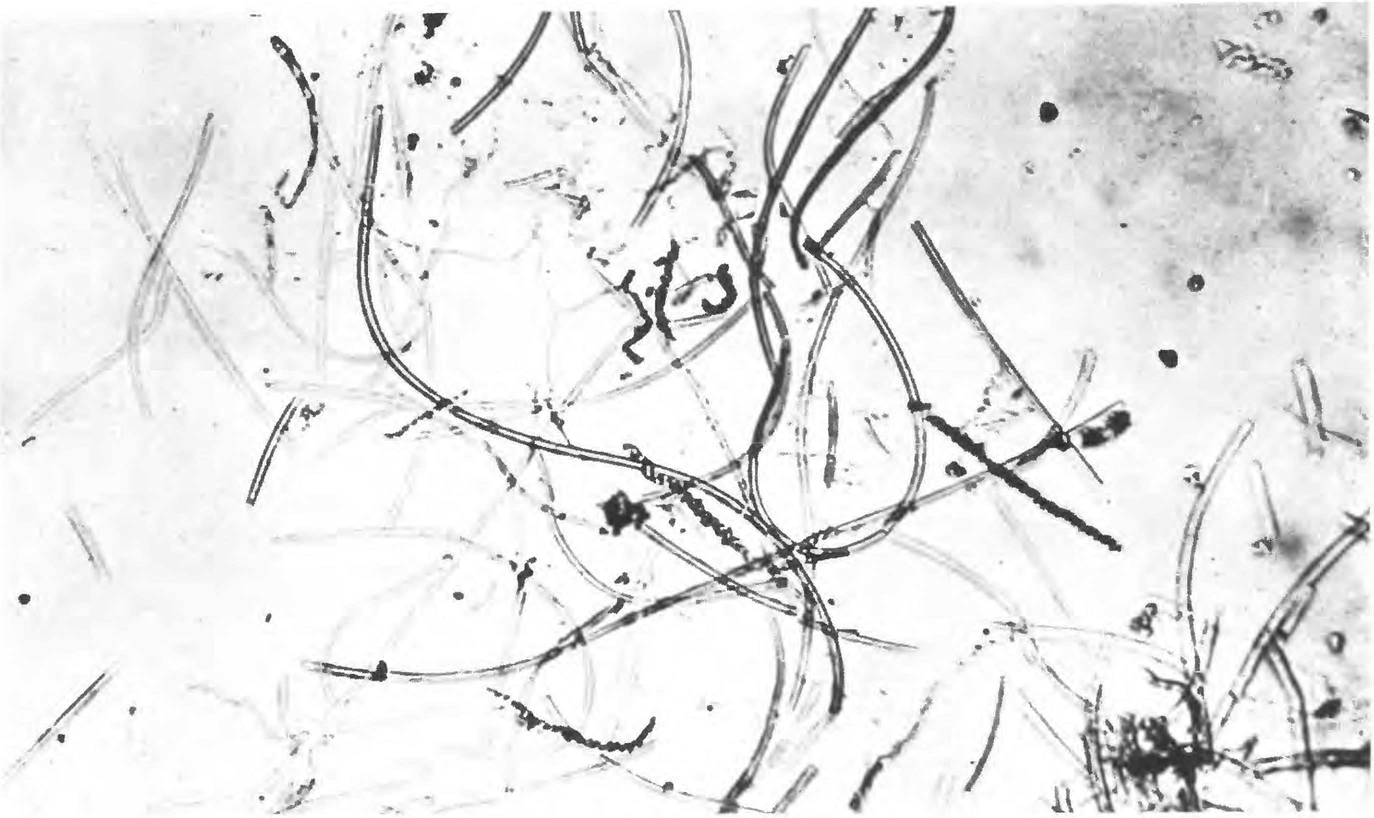
Investigations of iron included a new study by E. C. Harder, in cooperation with the Minnesota survey, of the Cuyuna iron range and of the magnetite ores by F. F. Grout and H. H. Brodt. Iron had been discovered in the Cuyuna district in 1904 because of the abnormal magnetic intensity but no ore had been shipped from the district until 1911. Considerable exploration based on the possibility of a connection between the Cuyuna district and the west end of the Mesabi district had been carried on but none was found when the Cuyuna became the subject of a separate investigation by the Survey. E. F. Burchard also continued his work on the iron ores of the Southern States, the red iron ores of the southern Appalachians, and the brown ores and carbonate ores of Texas and Louisiana.

F. L. Hess began a search for uranium and vanadium in southeastern Utah, and in the chemical laboratories W. T. Schaller made an extensive study of vanadium minerals, and George Steiger investigated methods of separating vanadium from large quantities of chromium. The uranium was of more interest than the vanadium. Radium salts were being used to treat cancer and other previously incurable diseases, but radium salts were high priced and scarce and much of the radium-bearing ore was being shipped out of the country. Early in 1914, Secretary Lane had bills introduced in Congress to reserve radium-bearing land from entry as mining claims and provide for the purchase

In connection with investigations of the iron deposits of the Cuyuna Range in Minnesota, E. C. Harder made a laboratory study of iron-depositing bacteria. Harder found that, in addition to the iron-depositing bacteria proper, many of the common bacteria of soil and water are active in the precipitation of ferric hydroxide or basic ferric salts from solutions containing iron salts of organic acids. From the laboratory study alone it was impossible to say to what extent the bacteria were instrumental in the formation of iron deposits. The illustration is a photomicrograph of material from the 262-foot level of the Kennedy mine, showing threads of *Spirophyllum ferrugineum*, *Chlamydothrix ochracea*, and *Gallionella ferruginea*. (From E. C. Harder, 1919.)

In a laboratory study of the ores of Tonopah, Nevada, geologists E. S. Bastin of the Survey and F. B. Laney of the Bureau of Mines found no mineralogical distinction between many veins that J. E. Spurr had classified as belonging to different periods and therefore questioned his classification of veins. They concluded that while the ores were mainly of hypogene origin, the primary mineralization was a process of considerable duration accomplished by solutions whose composition varied. Thus ore minerals deposited early in the mineralization were partly or wholly dissolved at a later stage and other minerals, more stable in the presence of the changed solutions, deposited in their places. The photomicrograph of the polished surface of ore from the 1,000-foot level of the Tonopah-Belmont mine shows galena (gal) has been partially replaced and quartz (q) slightly replaced by a fine aggregate of light-colored carbonate, argentite, and some chalcopyrite. (From E. S. Bastin and F. B. Laney, 1918.)



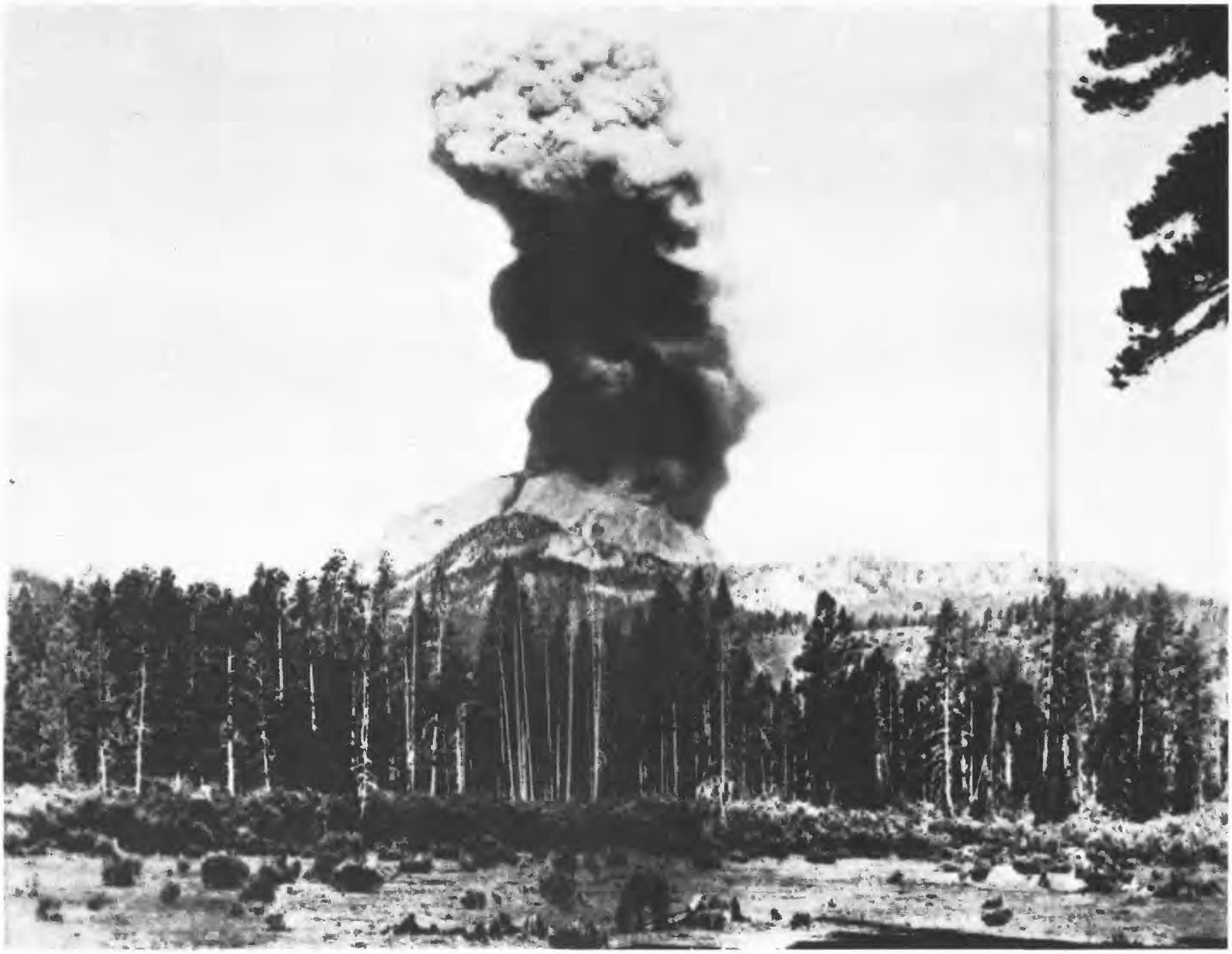


of ores by the Government. In an independent investigation, the Bureau of Mines devised a method concentrating the carnotite ores of Utah and Colorado so that thousands of tons of material that would have gone to waste under former methods could be utilized, and perfected a process by which radium could be recovered from these carnotite ores at a cost that was one-third the price asked by foreign producers.

M. R. Campbell, H. S. Gale, W. T. Lee, and R. W. Stone were diverted from the classification programs, along with N. H. Darton and J. S. Diller, to prepare geologic guides to railway routes for the benefit of travelers to the Panama-Pacific International Exposition to be held in San Francisco in 1915 to celebrate the opening of the Panama Canal. Diller, who had spent many seasons in the Cascade Mountains, also studied the eruptions of Lassen Peak, which began on May 30, 1914, with an outburst of steam that formed a crater in the snow-covered summit and covered the snow for a distance of 300 feet with a mantle of dark wet dust.

Ten parties were engaged in surveys and investigations in Alaska in the summer of 1914. About half the funds were spent in reconnaissance topographic and geologic surveys in south-central and southwestern Alaska. J. W. Bagley mapped about 4,000 square miles in the Copper and Susitna basins by phototopographic methods. A topographic survey of the Juneau district on a scale of 1:24,000 was begun as the district promised to become one of the most

A 10-minute outburst of steam from Lassen Peak in California at 5:30 p.m. on May 30, 1914, inaugurated a series of eruptions that J. S. Diller, who had first studied the Lassen region in 1883, said were "a great surprise not only to residents of the district but also to most of the geologists who are more or less familiar with the decadent volcanic energy of the Cascade Range." The enormous cloud above the crater, shown in the photograph, was composed of steam and perhaps other gases, and rock fragments and dust that under a petrographic microscope were seen to be pulverized portions of the rocks through which the steam and gases escaped. Diller concluded that the eruptions would end in the establishment of a solfatara on the summit but advised watching for earth tremors and other evidences of deeper-seated action. Lassen immediately became a mecca for travelers to West Coast expositions. (From J. S. Diller, 1915.)



important mining camps. Other investigations were made in the Prince William Sound area, the Kotsina-Chitina copper belt, the York tin district, and the gold placers of the Chisana district.

George Becker launched an investigation in 1914 to determine "what geological results of geodetic research we are bound to accept," in particular, the research of Hayford and Bowie of the Coast and Geodetic Survey on isostasy and gravity. Although both the Pratt and Airy theories had been proposed in the 1850's, not until 1909, when Hayford proposed uniform compensation at a depth of 122 kilometers to account for deflections of the vertical at 765 stations in the United States, did anyone undertake a rigorous mathematical proof. In 1912, Hayford and Bowie used this same hypothesis to account for nearly all observed anomalies in the intensity of gravity. Hayford and Bowie attributed the remaining small residual anomalies to small differences in load, although they admitted that they might be due wholly or in part to irregular distributions in density. G. K. Gilbert had been attracted to the latter idea, and after a theoretical investigation, so was Becker. Taking into consideration the experiments by A. F. Melcher on the effect of rupture and infiltration on density of rocks under confinement and those by C. E. Van Orstrand and F. P. Dewey on diffusion in solids, both done in Survey laboratories, and the work of Professor P. W. Bridgman of Harvard on the effect of pressure on minerals, Becker concluded that the effects of the transfer of matter at the level of isostatic compensation would be small and would be masked by the effects of irregular distributions in density. This seemingly purely scientific conclusion of the two of the Survey's elder statesmen before long led to the development of the gravity method of geophysical exploration.

Both water-resources investigations and topographic mapping programs received increased financial support through cooperative funds from the States and repayments from other Federal agencies in the fiscal year beginning July 1, 1914. For water-resources investigations, the amount received was more than two-thirds as much as the Federal appropriations, and for topographic mapping well over half as much. In both branches, therefore, much of the work was client-oriented.

Most of the water-resources work under the cooperative and repay projects was stream gaging and at the end of the year 1,350 stations were being maintained in 41 States and the Territory of Hawaii. This work included special gaging of the Colorado River and its tributaries for the Reclamation Service. The disastrous floods in southern California in January 1914 aroused public interest in flood control, and in connection with its study of possible reservoir sites, the Reclamation Service authorized installation of three recorders on the Green and Colorado Rivers and a gaging station on the San Juan River. The gaging station on the San Juan was about 180 miles from the nearest practicable railroad contact, its establishment fraught with some danger as the papers were full of news of Indian uprisings in the area—an old story to Arthur Powell Davis, the Director of the Reclamation Service, whose assignment in 1883, as a young topographer for the Geological Survey, to map the country north of the San Juan had to be postponed because of an Indian uprising. The greatest difficulty in 1914, however, turned out to be determining the river's velocity and the amount of silt it carried. As part of the Colorado River investigations, E. C. LaRue also began preparation of a manuscript on the utilization of the Colorado for irrigation, power, and navigation. The Survey had begun its study of the river in 1889, when gaging stations were established at Buttes, Arizona, and had collected data at about 180 points in the basin. The Reclamation Service, the Office of Indian Affairs, the Forest Service, and the Weather Bureau had also collected data which LaRue used. Ground-water investigations were made in 12 States, nearly all in the arid and semiarid region and with special reference to irrigation. Extensive work was done in California, in the Sacramento and Santa Clara Valleys and in San Diego County. Other investigations were made in southern Grant County, New Mexico, and in Big Smoky Valley, Nevada.

The increase of funds for topographic mapping continued to bring about a change in the scale of mapping rather than the size of the area mapped. In fiscal year 1915, no mapping was done at the 1:250,000 scale. East of the 100th meridian, all mapping was at the mile-to-the-inch scale; and west of that line, there were three principal scales, 1:125,000, 1:62,500, and 1:31,680, more than 70 percent at the smallest scale but a significant 6 percent at the largest. Some of the most detailed mapping was done in southeast Texas, where Harris County had allotted $35,000 to the Survey for mapping 7 1/2 minute quadrangles, and C. H. Birdseye and his party mapped 30 square miles of the Sabine and Trinity River projects for waterway development at scales of 1:12,000 with a contour interval of 2 feet.

In his State-of-the-Union Message on December 8, 1914, President Wilson discussed needed measures for the United States to adjust to new conditions brought on by the outbreak of war, which had "interrupted the means of trade" and also the "processes of production." Pointing out that

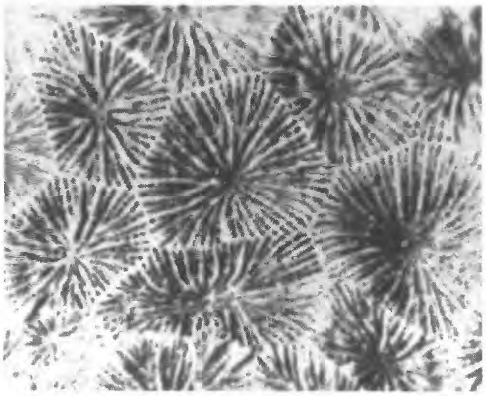
> We have the resources but are we fully ready to use them? And if we can make ready what we have, have we the means at hand to distribute it?

Wilson urged that provision be made for the development of a merchant marine and for passage of the leasing and water-power bills, already passed by the House, by the Senate.

> We have year after year debated, without end or conclusion, the best policy to pursue with regard to the use of the ores and forests and water power of our national domain in the rich States of the West, when we should have acted; and they are still locked up. The key is still turned upon them the door shut fast at which thousands of vigorous men, full of initiative, knock clamorously for admittance. The water power of our navigable streams outside the national domain also, even in the Eastern States, where we have worked and planned for a generation, is still not used as it might be, because we will and we won't; because the laws we have made do not intelligently balance encouragement against restraint.

The 63d Congress made only one change in public-land law. Although the Enlarged Homestead Act was already being questioned in the range country, Congress extended its provisions to Kansas and South Dakota, but provided that most of the applications be directed to registers and receivers in the land districts rather than to the Geological Survey. Despite Wilson's urging, neither mineral leasing or water-power bills were enacted. The Senate Committee rewrote the House leasing bill, including in it relief provisions which the minority attacked as being "designed to relieve oil corporations, including the Standard Oil Co., and certain individuals, from the results of their violation of the oil land withdrawals and naval petroleum reservations by, in effect, revoking and doing away with these reservations wholly or in large part." The Senate passed the bill, but the House refused to accept the Senate amendments. The Senate Committee also rewrote the House water-power bill; it was debated but not passed before the session ended.

By the time the summer field season began in 1915, the world war had come a little closer to the United States. On February 4, 1915, Germany announced that enemy merchant ships in British waters would be sunk on sight and neutral vessels entered the war zone at their own risk. The United States replied that the loss of American vessels or American lives would be considered a clear violation of neutrality. On May 1, an American tanker was struck by a torpedo, and on May 7, the British steamer *Lusitania* was sunk without warning



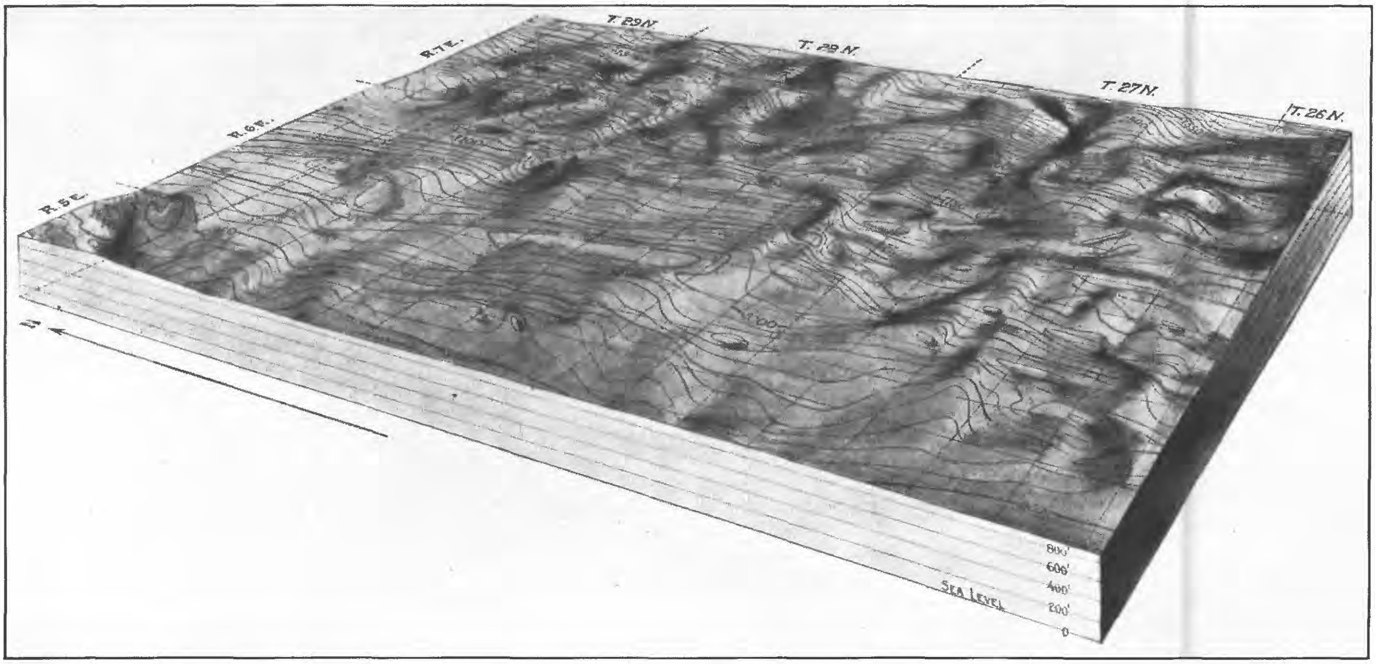
Earlier transcontinental (or rather transoceanic) "travelers" were noted by T. W. Vaughan who studied the more than 400 specimens of coral that W. C. Mendenhall had shipped to Washington from southern California in 1904. *Siderastrea mendenhalli* Vaughan belonged to the same group as one of the common corals (*Siderastrea siderea* Ellis and Solander) of the living reefs of Florida and the West Indies. The discovery of such reef corals at the head of the Gulf of California strongly suggested to Vaughan the existence of an interoceanic connection in Pliocene time. (From T. W. Vaughan, 1917.)

by a submarine; 128 Americans were among the 1,200 who lost their lives. Theodore Roosevelt and other leaders of the preparedness movement demanded that the United States enter the war immediately. President Wilson, however, drafted a peremptory note demanding reparations and an end to unrestricted submarine warfare. Secretary of State Bryan signed the note under protest but resigned rather than sign a second note in June. A third and stronger note was sent to Germany in July.

By the time the summer field season began in 1915, the mineral-resources picture had changed. Supplies of potash in the United States were becoming scarce and prices were rising as the result of the German embargo on the export of potash. The platinum supply was down as imports of crude ore had declined 38 percent and of unmanufactured platinum 43 percent during 1914. Both domestic production and foreign imports of manganese had declined in 1914. Adequate supplies of crucible-grade graphite were difficult to obtain even though domestic production of graphite had increased greatly. Sulfuric acid had become high priced and many feared that foreign shipments of pyrite might be curtailed. On the other hand, although demand for petroleum had increased significantly, production had more than kept up with demand. Marketed production of petroleum in 1914 had increased 7 percent over 1913 and, in addition, at least another 8 percent had gone into storage. The increased production was due to a country-wide drilling campaign stimulated by the high prices that prevailed in 1913. Spectacular results were obtained from deeper drilling in the Midcontinent and Gulf Coastal Plain regions, new fields were discovered in Wyoming, and a large number of gusher wells were completed in California. The demand for coal had begun to decline, however, and coal production was notably less in 1914 than in 1913. Conditions in many of the coal-mining regions during the last quarter of 1914 were little short of demoralized.

On May 1, 1915, E. W. Parker, who had been Chief of the Mineral Resources Division since 1907, resigned to join a coal producers' association. Parker, primarily a statistician, had been compiling coal statistics for the Survey for 25 years, during which time, he estimated, more than 80 percent of all the coal mined in the United States had been produced. Parker was succeeded as head of the division by H. D. McCaskey, who had been in charge of the compilation of statistics of metals, and as coal statistician by Carl Lesher of the Coal Section of the Division of Geology. With Lesher's appointment, the transformation of the Mineral Resources Division begun in 1905 was all but complete as all major and most minor mineral statistics were compiled by geologists. Under McCaskey, geologists in the Metals Section had been encouraged to go beyond the annual compilation and analysis of statistics and make field observations as well. D. F. Hewett, for example, had visited the manganese mines of Virginia and Maryland annually since joining the Survey and from the data thus obtained he postulated a relationship between the deposition of the ores and the physiographic history of the region. That encouragement was now extended to the whole division.

The Survey's search for potash was shifted from the Quaternary lake beds to the Permo-Triassic red beds of the Southwest. Field examinations had shown that there had been several periods of dry climate while the red beds were being laid down and had uncovered evidence of the deposition by evaporation of enormous deposits of rock salt, gypsum, and anhydrite in parts of the red beds country, especially in eastern New Mexico, northwestern Texas, and western Oklahoma. The composition and character of the rocks were similar to those that contained the great potash deposits of Germany and the periods of aridity and saline deposition were essentially contemporaneous in the two areas, so beds of potash salts might also lie buried in the American region. They were likely to be of very slight extent in comparison to the very great area of the red



In 1915, K. C. Heald of the Survey mapped the Foraker quadrangle in the extreme northwest corner of the Osage Indian Reservation in Oklahoma to determine the structural conditions related to oil and gas development. The area was some 30 miles north of the Boston field which Gypsy Oil Company's new geological department headed by M. J. Munn, formerly of the Survey, had mapped prior to a lease sale in 1913. To depict the structure, Heald prepared a stereogram, or sketch of the surface of the key rock, as reconstructed from the contours and shaded so that the features of the surface appear to stand out in relief. Heald stated that there was little doubt that oil and gas would be found in the Foraker quadrangle, and in 1920 Marland Oil Company's discovery well on one of Heald's anticlines opened the giant Burbank field. (From K. C. Heald, 1917.)

beds, however, so that even with the best geologic guidance many holes might be drilled in different areas before penetrating one such deposit. The Panhandle region of Texas was chosen for the Survey's first physical tests, as potash-bearing crystals of salt had been found near Boden and traces of potash found in brines or muds from wells at two or three other localities in the region. Drillers for oil and water in all parts of the red beds country were asked to cooperate by sending samples of brines and salt to the Survey for tests.

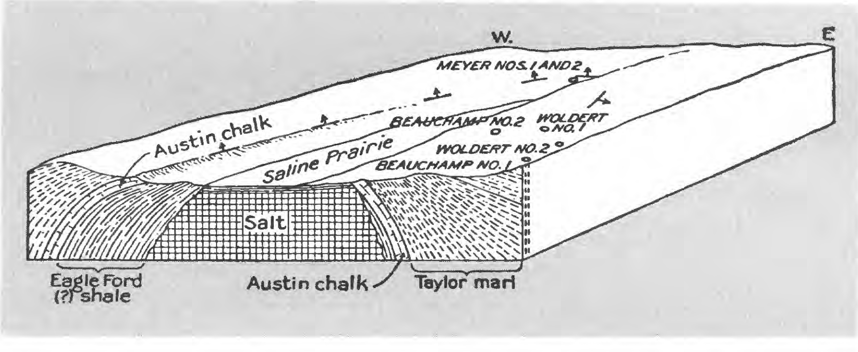
The Survey continued to search for areas structurally favorable for oil accumulation in the Midcontinent and Gulf Coast regions, and in Wyoming and Montana. K. C. Heald and R. H. Wood mapped in the Osage Nation, Oklahoma, while A. E. Fath examined an area east of the Cushing field. G. C. Matson and O. B. Hopkins completed field work in Louisiana and Hopkins continued structural investigations across the river in Mississippi. C. H. Wegemann, who had been mapping in Oklahoma, was given general charge of the investigation of the Salt Creek field in Wyoming, and a major study of the Bighorn Basin was continued under the direction of C. T. Lupton. Eugene Stebinger investigated the oil possibilities in north-central Montana. The oil-shale investigations were also continued. D. E. Winchester made numerous tests of the oil shale in northeastern Utah and found that the latent potential of oil shale as a source of petroleum was enormous, and also that a vast amount of nitrogen could be recovered as a byproduct.

Discovery of the Elk Basin field in Wyoming near the Montana line prompted the Survey to recommend withdrawal as potential oil land nearly 362,000 acres in south-central Montana, 280,000 acres in eastern Montana, and about 85,000 acres in North Dakota near the Montana line. A third Naval Petroleum Reserve was also established in Wyoming by Executive order on April 30, 1915. From among several sites suggested by the Survey, the Navy had chosen Teapot Dome, adjacent to the Salt Creek field. Teapot Dome had not been drilled, although the Salt Creek field was being exploited, so Teapot's oil content was speculative, but the Navy viewed that as less important than the fact that the entire acreage was owned by the Federal Government.

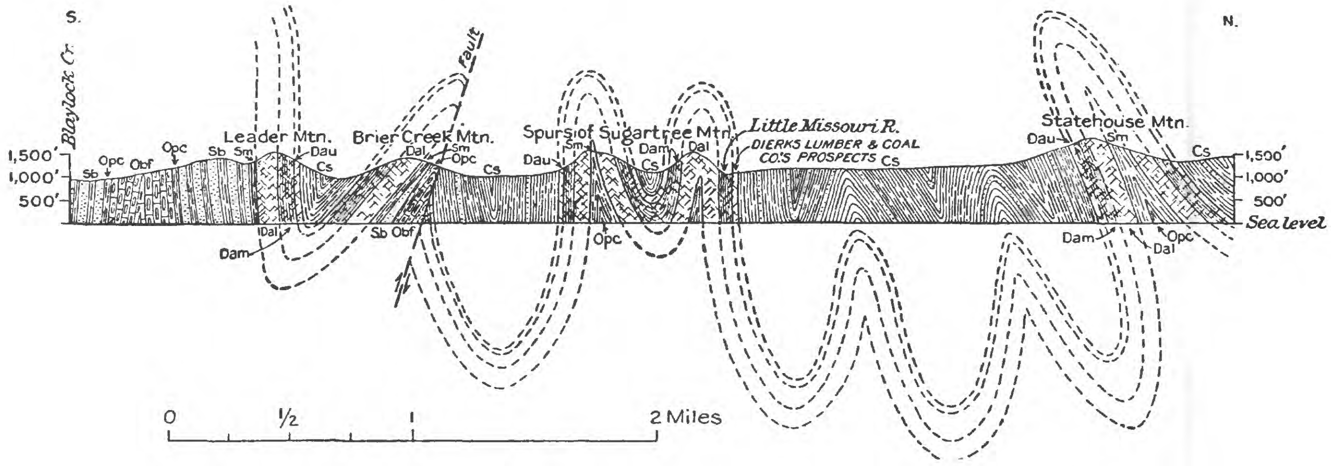
The investigation of the California oil-field waters disclosed an intriguing relationship between the composition of the water and proximity to oil. Chase Palmer of the Survey's chemical laboratory therefore began experimental studies of the reactions between water, petroleum, and adjacent mineral substances in an effort to determine the cause of the peculiar composition of the waters and the chemical variations in the petroleum itself. A. F. Melcher, who had been investigating the physical properties of rocks as part of Becker's study of isostasy made some preliminary determinations of the porosity of oil and gas sands as part of the overall investigation.

There was little change in the nature of the work in the Metals Section in 1915. B. S. Butler and G. F. Loughlin completed the general study of the ore deposits of Utah and made a reconnaissance of the Cottonwood-American Fork district in preparation for a detailed study, and J. B. Umpleby continued the study of the ore deposits of Idaho. H. G. Ferguson studied the Manhattan district in Nevada, and Adolph Knopf the northern part of the Mother Lode in California. A. C. Spencer and his associates completed field studies in the Santa Rita district in New Mexico, and Sidney Paige made a study of the copper deposits in the Burro Mountains in southern New Mexico. E. S. Bastin continued the investigation of the enrichment of silver ores, extending it to the Comstock, and he and F. B. Laney collaborated on a report on the genesis of the ores of Tonopah as interpreted from detailed microscope studies of the polished surfaces of ores. E. C. Harder, winding up the Cuyuna Range iron-ore investigations, prepared reports on the geology of east-central Minnesota and on the physiology, morphology, and activity of iron-depositing bacteria and the formation of certain iron-ore deposits, including an assessment of the relative importance of chemical and biologic processes in the deposition of iron ore. In the southern Appalachians, E. F. Burchard continued his studies of iron ores.

In the summer of 1915, 12 Survey parties were in Alaska where the war in Europe seemed very remote. About half the funds were spent for reconnaissance surveys in little known regions of the Yukon and Kuskokwim basins; the remainder supported detailed topographic and geologic surveys in southeastern Alaska, and the Prince William Sound, Copper River, and Cook Inlet-Susitna regions. P. S. Smith was appointed Administrative Geologist, succeeding George Ashley, and did not get into the field. The construction of the Government railroad from Seward to Fairbanks led to a demand for information about the tributary regions, most of which had been mapped in previous years, but two parties, under J. W. Bagley and S. R. Capps, were detailed to explore the less well-known regions east of Knik Arm and in the Talkeetna Mountains. Investigations of mineral springs were made in southeastern Alaska, the Yukon Basin, and the Seward Peninsula by G. A. Waring, of the Water Resources Branch, while G. H. Canfield began a study of water power in southeastern Alaska under a cooperative agreement with the Forest Service. General Land Office surveyors were also in Alaska, surveying the lands of the coal fields. Before leasing could begin, the Secretary of the Interior had to designate and reserve acreage in the Bering River and Matanuska fields and the Bureau of Mines had to determine the size of leases.



Oil had been found in association with salt domes near the coast in Texas and Louisiana but with only one salt dome in the interior before Survey geologists Sidney Powers and O. B. Hopkins began a study of three salt domes in northeast Texas in February 1917. They concluded that these domes, such as the Brooks dome in Smith County shown in the diagram, were so small in extent and had such a small "gathering ground" from which to drain oil that the oil might have been concentrated in spots that had not yet been found or might have escaped as the salt core rose. They also concluded that the most promising horizons for the occurrence of oil were near the top and base of the Austin Chalk and in the Woodbine Sand and predicted that the latter formation would be productive in eastern Texas wherever subsurface conditions were favorable. Oil was produced from the Woodbine in Anderson County in 1927, and that discovery led directly to the discovery of the giant East Texas field. (From Sidney Powers and O. B. Hopkins, 1923.)



Both the Director of the Geological Survey and the Director of the Bureau of Mines attended the American Mining Congress in San Francisco in September 1915. Joseph A. Holmes had died in July, and Van H. Manning had been appointed to succeed him in late August. Manning told the Mining Congress what the Bureau of Mines was doing and hoped to do for the metal mining industry. The Geological Survey, he said, had "done much to increase our knowledge of the character, geologic relations and areal extent of the mineral resources of the West * * *. The work of the Federal Bureau of Mines begins where the work of the Survey ends. Investigations to determine how mining methods can be made safer and more efficient, how milling and metallurgical methods can be improved so as to assure a larger extraction of metal, reduce waste and avoid damage to other interest, and how ores or mineral substances now unused can be made a source of wealth—these are all within the scope of its duties as defined by Congress." Manning believed that through such investigations the metal production of the Western States would be increased in value by millions of dollars annually. George Otis Smith spoke on "plain writing," primarily to state a policy on Survey publications. An effort was underway to make the Survey's professional reports more generally intelligible and useful through simplification of the language and the preparation of reports that were "popularly descriptive and instructive."

As part of this educational effort, M. R. Campbell began preparation of another guidebook, for the Denver and Rio Grande Railway from Denver to Salt Lake City. A. J. Collier prepared a guidebook to Mesa Verde National Park, and Frank Calkins and F. E. Matthes began preparation of a guidebook to Yosemite National Park. J. S. Diller made a special survey of the area involved in the volcanic eruptions in the Lassen Peak region and began preparation of an educational bulletin on the subject. Campbell and Matthes also served as members of a committee of the Association of American Geographers, under the chairmanship of N. M. Fenneman, appointed to prepare a new map of physiographic divisions within the United States.

In other parts of the Geologic Branch, geologic mapping, primarily for folio publication, was carried on in 29 States, most of it in close cooperation with State surveys and university departments of geology. The Coastal Plain Section compiled a preliminary map, on a scale of 1:1 million, of an area of 450,000 square miles, covering the entire Atlantic and Gulf Coastal Plains except the State of South Carolina and about 13,000 square miles adjacent to the Rio Grande in Texas, and began a major cooperative investigation of marine sediments in cooperation with scientists of the National Museum, the Bureau of Fisheries, the Carnegie Institution, the Bureau of Soils, the Bureau of Lighthouses, the Bureau of Plant Industry, and several scientists from the private sector as well.

The high prices being offered for manganese ores as a result of the war stimulated interest in the little-exploited manganese deposits of west-central Arkansas. In 1916, H. D. Miser, who was mapping the Caddo Gap and DeQueen quadrangles, examined the recently developed deposits, which occurred mainly as nodules, pockets, and short irregular veins at two definite horizons in the Arkansas Novaculite. The formations had been closely folded but the novaculite was very resistant so its upturned edges had formed ridges. Thus, the ore horizons could be followed for long distances along the slopes, and outcrops might be repeated on the slopes or crests of the parallel ridges. The illustration, a section through Leader, Brier Creek, Sugartree, and Statehouse mountains, shows the repetition of the two manganese horizons on different ridges. (From H. D. Miser, 1918.)

George Becker became interested in theoretical explanations of some engineering-geology problems. He was appointed a member of the National Academy of Sciences' committee investigating the slides in the Panama Canal and formulated a theory of the slides, showing that their mechanics were reducible to identity with a soluble problem in capillarity, which he had been investigating. His studies indicated that there was a limit to which the slides would extend. Then, with Arthur L. Day of the Geophysical Laboratory, Becker prepared a paper on the linear force of growing crystals, an experimental and theoretical refutation of attacks by some scientists on the deductions they had drawn ten years earlier. This linear force was now recognized as the reason for the partial failure of many dams.

Cooperative and repay funds for the Survey's water-resources investigations increased still more in 1915, the cooperative funds alone being more than three-fourths as much as the Federal appropriation. As most of the cooperative work was stream gaging, the number of river stations increased, and the increase made necessary several changes in the surface water districts in 1915. The North Atlantic district was divided into the New England and New York districts, and the Boston office was opened on May 1, 1915. The South Atlantic district was divided and Texas became a separate district with headquarters at Austin. Arizona and New Mexico were separated, Arizona becoming a separate district, and New Mexico part of the Rocky Mountain district.

Most of the work of the Ground Water Division continued to be field investigations in the Western States. In California, G. A. Waring resumed the ground-water survey of the San Jacinto Valley that had been recessed after Mendenhall's appointment as chairman of the Land Classification Board, and W. O. Clark continued the survey of the Santa Clara Valley. A. T. Schwennesen resumed work in the Arizona-New Mexico area, and A. J. Ellis began work in Montana. Plans were also made for a comprehensive manual on ground

Nathan Clifford Grover (1868–1957), Chief Hydraulic Engineer of the U.S. Geological Survey, 1913–1939. Before joining the Survey in 1903, as district engineer of the New England district, Grover had been a member of the civil engineering faculty of the University of Maine and had begun the stream-gaging program for the Survey. In 1904, he moved to Washington as district engineer and acting assistant chief hydrographer. From 1907 to 1911, Grover was employed by the J. G. White Company but in 1911 he returned to the Survey as Chief Engineer of the Land Classification Board. During his long tenure as Chief Hydraulic Engineer, the Water Resources Branch increased in size, as water problems became more complex and cooperative programs with many States and municipalities flourished, and for many years it was the Survey's largest branch. (From the files of the U.S. Geological Survey.)

water. Meinzer made a special investigation in the vicinity of Guantanamo Bay, Cuba, to advise the Navy in its efforts to develop a water supply for the naval station there, and G. A. Waring investigated the possibility of developing ground-water supplies for the garrisons on Angel and Alcatraz Islands in San Francisco Bay for the War Department.

Cooperative funds for topographic mapping were somewhat less than in 1914 and from fewer States; consequently nearly 70 percent of the area newly mapped in 1915 was west of the 100th meridian. The trend toward larger scales persisted, however, and more than 62 percent of all mapping was at either the mile-to-the-inch or larger scales, and nearly 18 percent, principally in Texas and California, was at 1:31,680.

Chief Geographer Marshall was informally loaned to the Secretary's Office for much of 1915 to organize trips to national parks as the Department began to push vigorously for a bureau of national parks. Stephen T. Mather, the wealthy Chicago industrialist who had coined the name "Twenty-Mule-Team-Borax" and was an old college friend of Secretary Lane, had written an irate letter in the fall of 1914 in which he described the condition of the national parks as a Federal disgrace. Lane had promptly invited Mather to come to Washington to run the national parks, and Mather became Assistant to the Secretary in January 1915. With two expositions on the Pacific Coast inviting transcontinental travel and a war in Europe discouraging transatlantic travel, the time was ideal for publicizing the parks. Mather invited another old friend, Robert Yard, then Sunday editor of the *New York Herald*, to come to Washington as national parks' publicity chief. The Survey gave Yard an appointment at $30 a month (a salary generously supplemented by Mather) and detailed him to Mather's office, the Bureau of Mines provided office space, and the Pension Office contributed an experienced secretary.

The summer of 1915 was a relatively quiet one on the Western Front in France. In late September, the French and British began a great offensive in Champagne to force a German withdrawal, but after several weeks of intense fighting the lines remained substantially the same. The Allies' Eastern Front, however, was crumbling. By the end of 1915, the Russians had lost Poland, Lithuania, and Courland and almost a million men, and Russia was unable to receive supplies from her allies because the British failed to force the Dardanelles.

In his annual message to Congress on December 7, 1915, President Wilson presented a comprehensive plan for national efficiency and security—or preparedness—calling for an increase in the standing army and in naval personnel, a reserve corps, construction of additional naval vessels and purchase or construction of ships for the merchant marine. There was no unanimity of opinion on these aspects of preparedness, however. The program antagonized a large body of rural voters. William Jennings Bryan threatened to disrupt the Democratic party if Wilson made further warlike moves. The Republicans were, if anything, more divided on the issue than the Democrats; Theodore Roosevelt and other Eastern leaders were militantly pro-Allies, but Midwesterners were not, and Senator LaFollette of Wisconsin was one of the most outspoken against the preparedness program.

As part of his program for national efficiency and security, Wilson said it was "imperatively necessary" to "safeguard and conserve the natural resources of the country" and to "put them at the disposal of those who will use them promptly and intelligently." Again he urged passage of mineral-leasing and water-power bills along the general lines of those brought up in the 63d Congress. Chairman Scott Ferris of the House Public Lands Committee filed bills at the opening of the new session for the leasing of mineral lands and development of water power essentially the same as those recommended by the Department of the Interior and passed by the House in 1914. Along with them, he filed a bill for stockraising homesteads similar to the one passed by the House in 1915. All three were reported out promptly and passed by the House.

While the mineral-leasing bill was being considered in the House, Senator Porter J. McCumber of North Dakota, by resolution, asked the Secretary of the Interior to supply information on the production, consumption, and price of gasoline because it appeared to him from the reports of the Geological Survey that the output of petroleum was declining and the price of gasoline had doubled. There might be a valid reason for these changes but if the oil fields were giving out or if there had been some "understanding" about the price increase, perhaps Congress should know about it. Senator McCumber asked 14 specific questions, such as the production, consumption, and price of gasoline for each year since 1900, what oil fields were being exhausted, what new fields were being developed, and what the possibilities were for the future. He also wanted to know about methods of increasing the percentage of gasoline from crude oil, new uses of gasoline and petroleum, the influence of the war and of the internal combustion engine on the increased use of gasoline, and the reason for the sudden extraordinary increase in its retail price. Before the resolution was passed, Senator Thomas J. Walsh of Montana added a 15th question: "Were there fields that were unproductive or limited in production because of deficiencies in the laws relating to the disposition of the public lands?"

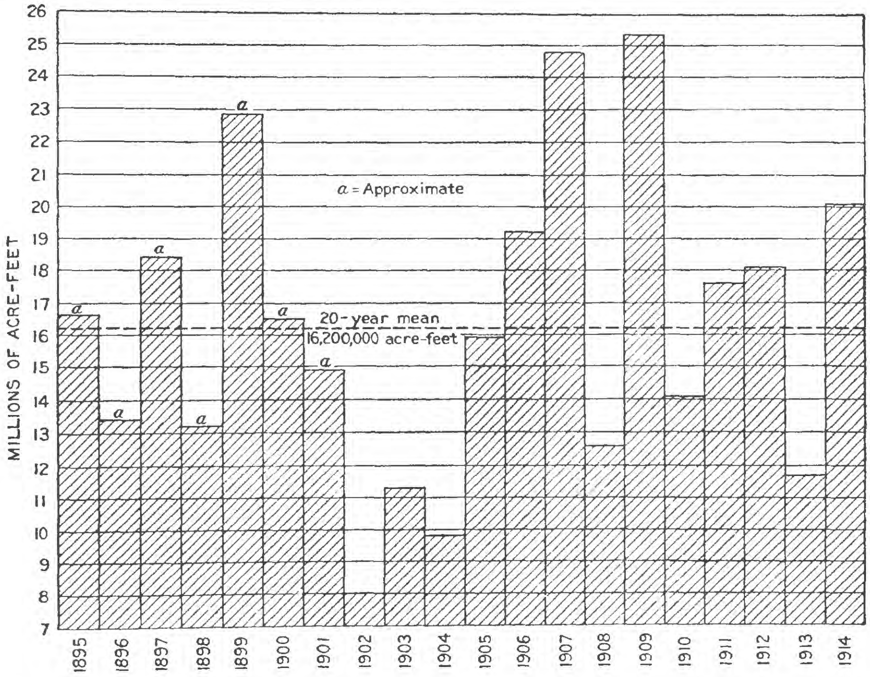
The Interior Department's reply listed 10 major oil fields, stated that the major producers in 1915 were the Midcontinent and California fields, and estimated the "percentage of exhaustion" as 93 for the Lima-Indiana field, 79 for the Gulf Coast and Colorado, 60 for Illinois, and 50 or less for the Midcontinent and all other fields; Wyoming, where the fields were only 5 percent exhausted, was most favorably situated. Still left in known fields, it was estimated, were 7,629 million barrels, with potential oil production from adjacent or unknown areas as much as 75 million barrels more. The increased price was attributed in part to increased consumption in the United States, increased exports, depletion of stocks, and decreased production of crude containing a large percentage of gasoline, specifically the Cushing field. (The cracking process was then new.) The increased consumption was not due to new uses but to a tremendous growth in old uses, such as automobiles—the number had more than doubled since 1913—as well as motorboats, motorcycles, aircraft, stationary internal-combusion engines, tractors, and general industrial and domestic uses. Oil exports had been increasing steadily for several years and had reached a new high of 2.3 billion barrels in 1915. Other factors contributing to the increased price of gasoline were the increased price of crude oil and "financial influences," translated as large companies being able to buy when the price was down and store until the price rose. The Geological Survey suggested investigation of the use of heavier distillates in internal combustion engines, more extensive use of cracking processes, and the development of processes for producing benzoil from coal and oil from oil shales as conservation measures. The answer to Senator Walsh's question was clearly yes; there were fields that would be more productive if the leasing law were passed.

The Senate Committee revised the mineral-leasing bill passed by the House, throwing out everything after the enacting clause and substituting its own bill, but after debating the bill the Senate itself did not pass it. The House water-power bill had a similar fate. The Senate, however, did pass the bill filed by Senator John Shields of Tennessee to provide for development of water power along navigable streams. The Senate also passed the stockraising homestead bill which authorized 640-acre homesteads on lands chiefly valuable for grazing and raising forage crops that contained no merchantable timber and were not susceptible to irrigation from any known source of water. Only lands designated by the Secretary of the Interior (that is to say, classified by the Survey) were to be opened to entry under the law. Congressman Kent of

California had filed a bill to authorize the establishment of grazing districts on the public lands, to be under the control of the Secretary of Agriculture. The Kent bill was favored by cattlemen and sheepmen but the Conference of Western Governors, whose first choice would have been outright cession of the lands to the States, endorsed the Ferris bill.

Congressman Kent was more successful with his bill to establish a bureau of national parks. Two such bills were filed early in the session, and in anticipation of the passage of one of them Secretary Lane on December 10, 1915, designated Chief Geographer Marshall general superintendent of national parks with the intention of making him director of the new bureau when it was established. Marshall would then be the third alumnus of the Topographic Branch to become director of an Interior Department bureau, along with Arthur Powell Davis, Director of the Reclamation Service, and Van H. Manning, Director of the Bureau of Mines. Sledge Tatum, the head of the Rocky Mountain Division of the Topographic Branch, was named Acting Chief Geographer to succeed Marshall but he died only a month later. W. H. Herron, head of the Central Division, then became Acting Chief Geographer, Glenn S. Smith took over direction of the Central Division as Acting Topographic Engineer-in-Charge, and C. H. Birdseye was appointed Topographic Engineer-in-Charge of the Rocky Mountain Division. Smith had first worked for the Survey as a field assistant in 1888 and had been appointed assistant topographer in 1890. Birdseye, a graduate of Oberlin College in 1901, had spent a season or two with the Survey as a summer field assistant while undertaking graduate studies and had been appointed to a full-time position in 1904.

The Kent bill to establish the National Park Service was passed by the House on July 1, 1916, by the Senate on August 5, and approved by President Wilson on August 25. As the bill provided no appropriation for the new bureau, an interim Park Service was put into operation with staff members borrowed from other Interior agencies. In addition to Chief Geographer Marshall, the Survey sent Isabelle F. Story, Arthur E. Demaray, who many years later became Director of the Park Service, and James V. Lloyd to help start the new bureau. The National Park Service supervised 16 national parks, two of them new: Hawaii, established on August 1, 1916, and Lassen Volcanic National Park, established August 9, 1916.



In 1914, E. C. LaRue of the Survey began assembling information collected by various agencies to provide a broad basis for consideration of plans for utilization of the Colorado River by controlling its flow through the use of storage reservoirs, thus avoiding further damage to the Imperial Valley in California, where a breach in the river bank had diverted the flow for 2 years, and at the same time make the enormous volume of flood waters available for profitable use. The project was one of special interest to Arthur Powell Davis, the Director of the Reclamation Service. The illustration shows the annual discharge of the Colorado at the Survey's Yuma, Arizona, gaging station from 1895 to 1914. The annual discharge was an important factor in developing the Colorado River Compact in the 1920's. (From E. C. LaRue, 1916.)

All of these debates took place against a background of increasing concern about international affairs. During the winter of 1915–1916, the Mexican situation had seemed to pose a graver danger to the United States than the war in Europe. The United States, along with several Latin American governments, had recognized the Carranza government in Mexico in October 1915, but some Constitutionalists, among them "Pancho" Villa, the bandit-revolutionary who had also fought Huerta, continued to oppose Carranza. The Carranza government invited American engineers to return to Mexico to operate the abandoned mines in Chihuahua, and Villa's band killed several of them at Santa Ysabel in January 1916. Villa also repeatedly raided Texas and New Mexico, and in his raid on Columbus, New Mexico, on March 9, 19 persons were killed. General John Pershing was ordered to head a punitive expedition and to pursue Villa into Mexico. On March 14, while Pershing was assembling his force, a German submarine torpedoed the *Sussex*, a French cross-channel passenger ship, and several Americans were injured. Secretary of State Robert Lansing favored an immediate severance of diplomatic relations with Germany; instead, President Wilson issued an ultimatum on April 18 that unless Germany abandoned its methods of submarine warfare, the United States would sever relations. At the same time there was a growing concern about the internal disorders on the Caribbean island of Santo Domingo.

The National Academy of Sciences held its annual meeting in Washington April 17–19, 1916, in the midst of this crisis, and voted, on the motion of astronomer George E. Hale, to offer its services to the President in the interest of national preparedness. On April 26, a delegation from the Academy, including its Vice President, Charles D. Walcott, presented the resolution to President Wilson with the suggestion that the academy might advantageously organize the scientific resources of educational and research institutions in the interest of national security and welfare. Wilson accepted the offer and the Academy was asked to proceed at once to carry it into effect.

The Director of the Geological Survey, George Otis Smith, who was not a member of the Academy, was at the time concerned about the organization of Federal science. At the celebration of the centennial of the U.S. Coast and Geodetic Survey, after extolling the harmonious relations that existed between the Coast and Geodetic Survey and the Geological Survey, Smith suggested that the rules for the control of corporations should also be applied to Federal scientific bureaus. Unrestrained competition in the public service, he said, was no less wasteful than unregulated competition in private business. The idea of natural monopolies in the Government scientific service should be recognized, which would insure the same real saving to society as had come with the growth of public-utility monopolies. If the scientific work of the Government was organized on the basis of specialization, however, then the correlative idea of adequate regulation must be adopted. A large share of the duty of insuring proper coordination of the public scientific work must fall to the bureau chiefs, who were constrained as public servants to avoid wasteful use of public funds and as scientists to conserve scientific effort by preventing duplication. "Faith in the effectiveness of highly specialized science must carry with it the belief that some one Bureau, by reason of its organization, personnel, and experience, can conduct scientific investigations of a certain kind better than any other bureau. * * * The attempt of an overzealous bureau chief to seek preferment for his bureau on other grounds is not in harmony with the public-service idea that the Federal scientific bureau is only an agency to get results that are of the largest value to the public it serves."

Smith evidently referred to the friction which was beginning to develop between the Survey and the Bureau of Mines, especially with regard to petroleum investigations on the public lands. Not only had the Bureau drawn into its ranks several members of the Survey, most recently Max Ball of the Oil

Classification Section of the Land Classification Branch to study the legal aspects of the withdrawn lands, but it had recently begun geologic mapping in the oil regions of Oklahoma. Moreover, Smith's concern of 1910, that the Bureau would affect the Survey's ability to obtain appropriations, seemed about to be justified. The Committee on Appropriations had cut the Survey's budget request by $260,000, making it $100,000 less than the current appropriation; the Bureau's estimate had also been cut, but by only $53,800, and its appropriation would still be $207,705 more than the current year.

The very practical work of the Bureau was likely to be perceived as more useful in the emergency situation than the work of the Survey. The National Defense Act of June 3, 1916, provided for expansion of the regular army, a national guard and reserve officers' training corps, and also appropriated $20 million for investigating the best, cheapest, and most available means for the production of nitrates and other products for munitions and useful in the manufacture of fertilizers. Survey geologists could and did investigate all reported discoveries of nitrates although with scant hope of locating new deposits. Processes for the extraction of nitrogen from the atmosphere had been worked out in Europe but the American chemical industry was not familiar with them, especially on a large production scale. The Bureau of Mines could and did investigate methods of fixing nitrogen and also developed new apparatus for oxidizing ammonia, making available in the United States processes that had been developed and carefully guarded in Europe.

The nitric acid supply was one of the problems to which the National Academy of Sciences' committee appointed to organize the scientific resources of the Nation directed its attention. In addition to setting up five committees to investigate pressing questions, among them the nitric acid supply, the committee in its first report on June 19 proposed establishing a National Research Council to be composed of leading American investigators, representing not only educational institutions and research endowments but also Federal scientific facilities. The organizing committee stated that the Council's activities should not be confined to research bearing directly on military problems but 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.

President Wilson accepted the proposal, promised the cooperation of Federal departments and agreed to appoint representatives of Federal bureaus as members of the council. Van H. Manning, Director of the Bureau of Mines, was appointed to represent the Department of the Interior on the council.

By the summer of 1916, other serious problems were developing in the mineral industry. The demand for an American supply of potash was urgent as stocks of imported potash salts had diminished almost to nothing and prices had increased tenfold. The Allied Governments had placed an embargo on the exportation of platinum and the platinum situation was so disquieting that producers had become secretive about their sources of supply. Domestic production of manganese had increased but could not meet the demands; importation of supplies was hazardous because of the blockade and submarine warfare. The tungsten industry had been temporarily paralyzed by the outbreak of war but had recovered quickly and now prices were rising astronomically as large orders for munitions were received. Domestic production of chromite had also increased but the foreign supply needed to supplement it was uncertain and prices were high. Prices for antimony were the highest known since the metal became a regular article of commerce as great quantities were used in making shrapnel bullets and shells. American manufacturers were having great difficulty in meeting the demand for sulfuric acid and the domestic production of pyrite was insufficient. The United States had been the greatest manufacturer and user of asbestos products, obtaining the asbestos from Canada until March 1916, when Canada had placed an embargo on the shipment of asbestos to other than British ports or by special license to Allied countries. Although the embargo was later modified to permit shipment to the United States on the guaranty that no crude or manufactured material would be reexported, these requirements caused asbestos users to look for an available domestic supply. Petroleum production had increased in 1915, although at a slower rate than in 1914, but the great Cushing field had attained its maximum production in April and then had entered upon a rather abrupt decline. The production of bituminous coal had increased and that of anthracite had decreased slightly but a shortage of railroad cars toward the end of 1915 had halted production in some areas and upset the industry.

Because of these changes, the Survey devoted an even greater proportion of its geologic work to the location and development of vital raw materials. To accommodate this realinement, the organization of the Division of Geology of the Geologic Branch was modified on July 1, 1916. F. L. Ransome, who had been chief of both Western Areal Geology and Metals since Lindgren left in 1913, was relieved of supervision of Western Areal Geology. Sidney Paige, who had been with the Survey since 1902, working principally in Alaska and the Southwestern States, succeeded Ransome as head of the Western Areal Geology. The subsection of petrology remained with Ransome as part of the Metals Section. Fuels investigations were divided among three sections. Chief Geologist White took immediate charge of all oil and gas investigations throughout the country, while George Ashley and M. R. Campbell divided responsibility for coal investigations in the Eastern and Western States.

The search for manganese was the most comprehensive and systematic of the metals investigations. Survey geologists examined all reported occurrences of manganese and made qualitative and quantitative estimates with a view to ascertaining possible outputs of different grades of ore for 1917, 1918, and 1919. J. S. Diller made a reconnaissance of 2,000 square miles in California to study the sources of supply and the possibilities of increasing the production of chromite. The problem of mining domestic pyrite of satisfactory grade sufficiently near to points of consumption and in quantities sufficiently large to take the place of a portion of the pyrite supply that had formerly been imported was investigated with the cooperation of several State geological surveys, especially those in the Southern Appalachian region. In addition, P. S. Smith made a special study of the sulfur deposits of Louisiana to determine to what extent they could be used for producing sulfuric acid. To aid the search for tungsten, F. L. Hess compiled a bulletin on tungsten minerals and deposits, showing by many illustrations, some in full color, the appearance of typical specimens.

Even the Alaskan Division felt the urgency of the Nation's metals situation in the summer of 1916. There were 11 parties in Alaska, and during the early part of the season work proceeded according to plan with surveys in southeastern Alaska, the Copper River region, Prince William Sound, and the Yukon Basin, most of them in mining districts. Then in August, J. B. Mertie, Jr., was directed to give special attention to the search for antimony and tungsten and thereafter made supplementary investigations in the Fairbanks area and in the Nome and other districts of the Seward Peninsula.

Nearly all the Survey's funds for potash investigations were devoted to drilling the buried saline deposits at Cliffside, Potter County, Texas, but without success. Borings in other areas of the salt-bearing formations in Texas and Oklahoma as well as one deep well in New Mexico were inspected and cuttings tested through the courtesy of the owners, but no deposits of potash-rich material were discovered. Other possible sources were also investigated, and

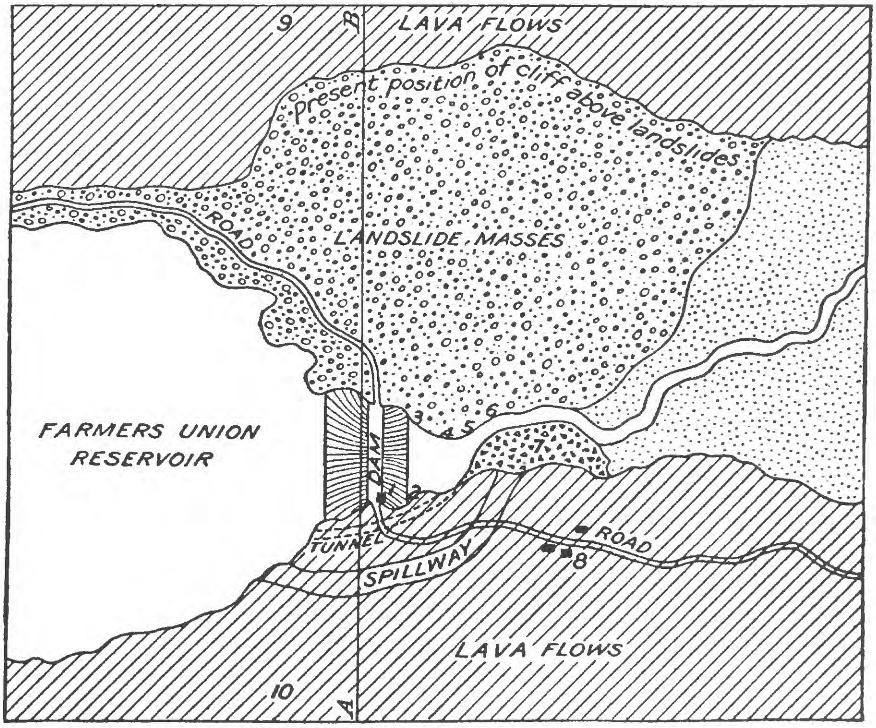
The rains that swept southern California in mid-January 1916, converting streams into torrents that overran their banks and devastated wide areas of the most fertile land in the State, revived memories of the flooding of the Imperial Valley a decade earlier and sparked public interest in plans for the utilization and control of the Colorado River. The most serious loss in 1916, aside from the loss of life, was the destruction of the results of the work of generations on well-developed farm lands. Dams, bridges, pipelines, and other man-made structures, the Survey observed, can be repaired or replaced if funds are available, but it takes a long time to efface completely the track of a flood in a fertile and intensively cultivated river valley. The photograph, taken one month after the storm, shows the flood devastation on the Winston Ranch in Mission Valley. (From H. D. McGlashan and F. C. Ebert, 1918.)

some promising results were found in examinations of greensands and other deposits of the Eastern United States by W. C. Phalen and George Ashley. In general, the best and most available deposits were those in New Jersey and Delaware, samples from which yielded 3.50 to 7.15 percent potash. P. S. Smith investigated sericite deposits in Georgia, North Carolina, and South Carolina to procure data for chemical engineers to determine the practicability of using sericite for the production of potash.

The oil and gas investigations were followed along many lines, not only the continued search for structurally favorable areas and studies of the physical properties of oil sands and of oil-field waters, but also estimates of resources and preparation of a new map of the oil and gas fields of the United States. In the Midcontinent region which had supplied the greatest oil production in 1915, A. E. Fath, R. H. Wood, and K. C. Heald mapped in Oklahoma, Heald extended his studies north of the State line into Kansas, and N. H. Darton investigated areas in western Kansas and Nebraska. G. S. Rogers was assigned to an exhaustive study of the salt domes of the Texas Coastal Plain with special reference to the origin and conditions of occurrence of salt, sulfur, oil, and gas in the domes. O. B. Hopkins examined oil indications, surface geology, and structural criteria at several places in Texas, eastern Louisiana, Mississippi, Alabama, Georgia, and Florida. In California, R. W. Pack and W. A. English extended the area of mapping in Salinas Valley and made a detailed study of the Belridge-Lost Hills district. Extensive work was done in Montana by Eugene Stebinger, E. T. Hancock, C. F. Bowen, and A. J. Collier.

The Survey's investigation of oil-field waters was expanded into a study of the chemical and physical interactions between petroleum and natural gas and associated waters and reservoir rocks of two quadrangles in Ohio where R. V. A. Mills and D. D. Condit had been working and the Butler and Zelienople quadrangles in Pennsylvania where G. B. Richardson had been mapping. Mills and chemist R. C. Wells investigated the origin and deposition of salts found in wells and pipe lines, A. F. Melcher assisted Mills in an experiment on the migration of natural oil in sands, and Chase Palmer analyzed oil-field waters from California. It had been widely assumed that the dissolved salts in the saline waters associated with petroleum and natural gas had been derived through the leaching of sediments by ground waters or that they were fossil ocean waters buried at the time of deposition of marine sediments. The investigation indicated, however, that the brines were the result of a long and complex evolution in which marine water of sedimentation and ground water from other sources, included and deeply buried in sediments, migrated in association with oil and gas and became concentrated in part by evaporation into moving and expanding gases. Salts deposited in wells during the extraction of gas and oil, those occurring interstitially in sediments, and those in the Louisiana and Texas salt domes all agreed closely in composition with hypothetical salts whose loss from solution during concentration was predicated by Mills and Wells on the basis of their experiments.

Despite the increased emphasis on minerals in short supply and on petroleum, peacetime investigations were continued as far as possible even in the Survey's economic-geology sections. Coal-field mapping continued in cooperation with the State surveys of Illinois, Ohio, Pennsylvania, Tennessee, and Virginia, and coal lands in the Western States were mapped and classified. In the Metals Section, J. B. Umpleby and E. L. Jones completed field work for the general report on the ore deposits of Idaho, and G. F. Loughlin and Professor W. O. Hotchkiss of the University of Wisconsin experimented with



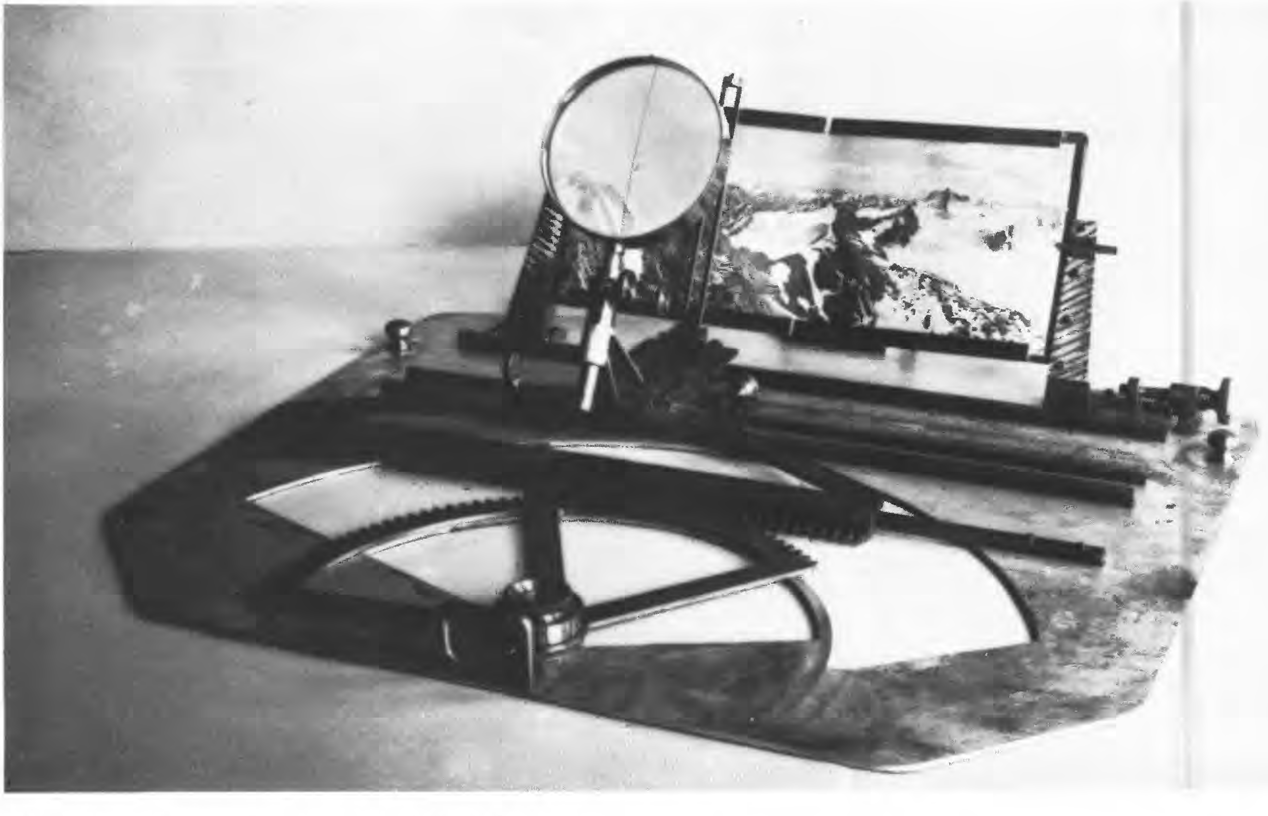
Experience in and near the San Juan Mountains of Colorado indicated that construction of dams and reservoirs without taking into account the geology of the sites could lead to less than satisfactory results. There an increase in farming had created a demand for a large supply of water for irrigation and many reservoirs were planned, most of them associated with glaciated canyons or lake basins. The dam of the Farmers' Union reservoir, for example, was built in a constricted portion of the Rio Grande, but the constriction, as the sketch map and cross section show, was caused by a large landslide area. Although the dam itself was watertight, the reservoir leaked because the water was able to penetrate the landslide material. (From W. W. Atwood, 1918.)

magnetic methods for detecting ore deposits other than iron in the Magdalena district in New Mexico, finding that the methods promised some usefulness in tracing contacts between igneous and sedimentary rocks. G. R. Mansfield mapped about 400 square miles as he continued the detailed examinations of phosphate deposits in Idaho.

Quadrangle mapping was also underway in 32 States in 1916, and geologic studies were also made in three national parks in preparation for popular and technical publications. Another problem in engineering geology was investigated in the San Juan Mountains of Colorado, where W. W. Atwood, who was studying the physiographic history of the area, examined several reservoir sites where leakage problems had developed. Most of the reservoirs were in mountain canyons and the sites for the dams had been selected where the valleys were somewhat constricted, either by glacial moraines or landslide deposits. Such materials were not water-tight, and even though water-tight dams had been constructed, the water had found its way underneath or around the ends of the deposits.

In 1916, the Water Resources Branch again received funds from cooperating States that amounted to about three-fourths of the Federal appropriation and also funds from other Federal agencies. Gaging stations were maintained in 41 States, Alaska, and Hawaii, including all the States in the Great Basin and on the Pacific slope and nearly all States in the Rocky Mountain and Western Gulf regions where water was necessary for irrigating agricultural land. Many investigations of the use of both surface and ground water were made in connection with the classification of public lands with special reference to their use for power, under permit, or for agriculture, under the Enlarged Homestead, Desert Land, or Carey Acts. In addition, several special ground-water studies were made. O. E. Meinzer studied the changes in the artesian water supply in the Pecos Valley, New Mexico, to determine changes produced by developments since 1906 and a means of preventing underground losses. G. A. Waring investigated the ground-water resources of

In 1917, the Survey published a bulletin on the use of the panoramic camera in topographic surveying, with which J. W. Bagley had been experimenting in Alaska since 1910, and notes on the application of photogrammetry to aerial surveys. The field cost of surveys made by use of the panoramic camera in conjunction with a planetable was far less than that of surveys made with the planetable alone, and, although the compilation of field data was more laborious, the final cost was nonetheless lower. The combined method was considered especially applicable to regions such as Alaska where the field season is short, the field cost high, and climatic conditions adverse to topographic work. The illustration shows a panoramic photo-alidade, an instrument set up to determine directions from a photograph. (From J. W. Bagley, 1917.)



the Reese River valley and part of the Humboldt River valley in Nevada, and W. O. Clark began a similar investigation in the Salinas Valley in California after completing work on the Truckee-Carson irrigation project in Nevada. A. T. Schwennesen investigated ground-water conditions in Quincy Valley, Washington, where water was needed to irrigate orchard lands, and A. J. Ellis continued the study of the ground-water resources of Montana. R. B. Dole continued to work on his comprehensive paper on the chemical composition of surface waters but died in January 1917 before completing it. A. A. Chambers was then placed in charge of quality-of-water investigations.

Cooperative funds for topographic mapping continued to decline in 1916, and 60 percent of the new area mapped was west of the 100th meridian. Use of larger scales continued to increase in that area, and east of the 100th meridian all mapping was for publication at 1:62,500. Most of the mapping in the 48 States was by conventional methods. In Alaska, however, J. W. Bagley continued to experiment with the use of phototopographic methods and mapped about 1,900 square miles in and east of the Port Wells district, Prince William Sound. His 6-year investigation of the use of photographic methods, including devising new instruments and methods as well as field tests, was reported in a Survey bulletin in early 1917. The methods were especially applicable to regions where the field season was short, the field cost high, and climatic conditions adverse to topographic work, but they promised a wider application. The field cost of the surveys was lower than surveys made by plane table alone, and though the compilation of field data was more laborious, the final cost of the completed map was lower. Because of the wide interest in aerial surveys, Bagley appended a discussion of the use of the camera in such work, based largely on French treatises, and presented briefly the principles and some of the methods of photogrammetry in its application to aerial surveys. "The subject," said A. H. Brooks, Chief of Alaskan Geology, "needs further study and experimentation."

The war in Europe dragged on through 1916 and seemed no nearer to a conclusion. The Germans began an attack on Verdun in February and captured it in June, but with heavy loss of life on both sides. A massive Anglo-French offensive launched on July 1 in the Somme area gradually petered out, ending in mid-November with nothing gained of prime strategic importance and great loss of life on both sides. Then the French succeeded in retaking Verdun, leaving that situation much as it had been at the beginning of the year. The Russians had launched a great offensive on the Eastern Front but failed to take their objectives, and the loss of about a million men left the Russian army demoralized.

As the summer of 1916 was drawing to a close, Italy declared war on Germany, some 15 months after it had declared war on Austria-Hungary. Germany declared war on Rumania, and Turkey and Bulgaria followed suit a few days later. The German navy raided the English coast and stepped up its campaign against shipping in the Atlantic. Germany had agreed to give up unrestricted submarine warfare in May in response to American protests, but with the stalemate on land its military leaders concluded in November that their best hope of winning the war was to starve the British by preventing supplies from reaching them.

Congress ordinarily adjourned early in election years but because of uneasiness over the European situation remained in session until September 8, 1916. In the closing days of the session, several defense measures were enacted. On August 29, a Council of National Defense was authorized under the Army Appropriations Act "for the coordination of industries and resources for the National security and welfare." On the same day, the "Big Navy Act" called for a 10-year plan of construction to make the United States Navy equal to any two others in the world. On the day before Congress adjourned, the Shipping

Act authorized creation of the U.S. Shipping Board to build, purchase, lease, or requisition vessels through an Emergency Fleet Corporation, that was capitalized at $50 million.

The Council of National Defense, a Cabinet committee of the Secretaries of War, Navy, Interior, Agriculture, Commerce, and Labor, was to supervise and direct investigations and make recommendations to the President and the heads of executive departments as to "the location of railroads with reference to the frontier of the United States, so as to render possible expeditious concentration of troops and supplies to points of defense; the coordination of military, industrial, and commercial purposes in the location of extensive highways and branch lines of railroads; the utilization of waterways; the mobilization of military and naval resources for defense; the increase of domestic production of articles and materials essential to the support of armies and of the people during the interruption of foreign commerce; the development of sea-going transportation; data as to amounts, location, method, and means of production, and availability of military supplies; the giving of information to producers and manufacturers as to the class of supplies needed by the military and other services of the Government, the requirements relating thereto, and the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation." The inclusion of "utilization of waterways" was the only direct reference to use of natural resources. The Council also was required to nominate an advisory commission of not more than seven persons, each of whom should have special knowledge of some industry, public utility, or the development of some natural resource, or be otherwise specially qualified in the opinion of the council.

The National Research Council, which held its first meeting three weeks after the establishment of the National Defense Council, also omitted natural resources from its earliest considerations. At its first meeting on September 20, George E. Hale, Director of the Mount Wilson Observatory, was elected Chairman and Charles D. Walcott, Secretary of the Smithsonian Institution, the First Vice-Chairman. In the series of committees set up at that time to organize research in the various branches of science, geology was conspicuously missing.

By the fall of 1916, however, supplies of not only petroleum and certain metals but even coal had become a problem. Production of both anthracite and bituminous coal had been limited by lack of market in 1914, 1915, and throughout most of the country in the spring of 1916, but the demand for bituminous coal sharply increased thereafter just about the time that a shortage of railroad cars developed because of the tremendous movement of heavy freight from manufacturing centers to ports for overseas shipments. The situation was complicated by the demand of the major railway union for an 8-hour day and a threatened strike. Faced with the possibility of a short supply for the winter, consumers began to buy coal in what amounted to a panic, and prices at the mines rose to five times the normal price. Anticipating the difficulty, the Survey had begun to publish monthly statements on the shipment of coal in August.

The Council of National Defense held an organizational meeting on October 11, 1916, at which time Secretary of War Newton D. Baker was chosen its Chairman and an Advisory Commission nominated. The President in due time appointed Daniel Willard, president of the Baltimore & Ohio Railroad; Bernard M. Baruch, New York financier; Howard E. Coffin, vice-president of the Hudson Motor Company; Julius Rosenwald, president of Sears, Roebuck Company; Hollis Godfrey, president of the Drexel Institute of Philadelphia; Samuel Gompers, president of the American Federation of Labor; and Dr. Franklin Martin, secretary-general of the American College of Surgeons. The Advisory Commission, however, did not meet until December 7, 1916, a month after the national elections.

The long campaign for a bureau of national parks was successfully concluded in August 1916 when Congress established the National Park Service. Two new national parks, in volcanic areas in Hawaii and California, were established in that same month, and in February 1917 Congress established Mount McKinley National Park in Alaska as a refuge and breeding ground for conservation of Alaskan big game against the inroads expected to develop when the new Alaskan Railway was completed. The photograph was taken by A. H. Brooks of the Geological Survey who served as vice-chairman of the Railway Commission. (From A. H. Brooks, 1911.)

President Wilson was reelected in November 1916 in an election so close that the result was in doubt for three days until the final count in California was announced. Although the Democrats retained control of both houses of Congress, the Republicans gained in both the Senate and House. Once the election was over, Wilson felt free to make an attempt at mediation of the European war, which the German Ambassador to the United States had proposed in September when German submarines were destroying Allied ships at such a rate that the German high command was confident of starving out Britain and winning the war. By the end of November, Wilson completed a draft proposal with a program for an equitable peace. Before he was ready to release it, the German Government announced its willingness to begin negotiations, but when Wilson asked the belligerent powers to state their terms for peace, Germany evaded a direct answer; the Allies rejected a negotiated peace and outlined peace terms clearly unacceptable to the Central Powers. Thus by January 1917, it was clear that the war would not soon end and on January 22 Wilson addressed Congress, calling for "peace without victory."

Commissioner Baruch of the Advisory Commission of the Council of National Defense had already begun a study of the steel and metal industries, and at the January meeting of the Commission he was encouraged to continue his efforts to bring about an understanding of how they could combine their resources. Commissioner Willard was authorized to undertake an investigation to develop ways in which the railroads could aid the defense effort.

The National Research Council's newly formed Committee on Geology also met for the first time in January 1917. The committee, under the chairmanship of John M. Clarke, president of the Geological Society of America, was composed largely of academic geologists and a few State geologists but included no one from the U.S. Geological Survey. As a preliminary procedure, the committee decided to make a census of all the geologists of the United States with reference to training, special skills and knowledge, and possible areas of public service. Plans were also made to prepare a brochure "What a geologist can do in war," and subcommittees were appointed on materials and facilities for rapid construction of roads and fortifications; measurement of earth vibrations as a means of locating heavy batteries; water supply for camps; and the geology of cantonments and geological instruction in training camps. The committee also examined the possibility of constructing a superior armor for the national army on the basis of the construction in armored Devonian fish.

By January 1917, petroleum supplies were already becoming critical, and the Survey's Division of Mineral Resources began collection and publication of monthly statistics showing the quantity of crude oil moved from field sources, delivered to refiners or consumers, and in storage at the end of each month for each of the major fields east of the Rocky Mountains. The information was compiled from reports submitted voluntarily by about 200 pipeline and refining companies and was admittedly incomplete. However, the data furnished an index to the status of the industry as 90 to 95 percent of the crude oil marketed each month was accounted for. In January 1917, also, the Ground Water Division of the Water Resources Branch and the Coastal Plain Section of the Geologic Branch joined forces to begin preparation of a series of reports on underground water supplies and soil drainage features of areas along the Mexican border and the Gulf and Atlantic Coasts for transmittal to the War College and the Army Engineers. In the Topographic Branch, a Division of Military Surveys was established, with Glenn S. Smith, commissioned a major in the Army Engineers' Reserve Corps, in charge. Director Smith had suggested such a unit to the War Department in August 1916, and after Congress appropriated $35,000 to the War Department for strategic mapping the division was set up and mapping was begun in Virginia.

At the end of January 1917, the German Ambassador notified Secretary of State Lansing that effective February 1, all ships, neutral or belligerent, armed or unarmed, in the war zone would be sunk on sight. The United States therefore severed diplomatic relations with Germany on February 3.

The Council of National Defense met with its Advisory Commission on February 12, at which time it agreed to ask the National Research Council to act as its research arm, and to concentrate its efforts on production and supply. Secretary of the Interior Lane called for a series of conferences with the leaders in each industry fundamentally necessary to defense, at which they could be asked to organize themselves to deal with the Council through one man or through a committee of not more than three men to whom the Council could submit problems. The Advisory Commission then organized itself into committees, each member being a chairman who could draw other members from either government or civil life or both. Daniel Willard became chairman of the committee on transportation and communication and Bernard Baruch, chairman of the committee on raw materials, minerals, and metals.

On February 26, 1917, President Wilson, still trying to avoid war, asked Congress for authority to arm American merchantmen in the hope of deterring submarines from attacking them to prevent an overt act that would precipitate war. The House approved the President's request on March 1, but in the Senate a small group filibustered until the mandatory end of the session on March 4 and no vote was taken. Meanwhile, on March 1, the State Department had released a decoded message from the German Foreign Secretary to the German Minister in Mexico, which the British had intercepted, directing the Minister, if war broke out between Germany and the United States, to propose a German-Mexican alliance. Germany would provide Mexico with generous financial support and bring about the cession of New Mexico, Arizona, and Texas to Mexico in the peace treaty.

On March 12, the State Department announced that all American merchant vessels sailing through the war zones would henceforth be armed. It had been determined in the meantime that specific approval by Congress was not necessary. On that very day, an unarmed American ship was sunk without warning, and on March 16, three more American ships were torpedoed. On March 20, the Cabinet unanimously recommended war, and on the 21st, President Wilson called the new Congress into special session on April 2.

As the United States' entry into the war became inevitable, the Topographic Branch of the Survey adjusted its plan for field work to conform to a program drawn up by the General Staff of the Army, and after March 26, 1917, all available funds were used to make maps for the War Department and all other surveys were recessed. Director George Otis Smith and M. R. Campbell were invited to become members of the subcommittee on the geology of cantonments and instruction in training camps of the National Research Council's Committee on Geology, and the Survey began preparation of a series of geographic handbooks that would be useful in both general and military instruction.

The Council of National Defense and its Advisory Commission met on March 24 at which time Commissioner Baruch reported that he had set up several committees, including committees on leather, rubber, steel, wool, nickel, oil, and zinc, and that negotiations were underway to provide the Government with its requirements of copper, zinc, lead, and steel products and to increase the output of tin cans and plate. Exactly what such requirements might be was not then known, for no one had calculated the materials necessary to equip and maintain an army of a million men.

The U.S. Geological Survey had by this time begun preparation of a bulletin "Our Mineral Supplies," the first chapter of which was published on April 13, the others at intervals during the next few months. Bulletin 666 was a more sobering document than George Otis Smith's Bulletin 599 issued as the war in Europe began. Minerals were now divided into three classes: those for which domestic supplies were adequate for all needs, those for which domestic supplies were not sufficient for all needs, and those that were "inadequate in quantity or quality, or both, the lack of which must be offset by imports, use of substitutes, or curtailment of use." The list of minerals of which supplies were inadequate had been doubled to include asbestos, chromite, graphite, high-grade manganese ore, and monazite as well as nickel, nitrates, platinum, potash, and tin. The situation with respect to manganese was especially critical. If conditions demanded the maintenance of the 1916 output of steel and if imports of manganese ore and ferromanganese were cut off, the Survey held that deposits of manganese then developed in the United States could not meet the demands, and much readjustment in the steel industry would be necessary.

Domestic supplies of antimony, mercury, mica, pyrite, strontium, and vanadium were considered sufficient for most peacetime needs but insufficient for all needs, and some stimulation or control would be needed. Even for minerals for which domestic supplies were considered adequate, a note of caution had crept into the Survey's report. Iron-ore reserves, enormous as they were, were not sufficient to prolong production for many decades if the rate of increase in consumption of ore was maintained. Conservation of the iron-ore supplies of the United States, discovery of new supplies, and development of methods for rendering supplies of low-grade ore available were vital to the maintenance of the industrial independence of the United States.

Moreover, the "impregnable position" of the United States with respect to mineral fuels had become vulnerable. Coal had become high priced and hard to get because of the shortage of labor and insufficient transportation. The outlook for petroleum was not one "to encourage optimism." Production then barely met the normal demands for petroleum products; an immediate increase in production to meet the war's abnormal demands was imperative. The Survey foresaw a serious shortage in the supply of motor fuel and suggested that

> this famine can be deferred by the exercise of strict economy in the utilization of the supply now available by every operator of a motor vehicle in this country and by the curtailment of the use of gasoline-driven vehicles for pleasure and for such business purposes as can not be efficiently accomplished by the substitution of electrically propelled vehicles. It may be still further deferred by the substitution in a multitude of small plants of one kind or another throughout the country of water, steam, or electric power for that now derived from gasoline.

Chapter 7.
Mobilization of All Resources, 1917–1919

> **It will involve the organization and mobilization of all the material resources of the country to supply the materials of war and serve the incidental needs of the Nation in the most abundant and yet the most economical and efficient way possible.**
>
> **—Woodrow Wilson**

On the evening of April 2, 1917, President Woodrow Wilson appeared before a joint session of Congress and asked for a declaration of war against Germany. The war resolution was passed by the Senate on April 4, concurred in by the House in the early hours of April 6, and signed by the President on the same day. In his eloquent war message President Wilson declared that the American objective was "to vindicate the principles of peace and justice in the life of the world as against selfish and autocratic power and to set up amongst the really free and self-governed peoples of the world such a concert of purpose and action as will henceforth insure the observance of these principles." The United States had no selfish ends to serve; it was entering the war to fight for the rights of nations great and small and the privilege of people everywhere "to choose their way of life and of obedience," and we would be "satisfied when those rights have been made as secure as the faith and the freedom of nations can make them."

The waging of war, Wilson pointed out, would involve not only equipping the Navy fully, especially to deal with submarines, and greatly expanding the armed forces, but also "the utmost practicable cooperation in counsel and action with the governments now at war with Germany" including the extension of liberal financial credits. The effort would also involve "the organization and mobilization of all the material resources of the country to supply the materials of war and serve the incidental needs of the Nation in the most abundant and yet the most economical and efficient way possible."

Wilson admitted to a confidant, Frank Cobb, editor of the *New York World*, that he had never been so uncertain about anything in his life as he had been about the war message. The consequences that he envisioned from American intervention were terrifying. "Once lead this people into war, and they'll forget there ever was such a thing as tolerance. To fight you must be brutal and ruthless, and the spirit of ruthless brutality will enter into the very fibre of our national life * * *." It would require, Wilson thought, a generation after the coming of peace to restore normal conditions.

Mobilization of the nation was a gigantic task, made more complex by distance from the front lines and American aversion to the discipline of the armed services or any control of civilian life. Americans responded at first with patriotic enthusiasm and then with patient endurance, and in time an effective organization was achieved. As the war went on, Wilson increasingly concerned himself with what he saw as the two great problems of the future: making a just peace and establishing an international organization to maintain that peace, for only peace for the entire world would ensure peace for the United States.

Geologists were then aware—and others would soon become aware—that no nation is completely self-sustaining in mineral resources. All nations depend on others for certain minerals or for markets for their excess minerals. The possibility of international cooperation or international control of minerals became very much part of the thinking of many geologists during the war, and much work toward this end was carried on, even at the Peace Conference. In the end, however, the effort came to nought. Part of the war's aftermath was the rejection, in every belligerent country, of the statesmen who had directed it. The United States turned against "foreign entanglements" and became preoccupied with domestic concerns.

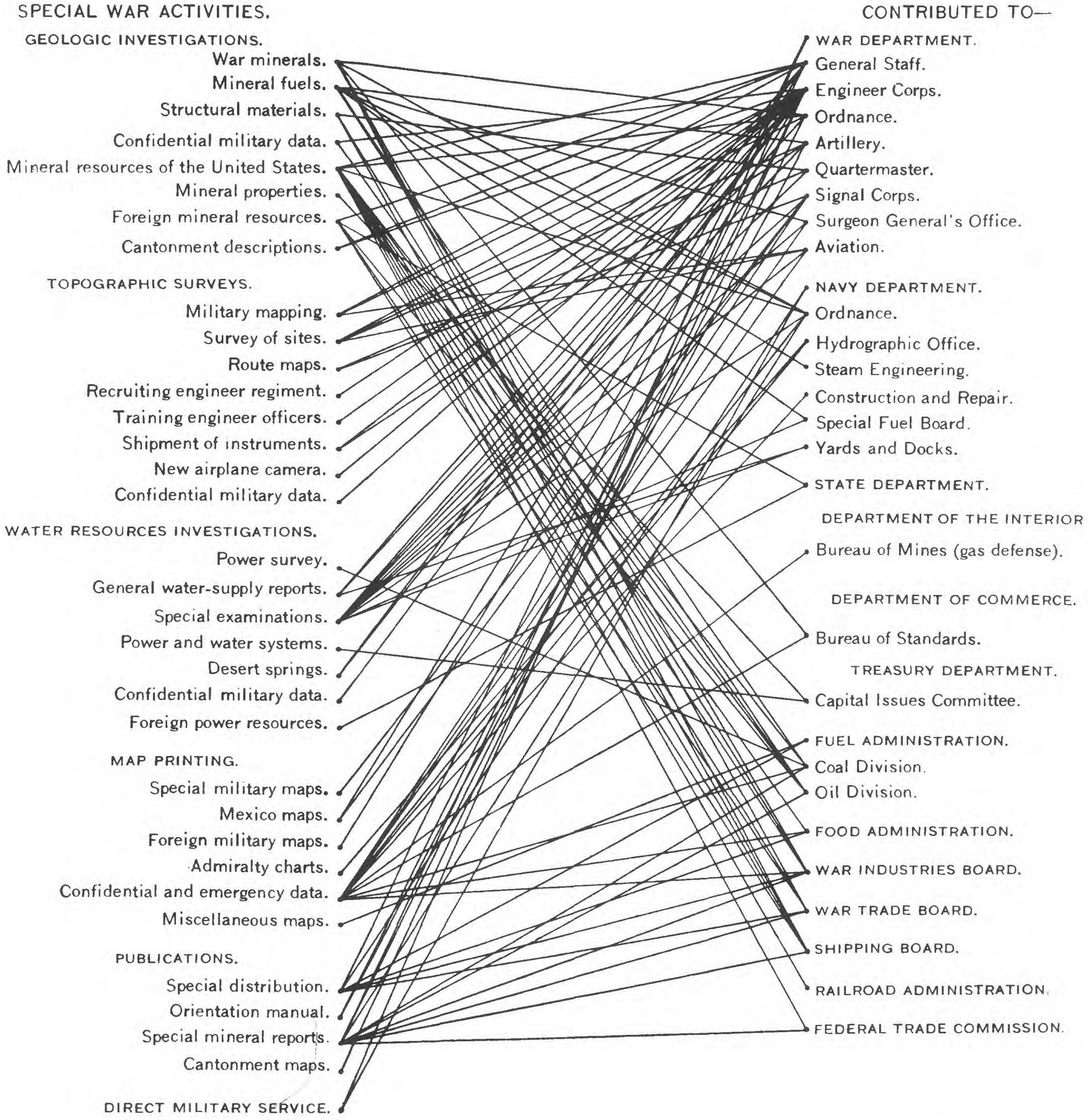
As soon as the United States declared war, many members of the Geological Survey volunteered for the armed services. A. H. Brooks, the Chief Alaskan Geologist, who was commissioned in the Engineer Officers Reserve Corps in April 1917, and Glenn Smith, Chief of the Division of Military Surveys of the Topographic Branch, were among those who sailed for France in June 1917 with the first contingent of the American Expeditionary Force. They were the vanguard of 411 from the Survey who served in the armed forces. Secretary Lane pointed out that the making of war in 1917 tested "the full powers of the Nation in every resource and capacity and especially along lines of scientific knowledge." Lane said that Brooks, who had spent 20 years studying Alaskan geology "until he had become identified with the rise of Alaska and was the embodiment of its hopeful spirit," would use his geologic knowledge to locate trenches into which the country would not drain and thus provide a healthier place for the American soldier; Smith and the other topographers would prepare maps of the land over which new railroads would run to carry men, supplies, and munitions to the front and the wounded back for medical care, of the places where the big guns would be placed, rivers, forests, "and all the details of a landscape that changes from day to day under the pressing advance or the forced retreat," now that "men by the millions move by the map." Those who remained at home became "adjuncts and auxiliaries" in the contest as they wrestled with problems of supplying raw materials and power to serve the military establishment and industry.

In the United States, certain problems were already manifest with regard to mineral raw materials, but the parameters of the mineral-fuels problems were unrelated to those of the metals and other minerals. The United States was then producing nearly two-thirds of the world's oil and was the world's largest producer of coal. Its reserves of both commodities were considered adequate to meet all demands; the problem was one of conserving production and controlling distribution to meet the extraordinary demands of war. Reserves of many metals and certain other minerals, however, were inadequate, and the problem was therefore not so much one of production and distribution as of locating new sources, increasing the yield from known sources, or of finding substitutes. Federal efforts to alleviate shortages of needed nonmetals such as potash and nitrates had been underway for some time before the United States entered the war. Within a few months after the declaration of war, the Federal Government took steps to conserve production and control the distribution of the mineral fuels. Geologists and mining engineers, however, organized the efforts to solve the metals problems, but for many months they lacked a sense of direction or even coordination. In fact, the war was almost over before the situation was remedied.

The first efforts to control fuels were made through the Council of National Defense. In March 1917, the Council established an Advisory Committee on Petroleum Production, headed by A. C. Bedford, chairman of the Board of Directors of Standard Oil of New Jersey, and composed solely of industry representatives. The committee was asked to ensure delivery of adequate supplies of petroleum products for the Navy and other branches of the Armed Forces, recommend allocations of available production to meet the demands of the Allies, and to balance such needs against the requirements of domestic war industries, all without creating shortages in any sector of the economy and without significantly increasing oil prices.

An Advisory Committee on Coal Production was established in April 1917, and asked to concern itself with the production and movement of coal needed by the Navy, the war industries, Federal institutions, and public utilities. The Coal Committee was an industry-Government committee, and both George Otis Smith, Director of the Geological Survey, and Van H. Manning, Director of the Bureau of Mines, were members of this committee. The Committee on Coal Production was a very active committee. It helped settle several labor disputes, arranged to procure supplies for the Government, and organized the coal operators for cooperation with the railroads to facilitate

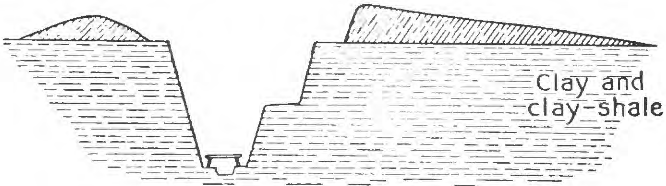
The U.S. Geological Survey was deeply and intricately involved in the war effort as is evidenced by this diagram in its 39th Annual Report. The diagram may also be taken to show the close involvement of the earth sciences in the common defense and general welfare of the people.



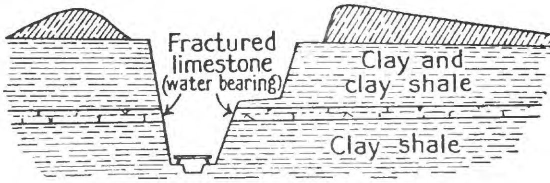
Alfred Hulse Brooks (1871–1924), Chief of the Division (later Branch) of Alaskan Mineral Resources, 1903–1924, Chief Geologist of the American Expeditionary Force and of the Peace Commission, 1917–1919. Brooks, who was commissioned a Major in the Engineer Officers Reserve Corps in June 1917 and later promoted to Lieutenant Colonel, is credited with initiating the idea of a reserve corps by suggesting that the War Department establish a roster of engineers and others in Government service whose special qualifications might be of value to the military in time of war. Brooks joined the Survey as a full-time employee in 1894 after graduating from Harvard University, and in 1898 was assigned to work in Alaska. He became so deeply involved in both Alaskan science and Alaskan development that he was commonly referred to as "Brooks of Alaska." The Brooks Range was named for him. (From the files of the U.S. Geological Survey.)

transportation. The committee also invited the coal operators to meet in Washington at the end of June 1917, and at that time the operators agreed to reduce the prices of coal at the different fields. A press release announcing the reductions quoted George Otis Smith as saying that the reduction to consumers east of the Mississippi River would amount to $15 million a month. The action of the committee, however, was not sanctioned by the Department of Justice, was repudiated by the Chairman of the Council of National Defense, and very nearly led to Secretary Lane's resignation. It was nonetheless effective in halting rising prices as most of the coal vendors adhered to the agreement.

Legislation then pending in Congress to conserve production and control distribution of food necessary to the war effort was amended to include fuel as well, and the bill was passed and approved on August 10, 1917, to be effective for the duration of the war. The Lever Act authorized the President to fix the prices of coal, coke, and other commodities, to license producers and distributors, and to prohibit unfair trade practices. The Food Administration was established immediately, and Herbert Hoover, who had gained an international reputation for his success as director of war relief in Europe, was ap-



Impervious material: Easily excavated. Trenches require complete revetment and drainage for surface water.



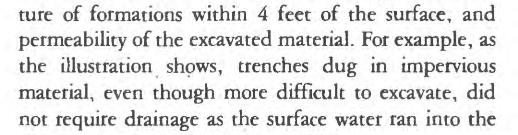
Impervious material: Easily excavated. Trenches require complete revetment and ample drainage for both surface and underground water.

pointed to head it. The Fuel Administration was established on August 23, with Harry Garfield, President of Williams College, as Fuel Administrator. The Food Administration, which might logically have been associated with the Agriculture Department, and the Fuel Administration were both provided office space in the new Interior Building.

The Council of National Defense also established several committees, all solely industry committees, on various metals and minerals. Then, on July 8, 1917, the council voted to establish a War Industries Board to "act as a clearing-house for the war-industry needs of the Government, determine the most effective ways of meeting them, and the best means and methods of increasing production, including the creation or extension of industries demanded by the emergency, the sequence and relative urgency of the needs of the different Government services, and consider price factors and, in the first instance, the industrial and labor aspects of problems involved and the general questions affecting the purchase of commodities." The Quartermaster General had by this time estimated that 400 ships in constant service would be needed to maintain a million U.S. troops in France. There were fewer than 650 ships of American registry capable of transatlantic voyages at the time and losses by submarine attack were expected to exceed gains by new construction for at least a year. Clearly domestic production of all possible materials was needed to conserve shipping.

Entirely apart from the Council of National Defense, geologists and mining engineers organized a War Minerals Committee on July 12, 1917, that its chairman, consulting mining engineer W. Y. Westervelt, characterized as "a voluntary committee * * * trying to organize a constructive attitude in Washington." W. O. Hotchkiss, State Geologist of Wisconsin, proposed the formation of such a committee in the spring of 1917 and interested Philip N. Moore, President of the American Institute of Mining Engineers, and F. W. DeWolf, State Geologist of Illinois, in the proposal. George Otis Smith at first saw no need for this unofficial agency but did not oppose it and named Chief Geologist David White to represent the Survey. Serving with David White and Hotchkiss, who represented the Geology Committee of the National Research Council and the Association of State Geologists, were Alfred G. White, mine economist of the Bureau of Mines, and Westervelt who represented the AIME and the Mining and Metallurgical Society of America. The War Minerals Committee, although it had no official status, was also given office space in the new Interior Building.

One of the important ways in which geology was of service at the front was in the construction of field works such as trenches, dugouts, and covered ways. These were almost always built in a hurry and often under shell fire, usually without taking time to make underground tests. In many localities, however, the surface formation indicated underground conditions, or a geologic map could provide needed information, such as depth of soil and subsoil, lithology and structure of formations within 4 feet of the surface, and permeability of the excavated material. For example, as the illustration shows, trenches dug in impervious material, even though more difficult to excavate, did not require drainage as the surface water ran into the ground. (From A. H. Brooks, 1921.)



Pervious hard material: Trench construction requires blasting but little revetment. No drainage required, as surface water runs into the ground.

The War Minerals Committee began its work by establishing three classes of minerals with which it would be concerned: those that had hitherto been imported but whose production could be stimulated by ordinary commercial means; those whose production would require some fostering on the part of the Government; and those for which domestic sources were inadequate and which would have to be imported. The three classes included minerals in nearly all mineral groups—precious metals, ferroalloy minerals, fertilizer minerals, and miscellaneous other metals and nonmetals; the most serious shortages were in the ferroalloy and fertilizer minerals. The United States had large supplies of iron ore but lacked adequate high-grade supplies of nearly all the principal minerals used to give special qualities to the finished iron and steel. The committee solicited reports from mining engineers and geologists on specific prospects and on the possibility of stimulating domestic production of the principal imported minerals. From these and later examinations and reports made expressly for the committee, they determined that a large amount of imported pyrite could be replaced by domestic pyrite, that a change in metallurgical practice would make possible greater use of domestic manganese, and that to a lesser extent, chrome and other minor metals might also be developed so that shipping tonnage could be released for transportation of war materiel.

David White, in addition to his work on the War Minerals Committee, continued to direct the Geologic Branch of the Survey in its two-fold task of developing information on the mineral production of the United States, the specific task of the Division of Mineral Resources, and field investigations to aid the discovery and development or increase in the production of minerals in short supply and of petroleum, primarily the task of the Division of Geology and Paleontology. For administrative purposes, a Section of the Geology of Iron and Steel Alloy Metals, or war minerals, was established in the Division of Geology and Paleontology with E. F. Burchard in charge; White himself took personal charge of the petroleum investigations. In practice, section and division boundaries were ignored, and the full strength of the branch was directed toward whatever work seemed most pressing.

The Division of Mineral Resources became the main source of information on the mineral production of the United States during the war, and the policy adopted more than a decade earlier of assigning geologists to the preparation of reports on mineral commodities paid handsome dividends under emergency conditions. The staff kept up with the regular annual and semiannual reports based on correspondence with about 110,000 mineral producers and also made special investigations, sometimes collecting information by telegraph and preparing weekly reports. So impressed were some procurement officials with the quality of the data the Survey provided on metals that they asked the Survey to supply data also on hides and mahogany, a request which Director Smith, to their surprise, declined.

Glenn Shepard Smith (1869–1951), who had been placed in charge of the Survey's new Division of Military Surveys on January 11, 1917, was commissioned a Major in the Engineer Officers Reserve Corps in June 1917 and sailed for France with the first contingent of the A.E.F. In France he served as assistant to the Chief of the Topographical Division, General Staff, and director of the Base Printing Plant of the 29th Engineers, and was later promoted to Lieutenant Colonel. After the war, Smith, who had been with the Survey since 1895, took charge of West Indian surveys and also served as Acting Chief Topographic Engineer in the absence of that officer. He became Atlantic Division Engineer in 1924, left the Survey briefly in September 1929 to serve as Interior Department representative and Secretary to the Southern Appalachian Park Commission, and returned to the Survey in December 1930 as Central Division Engineer. (From the files of the U.S. Geological Survey.)

The Survey's collection of statistics on coal was greatly expanded through the aid of the Fuel Administration. Early in June 1917, the Survey began to publish weekly statements, prepared by C. E. Lesher with the assistance of W. T. Thom, Jr., on the production of bituminous coal and the factors in each district that were limiting production and shipment. When the Fuel Administration was established in August, it did not build up an organization to handle coal statistics but used Survey data, and the group working with Lesher became the nucleus of a much larger organization financed by the Fuel Administration but administered by the Survey. This separation from the executive function of the Fuel Administration was later found to be of advantage in disputes between the Fuel Administration and other war boards.

Among the ferroalloy minerals in short supply, manganese was most important at the outset. Before the war began the United States had produced only 1 to 2 percent of its needs and had been able to increase that production only to about 35 percent. In June 1917, therefore, a field conference was held in the Central Valley of Virginia to test D. F. Hewett's hypothesis on the relation of physiographic and stratigraphic conditions to manganese deposits and its applicability to the discovery of new ore bodies. Then G. W. Stose, F. J. Katz, and H. D. Miser made an areal and structural study of the Shady Dolomite and contiguous formations throughout the manganiferous regions in that area and the Survey issued a short report recommending prospecting of six undeveloped tracts in the Shenandoah Valley. Stose and F. C. Schrader went on to make a detailed examination of the physiography and structure of the manganese-ore-bearing areas of eastern Tennessee in cooperation with the Tennessee Geological Survey. Stose also examined manganese deposits in Alabama, Schrader, the deposits in Georgia and North and South Carolina, and Miser mapped the geology of the Batesville area in Arkansas and estimated its manganese reserves. E. L. Jones, Jr., J. T. Pardee, and J. B. Umpleby made most of the manganese studies in the Western States.

Second to manganese in importance was chrome. J. S. Diller, long familiar with Pacific Coast geology, specialized in chromite, visiting the developed chromite deposits in California to determine their size and prospective output and also the chromite localities in Oregon and Wyoming. Eleanora Bliss examined the chromite deposits in Cecil County, Maryland, and the abandoned chromite mines and chromite-bearing serpentines of southeastern Pennsylvania. Tungsten was used in making high-speed-tool steels, and molybdenum and vanadium were sometimes used in place of tungsten. The United States had some of the richest deposits of molybdenum but the other metals were sought throughout the Western States. Tungsten, along with platinum and tin, were also sought in Alaska, where G. L. Harrington and J. B. Mertie began a systematic investigation of heavy placer minerals.

The fertilizer minerals in short supply were potash, nitrates, and pyrite and sulfur. The nitrates and materials for the production of sulfuric acid were in demand not only for fertilizers but in the manufacture of munitions. Reported nitrate occurrences in the Amargosa Desert of southeastern California were fully examined by Survey parties under L. F. Noble, G. R. Mansfield, F. C. Calkins, and Theodore Chapin. The search for pyrite took A. C. Spencer and E. S. Bastin to Maine, while G. R. Mansfield examined possible sulfur deposits in New Mexico, and E. S. Larsen, Jr., examined sulfur deposits in Nevada. On the possibility of obtaining sulfur in Alaska, A. G. Maddren investigated deposits on Unalaska and Akun Island in the Aleutians and near Stepovak Bay.

The desperate need for potash in the United States brought about a partial resolution of the long stalemate between House and Senate on the leasing of mineral lands. By the summer of 1917, the price of potash had gone up to $480 a ton. R. K. Bailey continued the Survey's search for potash, now in its seventh

Claude Hale Birdseye (1878–1941), Chief Topographic Engineer of the U.S. Geological Survey, 1919–1929; Chief of the Division of Printing and Engraving, 1932–1941. Birdseye, who joined the Survey in 1904, was Topographic Engineer in charge of the Rocky Mountain Division when he was commissioned a Captain in the Engineer Officers Reserve Corps in June 1917. He was promoted to Major before sailing for France in August as orienteur officer with the 1st Brigade of Coast Artillery, and promoted to Lieutenant Colonel in 1918 and assigned to the Office of Chief of Coast Artillery, A.E.F., in charge of artillery ranging and map information. Birdseye was a leading spirit in the development of photogrammetric methods of mapping and from 1929 to 1932 supervised the photogrammetric mapping of the site of Boulder Dam. He was one of the organizers and first president of the American Society of Photogrammetry, president of the Association of American Geographers, and also active in the American Association for the Advancement of Science. (Courtesy of the Library of Congress.)

year, in Texas and New Mexico but found no new deposits. Special investigations were also made of deposits of potash-rich silicates but these contained at best only small percentages of potash. Secretary Lane warned Congress that if action were not taken by the end of October 1917, potash would not be available for crops in 1918. The House and Senate then agreed on a bill, approved October 2, 1917, to encourage prospecting for potash on public lands, according to its title, but chiefly to open up to development the Searles Lake deposits which had been withdrawn in 1912. The Secretary of the Interior was authorized under terms of the act to issue permits to prospect on 2,560 acres of public lands for potash and to issue patents for 640 acres if potash were found and to lease the remaining acreage. Lands already withdrawn as potash lands were excluded from prospecting but immediately open to leasing. The President was authorized to regulate the price of the minerals and to restrict the use of the potassium to the United States.

To aid the production of petroleum, the Survey continued its geologic exploration of promising areas to find new sources of supply. Intensive studies were made in Oklahoma where leasing of Indian lands was planned. In March 1917, H. M. Robinson had been sent to investigate the lands proposed for leasing in Pontotoc and Hughes Counties, but during the summer of 1917, 20 geologists, including both Survey geologists who had been mapping in other areas and college professors who joined the Survey for the season, were assigned to map in the Osage Reservation. Maps were prepared by townships and a series of papers describing the geologic structure was planned, to be issued as rapidly as possible for the guidance of prospective lessees. In addition to the mapping in Oklahoma, A. E. Fath made a detailed examination of the Eldorado field and surrounding country in Kansas, and E. T. Hancock and Eugene Stebinger made a reconnaissance of the structure along the southwest front of the Black Hills and examined areas north of the Crow Indian Reservation and in Teton County, Montana. During the winter months of 1917-1918, L. W. Stephenson, O. B. Hopkins, and Sidney Powers began mapping in Texas.

Some of the Survey's basic research on the origin and accumulation of petroleum was continued until the press of war work forced its suspension. G. S. Rogers continued his investigation of salt domes in the Coastal Plain, and George Becker, who had been investigating capillarity and heat conduction and the part played by voids and interstitial spaces in rocks, devoted some time to the theory of the formation of salt domes. Both R. C. Wells and Chase Palmer continued for a time their studies of oil-field waters. In late winter, the work on salt domes was recessed and Rogers began a search for helium. Helium was particularly desirable for observation balloons because of its incombustibility and lightness. Early in the war, the British had made an unsuccessful search for this rare gas at home and in Canada. When the United States entered the war the project was revived, and after the Bureau of Mines had demonstrated the technologic feasibility of separating helium from other gases, the Survey was asked to locate the richest supplies and to estimate the quantity available.

While the Geologic Branch combed the United States for essential mineral resources, the Topographic Branch became to all intents and purposes part of the Army. By June 30, 60 of the Survey's topographic engineers had been commissioned, including the Chief Geographer, the Geographers-in-charge of three of the four divisions, and two of the three Inspectors of Topography. The branch organization took on a military flavor with Major Marshall in overall command, and Majors Herron and Gerdine in charge of the northeastern, eastern, southeastern, central, and southern "departments." G. R. Davis was left in charge of the western department where defense needs were less critical. At 66, topographer-artist J. H. Renshawe was too old for a commission but was nonetheless kept busy preparing relief maps, posters for the Navy, and color schemes for use in aerial photography. To carry on the routine phases of mapping, permission was obtained from the Civil Service Commission to appoint topographic field assistants without status in the classified service, and a training school was set up on July 1 to train the 75 candidates sent to Washington by engineering colleges throughout the country. The war gave considerable impetus to the development of photogrammetry. Newly commissioned Major J. W. Bagley, assisted by Alaskan geologists F. H. Moffit and J. B. Mertie, designed and constructed photographic cameras to be used in airplanes for mapmaking purposes. Sixteen engineer officers were trained in use of the instruments, and about 40 enlisted men assisted them in mapping airmail routes from Washington to New York and in other areas.

The Water Resources Branch, on the other hand, found its normal routine upset by having to undertake special investigations for which Congress had made appropriations. A major effort to examine and classify lands under the enlarged- and stock-raising homestead laws was begun. The Civil Service Commission had given a special examination and established a list of eligibles in the spring of 1917, a Division of Enlarged and Stock-Raising Homesteads was formed, under the direction of the Chief Hydraulic Engineer, the Division of Water Utilization was merged with it, and by the start of the new fiscal year field parties were being organized. Work began in the northern tier of States but as the field season advanced and the weather became unsettled, parties were transferred to the Southwest. Under instructions from Secretary Lane, field examinations were generally confined to lands for which applications had actually been made, and the Land Classification Branch was able to make the first designation of stock-raising lands on November 8, 1917.

A special appropriation had also been made for exploratory drilling for ground water for irrigation. After O. E. Meinzer and W. O. Clark had made a reconnaissance of a large part of east-central Nevada, Clark and C. W. Riddell made a detailed survey of Steptoe Valley, near Ely. Three wells were then drilled, two of which obtained large supplies of water within 100 feet of the surface.

The third special investigation was a survey of desert watering places, "to discover, develop, protect, and render more accessible for the benefit of the general public springs, streams, and water holes on arid public lands of the United States." This had been authorized on August 21, 1916, but no funds had been appropriated at that time. Because of the strategic importance of the area in southern California and southwestern Arizona, which was the driest, hottest, and least explored part of the desert and which included 350 miles of the Mexican boundary, regular Survey funds were used to supplement the special appropriation of $10,000 in the Sundry Civil Expenses Act so that the area could be surveyed in fiscal year 1918. Kirk Bryan, C. P. Ross, D. G. Thompson, and J. S. Brown, each accompanied by one nontechnical assistant, traveled by automobile carrying with them light-weight camping equipment and examined practically all the watering places in the region, erected signs at 305 sites, and made a general exploration of the geography, geology, and ground-water conditions. Their maps and data were made available to the Army Engineers for incorporation in the military map of the United States.

The Water Resources Branch also received cooperative funds from 22 States and the Territory of Hawaii in 1917, nearly all of it for studies of stream flow, and funds from other Federal organizations for studies of particular streams. Gaging stations were maintained in 40 States, Hawaii, and Alaska. A new laboratory for quality-of-water investigations was completed and the Quality of Water Division was organized on January 2, 1918, under the direction of A. A. Chambers.

When the United States entered the war in the spring of 1917, the situation in Europe had been pretty much of a standoff, and in the summer a negotiated peace even seemed possible as neither side seemed able to win a decision on the battlefield and both Allied and Central Power governments were becoming increasingly unstable. By the winter of 1917–1918, however, the picture had changed. The Russians had withdrawn from the war after the Bolshevik coup d'etat in November, and in December the Italian forces had been broken after a 2-month campaign. Allied war aims could be achieved only by military victory and victory would not easily be won for the Central Powers could leave only token forces on the Eastern and Italian Fronts and concentrate on a massive drive on the Western Front to force the decision there before American troops could arrive in strength.

President Wilson told Congress in the State-of-the-Union Message on December 3, 1917, that "in the present session of Congress our whole attention and energy should be concentrated on the vigorous, rapid, and successful prosecution of the great task of winning the war." Among the various measures needed, it was

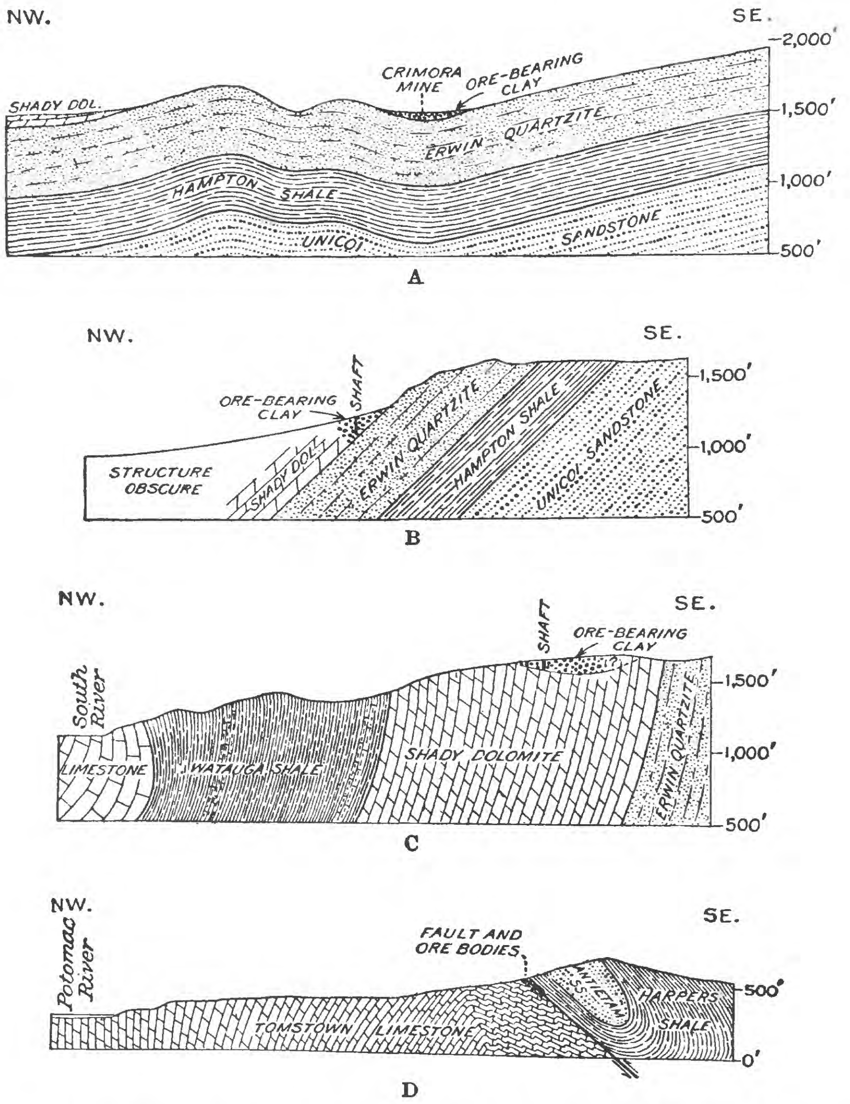
> **imperatively necessary that the consideration of the full use of the water power of the country and also the consideration of the systematic and yet economical development of such of the natural resources of the country as are still under the control of the federal government should be immediately resumed and affirmatively and constructively dealt with at the earliest possible moment.**

General leasing bills were then pending in both the Senate and the House. The Senate passed its bill early in January 1918. The House Committee on Public Lands, in what had become practically time-honored fashion, threw out everything after the enacting clause of the Senate bill, substituted its own bill, which was essentially the same as the House had passed in previous sessions, and the House then passed its bill. The conference committee was again unable to come to an agreement.

A draft of a comprehensive act to cover the development of water-power sites under Federal control was prepared by E. C. Finney, Chairman of the Board of Law Review of the Department of the Interior, George Otis Smith, N. C. Grover, Herman Stabler, and W. B. Heroy of the Geological Survey and O. C. Merrill of the Forest Service and filed early in December 1917 by Congressman Scott Ferris, Chairman of the House Public Lands Committee. The Senate put on its calendar a bill to regulate the construction of dams across navigable waters. In an effort to avoid the stalemate of previous sessions, President Wilson invited members of the committees involved to the White House and the House then established a Water Power Committee. However, no bills were passed.

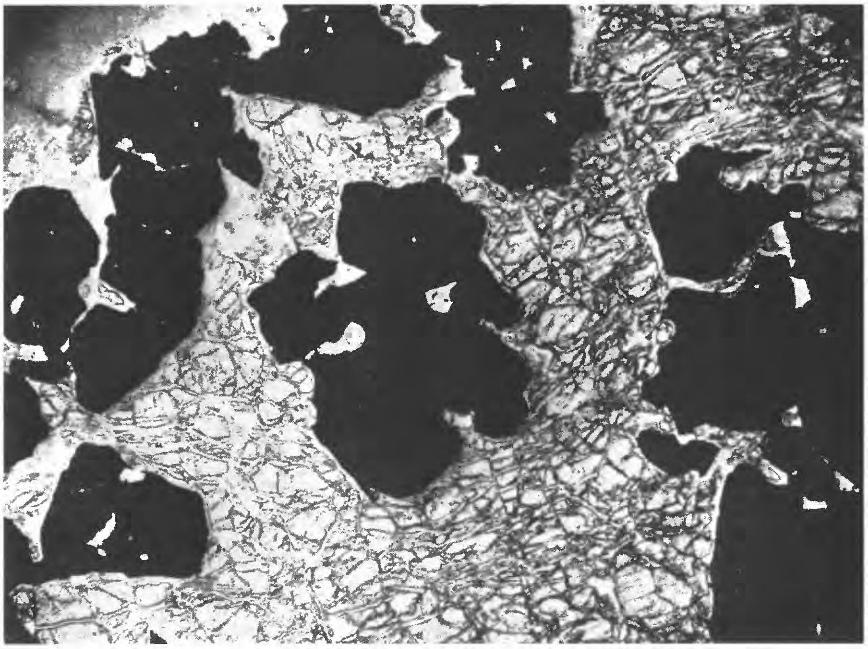
In January 1918, the Fuel Administration, which had at first been concerned only with coal, established an Oil Division to impose controls on production and marketing of petroleum. Mark Requa, a California petroleum engineer and a protégé of Herbert Hoover, was chosen to head the division, which was housed in some of the rooms in the Survey left vacant by the departure of topographers for the Army. Requa, like Hoover, was a firm believer in cooperation between business and Government rather than control of business by Government. One of his first actions was to ask for additional representation on the Committee on Oil Production of the War Industries Board, and Van H. Manning, Director of the Bureau of Mines, was appointed to represent the Department of the Interior. Requa made it clear that the Fuel Administration would encourage maximum production to meet war needs but would at the same time insist on the use of efficient conservation methods and the prevention of waste. Research to improve oil recovery, to which the Bureau of Mines had made notable contributions, was encouraged, but not scientific research to find more oil. For that, Requa favored tax reduction for oil producers.

As part of its war effort at home, the Survey made special field investigations and laboratory studies of the ores of metals used in manufacturing ferroalloys, pig iron, and steel. To test D. F. Hewett's hypothesis of the origin of the manganese deposits of northwestern Virginia, long the source of much of the manganese mined in the United States, a survey was made of a narrow belt on the east side of the Shenandoah Valley of Virginia. At least five different structural associations were recognized, and prospecting of six undeveloped tracts along the west front of the Blue Ridge was recommended. The illustration shows the vertical cross sections of four manganese mines in the region, representing four types of deposits. (From D. F. Hewett, G. W. Stose, F. J. Katz, and H. D. Miser, 1918.)



Although the supply of coal was ample, the transport of coal had become so snarled by January 1918 that Fuel Administrator Garfield shut down every industrial plant, except those producing food, east of the Mississippi for a period of 5 days, and then for 9 consecutive Mondays. On April 1, 1918, the Fuel Administration and the Railroad Administration jointly established a zoning system to control the distribution of coal by restricting the movement of bituminous coal to markets in territory near the mines. The "zones"—or areas within which there was both a coal-producing field and a coal-consuming market—were delineated by the Fuel Administrator and the Director-General of Railroads from information provided by the Geological Survey. The size of each zone was determined by the ability of the particular field to produce and supply the market, the shape and location of the zone were determined by the available transportation. Consideration of the questions connected with the zoning system led G. H. Ashley to study the classification of coals in general and to prepare a detailed and comprehensive scheme of classification by use that was presented for discussion at the September 1919 meeting of the American Institute of Mining Engineers.

The Fuel Administration also began an investigation of water-power resources in an effort to conserve mineral fuel supplies. As it had no field engineers of its own, it made a cooperative agreement with the Survey in the spring



Chromite was produced in quantity in the United States only in California before the war, although it was also known in Oregon; most of the chromite used in steelmaking had been imported from New Caledonia and Rhodesia. The demand for domestic chromite increased during the war because of the embargoes on shipping, a great advance in cost, and the uncertainty of ocean traffic. J. S. Diller, the chromium specialist in the Survey's Division of Mineral Resources, noted that numerous areas of peridotite and serpentine in the Klamath Mountains of California and Oregon contain grains of chromite scattered throughout as well as segregated in bodies of commercial interest. Chromite begins to crystallize before the silicates; in the photomicrograph of chrome ore from a mine in Shasta County, California, the silicates (the light areas) fill the spaces left by the more rapidly crystallizing chromite grains (the dark areas.) (From J. S. Diller, 1921.)

of 1918 whereby Survey engineers would be detailed to the Fuel Administration to investigate specific problems. Then on June 1, 1918, the Survey set up a Division of Power Resources in the Water Resources Branch to carry out these engineering investigations and also, like its counterpart in the Geologic Branch, to make statistical investigations of power resources. W. B. Heroy was transferred from the Land Classification Branch to take charge of the new division. The engineering investigations undertaken by the division went beyond such traditional Water Resources Branch activities as investigations of facilities for water storage and use of stored water for the production of power by hydroelectric plants to the feasibility of financing and constructing such plants and obtaining licenses for the purchase of construction materials and generating equipment. Studies were also made of power shortages affecting the production of war necessities, economies to be gained by the interconnection of electric power stations, and the installation of additional generating equipment in power plants.

The War Minerals Committee had early come to the conclusion that something similar to the Fuel Administration was needed for coordination and control of the various demands on the mineral industry. The committee first planned to establish controls for manganese and pyrite, but on the advice of Herbert Hoover, they proposed a single agency to control all minerals and prepared legislation, modeled on the Lever Act, that would extend its provisions to the mineral industry except fuels, already under the Fuel Administration, and industries whose materials came from the mineral industry. Before the legislation could be introduced, however, the acute shipping crisis that developed as the end of 1917 approached forced other actions. The loss of American ships to German submarines, the demand for ships for military supplies, and the impending demand for troop transports was greater than American shipbuilders could meet. It became imperative that the Shipping Board divert available shipping tonnage from commercial to military use and use the remaining commercial tonnage as efficiently as possible for war commodities, so the board set up a Division of Planning and Statistics to formulate the program for reducing imports.

Mineral imports presented a special problem in import reduction for some minerals were clearly needed for production of war materials. In December

1917, an informal joint committee of representatives of the Geological Survey's Division of Mineral Resources and the War Trade, War Industries, and Shipping Boards was arranged, under the chairmanship of E. S. Bastin, to systematize and coordinate more fully the exchange of information on mineral resources. Early in January 1918, the head of the Shipping Board's Division of Planning and Statistics called C. K. Leith, Professor of Geology at the University of Wisconsin, to take charge of investigating the possibilities of mineral embargoes. The Shipping Board believed that the situation required the immediate organization of a large professional staff, but Leith, who knew both the Survey and the Bureau of Mines, decided instead to confine his organization to a small committee and use the resources of existing agencies. A Committee on Mineral Imports and Exports was formally organized in late February with Leith as Chairman, and J. E. Spurr of the Shipping Board and Pope Yeatman of the War Industries Board as members. At about the same time, the informal joint committee chaired by Bastin was replaced by a Joint Information Board on Minerals and Derivatives to which 20 Federal departments, bureaus, or divisions of the war boards concerned in one way or another with mineral problems sent delegates. Yeatman served as chairman and Bastin as executive secretary of the new board, which met weekly to exchange information leading to better coordination and the elimination of duplication in mineral investigations.

The Leith committee obtained much of the data it needed—such as estimated imports for 1918 to meet probable needs, the proportion of estimated imports that might be eliminated by the development and substitution of domestic supplies, the principal districts or changes in mining or metallurgical practice through which such development could be achieved, and the extent to which this development could be left to private initiative—from the War Minerals Committee and the Geological Survey and Bureau of Mines. From time to time, technical assistants were taken on to meet special problems but the committee relied heavily on E. C. Harder, E. S. Bastin, D. F. Hewett, and other members of the Survey whose services were available to them through a cooperative agreement. In its work, the committee had to weigh the requirements of the Shipping Board, the War Trade Board, the War Industries Board, and the possible sources of supply, and then prepare reports on various commodities in which they indicated the nature, location and amount of domestic and foreign supplies, the overseas movements, and the war requirements and recommended either a reduction of overseas shipments by

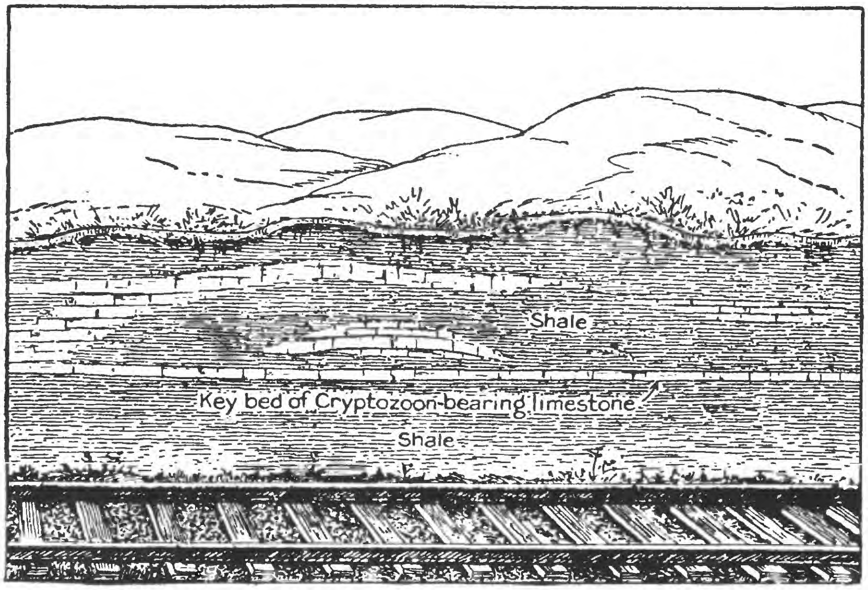
As nitrates were essential to the production of explosives, the war made it imperative that all possible sources of domestic nitrates be developed in case of cutoffs of supplies imported from Chile. Survey geologists made a special investigation of the nitrates associated with other water-soluble salts in the soil layers covering certain clay formations in the arid portions of Southwestern United States, especially those along the Amargosa River near the boundary between Inyo and San Bernardino Counties in California. Extractable amounts of sodium nitrate were found but the salts were regarded as not of immediate practical importance because of the relatively high cost of collecting and extracting the nitrate in commercial form. The photograph shows a geologist testing a sample of nitrate with a portable field outfit. (From L. F. Noble, G. R. Mansfield, and others, 1922.)

specified amounts from certain localities or the maintenance or increase of overseas shipments. The information thus assembled afforded for the first time something in the nature of a general survey of the world distribution and use of mineral resources.

The Leith committee had only a short life. The fragmentation of authority led to problems with the War Industries Board, which was responsible for domestic production and therefore sometimes countermanded the decisions based on scientific advice. In protest, Leith and Spurr resigned, and on June 7, 1918, the Committee on Mineral Imports and Exports went out of existence. Leith became Mineral Advisor to the War Industries Board and Spurr joined the Bureau of Mines to take charge of its war minerals program. Leith retained his office in the Interior Building and continued the work as a function of the War Industries Board.

In July 1918, the Geological Survey then set up a section of cooperation in the Division of Mineral Resources specifically to supply information on mineral matters to other Government departments, particularly the military establishments and the war boards. E. S. Bastin was in charge of the section but a large share of the work was directed by F. J. Katz because Bastin was also assigned by the Survey as mineral adviser to the Bureau of Research of the War Trade Board. Weekly statistics of the production of copper, lead, zinc, and aluminum were furnished for the guidance of Government purchasing agencies, and a system of monthly reports on the availability of mineral raw materials of chief war importance was established.

During the winter and spring of 1917–1918, the War Minerals Committee had devoted much of its energy to the mineral controls bill, seeking the support of the national mining, metallurgical, and geological societies, the various Government departments, and the President, and modifying the bill to meet the views of those concerned. Major metals such as iron, copper, lead, and zinc, and the precious metals, gold and silver, were dropped from the bill in order to gain industry support, and the bill became a minor minerals bill covering "the following named mineral substances and ores, minerals, intermediate metallurgical products, metals, alloys, and chemical compounds thereof, to wit: Antimony, arsenic, ball clay, bismuth, bromine, cerium, chalk, chromium, cobalt, corundum, emery, fluorspar, ferro-silicon, fullers earth, graphite, grinding pebbles, iridium, kaolin, magnesite, manganese, mercury, mica, molybdenum, osmium, sea salt, platinum, palladium, paper clay,

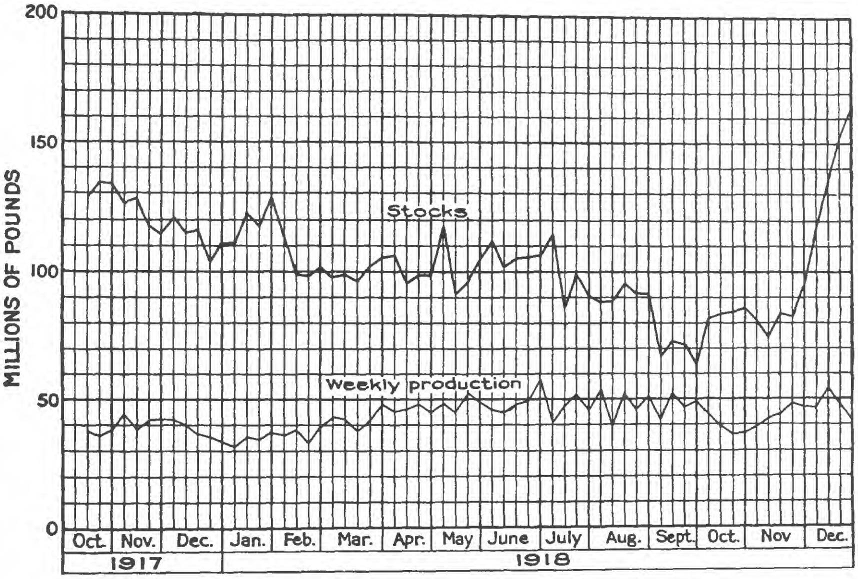


The Survey concentrated its oil-field investigations in the most promising undeveloped territory, beginning with the Osage Indian Reservation in Oklahoma which contained a large area of unleased lands. Productivity of developed fields there was high and pipelines and refineries were available, but bidders had little or no geologic information to guide them in evaluating new lease offerings. Survey geologists found that a limestone only 1 to 3 feet thick that could be distinguished by its lack of invertebrate fossils and the present of "*Cryptozoon*" (fossil remains of organisms whose nature had not been precisely determined), was remarkably continuous throughout the area and of great value in determining the structure. (From K. C. Heald, 1922.)

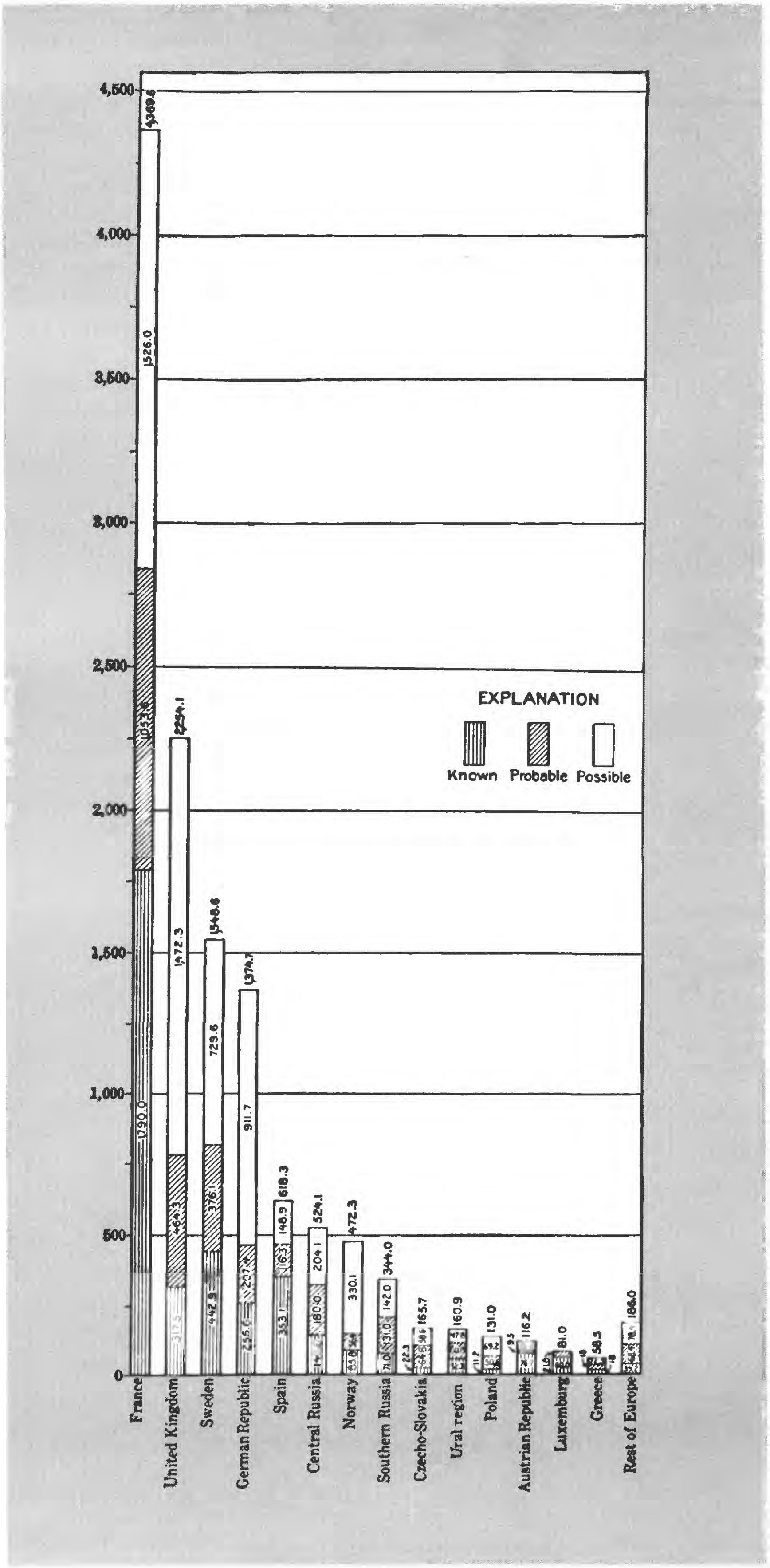
potassium, pyrites, radium, sulphur, thorium, tin, titanium, tungsten, uranium, vanadium, zirconium, and of other rare or unusual elements the supply of which may, in the judgment of the President, be inadequate for war and industrial needs.'' The bill made it unlawful to waste or hoard these substances, to make unreasonable charges for them, or to limit facilities for production or transportation of them. It authorized the fixing of prices and provided $50 million for stimulation of domestic production. The bill was introduced in the House on April 6, 1918, after preliminary hearings before the Committee on Mines and Mining at which Secretary of the Interior Lane, Director of the Geological Survey Smith, Director of the Bureau of Mines Manning, Chairman of the War Industries Board Baruch, and C. K. Leith all urged passage of the bill. The House passed the bill on April 30 and sent it to the Senate, where it became bogged down in committee.

Even before the war-minerals bill was submitted to Congress, the Survey had begun investigating minerals for peace. When President Wilson set forth his 14 points for peace on January 8, 1918, one was the removal of economic barriers and the establishment of equality of trade. At the request of the Secretary of State, the Survey, with the cooperation of the Bureau of Mines, prepared a preliminary statement in atlas form of the mineral production of the world. Work was then begun on a study of the distribution of the world's reserves of essential minerals with the specific aim of furnishing the American representatives at the Peace Conference with the economic data needed. The study was intended to serve two general purposes: to obtain a clear understanding of the relations between American war needs and foreign sources of supply from which these needs must or could be met; and to obtain an understanding of the bearing of mineral resources on the origin and conduct of the war and on political and commercial readjustments that would follow the end of hostilities. Adolph Knopf, A. C. Spencer, H. G. Ferguson, S. R. Capps, Max Roesler, Eugene Stebinger, Eleanor Bliss, and Doska Monical were all engaged in this work. Most of the information was obtained from published sources but American mining engineers and geologists also contributed some unpublished data. In June 1918, a small allotment of funds from The Inquiry made it possible to employ additional assistance, and a world atlas showing the production of the more important mineral commodities was completed as well as atlases showing the mineral reserves of Europe and South America.

In the spring of 1918, the Survey extended its search for war minerals to the Caribbean and Latin America, sending E. F. Burchard to Cuba, H. G.



Statistical information on the mineral production of the country, which the Geological Survey had compiled since 1882, proved invaluable during the war. When the war began in 1914, the Survey furnished the public with much information about the raw materials needed to fill war orders from Europe; when the United States entered the war in 1917, the Survey was called on to assist the War and Navy Departments and the various war boards. The graph shows the weekly production and stocks of refined copper from October 1917 to December 1918. The shortage and inefficiency of labor and the difficulties of transportation during 1918 resulted in unprecedented stocks of copper at the end of the year. (From B. S. Butler, 1921.)



The Survey began a study of the location and extent of foreign mineral deposits as part of a comprehensive survey of the world's mineral wealth for the guidance of the American Commission to Negotiate Peace and continued this work after the war as an aid to American foreign trade and a guide to rational development of domestic resources. The comparative chart shows the estimated known, probable, possible, and total amounts of iron in iron-ore deposits of several countries of Europe, compiled by Max Roesler from literature printed in many languages and much of it in obscure publications. (From Max Roesler, 1921.)

Ferguson to the Dominican Republic, and Max Roesler to Puerto Rico. H. S. Gale was detailed to the Office of the Chief of Engineers and sent to Guatemala to study the occurrence and manufacture of potassium nitrate. He also investigated the potash minerals in Chile.

At home, Survey geologists began a search for other minor minerals that had become important in the war effort. R. W. Stone examined the magnesite deposits of California and Stephens County, Washington, G. F. Loughlin examined a large quartz deposit in Connecticut to determine its suitability for the manufacture of optical glass, and W. T. Schaller sought new deposits of high-grade sheet mica and zircon. Heinrich Ries examined several clay-bearing localities in North Carolina in search of high-grade clays that could be used as substitutes for imported clays, and F. L. Ransome surveyed quicksilver deposits in California, Nevada, Oregon, and Texas. One of the more unusual searches took G. F. Loughlin to Arizona and New Mexico to examine volcanic cinder cones as a possible source of porous rock suitable for a lightweight aggregate in concrete.

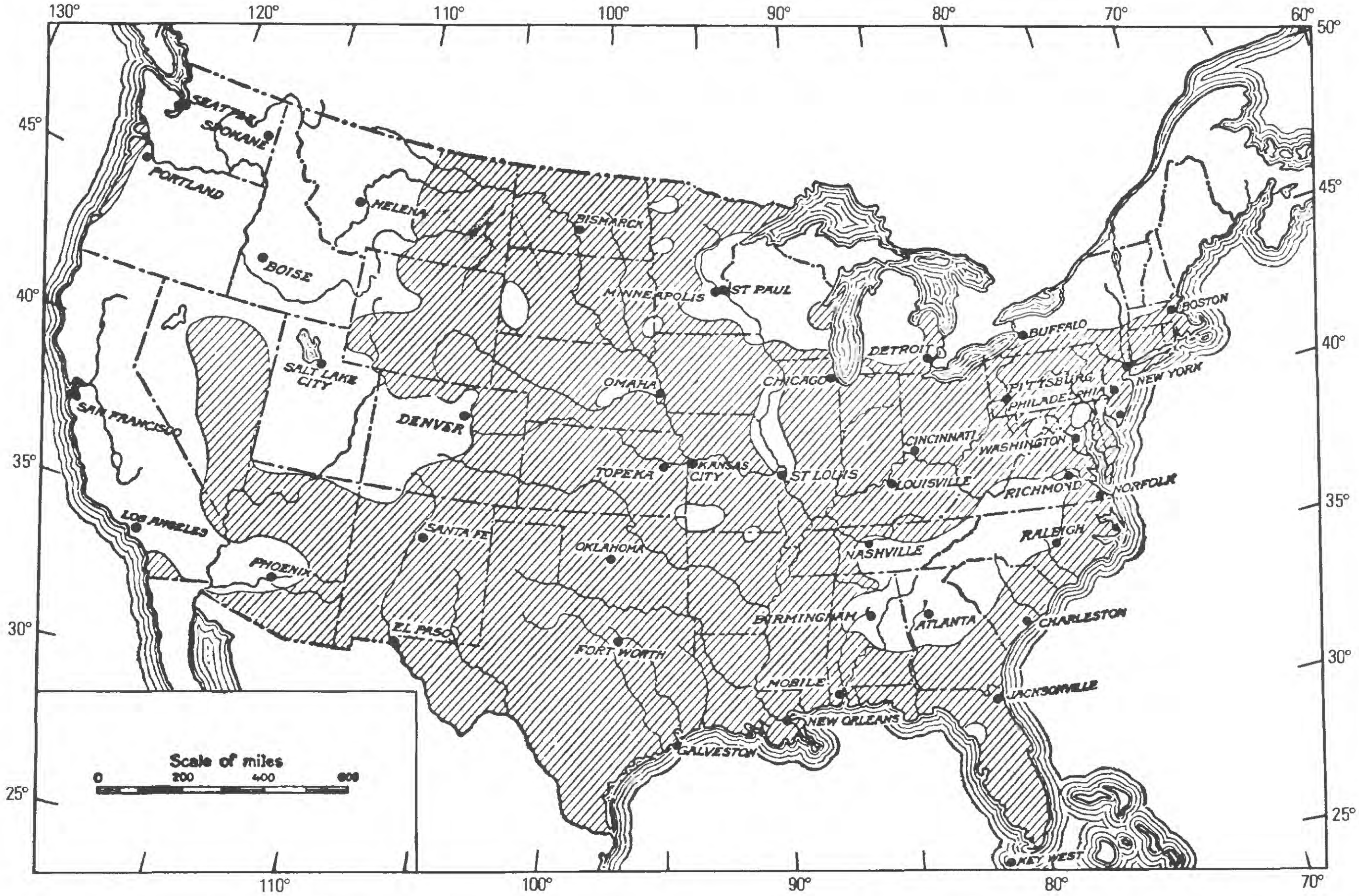
The Survey also continued its field investigations of potential oil regions. Once the reports were completed on the mapping of structures in the Osage Reservation in Oklahoma, W. A. English and W. S. W. Kew went back to California, A. J. Collier and Harvey Bassler began an examination of the stratigraphy, structure, and oil prospects in the Wind River Basin, Wyoming, G. B. Richardson went back to Pennsylvania, and W. E. Emery began compilation of a bulletin on the oil prospects in the undeveloped regions of the public-land States. Oil-shale investigations were extended as well. D. E. Winchester mapped the deposits in Battlement Mesa and an area near Grand Valley, Colorado, J. P. Buwalda examined deposits in Trout Creek, Utah, and D. D. Condit and Frank Reeves sampled the oil shales in several parts of Utah for distillation tests. The Survey also cooperated with the Bureau of Internal Revenue in the compilation of production of oil and gas fields, calculation of rates of depletion, and formulation of rules to govern the application of income-tax laws to the depletion of oil- and gas-field properties. Some of the basic studies of A. F. Melcher on the porosity of oil sands were used in this work.

By the summer of 1918, the campaign for domestic production of war minerals and the efforts toward conservation and economy in use of these materials had been proven effective. By late summer, the market for chromite was oversupplied, because of the increased importations authorized by the War Industries Board, and the market for manganese, pyrite, and sulfur was described as easy. Gold, however, had become one of the minerals in short supply. In July, Secretary Lane appointed a committee of Hennen Jennings, J. H. Mackenzie, and Charles Janin of the Bureau of Mines and H. D. McCaskey and F. L. Ransome of the Survey to study the rapidly increasing cost of producing gold and the declining output. The price of gold was then fixed at $20.67 an ounce and its purchasing power had been steadily declining as commodity prices increased. The United States held more than $3 billion in gold reserves, but it had contracted debts on a gold basis many times the prewar level, and maintenance of a sufficient gold reserve was considered essential to the security of national finance and credit. The committee found a cause-and-effect relationship between rising cost and declining output although the depletion of certain deposits and the lower grade of ore being mined in others were contributing factors. The committee recommended tax reduction and similar incentives to increase production and suggested forbidding the use of gold in manufactures and an appeal to turn in gold as a patriotic measure in order to maintain a visible gold reserve. Thought was given to adding gold to the list of minerals in the mineral-control bill, but the Senate, after some prodding by Secretary Lane and others, had finally passed the bill before the recommendation could be made.

When the mineral-control bill was finally approved on October 5, 1918, the war was nearly over. Massive convoys carrying American troops began sailing from Atlantic ports for Europe in March, as Germany launched the expected campaign to defeat the Allies on the Western Front before the Americans could arrive in force. By the end of May, the Germans were within 50 miles of Paris, but almost a half million American troops had arrived. The German advance was stopped at Chateau Thierry on June 4 as American forces collaborated with the French in their first major action. In July, the Germans launched an offensive to crack the last Allied line and open the road to Paris, but a million American soldiers and marines were then in France. The German offensive was stopped, and an American and French counterattack turned the tide of war. American and British troops began a pincer movement on the Western Front, to capture a strategic railroad line and force German evacuation of the Briey and Longwy iron fields. At the end of September, the Bulgarians yielded and the Turkish regime collapsed and asked for an armistice. On October 4, the Germans and Austrians jointly appealed for an armistice. The armistice was finally concluded and at 11 a.m. on November 11, 1918, hostilities ceased on the Western Front.

When the armistice was concluded, 66 topographic engineers and 4 geologists from the Geological Survey were serving as officers in the American Expeditionary forces overseas; others had been selected for overseas duty and were awaiting embarkation orders; and many more were serving in lower ranks. Most of the topographic engineers were in the 29th Engineers, which had its headquarters at Langres, Haute Marne, where a Base Printing Plant was set up under the direction of Major (later Lt. Colonel) Glenn Smith. At Camp Devens, Massachusetts, Major Frank Sutton organized the companies for surveying, mapping, and printing work to be performed overseas, and Company A arrived in France on December 3, 1917. In addition to those assigned to the Engineers, 13 Survey topographic engineers were selected as orienteur officers in the Coast Artillery and sailed for France in July 1917 under the command of Major (later Lt. Colonel) C. H. Birdseye. Birdseye was eventually put in charge of artillery ranging and map information for the A.E.F. and produced several manuals for use of the War Department. The others served as orienteur officers in the field and also instructed artillery officers in the use of surveying instruments and computations. Major (later Lt. Colonel) A. H. Brooks was Chief Geologist of the A.E.F. Under his direction, American geologists prepared geologic maps, based in part on earlier French reports and in part on new observations, with practical descriptions of formations from the military point of view so that the army engineers could tell which formations were filled with water, which were dry and suitable for dugouts, which would support vertical trench walls for a long time and which would require timbering, and which would yield road metal and other construction materials. Water-supply maps were also prepared, showing depth to ground water, existing wells, springs, and similar information. The early work proved so useful that in July 1918, plans were approved for providing five geologic officers for each army, two officers for work in communications, and a headquarters staff of six officers. The war ended, however, before the full complement was realized.

Literally within hours after the armistice on November 11, 1918, the Federal Government began to withdraw from its wartime activities to resume the pursuits of peace. The Minerals Control Act was never put into effect. Both the War Industries Board and the Department of the Interior had claimed administration of the act, but when an Executive order was issued on November 11 directing the Secretary of the Interior to exercise the power and authority given under the act to the President, except those related to duties on imports, it was no longer necessary to stimulate production to meet war requirements. The War Industries Board certified that the only war minerals in short supply at



The scarcity of fuel and labor during the war emphasized the need for serious consideration of the sources of the Nation's energy. Comprehensive information on the locations and relations of existing power plants and the possibility of improving their interconnections was lacking and so the Geological Survey collected the information on behalf of the Fuel Administration and the War Industries Board. Fully 80 percent of the power then generated in the United States for manufacturing and for operating public utilities was obtained from fuels although water power had unquestionably influenced the location of many industries and the establishment of many centers of population. The shaded areas of the map show where the greater part of the power in 1918 was derived from fuels, the unshaded areas, where the greater part of the power was derived from water. (From W. B. Heroy, 1919.)

the time were potash, zircon, and arsenic. The most pressing problem was one of overproduction of some minerals, which did not fall under the terms of the Minerals Control Act. The Joint Information Board formally went out of existence on January 1, 1919, and its records were deposited with the Division of Mineral Resources of the Geological Survey. The work of the Fuel Administration was gradually curtailed, and formal cooperation with the Geological Survey ceased shortly after January 1, 1919.

The Geological Survey too began an immediate return to its regular program of work, a process made easier by the fact that its organization had not been changed but simply adapted to the emergency needs. The Topographic Branch continued to map areas selected by the War Department for special military surveys for a short time, but several States made cooperative funds available with the understanding that matching Federal funds would be provided later, and civilian mapping was resumed. The Land Classification and Water Resources Branches again took up projects delayed by the war as soon as those who had been in active service returned. In the Geologic Branch, except for the Division of Mineral Resources, wartime projects were completed as soon as possible, economic and military results summarized, and scientific observations and discoveries that were byproducts of war organized and recorded so that long-term research projects could be resumed.

The war had given new meaning to the work of the Division of Mineral Resources. The Survey's first Director, Clarence King, had considered the collection of mineral statistics an essential part of economic geology, but the value of mineral statistics was perhaps appreciated fully for the first time during the war years when it became necessary to cope with shortages. The United States was unusually well endowed with mineral resources but not even the United States was completely self-sustaining in its mineral requirements, and the war's interference with commerce had cut off sources of supply of essential minerals just as industrial expansion was multiplying demands. During the war, adequate supply was considered more desirable than low price and industry was willing to pay a premium for an uninterrupted supply; the advantage of domestic independence in minerals, however, became apparent. By the time the war ended, it was realized that achievement of national independence required a careful consideration of emergency factors and the possibility of insuring supplies. At the same time, international cooperation was widely held to offer the best hope for the world's future. International agreements for the allocation of minerals had been made during the war to insure the proper proportion of supplies to the different countries for the most effective prosecution of the war, and many believed that some form of international control of minerals should be developed as a means of furthering the aim of world peace.

Mineral statistics were expected to play a part in the Paris Peace Conference. President Wilson designated the Central Bureau of Planning and Statistics as the official source of economic data for the American delegation to the conference, and C. K. Leith was invited to serve as the mineral representative. In Paris, Leith was concerned with the readjustment of the international mineral trade to new conditions, determination of damages on mineral properties in the war zone, valuation of mineral resources of the Central Powers and their colonies as a possible basis for reparations, collection and correlation of mineral resource data in connection with drawing of new political boundaries, and the consideration of mineral resources in relation to future international arrangements. The data collected by the Committee on Mineral Imports and Exports was the basis for many of the discussions of international economic cooperation, but, in the end, the Peace Conference did not consider the matter.

In the immediate postwar euphoria, the Survey's Division of Mineral Resources was reorganized to reflect this more optimistic view of the world. E. S. Bastin succeeded H. D. McCaskey, who retired for reasons of health as soon as the war ended, as head of the division. Bastin was also designated to represent the Survey on the Economic Liaison Committee organized, under the auspices of the foreign trade advisers of the Department of State, to bring the expert knowledge of specialists in various Government agencies to bear on foreign trade problems, and he also served as chairman of the subcommittee on mineral raw materials. The Section of Cooperation, which Bastin had previously headed, was discontinued, but a new Section of Foreign Mineral Deposits was established with J. B. Umpleby in charge. G. F. Loughlin took McCaskey's place as geologist-in-charge of the Metals Section. The reorganization also recognized the new importance of energy minerals. The Nonmetals Section was divided, and C. E. Lesher took responsibility for a new Section of Mineral Fuels while R. W. Stone took responsibility for all other nonmetals.

The idea of international cooperation had already been extended to scientific research in the Executive order of May 11, 1918, which made the National Research Council a permanent part of the National Academy of Sciences. The Council was "in general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare" and also to survey the "larger possibilities of science." The general lines of the permanent organization were drawn up shortly after the armistice and approved by the National Academy of Sciences on February 11, 1919. Plans were then made for a conference in Brussels in the summer of 1919 to complete the organization of an International Research Council and to form international unions, affiliated with the Council, to represent the individual sciences.

In the spring of 1919, the Geological Survey itself embarked on a program of international cooperation. In 1917, Rear Admiral H. S. Knappen, head of the U.S. military government in Santo Domingo, had requested information on the cost of necessary basic surveys, and in reply the Director had supplied that information and promised the Survey would undertake the work after the war ended. In March 1919, therefore, Glenn Smith and T. W. Vaughan visited the island to plan the surveys, and D. D. Condit, C. W. Cooke, and C. P. Ross, who had accompanied Vaughan, remained there for 3 months to make a general geologic reconnaissance of the country except the peninsula south of Samaná Bay. Other Latin American countries had also become interested in geologic work because of the war minerals investigations, so Vaughan and Smith also visited Haiti, at the request of Haitian officials, and made arrangements for a preliminary geologic and topographic survey of Haiti under the general supervision of the U.S. Geological Survey. The Cuban Government also asked for and was assured of the Survey's cooperation in a topographic and geologic survey of that island. A Division of West Indian Surveys was established in the Topographic Branch on July 1, 1919, to administer and execute such topographic surveys in the West Indies and other Latin American countries as the Survey might undertake. Glenn Smith was named Topographic Engineer-in-Charge, to act as personal representative of the Director and Chief Geographer and assume responsibility for all matters except those that affected general policy. Members of the Survey assigned to the work were furloughed from the Survey and paid by the Latin American governments, but the division was nonetheless regarded as an integral part of the Topographic Branch. The Geologic Branch assigned responsibility for its part of the program to the Coastal Plain Section.

Before long, however, domestic problems became more important than international cooperation. Among the mineral fuels, the chief concern was then with petroleum. Petroleum production had fallen short of consumption in 1918, and petroleum had to be drawn from storage and also imported to meet the demand. Mark Requa, Van H. Manning, and George Otis Smith addressed a joint letter of gloom to Fuel Administrator Garfield on Feburary 28, 1919. Careful calculations, they said, indicated that probably 40 percent of the available oil in the United States had already been exhausted. Production in the United States was becoming increasingly difficult because of the much greater depth to which wells had to be drilled to obtain oil. The cost of producing oil from oil shale was still too great for it to be a commercially feasible process. They therefore urged that American interests be encouraged to acquire foreign sources of supply, although they noted that American oil companies were seriously handicapped in their ability to compete throughout the world with the Shell-Royal Dutch combine. Requa, Manning, and Smith also urged that the Federal Government take action to make foreign control of American oil companies impossible.

The Fuel Administration was then being phased out of existence and was not in a position to propose legislation. In March 1919, however, the American Petroleum Institute was formed to facilitate cooperation within the oil industry and between the oil industry and Government. Requa, who became one of the directors of the new institute, urged it to embrace the cause of conservation and to raise the level of technical efficiency, not only to conserve the petroleum supply but for increased profits. API promptly announced plans to collect statistics and data on new processes and trends, to foster marketing of petroleum products, and to further the development of foreign oil sources and markets.

The Chief Geologist of the Survey, David White, had a different view. In March 1919, he told the American Association of Petroleum Geologists that the Survey estimated that as of January 1 there were 6.74 billion barrels of oil still in the ground. This was actually a small amount in relation to prospective consumption, so "the search for new oil fields is a necessity, rather than a mere duty, and * * * the search must be carried wherever new fields may be found." Consumption was bound to rise, for

> **our civilization, our social and industrial life is based on a prodigal use of petroleum. Extravagance in oil has become a fixed habit, and we are still inventing uses for gasoline and oil fuel.**

The United States, White said, had become complacent because for many years it had been producing more than 60 percent of the world's supply of petroleum, but he asked

> **Are we able to do that because we still have sixty percent of the world's reserves in the ground in the United States, or are we in order to produce sixty percent of the world's supply, exhausting our reserves more rapidly than other nations and so hastening the day when, instead of dominating the petroleum market, we will be the greatest purchaser or beggar for petroleum in the world.**

He conceded that American oil companies would do well to acquire foreign reserves but held that responsibility for finding undiscovered domestic fields came first, and finding them with skill and the least waste, rested on petroleum geologists in both the Survey and industry.

The metals industries were more concerned with oversupply of metals and called for enactment of measures ranging from financial assistance to mineral embargoes. As soon as it was announced that Secretary Lane had been appointed administrator under the Minerals Control Act, Washington was flooded with telegrams and letters urging the Government to support the market by purchasing chromite, manganese, and pyrite at the market price. Such action was not part of the act and by mid-December it was concluded that such action could be taken only if Congress were asked to authorize the application of the Minerals Control Act to the postwar problem. Instead, Congress passed new legislation and appropriated $8,000,000 for the Department of the Interior to pay relief claims. Secretary Lane appointed a commission of three, former Senator John Shafroth of Colorado, Dr. Martin Foster, former chairman of the House Committee on Mines and Mining, and Philip N. Moore, former president of the American Institute of Mining and Metallurgical Engineers, to pass on the claims, and the Bureau of Mines organized an investigative force to obtain the data on which the commission would base its decisions. In this endeavor, the Survey's role was simply one of supplying information.

Domestic concerns in 1919 went beyond the need for raw materials. The war had called attention to the defenseless condition of much of the country's border areas where the Army had no maps upon which to base campaigns. Industrial development, land reclamation, power-generation projects, and highway construction were also creating a demand for topographic data. The Engineers, Architects, and Constructors Conference on National Public Works, which met in Chicago in April 1919, recognized the great importance of adequate maps for the economical planning and construction of a large proportion of engineering works and adopted a resolution urging the President and the Congress to make adequate provision for the entire work of completing the topographic map of the United States in the shortest possible time compatible with requisite accuracy. Nearly 60 percent of the country was then still totally unmapped, and much of the area mapped was in need of resurvey. If these maps were to serve their full purpose, the Survey pointed out, the whole country should be mapped within a generation, or better within a decade. The cost of such a program was estimated as $40 million. To accomplish the work within the time desired, however, would involve more than the appropriation of that sum. It would be necessary to build up an organization of specially trained engineers to do the work. Active cooperation by the States was to be expected, so it was suggested that by gradually increasing appropriations, from $700,000 for the field season of 1919 to a maximum of $4.5 million in 1928, the field surveys could be made economically and effectively and the work completed by 1932.

Demands for water data also increased in 1919: water for power and water for use in industrial processes because of the increased industrial activity, water for municipalities as the Nation became more urban, as well as the long-standing demand for water for agricultural use.

Americans in the spring of 1919 were also concerned about inflation, recession, and revolution. From the beginning of the war in Europe to the armistice, prices had increased 50 percent, and, after a brief halt, they were again on the rise. Business activity had slowed with the end of the war. There were race riots and strikes, and before long an almost panic fear of a Communist revolution began to develop.

The new Congress was called into special session on May 19, 1919, because the 65th Congress had expired on March 4 without passing all the appropriations bills. President Wilson was still in France at the Peace Conference and his message stressed the need for appropriations and otherwise dealt only with the problems of labor. The new Congress, however, was controlled by the Republicans and was much more oriented toward the business-industrial-engineering complex. It was also very economy minded. Survey appropriations had been cut, rather than increased, during the war years. A small amount was taken from several items because the Interior Department would be responsible for maintenance of the new building and the Geological Survey would no longer have to pay the elevator operators, but large amounts were cut from the appropriations for topographic surveys, Alaskan mineral resources, and engraving, printing, and binding Survey reports because most of the Topographic Branch personnel were in the service, because investigations in Alaska were not believed to be directly connected with the war, and because report writing had been put aside for the duration of the war. The Survey had naturally hoped for an increased appropriation, or at least the restoration of items cut because of the war. When the appropriations bill for fiscal year 1920 was passed, however, although the cost of everything from paper clips to field vehicles had increased, the prewar level of these appropriations was not restored, and only the appropriation for preparation of the report of mineral resources was increased over the 1918 level. When Congressman Marvin Jones of Texas questioned the size of the appropriation for geologic surveys, because the Survey had said it had insufficient funds to undertake the many investigations desired in oil regions, Congressman James Good of Iowa, the new Republican chairman of the Appropriations Committee, dismissed the inquiry with the remark that these bureaus always asked for more than they expected to get. His Democratic colleague, T. U. Sisson of Mississippi, added that because the Geological Survey had helped win the war it was anxious to get a large appropriation but the committee just did not give them all that they asked.

Without additional funds, Survey programs had to be cut below prewar levels, and here the Geologic Branch experienced the greatest difficulties. The Topographic and Water Resources Branches were able to carry on substantial programs because funds were received from outside sources. The War Department supplied $260,000 for mapping for military needs, and 21 States and the Territory of Hawaii supplied an additional $190,000 in cooperative funds, to bring the total for topographic mapping to more than $750,000. For water-resources investigations, total funds were well over $500,000, divided almost equally among the direct appropriation, the appropriation for examination of lands under the Stockraising Homestead Act, and cooperative funds from States. Very little additional funding, however, was available for geologic work.

A massive loss of personnel after the end of the war made it difficult for the Survey to conduct a rational program, and here too the Geologic Branch was most seriously affected. Federal salaries were then much lower than those in industry. To compensate for the increased cost of living during the war, Congress had authorized a temporary increase of salaries in 1917 for employees at the lower end of the salary scale: 10 percent to those whose salaries were less than $1,200 a year and 5 percent to those with salaries between $1,200 and $1,800. In 1918, the temporary increase was changed to $120 a year for all employees receiving $2,500 or less, and for those receiving $2,500 or more enough to make the total $2,620. After the war ended, Congress established a joint commission to recommend the adjustments needed to provide uniform and adequate compensation for those employed in the District of Columbia. Patriotism had kept many in the Federal service during the war, but once the armistice was signed the number of resignations increased sharply. During the year ending June 30, 1919, there were 77 resignations from the Survey's scientific and technical staff, a loss of 17 percent. The percentage of resignations from the nontechnical and clerical staffs was even larger. The largest inroads on the scientific staff were made by the oil companies, which offered beginning salaries two to four times those paid by the Government. With a certain grim humor, Director Smith referred to himself as the head of a high-grade employment agency but forecast a decline in the popularity of the Survey as a recruiting station for oil-company personnel; the experienced oil geologists who had not already left, he said, were by personal preference immune to outside offers. Those who stayed had unexpected difficulties. The Survey was forced to give up nearly half its space in the new Interior Building to the Internal Revenue Service. Everyone was allotted 75 square feet of space, and with three people to a room, there was not enough space to study maps and collections and no room for visitors seeking information.

The Survey had also suffered a profound loss in the death of three of its senior scientists during the war years: Arnold Hague, on May 14, 1917; G. K. Gilbert, on May 1, 1918; and George F. Becker on April 20, 1919. All three had been appointed to the Survey in July 1879 and for the first time in its history the Survey was without any of its founders. Gilbert was, of course, the best known of the three. He was "a sort of father-adviser to the members of the Survey." W. M. Davis said that "Those already old when he was young * * * recognized in him one who would continue the work they had begun and carry it forward into regions of space and of thought they had never entered; * * * those still young when he was old * * * looked upon him with respect akin to awe as one who, surviving from an heroic age when a western frontier remained to be explored, had discovered there many of the facts and principles which they, on entering geological science, had found embedded in its foundations." T. C. Chamberlin thought it "doubtful whether the products of any other geologist of our day will escape revision at the hands of future research to a degree equal to the writings of Grove Karl Gilbert." Becker was also widely esteemed. He had begun as a mining geologist and had had an important role in the early development of mineral statistical work, being responsible for the precious metal statistics of the 1880 Census and successfully lobbying for the first appropriation for such work by the Survey in 1882. Becker's interests, however, had gone far beyond mining geology, and Arthur Day said that "With the possible exception of Gilbert, there was no man of his time in the Washington geological world who possessed greater versatility in discussion or such breadth of view. In consequence of this, no problem was ever brought to his attention, whether in private council or in the more formal atmosphere of the Geological Society, to which he was not at once ready to contribute some fertile suggestion or some novel viewpoint." Hague was less well known. He was not a prolific writer and the full report on his work in Yellowstone National Park, to which he devoted many years, was never completed. Many of the young men who first worked with Hague, however, went on to distinguished careers. He had a major interest in conservation, and Gifford Pinchot counted as invaluable his service as a member of the National Academy of Sciences' Committee on Forest Policy.

In the summer of 1919, the Division of Geology of the Geologic Branch placed as many parties in the field as funds permitted and the scientists who were unable to go into the field began new projects in the office. Fuels investigations were limited by loss of personnel as well as scarcity of funds but oil-field mapping was continued in the Los Angeles-Ventura region in California, in southeastern Arkansas and north-central Texas. Reconnaissance examinations were made of the Poplar Dome in Montana and the region including the Virgin City oil field in southwestern Utah. The Office of Indian Affairs supported an investigation in Caddo County, Oklahoma, the city of Dallas an investigation of the natural gas resources tributary to Dallas and other cities of northern Texas, and the city of Shreveport an investigation of the natural gas reserves available for that city. M. R. Campbell began compilation of a geologic map of Wyoming, which had been thoroughly mapped in earlier years, on a scale of 1:500,000, and G. B. Richardson supervised the preparation of a map of the oil fields and pipelines. Marcus Goldman and P. V. Roundy began studies of the lithology and microfossils in drill cuttings collected with the cooperation of oil companies. The search for potash, in cooperation with the Texas State Bureau of Economic Geology and Technology, was limited to observations of drilling in progress in the Red Beds region of Texas, sampling of saline deposits and brines, and collection of well logs. N. H. Darton began compilation of a reconnaissance geologic map of New Mexico on the basis of his earlier mapping of the Red Beds. Field investigations were resumed in the metalliferous regions in Utah, New Mexico, Nevada, and Idaho; the major work on the geology and ore deposits of Idaho was left in an incomplete stage when J. B. Umpleby resigned in August.

Travelers in the desert region of the United States depended for survival on water holes, many of which were separated from one another by a hard day's journey with team and wagon. In most of the region, the water holes had never been accurately mapped or described, no provision had been made for systematically maintaining them, and roads leading to them had not been marked although the American Mining Congress had for several years been calling for the Federal Government to undertake such work. In the summer of 1916, when relations with Mexico were strained and national defense of increasing importance, Congress authorized a program for surveying, marking, and protecting desert watering places. In 1917 and 1918, Survey geologists surveyed 60,000 square miles of the driest, hottest, and least explored part of the desert region in southeastern California and western Arizona, and erected signs directing travelers to water at 167 localities. The photograph shows the first signpost erected by the Survey. (From J. S. Brown, 1920.)

The noneconomic sections were less affected by the loss of personnel. Mapping for geologic folios, suspended during the war, was resumed, and W. C. Alden and F. E. Matthes began studies of the glacial geology of the northern Rocky Mountains and the Sierra Nevada. The Coastal Plain Section established a sedimentation laboratory, and T. W. Vaughan continued his research on the origin and distribution of the faunas of the Caribbean and Central American provinces, aided notably by the work in Haiti and Santo Domingo. Paleontologic research was pursued with some vigor; as Chief Geologist David White noted, "fortunately the services of the paleontologists are not sought by the oil companies so persistently as the services of the geologists; only one member of the staff has been lured away."

The other divisions of the Geologic Branch were similarly handicapped. Little research could be done in the Division of Chemistry and Physics because of the loss of personnel. After Becker's death, George Steiger was placed in charge of the chemistry section and C. E. Van Orstrand of the physics section. The Division of Alaskan Mineral Resources could do only about half as much field work as in a normal prewar year, but it made a special effort to complete the topographic and geologic maps of the region tributary to the Alaska Railroad.

Because of the nature of its funding, the Water Resources Branch devoted most of its energies in 1919 to surface-water investigations, primarily stream gaging, and land classification. Gaging stations were maintained in 39 States, Hawaii, and Alaska. The Division of Ground Water, however, branched out into new areas of investigation. Cooperative work with the State survey of Connecticut, which had been interrupted by the war, was resumed as J. S. Brown

studied the ground-water resources of 18 towns in the New Haven, Connecticut, area and a special study of the relation of sea water to ground water. The Survey had been receiving many inquiries about the prospects of obtaining fresh water from wells sunk near the sea as coastal regions were on the whole areas of intensive human activity, which required both large and many sources of water, and the importance of coastal areas for national defense, as well as commerce and recreation, had been recognized during the war. A geologic and hydrologic study on the slope of Mauna Loa in Hawaii was also begun, after Professor H. E. Gregory, who had been State Geologist in Connecticut, became Director of the Bernice P. Bishop Museum in Honolulu and interested citizens of the island in such an investigation.

In 1919, the Topographic Branch furloughed many of its engineers to undertake the mapping in the West Indies. Mapping in Santo Domingo, under the direction of Albert Pike, was by conventional methods but in Haiti the Survey experimented with photomapping. Features such as coast lines, cities and towns, and highways were plotted from aerial photographs, and field parties under Eugene L. McNair provided ground control. In the United States, all surveys were made by conventional methods and nearly all were made on behalf of the War Department or other Federal agencies or in cooperation with the States. In Arizona, the Reclamation Service, the State, and the Survey contributed equally to special surveys to ascertain the feasibility of the storage and diversion of the waters of the Gila River below San Carlos and the irrigation of lands in the proposed San Carlos project.

C. H. Birdseye returned to the Survey in June 1919 from war service and was designated as Acting Chief Geographer during Marshall's absence from the office. Marshall had developed a plan for storing the waters of the Sacramento,

Only a decade or so after the Reclamation Service was established, it became evident that practically all the tracts of land that could be readily made productive without irrigation had already been occupied and that practically all the streams that could be cheaply utilized for irrigation had already been appropriated. Greater attention was therefore paid to the possibility of using ground water for irrigation. In 1917, Congress authorized the Survey to undertake exploratory drilling in the arid region to discover ground water for irrigation. After a reconnaissance of valleys in western Utah and eastern Nevada, O. E. Meinzer chose Steptoe Valley, Nevada, as the site for drilling and pumping tests because of the railroad facilities and market for produce at Ely and other mining towns in the vicinity. (From W. O. Clark and C. W. Riddell, 1920.)

San Joaquin, and Santa Clara Rivers in California with the aim of reclaiming land, supplying water to Los Angeles, San Francisco, and the Bay cities, controlling floods, and ensuring the navigability of the rivers throughout the year. He turned his plan over to the State and at the end of September resigned as Chief Geographer to devote full time to lobbying for the project. On October 1, Birdseye was designated Marshall's successor with the title Chief Topographic Engineer indicating a more modern concept of the position.

By the fall of 1919, the national unity and sense of dedication of the war years had largely disappeared. The Peace Conference had dragged on for six months while the situation at home deteriorated, and the peace treaty was a great disappointment. Wilson battled for his idea of a new world order, but European statesmen clung to old ideas, and in the end the forces of hatred and revenge prevailed. There was no real consideration of the economic aspects of international relations, and the third of Wilson's Fourteen Points, calling for the removal as far as possible of all economic barriers, was completely ignored. Against considerable opposition, he did succeed in making the League of Nations part of the Treaty of Versailles and hoped that it would in time right the wrongs that had been done. When President Wilson returned to the United States and presented the treaty to the Senate for ratification on July 10, however, he found the Senate already divided over the League of Nations. Opinions ranged from immediate and complete acceptance through participation with certain reservations to complete rejection. On August 19, Wilson agreed to accept certain of the Senate's reservations, but then those who opposed the League completely refused to go along and launched a campaign against ratification. Wilson decided to take his case to the people and on September 4, set out on a speaking tour through the Middle and Far West, warning that "within another generation there will be another world war if the nations of the world do not concert the method by which to prevent it." He also prophesied that "what the Germans used were toys compared to what will be used in the next war." On September 25, he collapsed and was rushed back to Washington where on October 2 he had a stroke that incapacitated him physically for the rest of his term. On November 19, the Senate voted against accepting the Treaty of Versailles. It was brought up again in the second session, but again there were insufficient votes to ratify and the Senate returned the treaty to the President on March 20, 1920.

The war had been won, but the peace was lost. President Wilson had foreseen the war as placing civilization in the balance. General Jan Smuts of South Africa, who had worked with Wilson at the Peace Conference, said that the Paris peace "in destroying the moral idealism born of the sacrifices of the war * * * did almost as much as the war itself in shattering the structure of Western civilization." During the next 20 years, Americans tried to forget that they had ever been involved in the war. Geologists, however, who had hoped that the essential role of mineral resources in the world's economy would be recognized in the postwar reconstruction for peace, resolved that at least the United States would not make the same mistake again of failing to recognize the strategic value of mineral resources.

Chapter 8.
The Convergence of Science and Industry, 1919–1922

> **Science and industry in their present-day progress are treading paths that converge, until they are now well within each other's sphere of influence. Science is becoming more useful, and industry is becoming more efficient, and this mutual approach means a mutual attraction.**
>
> **—George Otis Smith**

In the fall of 1919, according to the *London Nation*, Herbert Hoover was "the biggest man who has emerged on the Allied side during the war"; John Maynard Keynes said he "was the only man who emerged from the ordeal of Paris with an enhanced reputation." Hoover returned to the United States after many months in Europe where he had served as director general of the American Relief Administration and directed the economic rehabilitation of Europe. He had already been named president-elect of the American Institute of Mining Engineers, and, in November 1919, he became head of the new Federated American Engineering Societies. Hoover was the "Great Engineer," the practical idealist, and all engineers took on a certain aura from his achievements.

In the traditional inaugural address of the president of the AIME in February 1920, Hoover chose to speak of the engineer's viewpoint on the problems that then confronted the American people. They were, he said, predominantly economic—national and international, and required quantitative and prospective thinking and a sense of organization. They were the sort of problems that the engineering profession dealt with daily. Speaking of the Federal Government, he said:

> **Out of the strain of war, weaknesses have become even more evident in our administrative organization, in our legislative machinery. Our federal government is overcentralized, for we have upon the hands of our government enormous industrial activities that have yet to be demobilized. We are swamped with debt and burdened with taxation. Credit is woefully inflated, speculation and waste are rampant. Our own productivity is decreasing. Our industrial population is crying for remedies for the increasing cost of living and are aspiring to better conditions of life and labor.**

In particular, Hoover pointed out that the organization and expenditures on public works and technical services in the Federal Government was appallingly inefficient. All such activities in his view should be in one department, as a practical matter, and they should be in the Interior Department. Another important need was a national budget.

Hoover believed that the solution to the many problems that faced the Nation depended on whether the American people in the aftermath of world war turned to reaction or radicalism, as others had done, or clung to the American social philosophy which held that the state should "in the region of economic activities apply itself mainly to the stimulation of knowledge, the undertaking only of works beyond the initiative of the individual or group, the prevention of economic domination of the few over the many, and the least entrance into commerce that government functions necessitate." This was a clear call for a return to a form of laissez faire, albeit with progressive overtones.

Many of the issues Hoover raised in this talk remained issues for several years, especially that of reorganizing the Federal Government. The Jones-Reavis bill, to transform the Department of the Interior into a Department of Public Works with a technically qualified Secretary and four technically qualified Assistant Secretaries, had already been filed in Congress although no action had been taken on it. A national budget had been recommended by President Taft but had not yet been adopted.

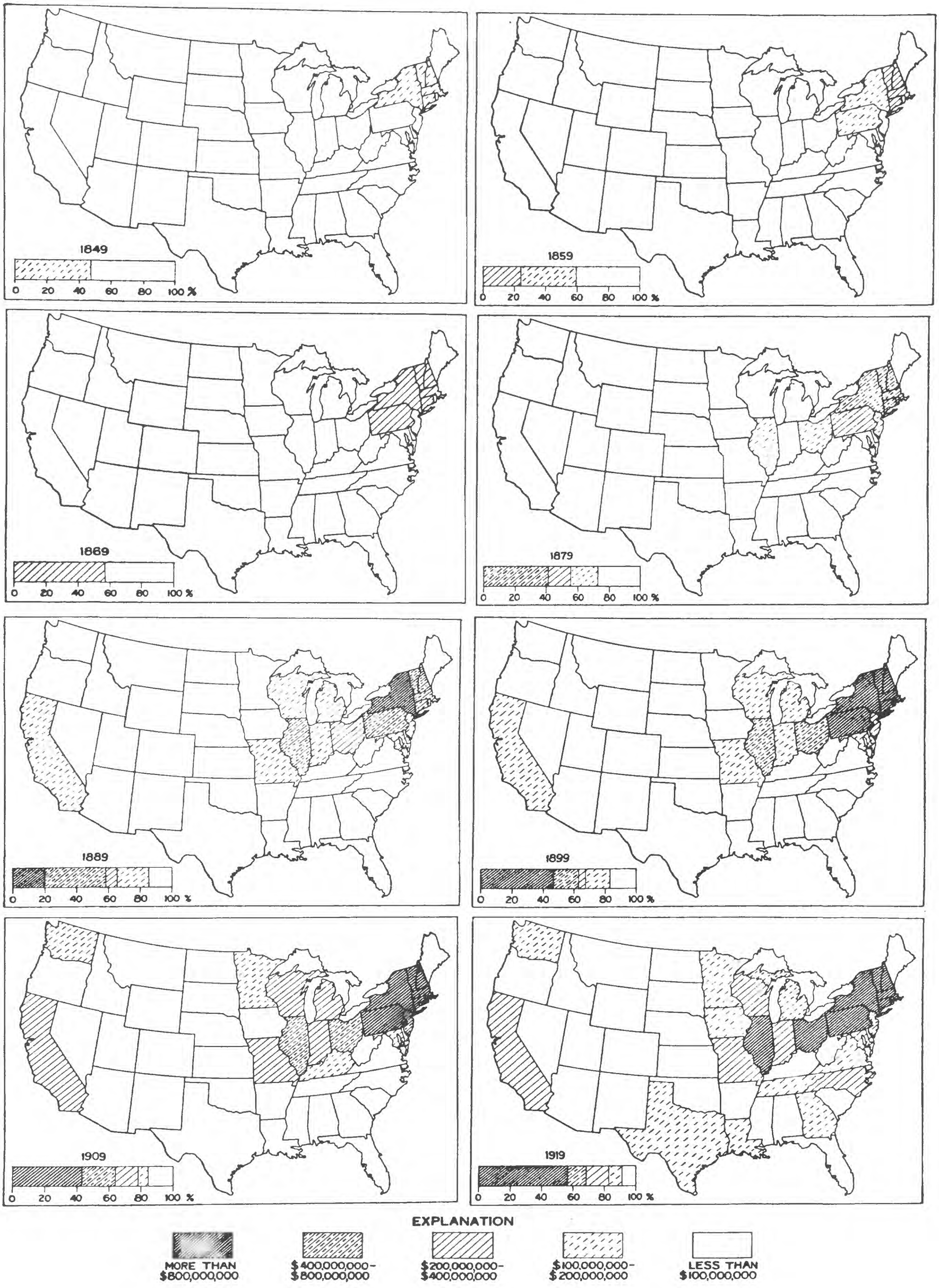
Hoover made no mention of science, Federal or otherwise, in his address other than a brief reference to engineers as the "scientific advisers on industry." The success of applied science and engineering during the war years had placed fundamental research at a distinct disadvantage, one that would persist for several years. According to E. B. Rosa, Chief Physicist of the Bureau of Standards, only one percent of Federal expenditures in fiscal year 1920 was used for education and for scientific research and development. In the spirit of economy that developed after the war, even that small amount was being carefully scrutinized. Could the Nation afford to carry on such work on so generous a scale?

To compound the problem for Federal science, during the war industry had become aware of the value of science, established its own facilities, and offered Government scientists far more attractive salaries than the Government was giving them. Federal salaries were then low, and in the hope that an adjustment might slow the rate of loss of personnel, Congress had established a Joint Commission in March 1919 to study the problem. In 1920, however, Congress did not even consider the salary system proposed by the Commission although it accepted its recommendation that a retirement system be established and speedily enacted a law whereby employees would pay 2 1/2 percent of their salaries into a retirement fund and be retired at 70. The Government would pay whatever additional amount was necessary to retire civil service employees on a sliding pension scale with a top limit of $720 a year. When Congress failed to act on salaries, more than a hundred Federal employees in responsible administrative and technical positions formed a "Federal Club" in June 1920, under the temporary chairmanship of Franklin D. Roosevelt, Assistant Secretary of the Navy, to facilitate the exchange of views on common problems and, where appropriate, joint action.

Although many left the Government service because of the low salaries, Eliot Blackwelder, who had held a w.a.e. appointment with the Survey for many years, suggested that many geologists were leaving the Survey for another reason, because they had "been gradually reduced from scientific investigators to technical clerks." Blackwelder believed that "the paucity of actual scientific opportunities" was the Survey's "most serious defect" and that many geologists would be willing to work for a relatively small salary provided they could pursue their chosen research. George Otis Smith was then insisting that in order for geology to be most useful in the days of world problems, a new type of geology was demanded—the application of geology in terms of commerce. Investigators in commercial geology, whether they be called geologists, mining engineers, or economists, must, Smith said, view "not simply the ore minerals as they have been deposited, segregated, or enriched by the processes of nature," but also "the smelted ore and the refined metal on their way to the markets of the world, where they can serve mankind."

F. L. Ransome, Chief of the Survey's Metals Section, also differed with Director Smith. In his presidential address to the Washington Academy of Sciences, Ransome rejected any taint of applied science or engineering for the Geological Survey. He believed that the Survey's work should be confined to

To aid the second industrial revolution, based on industrial chemistry, which followed the end of World War I, the Geological Survey began a series of reports on the industrial utility of public water supplies, showing the most favorable regions for the future expansion of certain industries. As these maps show, industrial activity in the United States had expanded since 1849, when five New England States and New York accounted for about 48 percent of the value of manufactures, to 1919, when 26 States accounted for about 92 percent of the value. The intensity of the shading indicates increasing increments of monetary value, thus in 1919 about 56 percent of the value came from the original five New England States and New York, plus Ohio and Illinois. Early industrial activity was confined almost exclusively to areas in which natural waters of excellent quality were abundant, and even though total industrial activity had spread, large industries that required the best water tended to remain in their original locations. (From W. D. Collins, 1926.) ▶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EXPLANATION
MORE THAN $800,000,000
$400,000,000- $800,000,000
$200,000,000- $400,000,000
$100,000,000- $200,000,000
LESS THAN $100,000,000

geology and necessary supporting activities and he was not certain that the supporting activities should include topographic mapping. A geological survey should have maps of the standard it required with the least possible delay, but it should not undertake to make them if existing organizations could and would provide the maps. The study of ground water Ransome would permit, but stream gaging and the estimation of water power would "scarcely fall" to a geological survey in any "ideal distribution" of duties. Geophysics and geochemistry, he decided on reflection, were appropriate in a geological survey, as were soil mapping and soil classification, but the compilation of mineral statistics was simply not suitable work for a geologist.

With regard to Government science in general, Ransome pointed out that it had become fashionable to emphasize usefulness as the chief criterion by which to judge its value, but no one had yet defined usefulness. Certainly usefulness was not predictable nor always immediate. The ideal was no doubt something like Pasteur's investigations, which had been undertaken to solve particular industrial and humanitarian problems but had at the same time enormously increased human knowledge. Pasteur's work, Ransome emphasized, had also demonstrated another important point: that apart from recognized usefulness, investigations that yielded results of interest to the general public were willingly supported by the people. A national scientific bureau, in order to survive, needed popular support and therefore must do some work that the majority of people could recognize as worth doing. Education was therefore a very important function of a Government scientific agency. The results of such education are

> cumulative and a direct and permanent gain to science, whereas, on the other hand, the consequences of prostituting the opportunities for scientific work to satisfy this and that popular demand for so-called practical results in any problem that happens to be momentarily in the public eye, is a kind of charlatanry that is utterly demoralizing to those who practice it and that must bring even popular discredit on science. A bureau that follows such a policy can neither hold within it nor attract to its service men animated by the true spirit of investigation.

Economic geology was at a disadvantage amid the hue and cry that science must be useful because many of the major problems in the mineral industry were socio-economic rather than scientific or technical. Some parts of the industry were troubled with oversupply. The coal industry, according to Hoover, was "functioning badly from an engineering, and consequently from an economic and human standpoint." The great increase in efficiency in the use of coal since the turn of the century and the wartime expansion had left the industry badly overextended. Employment in the mines was intermittent at best, so postwar conditions created unusual hardships for the miners, and they had gone on strike on November 1, 1919 to demand an increase in wages and the guarantee of a 30-hour week. On the other hand, steelworkers, who worked very long hours, had gone on strike in September seeking a shorter work week. The coal and steel strikes in turn were largely responsible for a 21 percent decline in the production of pig iron in 1919 and a consequent decline in iron mining.

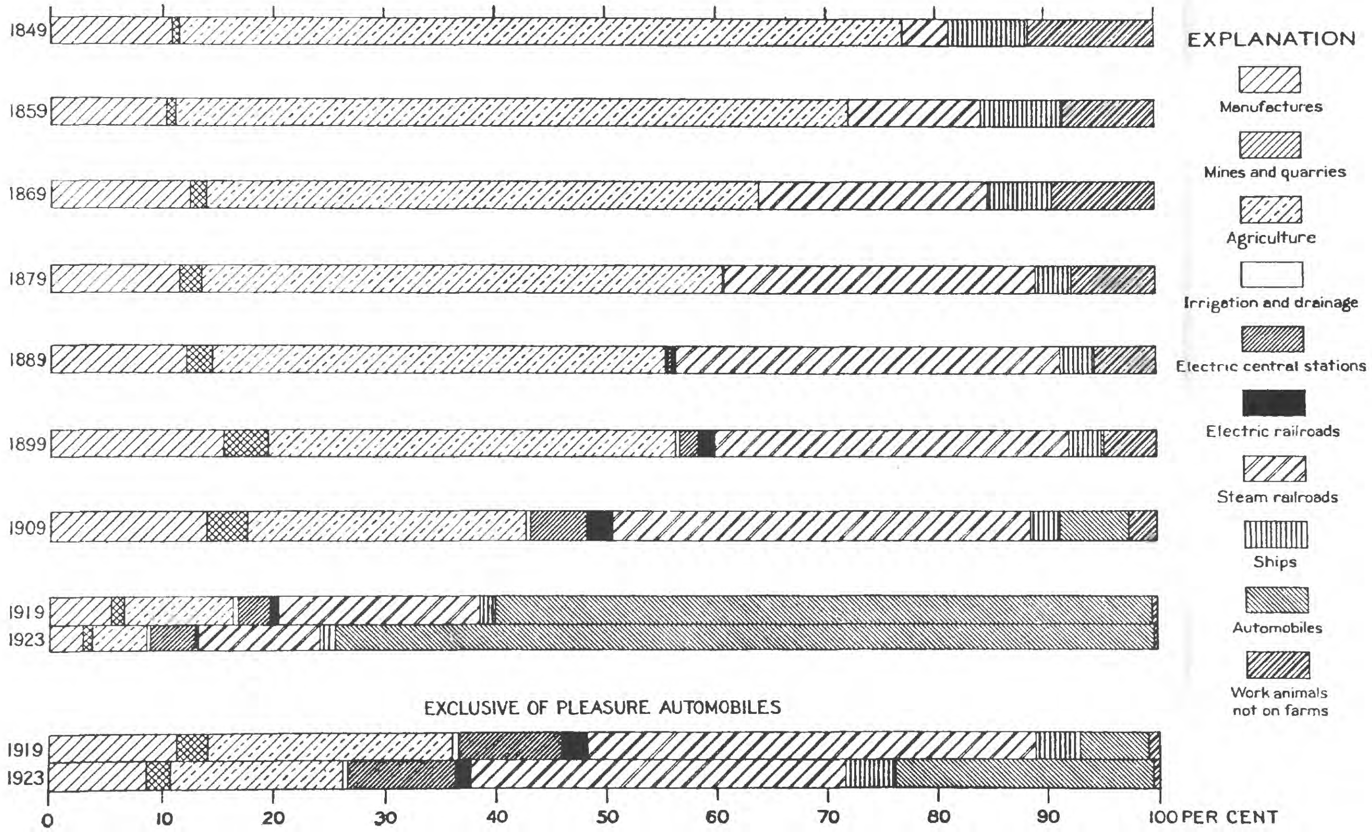
The greatest opportunities for economic geologists were in petroleum geology for the long predicted shortage of supplies had finally developed. Even among oil men, however, there were differences of opinion, and as many if not more would rely on conservation, tax incentives, or the acquisition of foreign reserves as on science to alleviate shortages. Both the Director of the Geological Survey and the Director of the Bureau of Mines publicly advocated the American development of foreign oil sources which they had proposed earlier to the Fuel Administrator. The Director of the Survey even maintained a liberal policy with regard to leaves of absence to permit Survey geologists to engage in exploration for oil in foreign countries, holding it to be for the public welfare. Smith said the position of the United States could best be described as "precarious" and that our world leadership in production was "more spectacular than safe." He charged that "we have been draining our own oil pools in part to supply the needs of the rest of the world, but have made little effort to render the rest of the world self-supporting in oil production. Whether such a national policy is to be characterized as that of a spendthrift or that of an altruist, it is a short-sighted policy." To ensure a future oil supply, he suggested that domestic fields be reserved for American development and foreign acquisition of oil needed at home be prevented, and that American capital be encouraged to enter foreign fields to assist in their development. Director Manning of the Bureau of Mines, agreeing on the need to develop foreign sources, also said that "the premier position of the United States to the present time has been due, perhaps, more to an intensive development of resource than to supremacy in the resource themselves." He noted that many people were inclined to question the estimates of oil reserves as too pessimistic; whenever in the past more oil had been needed new discoveries were made and unexpected fields brought forth new supplies. Estimates were fallible, Manning admitted, but even if they were 50 to 100 percent too low, the situation was not satisfactory because no matter how much oil was still in the ground, it was not being brought to the surface as fast as it was needed.

Chief Geologist David White was one of the few who thought that fundamental research might aid in the location of new oil sources. At the AIME meeting in February 1920, he said

> **In these days, when detailed investigations of stratigraphy, structure, and sand conditions so frequently result in the discovery of new oil fields, and applause from oil companies and the public, geologists do well to walk humbly, and punctiliously to admit that the geologic principles controlling the distribution of oil and gas have as yet been discovered only in part, and that what remains yet to be learned is probably vastly more than what is already known.**

White, who had seen his investigation of carbon ratios as confirmation of the organic origin of oil used as a tool in the search for new oil regions, listed a variety of factors to be considered: sufficient carbonaceous detritus and residues in the oil-forming rocks, stage of carbonization of the inorganic matter in the oil-bearing formations, folding of strata, thickness of sedimentary formations, and the conditions of deposition. But these, he suggested, were only a bare beginning.

The petroleum shortage forced Congress to come to a decision on the disposition of the reserved mineral lands. The Senate Committee on Public Lands reported out a bill, providing for leasing with royalties divided between the States and the Federal Government, which was passed after prolonged debate. The House amended the bill drastically, but the conference committee worked out compromises and the bill was finally enacted on February 25, 1920. The Mineral Leasing Act, more properly, the "Act to promote the mining of coal, phosphate, oil, oil shale, gas and sodium on the public domain," repealed the coal land law of 1873 and the Placer Act as it applied to oil and gas, phosphate, and oil shale, and substituted a general leasing law. Lands were to be obtained by competitive bidding, and royalty and other income to be divided, 10 percent to miscellaneous receipts in the Federal treasury, 52 1/2 percent to the Reclamation Fund, and 37 1/2 percent to the States. Minimum royalties and annual rentals were fixed by law. The act also specified leasing units. Coal lands, which had previously been sold, would in the future be leased in 40-acre lots, or multiples thereof, with a maximum of 2,560 acres in one tract. Leasing units for phosphate and sodium lands (sodium could be substituted for potassium for some purposes) were similar to those for coal.



Cheap energy had been a major factor in the development of industry, transportation, and communications in the United States, so the continued availability of such energy was a matter of national concern after World War I. Charts based on data collected in connection with the Geological Survey's studies of water resources and their utilization, together with data from the Bureau of the Census and the Federal Power Commission, show a striking change in the use of energy in the United States between 1909 and 1919. The dramatic increase in the use of automobiles affected steel production, petroleum production, led to a demand for road-building, and increased the demand for maps. (From C. R. Daugherty, A. H. Horton, and R. W. Davenport, 1928.)

For oil and gas lands, the act distinguished between areas "within any known geological structure of a producing oil or gas field" and those not within such structures. Only leases could be issued for areas within such known structures, only prospecting permits elsewhere. Only one lease could be given to any one applicant on any one structure, and not more than one-fourth of the area, or not more than 3,200 acres, could be leased to one claimant. Those who had made entries prior to the withdrawal of July 2, 1910, if they had continued operating in good faith after discovery, would be permitted to relinquish their claims in return for 20-year leases at the minimum royalty but they had to make payments on past production. In the naval petroleum reserves, the act specified that leases were to be issued only on producing wells unless the President chose to lease the remainder.

The Department of the Interior divided responsibility for administering the Mineral Leasing Act among the General Land Office, the Bureau of Mines, and the Geological Survey: the General Land Office would supervise the issuance of leases and permits and collect royalty and other income, the Bureau of Mines would supervise the operations on the leased lands, and the Geological Survey would classify the mineral lands. A major task under the new law would be the determination of the geological structure of producing oil or gas fields within which only leases were to be issued. The 50 million acres that had been withdrawn and not yet classified also had to be classified and restored to the public domain.

Congress also came to a decision, after many years of wrangling, on a water-power bill. The House passed its bill, essentially the same as that it agreed to in the previous session, on July 1, 1919. It then took 11 months more to get the bill through the Senate and the conference committee, but it was finally passed and sent to President Wilson on May 31, 1920, and signed by him on June 10. The Federal Water Power Act created a Federal Power Commission, composed of the Secretaries of War, Interior, and Agriculture, to issue licenses for the development of water power at sites on boundary waters, navigable streams, on public land adjacent to streams having sufficient fall for power, and on headwater streams if the plants would affect the flow on navigable reaches of the river. Licenses were to be issued for specified periods, not to exceed 50 years, with an annual fee based on power capacity (i.e., the horsepower developed on-site).

The Federal Power Commission was simply an interdepartmental commission rather than an independent agency, and it had only one employee, the Executive Secretary, O. C. Merrill. Merrill, Herman Stabler, of the Survey, and General Enoch Crowder of the Army Engineers drew up the regulations for administration of the act. They recognized that reliable and adequate records of streamflow would be required, and that responsibility for obtaining such records rested with the permittees and licensees. However, the records had to be collected by standard methods to make them acceptable to the varied interests involved in their use and interpretation, so as a general policy it was agreed that the streamflow records would be collected under the supervision of the Geological Survey but at the expense of the permittee or licensee. The arrangements for obtaining the records ranged from little participation by the Survey to complete performance by the Survey. The regulations also required that before the Commission could consider an application, the feasibility of the plan, its suitability to the particular site, and the financial ability of the applicant be determined. The three departments divided up the examinations—those on navigable streams were allotted to the War Department, those on public lands in the national forests to the Agriculture Department, and those on public lands outside the national forests to the Interior Department.

Secretary of the Interior Lane had asked Congress for two special appropriations in connection with power development. According to statistics developed by Survey engineers during the war, the generation of power in the United States then required not less than 800,000 tons of coal daily. The Secretary asked for an appropriation of $50,000 to continue the survey of power resources, and also for a special appropriation of $200,000 for an intensive study of the industrial zone of the East where power requirements were greatest. In the Sundry Civil Expenses Act in June 1920, Congress appropriated $125,000 for the special investigation and a report on the possible savings in fuel, labor, and material that would be gained by operating a comprehensive system for the generation and distribution of electricity to railroads and other industries in the region between Boston and Washington. No appropriation was made, however, to continue the survey of power resources.

Both water power and irrigation were at issue in the utilization of the Colorado River, which had been investigated by both the Geological Survey and the Reclamation Service. As a result of the continuing menace of floods in the lower Colorado River to the residents of Imperial Valley and the rapid increase of population in southern California which made further development of irrigation a necessity, Congress was besieged by petitions for action. On May 18, 1920, Congress directed the Secretary of the Interior to report on irrigation in Imperial Valley and related subjects. Construction of a reservoir as near as possible to the point on the river where the greatest flood menace would occur was proposed as a solution, but a large reservoir would be needed so that the heavy load of sediment carried by the river would not too quickly fill it. The Upper Basin States feared that a large reservoir on the lower river would deprive them of the use of Colorado River waters at a later date. At the invitation of the Governor of Utah, representatives of the seven Colorado River Basin States had met at Salt Lake City in January 1919 and formed a permanent organization. At a meeting in August 1920, the desirability of encouraging construction of a large reservoir in the canyon of the Colorado for flood control, power, and ir-

P O R T A G E
S C H O O L C R A F T
Portage
Schoolcraft
(B M 860)
Vicksburg
(B M 860)
Smith School
McKilroy School
Kinney School
School No 8
School No 7
Cox School
Austin Lake
Ramona Park
Cobb School
Gourdneck School
Tiffany School
Brick School
Lost Island School
Cooper School
School No 5
Prairie Grove School
West Lake
AUSTIN LAKE
Long Lake
Hampton Lake
Sugarloaf Lake
Little Sugarloaf Lake
Gourdneck Lake
Hogset Lake
Gourdneck
Sunset Lake
Barton Lake
Kimble Lake
Howard Lake
Mud Lake
Gars Lake
NEW YORK
CENTRAL
GRAND RAPIDS
TRUNK
KALAMAZOO CO
ST JOSEPH CO

The Geological Survey took part in an experiment to test the use of aerial photography in topographic mapping. In June 1920, a Army Air Service plane equipped with a K–1 camera photographed the 15-minute Schoolcraft, Michigan, quadrangle in 7 hours' flying time. The prints were matched together and reduced to a scale of 1:48,000, and from them such features as roads, streams, forests, and land corners were transferred to planetable sheets, which the topographic engineers then used in the field to contour the relief. The illustration is part of the Schoolcraft topographic map published by the Survey in 1922.

rigation was discussed, and a resolution was adopted calling for negotiation of an interstate treaty on the use of the Colorado River.

Executive, rather than legislative, action made a change in the Survey's mapping operations in 1920. On December 30, 1919, the Board of Surveys and Maps was created by Executive order "to coordinate the activities of the various mapmaking agencies of the Executive Departments of the Government, to standardize results, and to avoid unnecessary duplication of work." The Board, to be composed of a representative of each of the Federal Government's 14 mapmaking organizations, was to establish a central information office in the Geological Survey to collect, classify, and furnish to the public information concerning all map and survey data available in the Government departments and from other sources. The Board was formally organized in January 1920, with O. C. Merrill, Chief Engineer of the Forest Service, as its first chairman and C. H. Birdseye of the Survey as its first secretary. The Map Information Office was set up in the Survey under the direction of J. H. Wheat. *The Military Engineer*, the magazine of the Society of American Military Engineers, which had been organized to profit from the experience of the world war and to assist in the promotion of preparedness, was chosen as the official organ of the Federal Board of Surveys and Maps.

For the fiscal year beginning July 1, 1920, the Survey's appropriation was $1,730,700. Small increases were provided for the Survey's regular operations: $5,000 each for topographic surveys, geologic surveys, and stream gaging, and $15,000 for preparation of the report on mineral resources; in addition, having passed the Mineral Leasing Act which required the Survey to classify mineral lands in advance of leasing, Congress for the first time appropriated funds for the classification of public lands. The appropriation, $300,000, relieved the field branches of the burden of allotments for supporting the work of the Land Classification Branch. The Land Classification Branch, in turn, rather than undertaking independent investigations, allotted funds to the field branches: $106,000 to Water Resources, $37,000 to Geology, and $32,000 to Topography. The Topographic and Water Resources Branches also received repayments from other Federal agencies and substantial amounts for work in cooperation with the States and Territories; the cooperative funds amounted to about 81 percent of the direct appropriation for topographic surveys and 103 percent of the direct appropriation for water-resources investigations. They therefore had less difficulty in financing field operations than did the Geologic Branch.

Manpower problems were not solved by the new appropriation and its distribution, and here too the Geologic Branch was most seriously affected. In the Division of Geology, the Coal Section was practically wiped out, and in four other sections too few experienced geologists were left to train newcomers. The Division of Alaskan Mineral Resources lost some of its most experienced employees when six geologists went temporarily or permanently into private work (there were only eight on the staff at the beginning of the year), three topographic engineers were on furlough, and two remained in the Army. The Division of Physical and Chemical Research lost five chemists. In the Division of Mineral Resources, resignations and furloughs so depleted the staff that the division had to be reorganized, and 17 subjects were without direct supervision by a geologist or engineer specialist at the year's end. Although the Land Classification Branch had a turnover of 30 percent and the Water Resources Branch of about 45 percent, both branches were able to maintain full strength. The Topographic Branch, unlike the others, grew as 25 officers returned from the Engineer Officers Reserve Corps. The Topographic Branch thus became the most stable element in the Geological Survey in fiscal year 1921.

Topographic maps were then much in demand, particularly in the Eastern and Central States, because of the upsurge in construction after the war, especially in road-building. The advent of the automobile had caused a revolution in transportation as had railroads in the previous century. Highways, however, were from the first considered a public responsibility, and there was no prolonged debate over financing their construction. In 1916, Congress had approved a program of Federal aid to States on the dollar-matching basis. The war brought the program to a halt before it was well started, so road building was urgent in 1920 for the increased use of motor vehicles during the war had wrought havoc on existing roads. As a direct contribution to the road-building program, the Geological Survey prepared road maps of 28 States in cooperation with the Bureau of Public Roads and of Illinois in cooperation with the State. In addition, the Survey made topographic surveys in the 20 States and the Territory of Hawaii that contributed funds to expedite topographic mapping, and made special maps and river surveys in Nevada and Arizona, to ascertain the feasibility of storage and diversion of the waters of the Colorado River, and along the Snake River in Oregon and Idaho. Because so much of the Survey's mapping was in the Eastern and Central States, the Northwestern Division was discontinued as a separate unit and combined with the Rocky Mountain Division.

Some research in mapping methods was carried on. A Section of Photographic Mapping was established in the Washington office to investigate the usefulness of aerial photographs in making planimetric and topographic maps, and placed in charge of Thomas P. Pendleton, who had joined the Topographic Branch in 1905, and who had worked on the development of the 3-lens camera and of radial-line mapping methods as a 2d Lieutenant of Engineers during the war. Aerial photographs of 12,098 square miles of Haiti, where the Survey continued to supervise the mapping, were made in cooperation with the military services. In June 1920, an Army Air Service plane equipped with a K-1 camera photographed the Schoolcraft 15-minute quadrangle in Michigan in 7 hours' flying time. The photographs were reduced to a uniform scale of 1:48,000, features such as roads, streams, forests, and land corners were then transferred to planetable sheets that the topographic engineers used for contouring the relief. The War Department also established an aerial route to Alaska in the summer of 1920 and, in cooperation with the Survey, included in the pioneer flight a photographic survey of some of the inaccessible portions of the Territory.

The Water Resources Branch was deeply involved in problems of power development in 1920. The branch provided administrative control of the so-called Superpower Survey of the area between Washington and Boston which was made by group of engineers under the direction of W. Spencer Murray, a consulting engineer for the New Haven Railroad. One-fourth of the Nation's population was concentrated in the area investigated, and there were 315 electrical utilities, 18 first-class railroads, and 96,000 industrial plants, all operating for the most part independently of each other. The engineers estimated that if energy were supplied by a coordinated power system, by interconnecting existing plants and systems, constructing new steam-electric and hydroelectric plants at favorable locations, and electrifying a substantial portion of the railroads, the annual savings in 1930 would be $429 million and 50 million tons of coal. The branch also examined projects of the Federal Power Commission in Alaska, Oregon, California, Idaho, Wyoming, and Arizona. Surveys were made of the John Day and Grand Ronde River basins in Oregon, of the Green River and its tributaries above Green River, Wyoming, of the Snake River, and of various short stretches of river in Montana, Idaho, and Utah to classify lands with respect to their value for the development of water power. Statistical reports were prepared on the production of electricity and consumption of fuel by public-utility power plants, and transmission lines and power

Following the passage of the Mineral Leasing Act in 1920, the Survey's classification of oil and gas lands took on a new purpose, the determination of the limits of "any known geological structure of a producing oil or gas field." In 1920, Survey geologists examined lands in the Lost Soldier-Ferris district in south-central Wyoming, where development had begun in 1916 after the Lost Soldier Dome was recognized on a map accompanying an earlier Survey report on coal-land classification. The district was found to have rather sharply defined limits within which nine domes and anticlines were found. The most important formations because of their possible yield of oil and gas were all Cretaceous in age. One of them, the Frontier Formation, is shown in the photograph. (From A. E. Fath and G. F. Moulton, 1924.)

stations were mapped. The report on the water power of the world was compiled and sent to the printer for publication as Part II of the "World Atlas of Commercial Geology."

The Ground Water Division was largely concerned with the use of ground water for irrigation but included some innovative research in its activities in 1920. Kirk Bryan began a quantitative study of the geology and water resources of the San Pedro Valley in Arizona in cooperation with Professor G. E. P. Smith and the Arizona Agricultural Station. As part of this study, the rate at which water was withdrawn from the zone of saturation by vegetation was determined by a method devised by Smith. W. O. Clark and H. S. Palmer continued the investigations in Hawaii, but the study of ground water in eastern Montana was suspended when A. J. Ellis died suddenly in July 1920, for there was no one available to continue the work. W. D. Collins returned to the Survey after several years in the Department of Agriculture and began a general report on the hardness of water.

The Geologic Branch, in view of the continuing oil shortage, continued its geologic mapping of potential oil areas, principally in Wyoming, where there was some oil company interest, and in Montana, where only the Survey had as yet done any detailed work. Congress, meanwhile, had begun discussion of the possibility of substitutes for gasoline. Director Manning of the Bureau of Mines, as he was leaving to become Director of Research for the American Petroleum Institute, suggested that gasoline supplies might more easily be increased by acquiring supplies abroad or by encouraging domestic industry to increase the recovery from existing pools or by developing processes for making synthetic gasoline from heavy oils, oil shales, coals, lignites, or peat, all of which were functions of the bureau. He held out no hope of discovery of new pools.

The Division of Mineral Resources continued the very practical work of compiling statistics on oil and gas, enlarged the scope of the monthly report on petroleum production, and began preparation of a series of maps showing the oil and gas fields of different States. The division, however, was only a shell of its wartime strength. E. S. Bastin, the head of the division, had resigned in December 1919 to join the faculty of the University of Chicago. He was succeeded as division chief by G. F. Loughlin who continued to supervise the Section of Metal Resources. J. B. Umpleby, head of the Section of Foreign Mineral Deposits, resigned in midsummer 1920, and was succeeded by Eugene Stebinger, who was then in South America gaining firsthand information on foreign mineral deposits by searching for oil. C. E. Lesher resigned as head of the Fuels Section to become the statistician for the National Coal Association and editor of *Coal Age*. He was succeeded by F. G. Tryon. F. J. Katz, the administrative officer of the divison, was loaned to the Census Bureau for the 1920 census.

The Survey could make only a few other investigations in economic geology in 1920 because of the loss of personnel. E. F. Burchard, head of the Section of Iron and Steel Alloy Metals, was on leave for most of the year to work in the Philippine Islands. B. S. Butler, E. C. Harder, E. L. Jones Jr., Adolph Knopf, and J. B. Umpleby of the Metals Section all resigned to accept positions either in industry or in the academic world, and Hoyt Gale, head of the Nonmetals Section, who had been in charge of the potash project since its inception in 1911, also resigned from the Survey. F. L. Ransome continued work on the general report on the ore deposits of Nevada but the report on the ore deposits of Idaho was left unfinished after the resignations of Umpleby and

Passage of the Mineral Leasing Act also stimulated interest in exploration for oil. In Alaska, which had enjoyed a brief oil boom in 1901 that collapsed because of the rapid development of oil fields in California, there were small stampedes to all the accessible localities where oil seepages were known. The illustration shows one such seepage, near the head of Katalla Slough in the Katalla field, which had produced some 56,000 barrels of petroleum by 1920. (From G. C. Martin, 1921.)

Jones. F. B. Laney and Edward Sampson began work in Idaho, but Laney resigned at the end of the field season to become a professor at the Idaho School of Mines. Newly appointed Yale professor Adolph Knopf and his newly wedded wife, Eleanora Bliss Knopf, studied the Simon and Omco districts in Nevada before departing for New Haven, and Sidney Paige resumed his study of the Homestake mine, which had been suspended for several years. George Mansfield, who succeeded Gale as head of the Nonmetals Section, continued his stratigraphic and structural study of the phosphate region of Idaho. Meanwhile, Survey chemists in Washington were beginning to find small lumps of potash-rich salts in cuttings and salt crusts from Texas.

The Survey's work in Alaska during the summer of 1920 was designed to aid the development of the Territory but was hampered by the weather as well as a lack of funds and a shortage of personnel. A. H. Brooks was chairman of a committee appointed by the new Secretary of the Interior John B. Payne in April 1920, to advise him on steps to be taken to better conditions in Alaska, which industries could be developed and which resources exploited to give employment to a resident population that would, in turn, provide a home market for Alaskan products. The Brooks committee included in its recommendations the establishment of an interdepartmental committee to coordinate Federal work in Alaska; the interdepartmental committee was duly established with representatives of the Departments of the Interior, War, Navy, Commerce, Agriculture, and Post Office.

Geologists in general had agreed on the necessity of emphasizing fundamental research and in preserving a distinction between science and engineering. In the summer of 1920, they formed the Society of Economic Geologists, choosing that name by ballot over Society of Applied Geology or Society of Geological Engineers. In the words of the Society's first president, R. A. F. Penrose,

> **Economic geology cannot progress faster than new discoveries in geologic science. The latter must always be in the lead, just as the pathfinder in the forests must precede the highway.**

The Geologic Branch of the Survey, subscribing to this idea, turned to basic research wherever it could. Chief Geologist David White gradually relinquished control of the oil and gas investigations to K. C. Heald and resumed his own research, spending part of the 1920 field season collecting data on regional carbonization in Montana and collaborating with chemist E. T. Erickson in a study of fossil organic compounds in oil shale. Marcus Goldman studied cuttings from wells in the Ranger district of Texas to define the characteristic features of formations and to determine the conditions of deposition that might aid in determining the genesis of salt domes. C. E. Van Orstrand measured temperatures in deep wells in several States in his continuing study of geothermal gradients, and A. F. Melcher conducted both field and laboratory studies of the physical properties of oil, gas, and water sands.

W. T. Lee, one of the few survivors in the Coal Section, spent most of the year studying the possibility of using the airplane and aerial photography to secure information for geographic and geologic studies. Through the cooperation of the Air Services of the Army and Navy, he made several flights and Army photographers also made several trips at his request. Lee concluded:

> **It is perhaps premature to say much of the use of the airplane in the study of geology until it has been thoroughly tested. But it should be possible from the air to locate and map ore bodies, metalliferous veins, and outcrops of rock; for it is well known that rocks at the outcrop differ in color, in the forms of erosion developed in them, and in the kind of plants which they support.**

For the special use of oil geologists, the Survey in 1922 published data on the character and thickness of formations and the general structure in New Mexico accumulated by N. H. Darton in his study of the Red Beds regions of the Southwest in connection with the Survey's search for potash. New Mexico had not then produced any oil, but oil had been found in a few wells near Dayton in Eddy County, wide areas of the State were underlain by formations of the same age as those that yielded oil in adjoining States to the east, and structural conditions in many places were considered favorable for the accumulation of oil and gas. Darton suggested that the Carboniferous and Cretaceous areas of eastern New Mexico and the Cretaceous areas of the northwestern part of the State were the most likely areas for discovery of commercial oil fields and that the Chupadera Formation (name since abandoned), one of the Permian red beds that underlie a wide area in the Pecos Valley, should contain oil. The illustration shows the Chupadera Mesa in central New Mexico, the type locality. The extensive oil deposits in the Permian Basin of southeastern New Mexico were located later by geophysical means. (From N. H. Darton, 1922.)

Then he added a practical note: "The prospector should effect a great saving of time by using air photographs to guide him to places where he can find exposures of rock and to help him to avoid places where it would be useless to look for exposures. Particularly in wooded regions air photographs are valuable in indicating localities where exposures can be found in areas so covered with forest that examination on the ground would not be worthy of consideration." In fact, Lee noted, oil prospectors were already planning to use airplanes for that purpose in Canada and South America.

Other members of the Geologic Branch resumed areal mapping and stratigraphic studies in various parts of the country; in September, Wendell P. Woodring of the Coastal Plain Section led a party including W. S. Burbank and J. S. Brown of the Water Resources Branch to Haiti to begin geologic mapping of that country. Much effort also went into investigations of the principles of sedimentation. The National Research Council Division of Geology and Geography had set up a Committee on Sedimentation under the chairmanship of T. W. Vaughan, and there had been lengthy discussions of the subject at the 1919 meeting of the Geological Society of America. As part of the Survey's program, R. C. Wells of the chemical laboratory began physical and chemical investigations of sediments, natural brines, and the solubility of sodium and potassium carbonates.

By the summer of 1920, the conservative element, those who regarded the whole Theodore Roosevelt era as some sort of aberration, had taken control of the Republican party. While Progressives hoped for the nomination of Senator Hiram Johnson of California and the younger professional and managerial classes for the nomination of Herbert Hoover, the Republican National Convention chose Senator Warren G. Harding of Ohio as its candidate for President. The Democrats, divided on the League of Nations issue, on the 44th ballot chose Governor James Cox of Ohio largely because he had not been part of the Wilson administration. Senator Harding was a handsome, dignified man and a colorful speaker—he had told a Boston audience in May that what the country needed was "not heroism but healing, not nostrums but normalcy, not surgery but serenity, not the dramatic but the dispassionate, not experiment by equipoise, not submergence in internationality but sustainment in triumphant nationality." Cox was unprepossessing in appearance, a mild individual who had made few enemies. Harding elected to conduct a front-porch campaign, after the fashion of McKinley in 1896, and described himself as just a plain fellow, old-fashioned and even reactionary in matters of faith and morals. Cox did an extraordinary amount of traveling and speaking. Both managed to be sufficiently unclear on where they stood with regard to the League of Nations so that a voter with firm convictions could not be sure which way to vote. Underneath all the campaign rhetoric, however, the Republicans seemed to promise more business activity and the Democrats a somewhat higher level of Government activity. The voters decided that a return to old-fashioned values and the untroubled times of the past was what the country needed and elected Harding by an overwhelming majority.

In a reaction against the strong Executive leadership practiced by Wilson, Harding determined to rely on his Cabinet and to give them full responsibility for their departments. He promised to appoint the best minds to leading positions, and a few such choices were made. Herbert Hoover was persuaded to become Secretary of Commerce. For Secretary of Agriculture, Harding chose Henry C. Wallace, Iowa farmer, conservationist, and editor of a rural paper, *Wallace's Farmer*, which had been founded by his father. Wallace was a graduate of Iowa State College of Agriculture and had been an assistant professor of agriculture there for three years under James Wilson, Secretary of Agriculture under McKinley, Roosevelt, and Taft. Wallace had the technical background for the position of Secretary of Agriculture and also an abiding interest in the economic and social problems of farming people. For Secretary of the Interior, however, Harding chose his close friend, Senator Albert Fall of New Mexico, an avowed anti-conservationist, who in his 8 years in the Senate had consistently favored the rapid exploitation of natural resources by private enterprise and expressed little faith in the Government's ability in business matters and even less in science of any kind. Gifford Pinchot is reported to have said of Fall "On the record, it would have been possible to pick a worse man for the Secretary of the Interior, but not altogether easy."

Hoover had been told by one of his predecessors at Commerce that the job of Secretary would not require more than two hours a day. However, he found "a sentence of major importance" in the organic act of the Department: "It shall be the province and duty of the said Department to foster, promote, and develop the foreign and domestic commerce, the mining, manufacturing, shipping and fishing industries, the labor interests and the transportation facilities of the United States." In accepting the position as Secretary, Hoover asked for a reorganization of the Government that would bring all the relevant bureaus into his department. Former Secretary of the Interior Lane observed that "unless he gets to be the leading adviser he'll have to get out." Hoover did not get out. He very quickly became one of Harding's key advisers, along with Secretary of State Charles Evans Hughes and Secretary of the Treasury Andrew W. Mellon, and continued to be a key adviser to President Coolidge. Thus his energies were never confined solely to the Department of Commerce.

Harding's inaugural address on March 4, 1921, set the tone for his administration, in fact for most of the decade. The key words were noninvolvement, normalcy, economy, and efficiency. The United States would "seek no part in directing the destinies of the Old World." The "supreme task" before the Nation was the "resumption of our onward, normal way." He called for a reduction in expenditures, for "administrative efficiency, for lightened tax burdens, for sound commercial practices, for adequate credit facilities, for sympathetic concern for all agricultural problems, for the omission of unnecessary interference of Government with business, and for more efficient business in government administration."

Hoover lost no time in getting into action in the Commerce Department. The American people were demanding a return to the past, to "normalcy," but clearly there could be no complete return. Unemployment was a problem, but unemployment he regarded as part of the overall problem of reconstruction and development in the aftermath of war. On March 19, Hoover invited 25 leaders in business, labor, and agriculture to serve as an advisory committee to the Department on these problems, and plans were made for a national conference in the fall. After meeting with his advisory committee, he issued a short statement in which he pointed out that

We have many idle men walking the streets, and at the same time we are short more than a million homes; our railways are far below their need in equipment; our power plants, waterways, and highways are all far behind our national needs in normal commerce. To apply this idle labor to our capital equipment is one of the first problems of the country.

Hoover also suggested that "an infinite amount of misery could be saved if we had the same spirit of spontaneous cooperation in every community for reconstruction that we had in war."

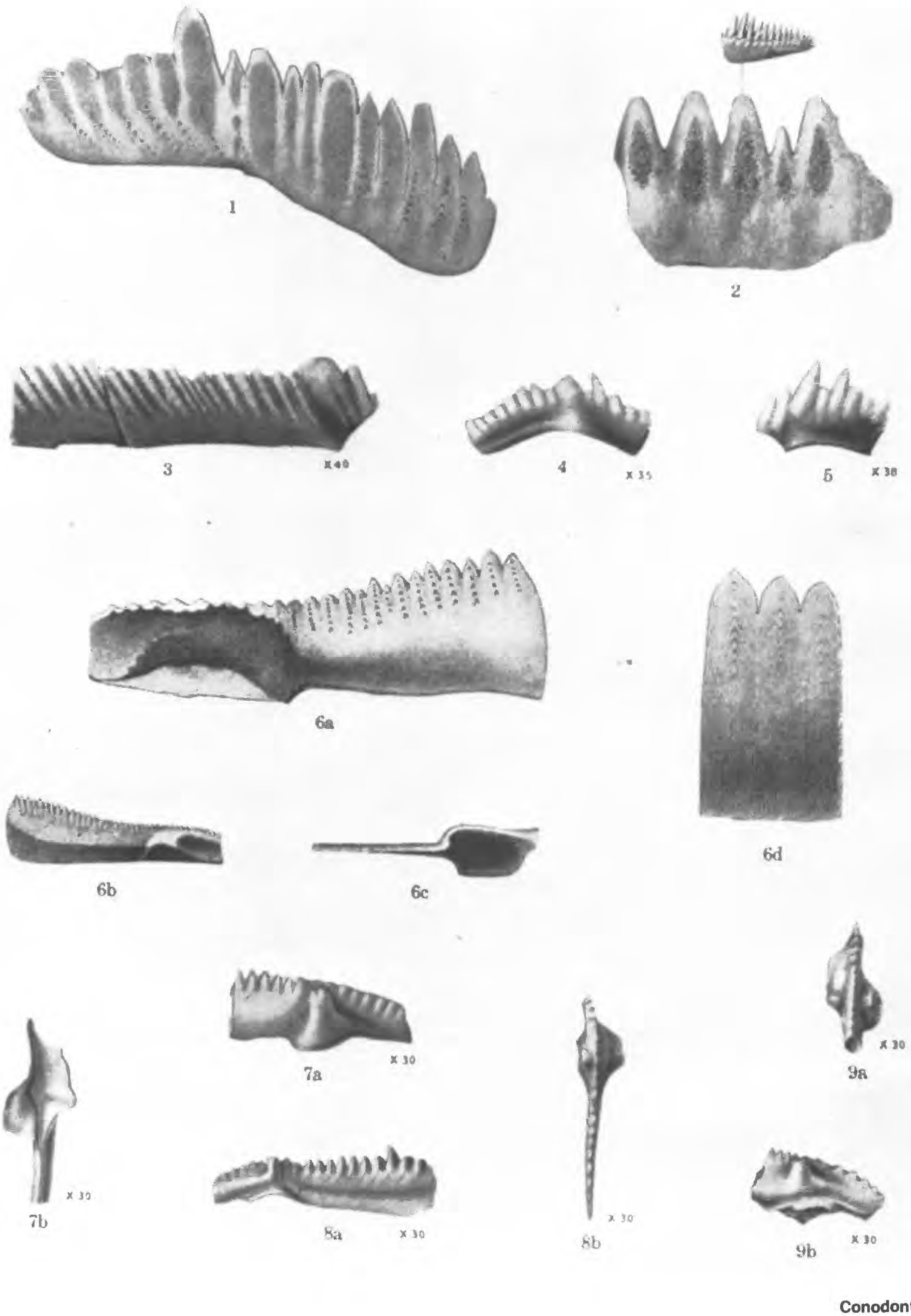
That spirit of spontaneous cooperation was still alive in the scientific community. In the spring of 1921, the Mining and Metallurgical Society of America set up a Committee on Foreign Mining Policy under the chairmanship of C. K. Leith. Secretary Hoover was asked to serve as a member of the committee; he declined but suggested that he could use the committee's advice in his department. Director George Otis Smith of the Geological Survey and Director Van H. Manning of the Bureau of Mines were members of the committee, along with H. Foster Bain, Sidney Ball, Horace Winchell, A. C. Veatch, and Pope Yeatman.

Another acute oil shortage had developed in the fall of 1920, and Secretary of the Navy Josephus Daniels had urged that all U. S. petroleum resources be nationalized, or at the very least that the Federal Government be given the power to prohibit the use of fuel oil for industrial purposes whenever it was needed for the Navy. Chairman W. H. Hurley of the U.S. Shipping Board suggested that the Federal Government collect the royalties it was receiving from its public lands in oil rather than money. The Geological Survey then asked the American Association of Petroleum Geologists to cooperate in preparing a new estimate of the oil remaining in the ground. David White, W. T. Thom, A. E. Fath, K. F. Mather, R. C. Moore (who was also State Geologist of Kansas), and K. C. Heald represented the Survey in this work; consulting geologists W. E. Wrather, Carl H. Beal, and Alexander Deussen, Professor Roswell Johnson, and oil-company geologists Wallace E. Pratt, Alexander McCoy, C. T. Lupton, and G. C. Matson, and Survey geologist K. C. Heald were designated as representatives of the AAPG.

The new Congress was called into special session on April 11, 1921, to deal with the "readjustments, reconstruction, and restoration which must follow in the wake of war." Hoover-backed bills were promptly filed, some of which affected the work of the Geological Survey: one by Senator Joseph S. Frelinghuysen of New Jersey to provide for the appointment of a Federal coal commissioner and to direct the Director of the Geological Survey to act as such commissioner, and another by Congressman Henry W. Temple of Pennsylvania to provide for a topographic survey of the United States. Both bills were referred to the Committee on Interstate and Foreign Commerce and were not heard from again during the session. Congress did, however, pass the Budget and Accounting Act, creating in the Treasury Department a Bureau of the Budget and an independent General Accounting Office under the Comptroller General of the United States. It also, by Joint Resolution, declared the world war ended and ratified treaties with Germany, Austria, and Hungary.

Meanwhile, Secretary Fall made his first moves to gain control of natural resources. He persuaded President Harding to issue an Executive order transferring jurisdiction over the naval petroleum reserves from the Navy Department to the Interior Department. Secretary of the Navy Edwin Denby acquiesced in the move, and the order was issued on May 31. A proposed Executive order, to transfer the Forest Service from the Department of Agriculture to the Department of the Interior, however, met with opposition and was not issued. Congress, on August 19, 1921, acceded to the request of the Governors of the Colorado River Basin States to authorize negotiation of a treaty among them on the rights of each State and the United States to the use and benefit of the

Oil was being obtained from greater depths but deep drilling was costly so operators turned to science to identify the formations penetrated by the drill. In areas where a knowledge of stratigraphy was well established, study of the fossils in drill cuttings was most useful but from wells drilled with cable tools large fossils were fragmental and often unidentifiable. Attention was therefore given to very small fossils that had to be studied under a microscope. Survey paleontologist P. V. Roundy, who began a study of the microfossils of Mississippian formations in Texas in 1919, considered faunas to be more reliable than individual species, and believed that conodonts, shown in the illustration, whose zoologic affinity was a matter of conjecture, would prove to be of considerable importance. (From P. V. Roundy, G. H. Girty, and M. L. Goldman, 1926.) ▶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waters of the Colorado and its tributaries, but it was Secretary of Commerce Hoover and not Secretary Fall who was chosen as the Federal representative and chairman of the commission.

The Geological Survey made rather extensive investigations in the Colorado River region in the summer of 1921. A topographic party made a survey of the Colorado River between the mouth of the Green River and Lees Ferry, and of the San Juan River from Bluff, Utah, to its mouth. E. C. LaRue of the Water Resources Branch went along to designate dam sites for detailed survey and to obtain information on the water-power resources. Geologists from the Geologic Branch accompanied the expeditions to determine the suitability of various dam and reservoir sites, taking advantage of the assignment to gain information on the geology of an extensive region that was little known and difficult of access. H. D. Miser and C. R. Longwell, with Kirk Bryan of the Water Resources Branch, studied the Paleozoic sections near Green River, Lees Ferry, and Bluff; Sidney Paige made geologic studies by river from Green River, Utah, to Lees Ferry, Arizona; Miser studied the geology along the lower San Juan and then joined Paige in Arizona.

In 1921, the Survey was again handicapped by lack of funds. Appropriations were almost exactly the same as those of the preceding year, and Congress had denied the Survey's request for an increase in the salary of the Director, still the $6,000 authorized in 1879, and for the establishment of the position of Assistant Director. Unheeded was George Otis Smith's plaintive statement: "All that we ask is that if we have accomplished anything, or if we have a well administered branch of the Government service, that we be given some reward in order that we may be prepared to do better service and to increase the service to the public. Now that is not an argument for an enlarged bureau. I think in a general way that the Geological Survey, the Bureau of Standards, and a few other scientific bureaus are about as large administrative units as is advisable, and I would not want to see the Geological Survey twice as large, but in some of the appropriations we need twice as much money as we used to have in order to do the same amount of work."

Development of water power as an alternative form of energy was stimulated by passage of the Water Power Act in June 1920. In 1921, a Geological Survey party that included members of the Topographic, Water Resources, and Geologic Branches explored and mapped the San Juan Canyon in southeastern Utah in connection with proposed power and storage projects, making the 140-mile trip down the river in two 16-foot flat-bottomed rowboats. The region trenched by the canyon was rough arid country, difficult of access, penetrated by few trails and still fewer roads, and parts of it were impassable for man and beast; in 1921, no one lived in the canyon and the entire region had only a few score inhabitants. The photograph shows a topographer at work in a view looking downstream toward Mexican Hat. (From H. D. Miser, 1924.)

Thus it was that in addition to its work on the Colorado River project in 1921, the Topographic Branch mapped only in the 20 States and the Territory of Hawaii that contributed cooperative funds. More than 42 percent of the area mapped was in just four States: Pennsylvania, West Virginia, Illinois, and Missouri. In Illinois, in addition to the quadrangle mapping, surveys were begun along proposed trunk-line highways, and the mapping done so it could be incorporated in standard topographic maps at a future time. Topographers also began a special survey of part of Shasta Valley, California, on a scale of 2,000 feet to the inch, for preliminary planning of an irrigation system as part of Robert Marshall's plan. It was understood that a resurvey would be necessary on a still larger scale if the project were found feasible. The topographic work in the West Indies was discontinued in the fall of 1921. On June 14, 1921, the United States had withdrawn from responsibilities assumed in connection with Dominican affairs in 1916, and in September the Military Governor issued instructions to discontinue the mapping. Triangulation in Haiti was discontinued in October when funds were exhausted.

The work of the Water Resources Branch in 1921 was also to a large extent dictated by the availability of cooperative and repay funds, which again exceeded the direct appropriation. Most of these funds were supplied for investigations related to the utilization of water for power or irrigation, and most involved measurements of streamflow. In connection with the administration of the Federal Water Power Act, the Survey also carried on stream gaging in 17 States in cooperation with Federal Power Commission permittees. During the year, the number of gaging stations being maintained increased to 1,540. Examinations were made to determine where water-power development existed in trespass and whether all lands that should be reserved for power purposes were actually included in power-site reserves in Utah and Idaho. B. E. Jones made a reconnaissance examination of power-site withdrawals along the Arkansas River and headwater tributaries west of Pueblo, Colorado.

The Ground Water Division began a systematic investigation of the artesian and other ground-water resources of Idaho in cooperation with the State Bureau of Mines and Geology. O. E. Meinzer organized the field work and made a general reconnaissance of large parts of the State east of Twin Falls. H. T. Stearns of the Ground Water Division and L. L. Bryan of the Surface Water Division, who had begun an investigation of the water resources of the Mud Lake basin in Idaho in April 1921 then continued the work. W. O. Clark completed the investigation of the ground water in the Kau district of Hawaii, and G. M. Hall took up the work in Montana left incomplete when Ellis died. Meinzer, who had become interested in the need to improve the technique of drilling wells to reduce the waste of ground water through leakage, was invited to attend the annual meeting of the North Dakota Well Drillers Association in January 1922. In a 3-day session, the members were instructed in the elements of geology, sanitation, and technical methods related to well drilling. Meinzer, who addressed the meeting, was elected an honorary member of the association.

In contrast to the Topographic and Water Resources Branches, the Geologic Branch in the summer of 1921 was more concerned with long-range studies rather than immediate results. Economic geology was again principally petroleum geology. The scope of the mapping in Montana, where there had been little commercial interest, was increased and several recently appointed young geologists were assigned to work under W. T. Thom, Jr., Frank Reeves, A. J. Collier, and S. H. Cathcart. In Wyoming, which was favored oil country that year for commercial prospecting, the Survey's efforts were limited to K. C. Heald's study of the geology and probable productivity of Teapot Dome. In the Midcontinent region, the great El Dorado field had been brought in in January 1921 in what had been a poorly regarded wildcat area in southern

Arkansas. W. W. Rubey collected drill records and other data about the field and concluded that its structure was unlike that of any other known field of similar size, that in fact the structure of the oil sand had been produced by lateral movement along a fault.

Areal geologic mapping was resumed in many parts of the country in 1921 and after many years, the branch was once again able to undertake a reconnaissance exploration of a still largely unknown area, and H. G. Ferguson and party began mapping the 4,000-square-mile Tonopah quadrangle in Nevada. In addition to the stratigraphic studies being made as part of the Colorado River investigation, W. T. Lee and J. B. Reeside, Jr., began detailed stratigraphic investigations in northern Colorado and southern Wyoming. By accurately measuring sections so close to each other that there was little opportunity for error, they were able to resolve problems about the age and stratigraphic position of certain oil sands as well as to learn much about the geologic history of the region. At the meeting of the American Association of Petroleum Geologists in the spring of 1922, it was suggested that similar stratigraphic studies would be of more assistance to the oil companies than the Survey's structural mapping even though the Survey's maps had been the basis for several discoveries.

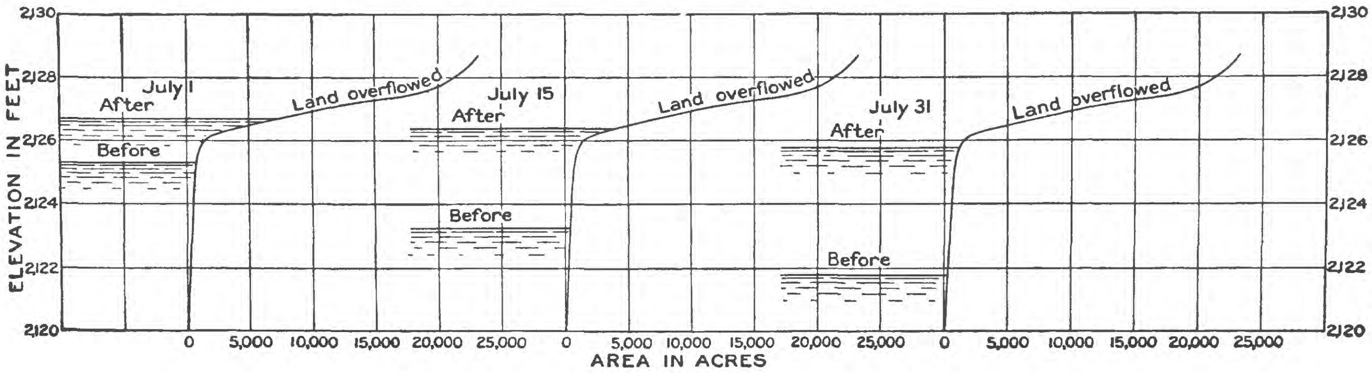
In another venture into the unknown in 1921, L. F. Noble began detailed mapping along the San Andreas fault and reconnaissance mapping elswhere in California as part of a program outlined by the Advisory Committee on Seismology of the Carnegie Institution of Washington under the chairmanship of Arthur L. Day. The program, essentially that suggested by H. O. Wood in 1916 when he was an associate at the Carnegie Geophysical Laboratory, was aimed at predicting major earthquakes and devising practical measures to minimize the danger from their occurrence and to mitigate the disaster caused by destructive shocks. The program included geologic, geodetic, geophysical, and laboratory investigations which were undertaken by the U.S. Geological Survey and the U.S. Coast and Geodetic Survey, as well as some private institutions such as the California Institute of Technology.

In late 1921, the Survey's Director, George Otis Smith, proclaimed a partnership between geology and industry. Science of all kinds had become more practical, he said, and the utilitarian trend of science had brought it into close touch with industry. Overlooking the Survey's early relations with the mining industry, Smith claimed that geologists had only recently come into this relationship, when they had been called on during the war to solve raw materials problems, and remarked that

> only as the utilitarian value of geology has become recognized has a use been found for geologists.

The Pick and Hammer Club noted ruefully "Once economic studies helped a miner find his ore * * * But in those days statistics had not yet come to the fore."

The Survey's Chief Geologist did not comment publicly on Smith's idea, but A. H. Brooks, in his presidential address to the Washington Academy of Sciences, observed that the terms "practical" and "pure" should never have been applied to science. If the one was practical, the other must be impractical; if one was pure, the other was impure. Brooks thought there was no basic difference between practical and pure science. Federal scientists chose to investigate economic problems not because of any lack of thoroughness or any abasement of scientific ideals but because the organic or appropriations acts of most Federal scientific bureaus required them to direct research toward problems whose solution would contribute to the general welfare. The widespread belief that reorganization would cure all faults, Brooks feared, would not lead to much good for some of the plans were based on a misapprehension of the



The development of water power sometimes caused unexpected problems as in Idaho, where R. W. Davenport was sent to investigate the controversy between landowners around Coeur d'Alene Lake and the Washington Water Power Company, which used the lake as a reservoir to store flood water in the spring and release it in low-water periods to assure the output of power from its hydroelectric plants on the Spokane River. Before the lake was used for storage, the water surface during July, under average conditions, was 2 to 5 feet below the main part of the bottom lands and drainage was facilitated; when the lake was used for storage, the water surface during July was within 1 to 2 feet of most of the bottom lands, drainage was retarded, and the land became unsuitable for growing crops, even wild hay. (From R. W. Davenport, 1922.)

purposes and methods of science. In particular, he pointed out that there must be a complete separation between scientific research and the administration of law.

Smith's "partnership" between geology and industry encountered problems almost as soon as it was announced. In November 1921, the Leith Committee on Foreign Mining Policy published a preliminary report in the hope of stimulating the mineral industry to think about the development of a national policy. The committee proposed a set of principles they believed to be "basic to the formulation of laws and agreements affecting natural resources." In general, the committee held that unless local conditions made the cost excessive, it was usually best to concentrate, smelt, or fabricate the mineral resources near the source of supply. There were two exceptions: it was more efficient to process some minerals near the source of coal than in the mining area, and shipping conditions sometimes made it cheaper and more efficient to carry crude ores to secure proper combination cargoes and to balance local imports and exports. The committee also held that freedom of trade and freedom of exploration were essential. "Any restrictions, national or international, which interfere with the necessary searching of the earth are in principle undesirable." They urged the United States Government to keep in close touch with American activities in foreign minerals fields, use mineral specialists on the staffs of consuls or other agencies abroad, coordinate mineral information to make it available to interested parties, and utilize international fact-finding committees such as the International Geological Congress.

The Leith committee divided United States mineral resources into four categories: minerals available in large quantities for export, minerals in adequate supply for American needs, minerals of which the United States had some supplies but not enough to meet the domestic demand, and minerals almost entirely lacking in the United States. The committee believed that protective legislation, designed to keep foreign supplies out and to utilize domestic resources, would succeed for minerals in the last two classes only at an excessive cost in efficiency and money, and, further, that Government restrictions on imports might bring retaliation from foreign governments and make it difficult for American enterprise to find and develop needed reserves of scarce minerals in countries that had more favorable geologic conditions.

The Leith committee's report was attacked as soon as it was published. Those who sought high tariffs denounced it as a free-trade document. Others objected to the classification of the various minerals. The American Mining Congress pointedly refused to endorse it. The War Department, however, had already begun to consider plans for procuring essential metals in times of national emergency, and the Assistant Secretary of War asked President A. S. Dwight of the American Institute of Mining Engineers to cooperate in the project. Leith was asked to serve on the AIME Committee on Industrial Preparedness. He and Dwight agreed that, to avoid duplication of effort, subcommittees on specific minerals of the AIME Committee and of the Mining and Metallurgical Society Committee would for the most part include the same people, and that reports of the MMS Committee would be expanded to meet the needs of the War Department for estimates of the United States' requirements under war conditions and for recommendations for stockpile purchases.

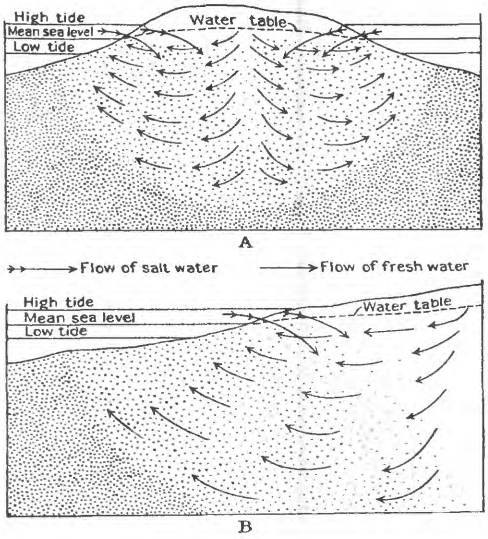
In January 1922, the joint AAPG-USGS committee announced its estimate of the Nation's petroleum reserves—9,150 million barrels, 5 billion "in sight" and 4 billion "prospective and possible." This report was also promptly attacked. Thomas A. O'Donnell, president of the American Petroleum Institute, decried the "super-scientists" who were "constantly measuring the petroleum resources of the world and pointing out various kinds of disaster following its exhaustion" and the "very able writers with a great command of the English language and a new use of mathematics" who used the statements of the scientists for some "wonderfully interesting articles" that gave "an exaggerated viewpoint to the public mind as to the immediate danger confronting our country through lack of the necessary petroleum resources of the future." E. L. DeGolyer, consulting geologist to oil companies, complained that producers were suffering from low prices because of overproduction and a glutted market at a time when the estimates of geologists, and the conclusions that industry leaders had drawn from them, indicated that petroleum would be in great demand and consequently high-priced. He feared that the new fields in the United States and Mexico would bring on more overproduction and panic prices. According to DeGolyer

> **It behooves the geologist, to consider seriously the value of these general estimates which he presents from time to time as well as the adequacy of the bases which he may have for making estimates at all. One might even question the necessity and desirability of trying to make such general estimates. It is doubtful whether they have been of value or service beyond giving concrete expression to and thus providing for popular education in the fact that our petroleum resources are not inexhaustible.**

DeGolyer especially objected to estimates of what might be expected from undiscovered fields, which he labeled as pure guesswork. Arthur Veatch, then chief geologist for Sinclair, promptly disagreed with DeGolyer. Petroleum occupied a "paradoxical position" among minerals in that new discoveries, new researches, and new developments tended to increase, rather than decrease, the possibilities of its occurrence in hitherto unsuspected regions. The growth of knowledge about oil had progressively extended its known range through rocks of different ages and multiplied the conditions under which it might occur in commercial quantities. Veatch thought it quite possible to make a useful estimate of oil in unknown territory but questioned the attempt to express exhaustion in terms of years because that ignored fundamental economic factors.

> **Long before the world has reached a stage when high prices will fail to bring temporary overproduction—and I believe that time is more distant than some recent estimates indicate—petroleum prices will approach the economic limit, which will, on the one hand, curtail certain uses of petroleum products, and, on the other, make it commercially feasible to manufacture substitutes for many petroleum products, or to derive them more extensively by distillation from the very widely distributed oil-shale deposits, or what is probably a much more important source—the high-volatile coals.**

The AAPG-USGS committee had not relied solely on its own judgment in making the estimate of petroleum reserves. State geologists, regional geologists, consulting specialists, and geologists and engineers attached to many companies had worked with the committee. Local and State committees had reviewed reports for districts, counties, and fields before the joint committee considered them. But before the report was issued, previously discovered



The proximity of salt water makes it difficult to obtain supplies of fresh water of good quality at many places along coasts. Wells near the sea may become salty by the admixture of sea water, and the water level may rise and fall with the tides. Contamination (the Survey preferred to reserve the term "pollution" for unsanitary conditions of water due to sewage and industrial wastes) by sea water was by far the most ◀ troublesome problem, for sea water, even in small quantity, makes ground water unfit for both domestic and many industrial uses. The illustration is an ideal diagram showing movements of fresh ground water and the gradation into sea water along shores composed of uniformly porous sand on (A) a small island and (B) a mainland shore. Sea water is shown by heavy stipple, fresh water without stipple, and mixtures by a light stipple. (From J. S. Brown, 1925.)

fields whose development had been hampered by drilling difficulties or legal restrictions came into production, and new fields were discovered in California, Oklahoma, Arkansas, and Texas. Only a month after the estimate was made public, daily production of oil began to exceed consumption. The estimate, although made on the best information available at the time it was completed, confirmed Chief Geologist White's statement that "the geologic principles controlling the distribution of oil and gas have as yet been discovered only in part, and what remains yet to be learned is probably vastly more than what is already known."

While these arguments on petroleum resources were being aired, Secretary Fall on April 7, 1922, leased part of the Salt Creek field and the naval reserve in Teapot Dome to Harry F. Sinclair. The leases very quickly came up for discussion in Congress. On April 15, the Senate, acting on a resolution proposed by Senator John B. Kendrick of Wyoming, called on Secretary Fall to explain the lease of Naval Petroleum Reserve No. 3. Senator Kendrick said two questions were involved: Was there present need for the development of Teapot Dome? The adjacent Salt Creek field was not producing fully and leases there had been suspended. If Teapot Dome were to be developed, were the interests of the Government best served by public or private sale?

Acting Secretary of the Interior Finney and Secretary of the Navy Denby submitted a joint reply on April 21, stating that "The naval reserves in California have, by drilling and production on privately owned lands ajoining, already been drained to a very large extent, involving a loss to the Government of millions of barrels of oil, and from a careful geologic study recently made by an expert of this department it was found that the Teapot Dome was menaced with similar drainage danger." The report also stated that one of the reasons why the Salt Creek field was partly shut down was the lack of pipelines in the Wyoming area, and so Secretary Fall had considered proposals from several oil companies and individuals for development of the reserve with the accompanying guaranty of construction of adequate pipeline facilities. After full consideration of all offers submitted, a contract had been signed on April 7 with the recently incorporated Mammoth Oil Company. As oil in the ground, or even as it came from the ground before refining and transportation, was of no use to the Navy, this procedure, Finney and Denby added, was in the Navy's best interest.

On the day that the joint reply was received, Senator LaFollette introduced a resolution calling on the Secretary of the Interior to produce information and documents on the status of leasing in all three naval petroleum reserves. The resolution was allowed to lie on the table for several days, during which time

Salt water could also be a problem in the interior. In northwestern Oklahoma, the average precipitation is only about 20 inches a year, barely sufficient for farming. Precipitation had been deficient for 2 or 3 years when a large flow of water, reported to be 40,000 to 50,000 barrels a day, was struck at a depth of 508 feet in a well being drilled for oil in Ellis County. After an investigation, D. G. Thompson of the Survey concluded that water could probably be obtained in deep wells in sufficient quantity for irrigation but it would be so salty that it would kill crops and spoil the land for future use. In the uplands, water suitable for irrigation might be obtained from shallower wells but at a prohibitive cost. Farmers were advised to find relief from drought by a careful study of the crops and farming methods best adapted to the climate. (From D. G. Thompson, 1921.)

For most of the metals industries, the immediate postwar problem was oversupply, but a decrease in gold production was cause for concern because a sufficient gold reserve was considered essential to the security of national finance and credit. The depletion of some deposits, the lower grade of ore mined in others, and the fixed price of gold all contributed to the decline, and the elusive character of the metal complicated the search for new deposits. F. L. Ransome found that in the Oatman district in northwestern Arizona, for example, where gold had been discovered during the Civil War, small-scale mining had been carried on since the 1890's, and rich discoveries had been made in 1915 and later years, some of the largest ore bodies gave little or no indication of their presence at or near the surface, and some of the more conspicuous vein outcrops had little of value beneath them. Moreover, although the veins were mineralogically simple, gold was visible only in unusually rich ore. The photograph shows the Gold Road vein exposed on the Oatman-Kingman Road. (From F. L. Ransome, 1923.)

the Elk Hills Naval Reserve in California was leased to E. L. Doheny. On April 28, LaFollette attacked the leasing of Teapot Dome in a long speech. He denied that there was any danger of drainage, and to substantiate his statement quoted several geologists, among them the Survey's Chief Geologist David White who had said that he had no evidence in his office to support any such claim. The LaFollette resolution was then unanimously passed by the Senate on April 29.

There was far more public interest in coal than in oil at the time, for another coal strike had begun on April 1, 1922. The problem was the same as in 1919; the industry was overdeveloped, the miners wanted steady work, the operators wanted to cut costs, and the public wanted cheap coal. When the operators in the bituminous fields refused to renew the existing wage agreement and called for drastic wage reductions, 500,000 bituminous coal miners went out on strike and were joined shortly by 150,000 anthracite workers. In mid-May, Secretary Hoover called a small group of coal operators together in conference, and then called a general meeting of coal operators on May 31 to consult with them "as to what measures could be taken to restrain runaway prices, profiteering, and speculation in coal during the strike." The preliminary conference suggested that the Garfield prices of October 29, 1917, be used to compute fair sales prices and that plan was agreed to in the general meeting despite a certain amount of criticism. *Coal Age* hailed the agreement as an "epoch in industrial progress," and praised Hoover's ability to get things done, noting that 99 percent of the operators approved the plan even though it would prevent them from recouping losses. George Otis Smith said that after "living with the coal question for weeks" he was "fully convinced that the plan Secretary Hoover is engineering in the interest of the public holds a larger promise of keeping coal prices down than any other move that is feasible at this time."

While Secretary Hoover was receiving accolades for his handling of the coal crisis, President Harding sent Secretary Fall's reply to the LaFollette resolution to the Senate. Although the President stipulated that the reply was not to be construed as a defense of either specific acts or general policies, it was chiefly a defense of the leasing of the Teapot Dome reserve. The report showed that the Geological Survey and the Bureau of Mines held different views on the possible drainage of the reserve and that Fall had placed greater credence in the Bureau's findings. The crux of the matter was the relation of the Salt Creek field to Teapot Dome. C. H. Wegemann had mapped the Salt Creek and Teapot Dome structures as separate in 1909, and when the reserve was established in 1915, a small part of the Salt Creek field had been included. In

1921, after Wegemann had left the Survey for private industry, he suggested that there was evidence of a fault in the area and that the Salt Creek wells might draw on the reserve. K. C. Heald had examined the area in 1921 and concluded that Wegemann's map should indeed be modified; the structure was probably a single, faulted dome and part of the reserve would be drained, but that the drainage would be exceedingly slow. At the rate of production then current, Heald concluded it would be a year or more before any part of the reserve would be appreciably damaged, but recommended that if appreciable loss became imminent because of intensive drilling near the line between the reserve and the Salt Creek field, a certain few fractions in the reserve should be leased. The Bureau of Mines engineers, however, had concluded that the danger of loss by drainage was imminent and serious. Fall's report was referred to the Committee on Public Lands and no more was heard of it.

Early in July 1922, the Federal Trade Commission filed a report on conditions in the petroleum trade in Wyoming and Montana for the stated purpose of bringing to the attention of Congress a situation which appeared to call for legislative action. Early in 1921, the prices of crude petroleum had been radically reduced in all the oil fields east of the Rocky Mountains, but the slow and unequal decline in prices of gasoline throughout the country brought complaints to the FTC, especially from Montana. The Commission pointed out that the petroleum industry of Montana, in fact of the whole Rocky Mountain region, was dominated by Standard Oil interests which legally were supposed to be strangers to each other but which were actually related through interlocking stock ownership. The fact that Standard of Indiana owned a half interest in Sinclair Pipeline and Sinclair Crude Oil Producing Company suggested to the commission that the contemplated entrance of Standard-Sinclair interests in the producing and transportation of Teapot Dome oil would increase the monopolistic control of the industry. The report was duly received and referred to the Interstate Commerce Committee but no action was taken.

The Survey had, meanwhile, begun the new fiscal year with an appropriation that was about 9 percent less than that for the preceding year. Under the

In the years immediately after World War I, when funds were short and scientists were leaving the Survey for private industry, the Geologic Branch supported basic research in various ways. In the summer and fall of 1919, surveying instruments and field equipment were loaned to Yale graduate student C. R. Longwell for his study of an almost unmapped area in southeastern Nevada and northwestern Arizona. The pioneer scientists who had studied the Colorado Plateau and Great Basin regions had given only passing notice to the area, and although it was of critical interest, being near the boundary of two provinces, later efforts had been discouraged by the climate, scarcity of settlements, and lack of base maps. The area included Boulder Canyon, shown in the photograph, now covered by Lake Mead. (From C. R. Longwell, 1928.)

Budget and Accounting Act, appropriations were scheduled in bills framed along departmental lines, and the Senate and House Appropriations Committees established subcommittees to specialize in the work of the different departments. L. C. Cramton of Michigan, chairman of the House subcommittee on the Interior Department, characterized the Survey as "a great service, which has been remarkably well administered under Dr. George Otis Smith. It is a service which joins in an effective and very necessary way with every activity in connection with the national domain, and has other important work." Nonetheless the committee delved into such matters as the number of automobiles and trucks in use, obviously fearing that Government employees would be tempted to ride around in them, questioned attendance at scientific meetings, another privilege that might be abused, and then reduced the budget "not because of any lack of confidence in the survey or any lack of appreciation of their work but because we have felt that some of its activities which must be done sometime are some of the things that now can wait." The major cuts were made in the appropriations for geologic surveys, classification of public lands, and engraving of geologic maps. A House cut in the appropriation for topographic surveys was restored by the Senate, and in the end that appropriation was cut only $5,000.

Percentagewise and dollarwise, the appropriation for classification of the public lands was cut most severely, so less field work for purposes of classification could be done. Because the Land Classification Branch was allotting funds to the field branches for such work, however, the cut was in large part simply passed on to the field branches. This did not greatly affect the Topographic and Water Resources Branches, both of which again received substantial funds from other sources to supplement the directly appropriated funds. Twenty-two States and the Territory of Hawaii contributed $286,000, equal to about 86 percent of the direct appropriation, for cooperative topographic surveys, and other Federal agencies supplied an additional $23,000. Outside funds for water-resources investigations were again considerably more than the direct appropriation. In the Geologic Branch, on the other hand, funds for the Division of Geology were about 14 percent less than in the preceding year; the appropriation for the Division of Physical and Chemical Research was the same as it had been since 1911, for the Division of Mineral Resources the same as it had been in 1920.

The appropriation for investigation of the Alaskan Mineral Resources had not been increased since it was cut in 1918 on the theory that the war was far away from Alaska. However, the Division of Alaskan Mineral Resources was no longer part of the Geologic Branch but a Branch in its own right. Secretary Fall's efforts to take over the Forest Service had been thwarted by a well organized campaign that produced a stream of editorials and letters opposing the transfer, and his disposition of the naval oil reserves was being scrutinized. His interest in developing, or exploiting, Alaskan resources, however, met with more success, and the President himself encouraged him. In line with the development policy, the Division of Alaskan Mineral Resources was separated from the Geologic Branch on April 1, 1922, and made an independent branch. A. H. Brooks, who remained in charge, adopted the title "Chief Alaskan Geologist."

During the summer of 1922, Brooks accompanied a Department of Commerce expedition to study the fishing and fur-seal industries of the northern Pacific, taking advantage of the opportunity to study the geology and mineral resources of the coastal regions of Alaska, the adjacent islands, and portions of the coast of Siberia. R. H. Sargent was in charge of a double party making a reconnaissance topographic and geologic survey of the oil fields of the Alaska Peninsula. W. R. Smith accompanied Sargent, and R. K. Lynt and A. A. Baker formed the second party.

In 1920, W. T. Lee, one of the few coal geologists who had not left the Survey for private industry, spent several months making a practical test, with the aid of the air services of the U.S. Army and the U.S. Navy, of the use of aerial photography in studying the physical features of the surface of the Earth. Aerial photography had been used during the war to record enemy positions, and A. H. Brooks, Chief Geologist of the A.E.F., had found that he could infer geologic information from such photographs. Lee concluded that aerial photography would aid both geographic and geologic investigators and could also be used to aid prospectors in their search for ore or oil. The photograph, taken by Lee, shows a tidal delta partly above water, and the hook-shaped bars built across the outlet of Popes Creek, Virginia, by tidal currents from the Potomac. (From W. T. Lee, 1925.)

The Topographic, Water Resources, and Geologic Branches again collaborated in special investigations in the Colorado River drainage basin in 1922. River surveys were made along the Green River from Green River, Wyoming, to Green River, Utah, and on the Yampa from its mouth to the Cross Mountain reservoir site to ascertain the feasibility of storing and diverting the waters of the Green River for irrigation and generation of power. R. R. Woolley accompanied the Green River party to designate dam sites for detailed survey and Warren Oakey was attached to the Yampa River party for the same purpose. J. B. Reeside, Jr., accompanied the Green River party to make geologic examinations of proposed dam and reservoir sites.

E. C. LaRue served as chairman of the Arizona Engineering Commission established by the State to study the possibility of irrigation in Arizona by water from the Colorado. He also made a special survey of the river between Halls Crossing, Utah, and Lees Ferry, Arizona, to examine in detail some of the possible dam sites disclosed by maps made from the surveys in 1921, and examined power sites at the mouth of Diamond Creek and on the lower portion of the river from Boulder Canyon to Needles. F. L. Ransome studied the geology of the Boulder Canyon and Black Canyon dam sites, and H. A. C. Jenison examined the possible economic resources of the reservoir sites.

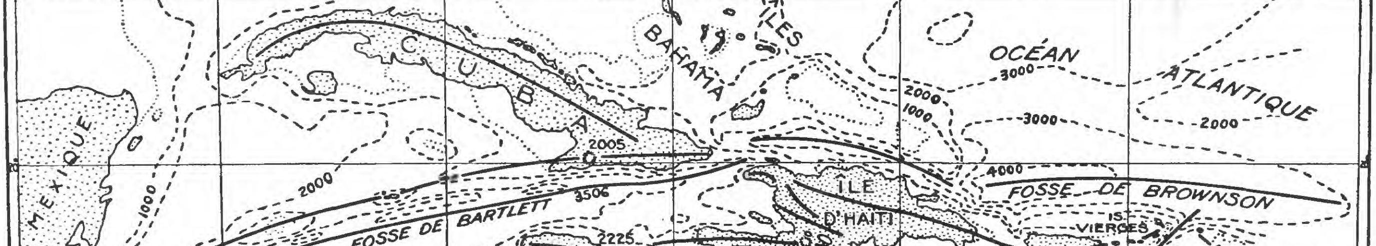
The Topographic Branch made two special surveys of the Klamath-Shasta Valley irrigation project in California in 1922, as well as special surveys of several counties in Utah, in cooperation with the counties and the Reclamation Service to aid in planning irrigation and drainage systems. Topographic surveys were also made in 24 States and in Hawaii, but only 60 square miles were mapped in the two States that did not contribute cooperative funds.

In the Water Resources Branch, nearly all the work done under cooperative agreements was concerned with streamflow, and stream measurements were also made for the Reclamation Service, the Office of Indian Affairs, the National Park Service, the Forest Service, the city of San Francisco, and the Federal Power Commission. At the end of the year, the number of gaging stations had increased to 1,591. Ground-water geologists had several reports in preparation but were unable to undertake much field work. The investigations in Idaho, begun in 1921, were continued by H. T. Stearns and L. L. Bryan of the Surface

Water Division, and Kirk Bryan studied the ground-water conditions in Yosemite National Park and made a special investigation of the proposed dam sites in Paradise Valley, Nevada. Norah Dowell was detailed to the Fort Caswell laboratory of the Public Health Service in May to assist in experiments to determine the extent to which *Bacillus coli* and the germs of typhoid fever were transported by ground water. Later in the year, the division established a small hydrologic laboratory to determine the mechanical composition, porosity, moisture equivalent, and permeability of water-bearing materials and placed Dowell in charge.

The peak of homesteading under the Stock Raising Homestead Act had been reached in 1921, and the decline thereafter seemed to bear out the earlier predictions of some sheepmen and cattlemen's associations that the breakup of the range into 640-acre homesteads would damage its carrying capacity. A Department of Agriculture bulletin issued in October 1922 went so far as to state that the Act of 1916 was proving an outright snare to deluded people, that much of the land classified as suitable for stock raising homesteads was "barely up to the requirements of the Land Classification Board" and that trying to make a living on 640 acres in most cases was "extremely hazardous." Although the General Land Office continued to hold that the results of the act were on the whole beneficial, the Division of Homestead Classification of the Survey's Land Classification Branch, under instructions from the Secretary of the Interior, began a cooperative program with the Department of Agriculture's newly formed Bureau of Agricultural Economics in studying the agriculture and utilization of land in the northern Great Plains region. Henry C. Taylor, the head of the new bureau, was a pioneer in the field of agricultural economics. A native of Iowa and a graduate of the Iowa State College of Agriculture, he had also studied at the University of Wisconsin where he came under the influence of Richard T. Ely. From 1901 until 1919, Taylor had been a member of the faculty of the University of Wisconsin, but left to join the Department of Agriculture, which he felt gave an opportunity to expand the work on agricultural econimics on a nationwide basis.

The Geologic Branch accommodated itself as best it could to the reduced funds in 1922 and for the most part emphasized completion of projects already begun rather than undertaking any new work. The Metals Section made a definite effort to finish up the work in Arizona. F. L. Ransome finished field work in the Oatman district, C. P. Ross completed the field studies of the Christmas quadrangle and the Aravaipa and Stanley mining districts, and special arrangements were made to permit Waldemar Lindgren to investigate mining districts in Yavapai County and E. S. Bastin to complete a report on the silver ores near Chloride and Kingman. Edward Sampson and J. L. Gillson continued the investigation of the mineral resources of Idaho. In Nevada, H. G.



In the fall and winter of 1920-1921, W. P. Woodring, J. S. Brown, and W. S. Burbank of the Survey made, at the request and expense of the Haitian Government, a reconnaissance survey of the Republic of Haiti and a detailed reconnaissance of several specific regions to ascertain the extent of mineral deposits and the possibility of utilizing the ground-water resources. In their report they also pointed out that the most striking thing in the morphology of the West Indies is the arrangement of its geographic features in arcs, seen in the trends of the islands and mountain ranges, and of the ridges and troughs in the submerged areas. No attempt was made to determine the significance of the arrangement although it was noted that the arcs were similar to the arcs of folded mountains in other areas. (From W. P. Woodring, J. S. Brown, and. W. S. Burbank, 1924.)

Ferguson, assisted by S. H. Cathcart, continued mapping the Tonopah and Hawthorne quadrangles, and L. G. Westgate, assisted by C. H. Dane, began field work in the Pioche mining district. At the request of B. S. Butler, L. C. Graton, and others who were investigating the native copper ores of the Lake Superior region, chemist R. C. Wells began experiments on the chemical changes by which copper may be formed in nature, resuming the fundamental work done by Stoke some years earlier. E. F. Burchard of the Section of Iron and Steel Alloy Metals returned from the Philippines and began a field study of the brown iron ores of west-central Tennessee in cooperation with the State survey. Mapping of potential oil areas was continued, chiefly in Montana, but also in parts of Wyoming, Oklahoma, and Los Angeles County, California. Research was also continued on the source materials of petroleum, the physical properties of reservoir rocks, microfaunas as aids to the identification and correlation of beds, and on salt-dome caprocks. The potash program was experiencing difficulties as few samples were being obtained for analysis since the adoption of core drilling. G. R. Mansfield continued his field work in the phosphate regions of Idaho.

Among the noneconomic sections, the Coastal Plain Section was especially active in 1922. T. W. Vaughan and associates, both within and outside the Survey, were engaged in special studies of the physical and chemical properties of sediments and the fundamental principles of sedimentation. George Steiger of the Chemical Laboratory also spent most of his time on sedimentation studies, and devised a method for analysis of sediments that was applied with satisfactory results to bottom samples from the Bay of Maine and from the vicinity of Samoa. Areal mapping and stratigraphic studies were continued in various parts of the country, and C. W. Cooke and L. W. Stephenson spent some time in Alabama to establish boundaries for a State geologic map.

The coal strike had continued into the summer of 1922 and became the cause of much public concern as the fall approached. Strikebreakers had been brought into a southern Illinois field late in June, and the resulting violence had left a score dead and many injured. In July, a conference was held in the White House, much like the one convened by Roosevelt in 1902. This time, the operators agreed to accept arbitration and to reopen the mines on the terms in effect before the walkout, pending final settlement, but the miners demurred. The miners finally agreed to return to work on the old scale with the understanding that a Federal investigation of the industry would be made.

By mid-August, the situation had become very serious; Survey information indicated that coal stocks were little more than one-third what they had been on April 1. President Harding addressed a joint session of Congress on August 18, characterizing the situation as "menacing to the Nation's welfare," and asked for creation of a commission to make a "searching investigation of the whole coal industry." The House passed such a bill on August 23; the Senate, which had two coal commission bills on its calendar when the House bill arrived, delayed until September 8 before passing a bill. The final bill, agreed to by both houses, called for a commission of 7 members, to be appointed by the President with the advice and consent of the Senate, at an annual salary of $7,500, "to investigate and ascertain fully the facts and conditions and study the problems and questions relative to the coal industry with a view to and for the purpose of aiding, assisting and advising Congress in matters of legislation which will insure a supply of this commodity to the industries and the people generally."

On October 10, President Harding, acting without the advice and consent of the Senate, which had already adjourned to campaign for the November elections, nominated the seven members of the Coal Commission: John Hays Hammond, the well known mining engineer, chairman; former Vice President Thomas R. Marshall; Judge Samuel Alschuler, noted labor arbitrator; Clark

Howell, editor of the *Atlanta Constitution*; Dr. Edward Devine, former professor of social economy at Columbia University; Charles P. Neill, former Commissioner of Labor Statistics; and George Otis Smith, Director of the U.S. Geological Survey. The selection met with mingled cheers and jeers from the coal operators and miners. George Otis Smith planned to divide his time between the Survey and the Coal Commission, but the Comptroller General ruled that he could not hold two Government positions at the same time. Concluding that service on the Coal Commission was "not only a deserved honor to the Survey but also a desired chance to make the largest use of Survey data and personnel to the advantage of the public," Smith resigned as Director of the Geological Survey on October 31, 1922, with the understanding that he would be reinstated when the Coal Commission expired by law on September 22, 1923. In the person of the Director of the Geological Survey, at least, science and industry had converged.

Chapter 9. The Sound of a Different Drum, 1922–1925

If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music which he hears, however measured or far away.

—Henry David Thoreau

By November 1922, the U.S. economy had pretty well recovered from the protracted slump that began in the spring of 1920 and a new era of prosperity was underway. The Nation was well launched on a second industrial revolution as the result of the increase in manufacturing capacity during the war, the increase in electrical power, and the development of industrial chemistry, especially in the manufacture of special-purpose steels and of synthetics. Automobile production was on the rise (to become before long the Nation's most important industry), and it stimulated other industries by its demands for metals, glass, rubber, and textiles. The increasing use of automobiles stimulated the demand for gasoline and for good roads. At the same time there emerged a new generation of business leaders and a new form of competition, which relied not on the cutthroat tactics of an earlier generation in the development of monopolies but a more subtle collaboration within an industry to maintain prices and profits.

There was, however, a spirit of unrest also evident, particularly among farmers and labor who did not share in the general prosperity, and many Progressive leaders, both in and out of Congress, were calling for reform of the economic system. In the elections in November 1922, the Republicans lost 76 House seats and 8 Senate seats although they managed to retain control of both houses. Senator Robert LaFollette of Wisconsin, who was reelected by a large majority, assumed leadership of the Progressive group and was nominated for President on a Progressive ticket in 1924. The continuing prosperity enabled the Republicans to weather even the scandals that came to light after President Harding's death in 1923 and to elect Calvin Coolidge as President by a clear majority and increase their strength in both houses of Congress. Under Coolidge, Government efficiency and economy were stressed even more than under Harding and business was all important—as Coolidge himself put it, "The business of America is business."

The Nation's mineral industry, with but few exceptions, notably the coal industry, shared in the general prosperity in 1922. Iron, steel, and aluminum production were all increasing, but the Cinderella of the industry was petroleum. Following the years of short supply in 1919 and 1920, which had led to fears for the future of the world's oil supply, production had increased dramatically, and in 1922, U. S. production alone was more than the entire world production in 1919. In the next 3 years, the increase in steel production began to cause some concern about reserves of manganese and other steel-hardening metals. The problems of the coal industry were alleviated, although not solved. Petroleum production continued to soar; in 1924, world production was more than double what it had been in 1918; U.S. production had kept pace and was still about 70 percent of the total.

In the Geological Survey, David White's retirement as Chief Geologist on November 15, 1922, after ten years in the position and in accordance with his frequently repeated request to return to research, was announced at the same time as the resignation of George Otis Smith as Director so he could serve on the Coal Commission. White had become Chief Geologist as the Geologic Branch was attempting to resume basic research after several years' involvement in public-land administration, a trend that was soon interrupted by the necessity of undertaking multifarious tasks as part of the preparedness and war efforts. Resumption of basic research in the immediate postwar era was complicated by energy shortages, the loss of personnel to industry, and lack of Federal funds.

Walter C. Mendenhall, Chief of the Land Classification Branch, was named to succeed White as Chief Geologist. Mendenhall's first assignment in the Survey in 1894 had been with the Geologic Branch, but he had left the branch in 1903, serving first in the Water Resources Branch where he made some of the pioneer studies in ground-water geology. Since 1908, Mendenhall had been engaged in administrative work, as the head of ground-water studies in the Water Resources Branch and as a member and then head of the Land Classification Board and then as head of the Land Classification Branch where he had established a reputation as a superb administrator. Herman Stabler, Chief Engineer and head of the Division of Hydrographic Classification, succeeded Mendenhall as Chief of the Land Classification Branch.

Mendenhall's ability as an administrator may have been the principal reason for his selection as Chief Geologist, for in announcing White's retirement, George Otis Smith said that he had planned to start a somewhat radical reorganization of the Geologic Branch, a task he would have to leave to the new Chief Geologist and to Acting Director P. S. Smith. The Survey, said George Otis Smith, depended on scientists for administration, and yet that dependence had robbed it of research capabilities and too many scientists were spending time on tasks for which they were not trained. The reorganization, he suggested, would provide greater flexibility, a somewhat curious choice of words inasmuch as David White had been noted for his casual attitude about organizational boundaries and chains of command. White's methods had produced results but not the engineering efficiency demanded by the mood of the day.

Engineering continued to outrank science in public esteem, and so the Topographic and Water Resources Branches of the Survey continued to obtain financial support from the States and other Federal establishments. Stringent Republican economy was relaxed sufficiently to provide a substantial increase in

For studies of the utilization of the Colorado River, partial topographic information along the course of the river was available from various expeditions, beginning with John Wesley Powell's historic exploration of 1869, except for the Grand Canyon section, the most dangerous part of the river because of rapids and turbulent water. In 1923, a daring expedition led by the Survey's Chief Topographic Engineer, C. H. Birdseye, filled that information gap. Traveling in four wooden boats, the party established a continuous river line from a geographically known point near Lees Ferry to a monumented station below the mouth of Diamond Creek, a distance of 251 miles, and selected several possible reservoir and dam sites. The photograph, taken by E. C. LaRue, shows one of the boats running a rapid 2 miles above Havasu Creek, one of the 84 rapids run by the expedition. (From C. H. Birdseye and R. C. Moore, 1924.)

Federal appropriations for topographic surveys in fiscal year 1925. The Geologic Branch was unable to command much cooperative support and its appropriations remained static. Under the new Chief Geologist, however, the branch gradually recovered from the exodus of scientists to industry and the academic world of the early postwar years and once more developed its research capabilities. At the same time, however, it became a smaller and smaller part of the Survey.

Secretary of Commerce Hoover remained the indefatigable exponent of the need for a general reorganization of the Federal Government but Congress moved toward that goal slowly. Shortly after his inauguration, President Harding had asked that a representative of the executive branch be added to the Joint Congressional Committee on Reorganization. Congress had agreed but thereafter seems to have washed its hands of the affair until a report was submitted to the lameduck session of the 67th Congress. This report was promptly deemed the opinion of the executive branch alone, and the committee was given until July 1, 1924, to prepare another report. Congress did, however, pass the Classification Act which was approved by the President on the final day of the session. The act established six grades of positions in the professional and technical services, with salaries ranging from $1,860 per year for beginning scientists and engineers to $7,500 a year for chief scientists and engineers with many years of experience. The salaries were to take effect on July 1, 1924, leaving somewhat more than a year for classification of positions.

The Interior Department Appropriations Act which had been approved on January 23, 1923, provided for the Geological Survey in the fiscal year beginning July 1, $1,670,190, or $219,250 more than in the year ending June 30. The largest part of the increase came through an amendment proposed by Congressman Henry Temple, Republican of Pennsylvania, to increase the appropriation for topographic surveys from $325,000 to $500,000. Congressman James Begg, Republican of Ohio, called for a point of order—there was no authorization for the Geological Survey to make topographic surveys. After considerable discussion, the point of order was denied on the basis of the ruling in 1906 that a topographic map is a public work in progress and therefore not subject to a point of order. During the debate, however, it became apparent that several members of the House felt that the topographic surveys were being delayed by the greater detail with which mapping was being done in cooperative projects, in particular the smaller contour interval. Before the Temple amendment was approved a proviso was added: "That no part of the appropriation be expended in cooperation with States or municipalities except upon the basis of a State or municipality bearing all of the expense incident thereto in ex-

The Survey's continuing examination of western water-power capacities indicated that by 1920 the water resources of the Great Salt Lake Basin were already rather intensively developed. Irrigation and power development completely utilized the low-water flow of most streams, and considerable progress had been made in conserving flood flow by building reservoirs, but the gross undeveloped storage capacity in the basin was estimated to be only about half the storage capacity of Bear Lake, the largest existing reservoir in the basin. Plans for future development would also have to take into consideration competition from power developed from Utah coal or developed at sites along the Snake, Green, and Colorado Rivers and their tributaries and transmitted to Utah. The photograph shows the Wheelon plant on Bear River which began as an irrigation project during the days of the Irrigation Survey in 1889 and was completed with construction of the power plant in 1903. (From R. R. Woolley, 1924.)

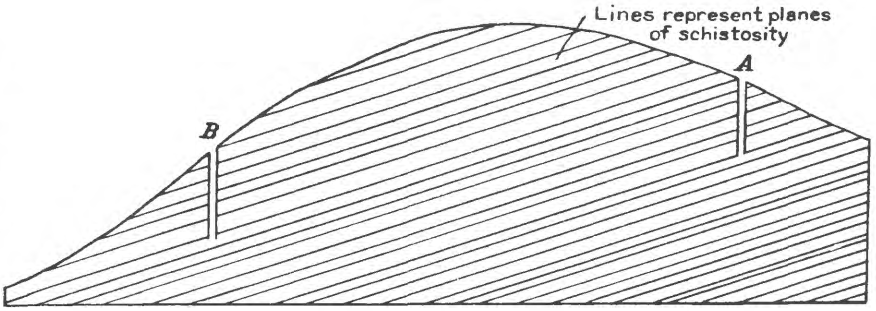
cess of such an amount as is necessary for the Geological Survey to perform its share of standard topographic surveys." The other major increase, $55,000 for classification of public lands, was less than the Department had requested. The appropriation for stream gaging was cut by $10,000.

Even though his reorganization plans had not succeeded, Secretary of Commerce Hoover had enhanced his reputation for accomplishment and extended his influence within the executive branch. In November 1922, after the Coal Commission had begun its work, Hoover had met with the Colorado River Commission, and after two weeks of marathon sessions, a draft of a compact apportioning water between the Upper and Lower Basin States in perpetuity had been prepared and signed. Six weeks later, the White House announced the resignation of Secretary of the Interior Fall to take effect in March 1923. The stated reason for Secretary Fall's resignation was that he had not intended to stay in the post indefinitely and now wished to return to private business. It was, however, apparent that although President Harding continued his personal friendship with Secretary Fall, he was relying more and more on Secretaries Hoover and Hughes.

The new Secretary of the Interior was Dr. Hubert Work, a Colorado physician who had been active in Republican politics. In 1920, he had organized farmers in support of the Harding-Coolidge ticket. In 1921, he was appointed First Assistant Postmaster General and in 1922, Postmaster General. Work shared Hoover's enthusiasm for efficiency and economy in government. Work continued as Secretary of the Interior until 1928, when he resigned to become Hoover's campaign manager. During the intervening years, he was diligent in his efforts to reduce the size and cost of the Department of the Interior although he complained that "applying business methods to a great government department is a tedious process."

In the Geological Survey in the fiscal year beginning July 1, 1923, four of the five branches had more money than ever before. Funds for topographic mapping soared to more than $900,000, or 1.8 times the direct appropriation, with the receipt of more than $350,000 from 19 States and the Territory of Hawaii and funds from the War Department for military mapping. The Water Resources Branch had cooperative agreements with 30 States and the Territory of Hawaii, which contributed funds equal to 1.65 times the direct appropriation, and in addition funds from several other Federal bureaus, so the cut in appropriation of $10,000 was insignificant. The Alaska Branch's appropriation was matched by an allocation of $75,000 from the Navy for exploration of the newly designated Naval Petroleum Reserve No. 4. The financial plight of the Geologic Branch, which had no increase in funds, was accentuated by comparison.

There was, however, no radical reorganization of the Geologic Branch, as proposed by George Otis Smith, but the beginning of a gradual change that took several years to complete. The work became, if anything, less rather than more utilitarian, except in the Division of Mineral Resources whose future was clouded by the opposition of the Department of Justice to the dissemination of trade statistics. The division devoted considerable attention to coal; in addition to its regular statistical compilations, it issued a weekly report on coal and coke, assisted the Coal Commission and the Department of Commerce in special studies of the coal industry, and, in cooperation with the Bureau of the Census, undertook four canvasses of consumers' stocks of coal. Special statistics on petroleum and natural gas were compiled for the Federal Trade Commission and maps showing petroleum and natural gas fields and petroleum pipelines in Texas were compiled. The section of foreign mineral reserves completed a world atlas of fuel reserves but the metals and nonmetals sections did no more than the routine compilation of statistical material.



The occurrence of ground water in southeastern Pennsylvania depended to a large extent on geologic structure. Rocks that might be good aquifers were so deeply buried that they were not easily accessible or lifted so high that they were removed by erosion, and large displacements along major faults restricted the circulation of ground water. Minor structures could also be important. The Wissahickon Schist, for example, was a fairly good source of water supply but wells had to be situated to take advantage of the dip of the schistosity and the direction of flow of the ground water. Well A in the illustration could be a failure and well B successful because water falling on the east side of the hill passed down the planes of schistosity to B, leaving A only a small area from which to draw. (From G. M. Hall, 1934.)

The Alaskan Geology Branch continued the program already planned before the Navy requested the investigation of the Naval Petroleum Reserve, for the most part investigations aimed at the development of the Territory. The Alaska Railroad bridge across the Tanana River was completed in March 1923 and the railroad opened for direct traffic between Seward and Fairbanks. S. R. Capps began a study of the metal deposits along the route as the mining industry in the region tributary to the railroad seemed certain to expand with the improved transportation. J. B. Mertie, Jr., explored an area of about 4,000 square miles some distance north of Fairbanks, between Beaver on the Yukon and the Chandalar placer district. George Martin continued his study of the stratigraphy and petroleum resources of the Alaska Peninsula, in which combined topographic and geologic parties mapped areas between Kamishak Bay and Katmai and between Katmai and Cold Bay. F. H. Moffit studied the copper deposits of the Prince William Sound area and A. F. Buddington's investigation in southeastern Alaska was broadened to include investigations of mineral deposits in widely separated districts. Sidney Paige, the head of the Division of Geology and Paleontology of the Geologic Branch, was detailed to the Alaska Branch and led an expedition of three parties to northern Alaska to explore the Naval Petroleum Reserve No. 4, taking with him James Gilluly and W. T. Foran as geologists.

The Geologic Branch also aided the work of the Land Classification Branch in 1923. W. T. Thom, Jr., had succeeded M. R. Campbell as head of the Coal Section at the end of January, and the section, its strength renewed by the maturing of the young men appointed in previous years, undertook detailed studies of coal fields in public-land States for purposes of classification and for administration of the Leasing Act, as well as to guide future development on a somewhat larger scale than in past years. The Oil and Gas Section continued its structural and stratigraphic studies in the oil regions of the Midcontinent, Rocky Mountains, and California. In part because of the work in the Geologic Branch, the Land Classification Branch was able to act on more than 6,000 applications for permits, leases, and patents of mineral lands, and at the same time defined or redefined the known geologic structures of 9 producing oil fields, classified some of the withdrawn lands, and restored to the public domain nearly 3 million acres previously withdrawn as possible coal land and more than 400,000 acres previously withdrawn as possible oil land.

The branch continued fundamental investigations of oil shales, salt-dome rocks, the chemical nature of the organic matter in oil shales, and the pore space of oil and gas sands, and David White used his newfound but short-lived freedom from administrative responsibilities to prepare papers on radioactivity in relation to oil fields and the use of gravity observations in the solution of problems in historical and economic geology as well as in dynamic geology and tectonics. The latter was the subject of his presidential address to the Geological Society of America. In April 1923, White became Home Secretary of the National Academy of Sciences and thereby a member of the Executive Board of

the National Research Council. In 1924, he became Chairman of the NRC's Division of Geology and Geography.

Some research had to be discontinued when two senior scientists left the Survey for the academic world, E. S. Larsen, Jr., to become Professor of Petrology at Harvard University and T. W. Vaughan to become Director of the Scripps Institution of Oceanography in California. New research was undertaken, however, following the recommendations of the Committee on Geology and Geography of the National Research Council. George Steiger prepared a paper on the chemical and mechanical analysis of sediments for the "Treatise on Sedimentation" and R. C. Wells, after completing his experiments on the mode of formation of metallic copper in ore deposits, began a study of the measurement of geologic time by atomic disintegration. Areal mapping and stratigraphic studies were also continued and much work was done on the State geologic maps of Alabama, Arizona, and Oklahoma.

The Geologic Branch programs that experienced the most difficulties in 1923 were those in metals and nonmetals. The Chief of the Metals Section, F. L. Ransome, was given leave to teach at the University of Arizona, and Edward Sampson left to join the Princeton faculty. C. P. Ross continued the work in Idaho but very little else was done except the mapping in Nevada. In the Section of the Geology of Iron and Steel Alloy Metals, E. F. Burchard examined iron deposits in Alabama, Washington, and Idaho in addition to his investigation of the Tennessee ores, and W. S. Bayley and W. S. Burbank began a study of the magnetite deposits of New Jersey and Pennsylvania. The search for potash was continued at a minimal level.

Investigations of dam-site geology were transferred to the Water Resources Branch. F. L. Ransome had made many of the dam-site investigations requested by the Reclamation Service, including, in 1921, an examination of the dam sites in Boulder and Black Canyons which the Reclamation Service found most suitable for construction of a dam on the Colorado River. At a symposium

In central and southern Rosebud County, Montana, water quality, which was related to depth below the surface, was an important factor in utilization of ground water. The chief water-bearing formations are the Lance and the Fort Union, one or the other of which is at the surface over most of the area. (The photograph shows a sandstone in the lower part of the Tongue River Member of the Fort Union Formation.) A supply of water could generally be obtained wherever these units extended below the water table but the water from shallow depths (less than about 125 feet) contained considerable calcium and magnesium and water from greater depths only small amounts of these elements. Both shallow and deep water was generally satisfactory for domestic purposes and the water from shallow depths for irrigation. The water from greater depths was unsatisfactory for irrigation because it produced a hard black alkali crust at the surface. Water from shallow depths contained a considerable amount of scale-forming constituents and water from greater depths foamed in boilers. (From B. C. Renick, 1929.)

in Salt Lake City in 1922, Bailey Willis had raised the specter of movement along old faults in the area and had also questioned the suitability of the foundation rocks for a dam. The Reclamation Service again requested the services of the Geological Survey and Ransome had reexamined the sites in late 1922, seeking in particular evidence that the faults in the area were not now active. He concluded that the presence of potholes cut into fault surfaces and fault gouges now at an elevation of 900 feet above the river indicated that no movement had occurred during the period necessary to cut canyons 900 feet deep. When the Reclamation Service, in the spring of 1923, requested the services of a geologist to investigate sites along its Columbia Basin project, Kirk Bryan of the Ground Water Division was given the assignment. Bryan went on to develop a special expertise in dam-site geology in the next few years.

Most of the ground-water investigations in 1923 were made in the Western States, concerned, in particular, with water for irrigation. However, the division also began a major investigation of urban and industrial water supplies in New Jersey, which was the fourth most urbanized State according to the 1920 Census. Quantitative data were needed, and so David G. Thompson, who headed the investigation for the Survey, had water-stage recorders installed in wells to obtain continuous records of the fluctuations of water level, to be studied in relation to fluctuations in pumping, and also had samples of sand analyzed for porosity and permeability in the hydrologic laboratory to aid in determining the rate of flow. Meinzer completed a major report on the occurrence of ground water in the United States with a discussion of the principles of ground-water hydrology which was published as a Water-Supply Paper.

Most of the work of the branch was devoted to surface-water investigations, and the number of gaging stations increased to 1,673. Water-power investigations, a major element of the work, were often made in conjunction with engineers of the Topographic Branch. Engineers from the two branches, for example, worked together on the Klamath and Umpqua Rivers in Oregon and along the Clearwater River in Idaho. Other surveys were made along the Sweetwater and Encampment Rivers in Wyoming, the South Platte in Colorado, in the Uinta Basin, and along the Missouri.

The Topographic Branch made field surveys in 27 States and Hawaii, nearly all in cooperation with the States or of areas requested by the War Department or other Federal agencies, among them many related to water projects. In Texas, 25 7 1/2-minute quadrangles were completed and 35 more begun in cooperation with the Board of Water Engineers, and 10 reservoir sites were surveyed in detail. In Utah, 306 square miles were mapped in cooperation with several counties and the Bureau of Reclamation to aid in planning irrigation and drainage systems. Los Angeles County, California, provided funds to aid in mapping 326 square miles on the scale of 1:24,000 with a contour interval of only 5 feet.

The Geological Survey also made special plan and profile surveys of the Colorado River during the summer of 1923, in anticipation of the early ratification of the Colorado River Compact which had been signed on November 24, 1922 and then submitted to the legislatures of the signatory States for ratification before being submitted to the U.S. Congress. During these surveys, some 253 miles of the Colorado River between Lees Ferry, Arizona, and Black Canyon on the Arizona-Nevada line were traversed and mapped and 75 miles of surveys were carried up side canyons to appropriate controlling elevations. As part of the work, 22 dam sites were surveyed on the scale of 400 feet to the inch with a contour interval of 10 feet. The Colorado River expedition attracted public attention because of the danger involved although Colonel Birdseye, who reserved the leadership of the expedition for himself, regarded the danger as all part of the day's work. The expedition set out from Lees Ferry on August

1 in four specially designed boats and at the end of the second day, when it encountered the second set of rapids in Marble Canyon, stopped for the night. While the party was in camp, they turned on their small radio set and heard the startling news that President Harding had died in San Francisco. To get away from Washington and its problems, Harding had set out in late June on a speaking tour that took him across the continent and to Alaska. With his party were the Speaker of the House and the Secretaries of Agriculture, Commerce, and Interior. With Harding's death, Calvin Coolidge of Vermont became President of the United States.

Coolidge's concept of the role of President was limited. The President was, in his mind, first and foremost the party leader, and so it was his "business * * * to do the best he can to see that the declared party platform purposes are translated into legislative and administrative action." He was also head of the Government, and as such had "a certain responsibility for the conduct of all departments, commissions and independent bureaus;" he was therefore "willing to advise with any of these officers and give them any assistance" in his power although he felt "they should make their own decisions and rarely offered any advice." He believed that "In the discharge of the duties of the office there is one rule of action more important than all others. It consists in never doing anything that some one else can do for you."

Coolidge was if anything even more committed to economy and to furthering the interests of business than Harding. Secretary of Commerce Hoover characterized him as reluctant to undertake much that was new or cost money. In his first annual message to Congress, in December 1923, Coolidge supported the tax reduction plan of Secretary of the Treasury Mellon, opposed the cancellation of Allied war debts and the payment of a veterans' bonus, and called for a scaling down of Government expenditures, a minimum of Government interference in business, and increased Government aid to industry and commerce.

By the time Congress convened, however, the Senate Committee on Public Lands had already uncovered some unsavory material in relation to the leases of the Naval Petroleum Reserves. The Committee had begun public hearings on October 22, 1923. The two experts appointed to aid the committee, F. G. Clapp, consulting geologist formerly with the U.S. Geological Survey, and James O. Lewis, formerly chief petroleum technologist of the Bureau of Mines, testified that the oil content of Naval Petroleum Reserve No. 3, Teapot Dome, was 26 million barrels or less. Their testimony was widely quoted as supporting Secretary Fall's contention that the reserve was subject to drainage. Clapp complained, however, in a letter published in the November 17th issue of the *Engineering and Mining Journal*, that the press has misstated the results of their investigation. He and Lewis had not claimed that the oil content of the Reserve had been reduced from 135 million barrels to 26 million barrels or less by drainage; they had reduced the estimate of the original oil content of the reserve to 26 million barrels because more recent work in the area had made possible a more accurate estimate.

The first inkling of the sensational nature of the ultimate disclosures came on November 23, after a month of technical testimony, when witnesses from New Mexico began to describe the sudden affluence of the former Secretary and the many improvements to his formerly rundown ranch. The possibility of malfeasance was freely discussed in Congress, and although no hard evidence was developed before Congress adjourned for the Christmas recess, Senator T. H. Caraway of Arkansas introduced a joint resolution on January 7, 1924, directing the President to institute and prosecute suits to cancel the leases and incidental contracts. President Coolidge withheld comment until late in January although evidence of bribery mounted. The Caraway resolution had not been acted on, but as the Senate prepared to bring it up Coolidge anticipated

The increased understanding of the importance of geology in the selection of reservoir and dam sites prompted the Bureau of Reclamation, which was considering construction of one of the highest dams in the world in southeastern Oregon, to call on the Survey in 1923 for geologic advice. Kirk Bryan found both Tertiary volcanic rocks and water-laid deposits, traversed by numerous faults and fissures and tilted, in the area around the Owyhee and Malheur Rivers. He concluded that the red felsite at the favored site, shown in the photograph, was suitable for the foundation of a high masonry dam, except for fractures which could be grouted and the peculiar shape of the rock mass with respect to the topography of the gorge. Bryan recommended that the dam be located far enough within the throat of the gorge to rest wholly on an ample thickness of the red felsite. The Bureau later selected a site about 1,000 feet downstream from the previous site. (From Kirk Bryan, 1929.)

the move and issued a statement to the press: "If there has been any crime, it must be prosecuted. If there has been any property of the United States illegally transferred or leased, it must be recovered." The resolution was passed by Congress and approved by the President on February 8, 1924. A second resolution, to institute court proceedings to establish the title of the United States to lands in Naval Petroleum Reserve No. 1 was passed and approved on February 23. Coolidge then nominated Owen J. Roberts and Atlee S. Pomerene to be special counsel to have charge and control of the prosecution of the litigations, and both nominations were confirmed by the Senate. The Public Lands Committee continued its investigation until May 1924 but with the appointment of special counsel the initiative shifted to them and to the courts. Suits were filed and in 1927 the Supreme Court declared the leases invalid. Secretary Fall was indicted for bribery and conspiracy and convicted of bribery. Secretary of the Navy Denby was forced to resign. George Otis Smith had meanwhile resumed his duties as Director of the Survey on September 24, 1923, and was pleased to note that "his year's absence had in no wise interrupted nor retarded the progress of the work; indeed notable advances had been made in the effectiveness of this branch of the public service."

Curtis D. Wilbur, Chief Justice of the California State Supreme Court and an Annapolis graduate, succeeded Denby as Secretary of the Navy and acted promptly to protect the Navy's interests. On March 25, 1924, President Coolidge announced the appointment of a three-man commission to study the fuel oil needs of the Navy: George Otis Smith, Director of the Geological Survey, Admiral Hilary P. Jones, President of the Navy's General Board, and Reed D. Bush, State Oil and Gas Supervisor for California. The mission given them was a general study, but they were specifically requested to "review the situation in each one of the Navy's reserves and endeavor to ascertain whether it will be possible by assignment of additional public land, transfers, trades, purchases, or otherwise to create large and better protected reserves than those existing at present." The White House announcement reversed the Fall policy and put Coolidge on the side of the conservationists by stating that "The purpose for which the naval oil lands were set aside was to provide reserves for the future. In order to do this in the best manner the oil should be, wherever possible, retained in the ground." Some historians have suggested, however, that the motivation for appointment of this board and of the Federal Oil Conservation Board in December 1924 was not so much concern for natural resources as concern for business; the rapid increase in oil supply was beginning to weaken the price structure.

As a scientific byproduct of dam-site investigations in Northwestern United States, J. T. Pardee and Kirk Bryan deciphered a bit of geologic history in an area near Spokane, Washington. The Latah Formation, a series of leaf-bearing beds that fossil evidence indicated to be of lower or middle Miocene age, rests on a rough surface of granitic and schistose rocks of unknown age and is overlain without angular discordance by rim-rock basalt flows, probably of Miocene age, as shown in the photograph. The rim rock flows are in turn overlain by valley flows of later Tertiary age and gravel of Pleistocene age. Pardee and Bryan suggested that the Latah beds accumulated when the advancing floods of basalt, although held back from the Spokane area by a ridge, obstructed the drainage outlet. Later, the lava topped the protecting ridge and spread over the sediments. After a period of time during which valleys were cut through the basalt to a depth of 800 feet, another series of basalt flows occupied parts of the valley. (From J. T. Pardee and Kirk Bryan, 1926.)

The combination of a Presidential election year and the disclosure of other scandals in the Harding administration in addition to the leasing of the naval oil reserve meant that other matters sometimes received scant attention or were postponed, among them some affecting the Geological Survey and the Department of the Interior. Shortly after Congress convened in December 1923, Senator S. M. Shortridge of California and Senator T. L. Oddie of Nevada filed bills to remove the Geological Survey and the Bureau of Mines from the Department of the Interior as the nucleus of a new Department of Mines. Both the Director of the Survey and the Director of the Bureau of Mines were reported to have endorsed the Oddie bill. In its December 21 issue, however, the *Engineering and Mining Journal* called attention to a provision in the Organic Act of the Commerce Department which authorized the President to transfer to it any scientific or statistical bureau whose work fell within the scope of the Department's activities, and speculated that the President would issue an Executive order transferring the Bureau of Mines and the Survey's Division of Mineral Resources to the Department of Commerce before January 1, 1924. The problem, according to the *Journal*, was what to do with the supervision of mineral leasing activities on the public lands, then the responsibility of the Bureau of Mines. It was assumed that this function would be transferred to the Geological Survey but the *Journal* considered it undesirable to separate it from the technologic research of the Bureau of Mines. Neither the Shortridge or Oddie bill ever emerged from committee, but the expected Executive order was also held up. In time, President Coolidge let it be known that he favored an expanded Bureau of Mines rather than a department of mines. The Institute of Government Research countered that with the suggestion that the Bureau of Mines be abolished because it was not doing anything that could not be done by the Geological Survey and the Bureau of Standards.

Secretary of the Interior Work, although in no way involved in the scandals, had his hands full during the winter and spring months with problems engendered by his handling of the reclamation program. One of the major problems in the Department when Work succeeded Fall had been the dissatisfaction of the water users, particularly with the repayment for water which was written into the reclamation law. Work's solution had been to reorganize the Reclamation Service into the Bureau of Reclamation, in the course of which the position of Director of the Reclamation Service, which was under Civil Service, was abolished and replaced by that of Commissioner of the Bureau of Reclamation. Arthur Powell Davis, who had been Director of the Reclamation Service since 1913, was then replaced by David W. Davis, former Governor of Idaho, because, Work explained, he needed a businessman, not an engineer, to direct the reclamation program. Nearly every engineering organization in the Nation protested, and the new commissioner proved an unhappy choice. Work's departure from the Cabinet was rumored but the situation was retrieved when Elwood Mead, the distinguished irrigation engineer from Wyoming, was named Commissioner of Reclamation and David W. Davis was placed in charge of a newly established Finance Division.

The Joint Committee on Reorganization of the Executive Branch finally endorsed Secretary Hoover's desires for the Department of Commerce in a report issued on June 4, 1924. Among the agencies that the committee recommended be transferred to the Department of Commerce were the Bureau of Mines and the Patent Office of the Department of the Interior. The committee also recommended that the collection and publication of statistics on mineral production be transferred from the Geological Survey to the Bureau of the Census in the Department of Commerce. The committee then recommended that other Interior functions, such as the Bureau of Pensions, St. Elizabeth's Hospital, and Howard University be placed in a new Department of Relief and that the remaining parts of the Department of the Interior be organized in two divisions, one pertaining to the public domain, the other to public engineering works. Under this scheme, the Geological Survey would be assigned to the Division of Public Domain. Bills were filed to bring about the proposed changes but were not acted on before Congress adjourned.

On June 6, 1924, the House Committee on Foreign and Interstate Commerce reported out the Temple bill to provide for a topographic survey of the United States with the recommendation that it be passed. In its report, the committee noted that of the 12 agencies then engaged in some form of topographic mapping, all but the Geological Survey, the Coast and Geodetic Survey, and the Corps of Engineers would cease such work if authorized agencies for the work existed and were able to meet their mapping needs. As matters stood, however, neither the Geological Survey nor the Coast and Geodetic Survey could plan work in advance of the fiscal year for which appropriations were known, so the program was often designed to meet the most insistent demands. A program definitely authorized for some years in advance was needed, and, in fact, advance planning could result in savings of as much as 10 percent. No further action was taken as Congress adjourned on June 7.

The appropriations bill, passed in the closing days of the session and approved on June 5, provided the Survey with the same money for fiscal year 1925 that it had in the current year, and that was favorable treatment. The 68th Congress had seen eye-to-eye with President Coolidge on the need for economy and Chairman L. C. Cramton of the House Subcommittee on Interior Appropriations had warned its members that the committee was bound not only not to increase the appropriations recommended by the Bureau of the Budget but to make further reductions where possible, even though increasing familiarity with the work of the Department had impressed the committee with the importance of the part the Interior Department played in the present and future of the Nation. Thus increases in appropriation items to cover salary adjustments under the Classification Act of 1923, although approved by the Bureau of the Budget, were not approved. The committee held that the salaries had been increased so that the Government would be able to get better employees and keep them longer, and so get along with fewer. Then the committee placed a limitation on the amount that could be used for salaries in the District of Columbia, posing a special problem for the Survey for most of its scientific and technical employees divided their time between office and field. Without additional funds, their field time would have to be drastically cut; the limitation on funds to be spent in the District of Columbia would then keep

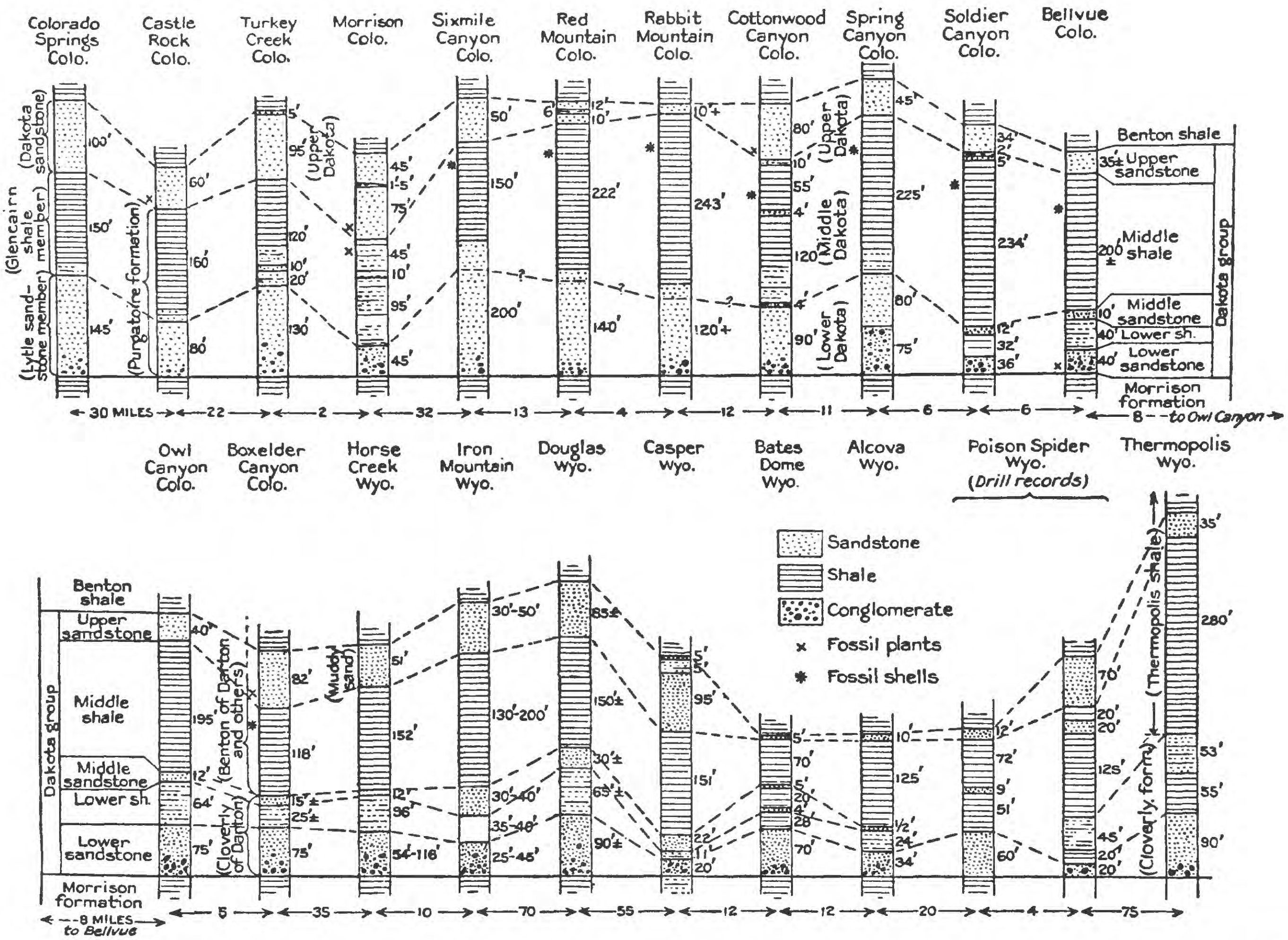
Another scientific byproduct was H. T. Stearns' study and documentation of the unusual explosive activity at Kilauea Volcano in May 1924, shortly after he arrived to study the ground-water resources of Hawaii. The explosive activity lasted only a few weeks and followed subsidence of the lava column in February, its disappearance in April, and then the collapse of the surrounding walls. The lava reappeared during the summer. Stearns' photograph was taken on May 18 when the eruption cloud was about 11,500 feet high and rising at a rate of 13 feet a second. His study indicated that the explosions were phreatic, that is, primarily low-temperature steam explosions and that the water was derived from the ground-water reservoir rather than from magma. He concluded that when the walls collapsed, the water table had closed in above the column, and ground water flowing into the area was then heated by gas effervescing from the lava column and converted into steam that produced the explosions. (From H. T. Stearns, 1925.)

the Survey from paying them while in the office. Some months later, Congress relented and passed a deficiency appropriation to cover the adjustment of salaries.

The political scandals uncovered in the winter and spring of 1924 had little influence on the presidential election campaign later that year. Most of the Nation was prosperous, and the prosperity was attributed to the businesssmen's program enacted by Congress. Businessmen were beginning to supplant the politicians in controlling the Republican party, and when the Republican convention met in Cleveland on June 10, Coolidge's nomination for President was assured. Charles G. Dawes, the first Director of the Budget, was chosen as the candidate for Vice President. The Democrats, on the other hand, were divided over several issues, and a tempestuous convention took 103 ballots to nominate as its candidate for President, John W. Davis of West Virginia, a distinguished lawyer with Wall Street connections. Having alienated the West by choosing Davis, the delegates assured Democratic defeat in November by choosing Governor Charles W. Bryan of Nebraska, brother of William Jennings Bryan, as the candidate for Vice President, thus alienating eastern conservatives.

Dissident agrarian and labor groups, who did not share in the Nation's general prosperity, met in convention early in July. At the insistence of Senator Robert LaFollette, who pointed out that a third party would jeopardize the seats of the many Progressives in Congress who had won their seats as Republicans or Democrats, they did not form a third party at that time but nominated an independent ticket for President and Vice President, choosing LaFollette as the Presidential candidate and Senator Burton K. Wheeler, Democrat of Montana, who had won acclaim as the chief Senate investigator of the scandals in the Department of Justice, as the Vice-Presidential candidate. The convention adopted a platform, written by LaFollette, which pledged "recovery of the navy's oil reserves and all other parts of the public domain which have been fraudulently or illegally leased, or otherwise wrongfully transferred, to the control of private interests; vigorous prosecution of all public officials, private citizens and corporations that participated in these transac-

Broad scientific studies became the basis for classification of western mineral lands after Congress began appropriating funds specifically for classification. For example, both topographers and geologists mapped the Wasatch Plateau in Utah, which is underlain by Cretaceous rocks that contain valuable coal beds, and then geologists made detailed studies of the coal-bearing formation in the Wasatch Plateau coal field, measured complete stratigraphic sections, and mapped structure in as great detail as exposures permitted to aid in outlining the future development of the field. The photograph shows the eastern part of the Hiawatha area, which contained the largest number of thick beds and was favorably situated for mining and shipping. (From E. M. Spieker, 1931.)

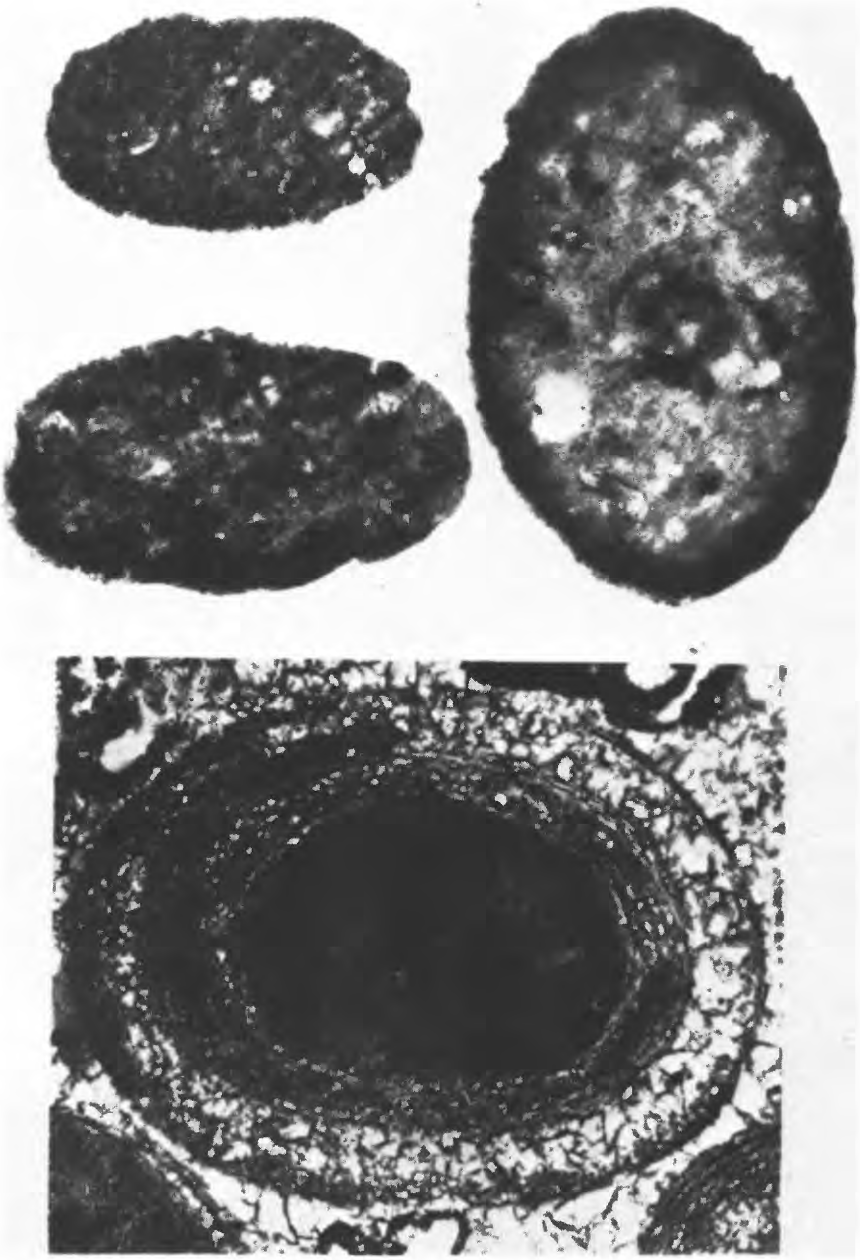


W. T. Lee and J. B. Reeside, Jr., examined the sequence and mutual relations of formations along the foothills of the Rockies from Colorado Springs, Colorado, to the Bighorn Basin in Wyoming, physically tracing the units from place to place where possible and using fossil evidence where tracing them was not possible. They found that the so-called Dakota Sandstone consisted of five distinct sandstone and shale units in the type section near Bellevue, Colorado, and that these units could be found in conformable sequence throughout the area examined. As oil-bearing sands had been found in Wyoming and its neighbor States although the exact number, the region in which each was productive, and the identity and stratigraphic position of the sands in particular areas had not been previously determined, such long-range stratigraphic correlations immediately became a tool of great value in exploration for petroleum. (From W. T. Lee, 1925.)

tions; complete revision of the water-power act, the general leasing act, and all other legislation relating to the public domain.'' The platform also favored ''public ownership of the nation's water power and the creation and development of a national super-water-power system, including Muscle Shoals, to supply at actual cost light and power for the people and nitrate for the farmers, and strict control and permanent conservation of all the nation's resources, including coal, iron and other ores, oil and timber lands, in the interest of the people.''

The voters, however, chose to ''Keep cool with Coolidge.'' Coolidge's popular and electoral majorities exceeded the combined Davis and LaFollette vote. Moreover, the Coolidge landslide carried into office overwhelming Republican majorities in both the Senate and the House and ensured a conservative Congress.

While the Progressives were in session and calling for public power and the conservation of natural resources, Director George Otis Smith and John C. Hoyt were in London attending the First World Power Conference, Smith as the personal representative of the Secretary of the Interior and Hoyt as the Survey representative. The London conference was organized by the British Electrical and Allied Manufacturers' Association in cooperation with numerous technical, scientific, and commercial organizations to consider the sources of world power by evaluating the resources of each country, by comparing experiences in the development of scientific agriculture, irrigation and transportation, and by conferences and discussions looking to the establishment of a permanent world bureau for the collection of data and exchange of industrial



The study of sedimentary rocks and sedimentary processes became more intensive and specialized during the 1920's, spurred by the efforts of the Committee on Sedimentation of the National Research Council and the great increase of interest in petroleum geology. Marine sedimentary rocks, if areal extent was an index of relative importance, seemed by far the most important class of rocks at the surface of the Earth, but ancient marine sediments could be interpreted only in the light of data derived from studies of modern marine sediments. The illustration shows one of the unsolved problems that intrigued T. W. Vaughan, first chairman of the Committee on Sedimentation, the origin of the ellipsoidal aggregates in bottom muds (shown at the top), which are similar in external features to oolite grains (shown at the bottom), but lack their internal concentric structure. (From T. W. Vaughan, 1924.)

and scientific information. O. C. Merrill of the Federal Power Commission served as Chairman of the American delegation, which included representatives of many private power interests as well as Government officials. At its concluding session, the conference adopted a general resolution:

> **That this conference is of the opinion that the world's most crying need today is greater production and manufacturing activity among its peoples under conditions which will promote individual prosperity and happiness, and that this can be largely achieved by the fuller development of national power resources and by the establishment of the most economic means for the general distribution and utilization of energy.**

In the fiscal year that began July 1, 1924, the Geological Survey continued to devote a considerable effort to the development of information on water power. The effort was concentrated in the Water Resources Branch, which continued to grow through receipt of cooperative funds, amounting to 185 percent of the direct Federal appropriation, as well as receipt of funds from other

Federal organizations and from Federal Power Commission permittees. Most of these funds were used for stream gaging for various purposes including the water-power studies. Gaging stations were maintained in 41 States and Hawaii and at the year's end, the number had increased to 1,715, only 11 of which were maintained solely by the Survey. Several hydrographic engineers were involved in power- and dam-site studies. In the Colorado drainage area, E. C. LaRue examined promising dam sites in the stretch of the Colorado River beginning about 10 miles above Pierces Ferry and the El Dorado dam site in the lower end of Black Canyon, E. E. Jones made reconnaissance surveys of the power value of streams tributary to the Colorado, and R. R. Woolley examined power sites in the Uinta Basin. In the Pacific Northwest, surveys were made in Idaho and Oregon by Warren Oakey, W. G. Hoyt, and B. E. Jones.

Ground-water investigations continued to be a mixture of practical work and research. O. E. Meinzer, for example, completed a paper on the large springs in the United States, made progress on his second major report on ground water, and wrote a paper on plants as indicators of ground water. He also lectured, for the second year in succession, to a well drillers' association in the northern Great Plains region. Norah Dowell Stearns began a study of the thermal springs of the United States to bring up to date the compilations and discussion by G. K. Gilbert in 1875 and A. C. Peale in 1883. Work continued in New Jersey, New Mexico, and Hawaii, and G. M. Hall investigated an improved water supply for the oyster industry of Chincoteague Island in Virginia and the possibility of obtaining water from deep wells in the Valley of Virginia.

The Survey's topographic mapping program also continued to grow through receipt of funds from outside sources: cooperative funds from 21 States and the Territory of Hawaii that amounted to 81 percent of the direct appropriation and funds from the War Department for special surveys. Glenn Smith had been given charge of the Atlantic Division after Frank Sutton retired in March 1924, and Chief Topographic Engineer C. H. Birdseye had resumed supervision of the Rocky Mountain Division. However, the distribution of work was such that only three division chiefs were needed so on January 1, 1925, the Rocky Mountain Division was eliminated as a separate organization and the States composing it were divided between the Central and Pacific Divisions headed by W. H. Herron and T. G. Gerdine. Topographic field work was done in 22 States and Hawaii, and the area mapped bore a close relation to the amount of outside funds supplied. More than 62 percent of the area mapped was in just six States: Pennsylvania, Illinois, Missouri, Texas, California, and Oregon. Most of the mapping was done by conventional methods although the branch continued to experiment with the use of aerial photographs and prepared base maps for surveys of 79 quadrangles and 3 special areas.

The Geologic Branch, however, continued to pursue its independent course in 1924. More funds were allotted to research with economic motives than to research without them, but even among the economic investigations priorities changed and long-range studies received increased emphasis. Fuels investigations played a lesser role than they had during the days of the oil shortages; coal received as much if not more attention than oil. Metals investigations received more support than they had had for several years. The Division of Physical and Chemical Research collaborated closely with the Division of Geology and Paleontology in several fundamental studies; the Division of Mineral Resources, on the other hand, was reduced to the routine compilation of statistics.

Associated with these changes were changes in the organization and administration of the Geologic Branch. K. C. Heald, Chief of the Section of the Geology of Oil and Gas Fields resigned to join the Yale faculty, and the section was once more combined with the Coal Section as the Section of the Geology of Fuels under W. T. Thom, Jr. F. L. Ransome, Chief of the Metals Section, resigned to join the faculty of the University of Arizona, and G. F. Loughlin, the head of the Mineral Resources Division, became the new Chief of the Metals Section. Loughlin graduated from the Massachusetts Institute of Technology in 1903 and received a Ph.D. from Yale in 1906. He had joined the Survey full time in 1912 after combining teaching and summer work for the Survey for several years. Loughlin had worked with Lindgren at Tintic for 3 years, and was now following in his footsteps up the Survey's administrative ladder, having served as Chief of the Metals Section of the Division of Mineral Resources before becoming Chief of the Metals Section of the Division of Geology and Paleontology. F. J. Katz succeeded Loughlin as acting head of the Division of Mineral Resources.

The Metals Section took on a new and yet an old look in 1924 as its geologists returned to some of the districts where the Survey had first worked. Loughlin followed in the footsteps of the section's first chief, S. F. Emmons, in studying new developments at Leadville and then in the Cripple Creek district where Cross, Penrose, Ransome, and Lindgren had previously worked. Adolph Knopf, aided by newly appointed junior geologist Thomas B. Nolan, resumed a critical study, begun in 1915 but recessed after one year, of the quartz veins of the Mother Lode in California. The relations there between ore shoots and barren veins had yet to be unravelled although Becker, Turner, Ransome, and Lindgren had all worked in the area. H. G. Ferguson returned to the Alleghany district in California, where he had spent the 1913 field season, for further study of the gold veins. B. S. Butler returned to the Survey after 4 years of investigating Michigan copper deposits for the Calumet and Hecla Company. The company turned the general geological results over to the Survey, and the Survey, after consulting other companies in the area, planned to extend similar investigations throughout the district.

There were no marked changes in the Fuels Section. Mapping was continued in the oil regions of California, Wyoming, and the Colorado Plateau, and reconnaissance examinations were made in Louisiana, Colorado, Utah, and New Mexico. W. H. Bradley mapped oil-shale lands in Colorado and made a reconnaissance of Naval Oil Shale Reserve No. 1. Coal-field mapping was also continued, particularly in western areas on behalf of the Land Classification Branch. Julian D. Sears, a Johns Hopkins Ph.D. who had joined the Survey in 1918, succeeded P. S. Smith as the Administrative Geologist.

Fundamental research related to the origin and movement of petroleum was continued in the Division of Physical and Chemical Research by E. T. Erickson and A. F. Melcher. After Melcher's resignation to become head of the section of physical research of the Marland Oil Company, the Survey secured the services of P. G. Nutting to carry on the work. Nutting had been appointed an assistant physicist in the National Bureau of Standards in 1903 after receiving his Ph.D. from Cornell. He had left the Bureau in 1912 to help organize the Eastman Kodak Laboratories, and had left Eastman in 1916 to help organize the Westinghouse research laboratories. After 1920, he was a consulting engineer and was responsible for designing the lighting for the motion picture industry. Nutting was one of the founders and first president of the Optical Society of America. C. E. Van Orstrand also continued his study of subsurface temperatures. After measuring temperatures in the deepest well in the world at the time, near Long Bridge in Westmoreland County, Pennsylvania, and in some oil fields, he concluded that the highest temperatures were observed near or at the crests of anticlines. This conclusion led W. T. Thom, Jr., to suggest that if there were a systematic relationship between Earth temperatures and structural uplifts, observations of temperatures in deep wells might afford a relatively cheap and effective method of finding not only oil fields but other deposits of economic value that were related to structural uplifts, buried topographic features, or magmatic features.

Much less research of a fundamental nature could be undertaken on coal because of lack of funds and personnel. However, attention was called to the fact that "certain kinds of research concerning coal are pressingly demanded, such as research as to its nature and composition, its origin, and its special fitness for use in particular industries," and that "the ever increasing demand for power implies the necessity for a more intelligent and therefore more economical use of the heat units in coal, now so lamentably wasted." The words were somehow reminiscent of C. D. Walcott's statement to Congress in 1898 that led to the Survey's coal testing program begun in 1904 that had demonstrated the usefulness of such research. The *Mining Congress Journal*, however, seized upon the recommendation as almost a brand new idea.

Research without evident economic motivation was expanded in the Geologic Branch in 1924. Areal mapping was continued in various parts of the country, and at least 10 State geologic maps were in various stages of production from preliminary discussion to printing. Stratigraphic studies were underway in the High Plains of Texas by T. W. Stanton, in the Guadalupe Mountains of Texas and New Mexico by N. H. Darton and J. B. Reeside, Jr., and in the Black Hills by W. W. Rubey, M. N. Bramlette, and F. A. Melton. Interest in physiography and glacial geology was revived, as Frank Leverett attempted to distinguish between deposits of the first and second glacial stages in Kansas, J. T. Pardee studied glacial features in southwestern Montana, and F. E. Matthes investigated the physiographic history of the Sierra Nevada. The genesis of lithium pegmatites was studied in the field and laboratory by W. T. Schaller and E. S. Larsen, Jr., and Schaller concluded that the lithium pegmatites of southern California were not original crystallizations from a magma but the result of replacement of preexisting rock, probably by hydrothermal solutions.

The work of the Alaskan Geology Branch in 1924 continued to be almost entirely economically motivated. The first season's work in the Naval Petroleum Reserve No. 4, in the summer of 1923, had verified the reports of large seepages of oil and of geologic conditions sufficiently favorable to oil accumulation to warrant a second expedition, this one staffed by the Alaskan Geology Branch. P. S. Smith, J. B. Mertie, Jr., Gerald FitzGerald, and R. K. Lynt left for Alaska in January 1924 and went overland to the Reserve to make surveys in unmapped areas in its southern and eastern parts. During the open season, W. T. Foran and O. L. Wix went by sea to Wainwright and surveyed a

In 1923, the Navy supplied funds for the Survey to explore Naval Petroleum Reserve No. 4 in northern Alaska for evidence of petroleum. The geologists found the Point Barrow region underlain by more than 15,000 feet of sedimentary rocks, chiefly shale, sandstone, and conglomerate with some thin beds of limestone, all regarded as Mesozoic in age. Two large oil seeps at Cape Simpson, one of which is shown in the illustration, were believed to emerge from this rock sequence although there was no clue as to which part. The part of the reserve investigated appeared to contain structural features favorable to the entrapment of petroleum. The evidence obtained in the first season justified continuation of the exploration. (From Sidney Paige, W. T. Foran, and James Gilluly, 1925.)

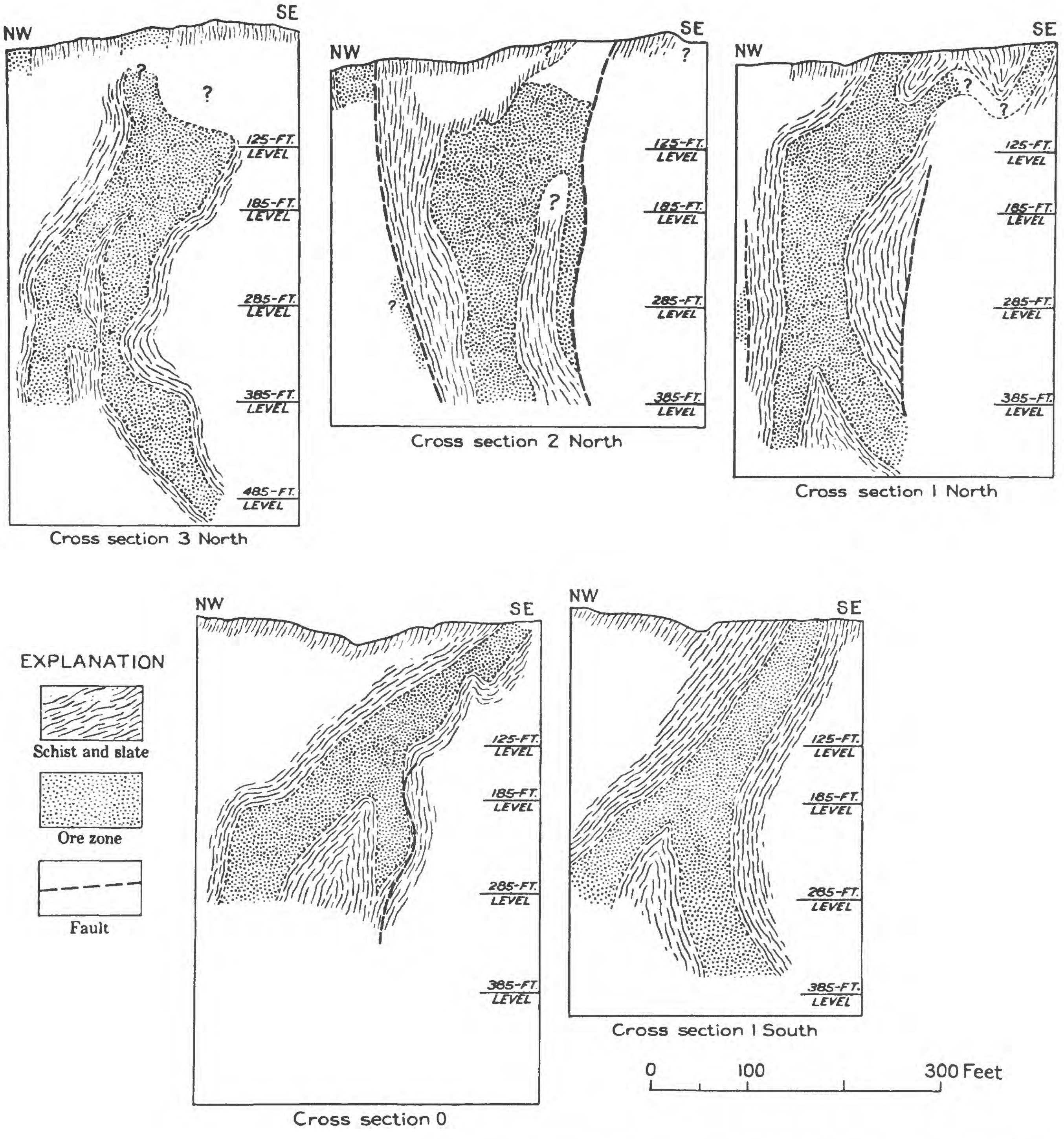
strip of country in the western and southern parts of the Reserve. S. R. Capps, with K. K. Landes as assistant, spent the field season of 1924 mapping the coal-bearing rocks in the upper Matanuska region, an area expected to benefit from the completion of the Alaska Railroad. Other projects were continued in southwestern and southeastern Alaska.

A. H. Brooks, the Chief Alaskan Geologist, collapsed at his desk and died on November 22, 1924, bringing to an end so long and intimate an involvement in the development of Alaska that he was commonly known as "Brooks of Alaska." P. S. Smith, for many years a member of the Alaskan Branch and who succeeded him as Branch Chief, said that Brooks "through his long experience, sympathetic understanding of the problems of the mineral industry in a frontier country, and broad technical knowledge, was in large measure personally responsible for the application of sound scientific principles to the search for and development of the Territory's mineral resources." Brooks, however, was much more than an Alaskan geologist, as his services during World War I as the Chief Geologist of the American Expeditionary Forces testify. Director George Otis Smith, who had twice asked him to become Chief Geologist, said that "He was the associate to whom I, like others, turned most frequently for wise counsel and frank criticism." Brooks, he said, "had a genius for truth, and his loyalty to scientific truth made pretense impossible, although his unfailing humor often concealed his real contempt for any effort to make science appear what it is not. His service to pure science was not lip service."

Congress convened on December 2, 1924, for the lameduck session and, in keeping with presidential priorities, received the budget message before the State-of-the-Union Message. The budget message forecast receipts of more than $3,641 million and a surplus of nearly $374 million for the next fiscal year. In the State-of-the-Union Message, however, Coolidge said: "Our domestic problems are for the most part economic. We have our enormous debt to pay, and we are paying it. We have a heavy burden of taxation to reduce, and we are reducing it. But while remarkable progress has been made in these directions, the work is yet far from accomplished. * * * In my opinion the Government can do more to remedy the economic ills of the people by a system of rigid economy in public expenditure than can be accomplished through any other action. * * * The present estimated margin between public receipts and expenditures for the fiscal year is very small. Perhaps the most important work that this session of Congress can do is continue a policy of economy and further reduce the cost of government." Coolidge's inaugural address on March 4, 1925, also emphasized economy. In other speeches during the spring months, he said that what the United States needed was not more Federal Government but better local government, and deplored the tendency of States to turn to the Federal Government for aid toward projects that should be paid for by the individual States.

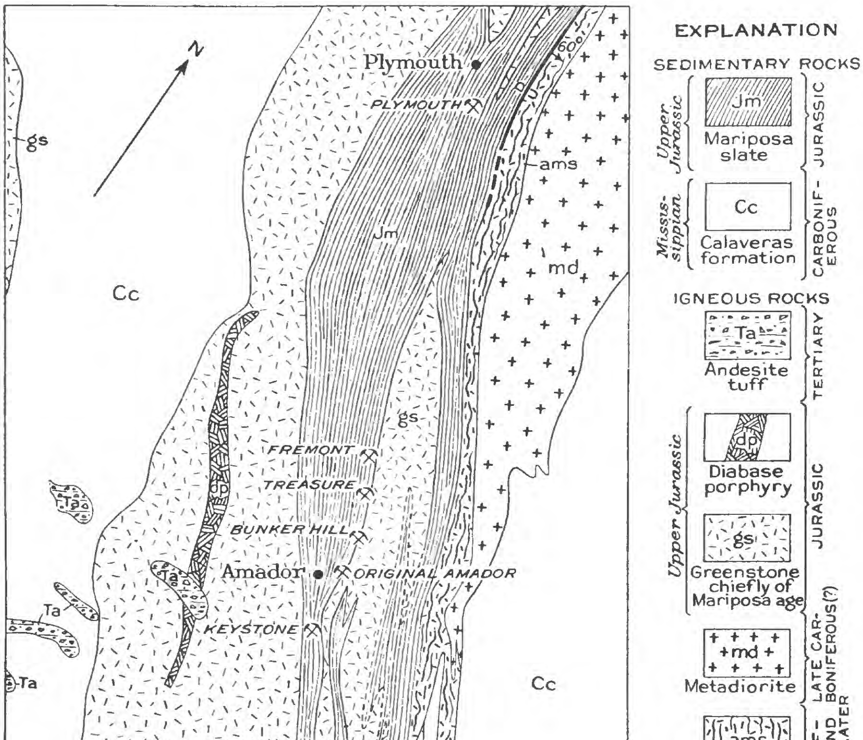
The appropriations bill for the Department of the Interior was reported out on the opening day of the Congressional session in December 1924 and enacted one day before adjournment in March 1925. For the Department as a whole, the Bureau of the Budget recommended a cut of about 10 percent in the total approved for the fiscal year in progress. In the hearings before the Appropriations committee, Secretary Work forecast new economies in the Department. Attention was then being given, he said, to curtailing unnecessary publications and to decreasing the size of the edition of those that were published. The Bureau of the Budget had reduced most Survey items, but only that for topographic surveys by the full 10 percent. Congress accepted the recommendations except that for topographic surveys, which in the end was cut only 3 percent.

Although the Ducktown ore deposits in Tennessee had been studied for more than 70 years and by many geologists, opinions still differed on their origin when W. H. Emmons returned to the field in 1922 to complete a study begun more than a decade earlier with F. B. Laney. The deposits were broadly tabular bodies included in a siliceous mica schist. (The illustration shows five cross sections through the ore body in the Polk County mine.) From the surface downward, the deposits consisted of limonite with kaolin, quartz, and other minerals, chalcocite, and a yellow sulfide ore. Along the strike and down the dip the ore graded into a lime silicate rock and, in some places, into marbleized limestone. Emmons concluded that the deposits were bodies of limestone that had been replaced and complexly folded and faulted but was uncertain about the source of the ore-depositing solutions. (From W. H. Emmons and F. B. Laney, 1926.) ▶

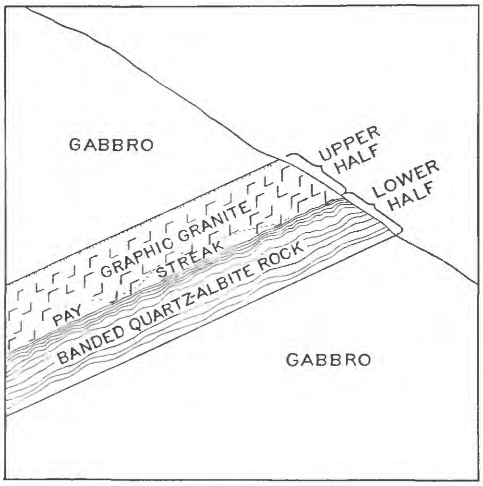


Congress also passed the Temple bill for a topographic survey of the United States. The House took the bill up under the unanimous consent rule which limits debate to 5 minutes and passed it on January 21, 1925. The Senate passed the bill on February 18, again with a minimum of debate. Senator Smoot argued that the map could not be completed in the time specified so the time should be extended but he was persuaded not to disagree with the House and delay the bill so that it could not be passed before the session ended. President Coolidge signed the bill on February 27. The Temple Act authorized the President to complete, within 20 years of the date of passage, "a general utility topographical survey of the territory of the United States, including adequate horizontal and vertical control, and the securing of such topographic and hydrographic data as may be required for this purpose, and the preparation and publication of the resulting maps and data." The President was further authorized to use the services and facilities of agencies already existing or that might be established thereafter, and to allot funds, from appropriations authorized in the Temple Act or appropriations made thereafter for the same purpose. The agencies engaged in carrying out the provisions of the act were also authorized to make cooperative arrangements with States or other civic subdivisions and to receive funds from them to expedite mapping within their borders. For the first year, the bill authorized an appropriation of $950,000.

Congress had not acted on any of the pending reorganization bills in the short session. President Coolidge was then persuaded to issue an Executive



In 1924, Adolph Knopf completed another segment of the Survey's investigation of California gold, a detailed study of the Mother Lode system in the Sierra Nevada. The geologic map shows a 10-mile section of the system in western Amador County which contains all the very deep mines. The gold deposits were principally parallel or acutely intersecting quartz veins and mineralized country rock adjacent to the veins or in broad zones of fissuring. The Mother Lode system traversed steeply dipping slates, schists, and greenstones, including some intrusive masses of serpentine, which formed a series of belts trending northwest parallel to the course of the range. Knopf concluded that the Mother Lode system occupied a series of auxiliary fractures in a zone parallel to a great reverse fault, and that the veins had grown by successive enlargement along fissures that were reopened from time to time by renewal of movement along the fractures. (From Adolph Knopf, 1929.)



Field and laboratory studies convinced Survey mineralogist W. T. Schaller that the lithium pegmatites as now seen are not the result of an original crystallization of a magma but of hydrothermal replacement of a much simpler, earlier-formed magmatic rock essentially free of any lithium minerals. In the California tourmaline field, the rock replaced was a graphic granite, and its peculiar structure and texture was the key to determining the replacement processes in which albite replaced microcline and quartz and was later replaced by lithium minerals. A few of the pegmatites were uniform in mineral compositon and texture but others were divided into two parts in which the mineral composition, rock texture, and structure were different. In some pegmatites the transition between the two parts was gradual, in others sharply defined, and in many there was a seam of rock different from either the upper or lower parts, called the "pay streak" because both gem and nongem lithium minerals are concentrated in it. (From W. T. Schaller, 1925.)

order on June 4, 1925, transferrring the Patent Office, the Bureau of Mines (except the supervision of mineral-leasing operations on the public lands), and the Division of Mineral Resources of the Geological Survey from the Department of the Interior to the Department of Commerce, effective July 1, 1925. The supervision of mineral-leasing operations was then assigned by the Department to the Geological Survey. In announcing the change, Secretary Work said "The change is one of the reorganization plans approved by the Joint Congressional Committee. The primary objects of such segregation are of course to secure economy in administration and a more efficient relationship with the public." He added, hopefully, "This transfer presages action by the Congress and opens the way for the transfer to the Department of the Interior of bureaus from other executive branches of the Government administering public lands and public works as recommended by this committee." In this expectation, however, he was disappointed. The Survey's Pick and Hammer Club viewed the loss of the Division of Mineral Resources philosophically, explaining in a song that

Secretary Hoover said "They've great efficiency
And all that is efficient must of course belong to me."

The Mineral Leasing Division and the part of the Petroleum Division of the Bureau of Mines that were transferred to the Geological Survey on July 1, 1925, had been involved in both technical engineering and inspectional and regulatory functions in respect to the discovery and development of petroleum, natural gas, oil shale, coal, phosphate, sodium, and potassium on the public lands, the development of petroleum and natural gas in the three Naval Petroleum Reserves, and a variety of services on behalf of the Office of Indian Affairs in connection with mineral developments on Indian lands. Properties under development were inspected to prevent waste or damage and injury to life and property. Plans and operating procedures were approved, tests were made or witnessed, receipts for royalty oil were issued, pipeline companies authorized to receive oil or gas from Government leaseholds, royalties determined, and records maintained, all in addition to advising or assisting lessees in the solution of technical or engineering problems. To carry out these duties, funds amounting to $349,550 and 138 people were transferred from the Bureau to the Survey.

At the time of the transfer, the petroleum situation was dramatically different from what it had been when the Mineral Leasing Act was passed in 1920. U.S. petroleum production in 1924 was almost double that of 1919; so was world production. A Committee of Eleven Members of the Board of Directors of the American Petroleum Institute estimated in 1925 that there were 5.3 billion barrels of crude oil recoverable by existing methods of flowing and pumping in proven territory in the United States, not too different, at first glance, from the AAPG-USGS estimate of 1922 of 5 billion barrels "in sight." However, in the 3-year period 1922–1924, about 2 billion barrels had been produced. The Committee of Eleven estimated that an additional 26 billion barrels left in the ground by existing methods could be won by methods of flooding, unwatering, forced air pressure, or mining when the price justified. They made no estimate of the quantity of oil to be found in unknown fields or by drilling to deeper horizons in existing fields. The Coolidge administration now clearly supported conservation of oil and President Coolidge had appointed a Federal Oil Conservation Board, consisting of the Secretaries of War, Navy, Commerce, and Interior on December 19, 1924, to review Federal oil policies. The Board had in turn established an advisory committee to assist it, and had appointed the Director of the Geological Survey George Otis Smith to act as its chairman.

On July 1, 1925, the Conservation Branch was established in the Geological Survey to incorporate the new functions transferred from the Bureau of Mines with those of the Survey's Land Classification Branch and the Division of Land Classification Investigations of its Water Resources Branch. The duties of the Conservation Branch were defined as "the classification of lands according to their highest use; the protection of the public interest in undeveloped mineral, water-power, and agricultural resources; and the promotion of economical and efficient development of mineral deposits on public and Indian land."

The new branch was organized in four divisions: Mineral Classification, Power, Homestead, and Mineral Leasing, the first three to cover the work already being done in the Survey, the last to include the work previously done in the Bureau of Mines. The Mineral Classification Division remained essentially the same as it had been under the Land Classification Branch. The Power Section of the former Division of Hydrographic Classification was upgraded to a full division, testifying the importance of water power. The Irrigation Section and the Division of Land Classification Investigations of the Water Resources Branch were combined as the Division of Homestead Classification.

Survey men retained direction of all units except the Mineral Leasing Division. Herman Stabler, Chief of the Land Classification Branch, became the first Chief of the Conservation Branch, and J. D. Northrop its first Assistant Chief. Northrop was also Chief of the Division of Mineral Classification, B. E. Jones, Chief of the Power Division, and A. E. Aldous, Chief of the Homestead Division. H. I. Smith, who transferred from the Bureau of Mines, was Chief of the Mineral Leasing Division. W. G. Hoyt, who had been Chief of the Division of Hydrographic Classification before it was broken up, remained as a consulting engineer on the branch staff.

In the new Geological Survey, geologists became a distinct minority, even, one might say, an endangered species. In 1925, there were all told only 126 geologists in an organization of more than a thousand people, and 108 of them were concentrated in the Geologic Branch.

During the remarkable development of the science of geography in the early decades of the 20th century in the United States, the significance of environmental factors in influencing human activities came to be appreciated. W. W. Atwood and K. F. Mather noted that such influence on routes of travel, location of settlements, human occupation, and ultimate utilization of natural resources was strikingly illustrated in the San Juan region of Colorado. The mineral resources first attracted the attention of prospectors and miners, who founded several mining towns in the 1880's, among them Ouray in the valley of the Uncompahgre, shown in the background of this photograph by Whitman Cross. Nearly all these towns were located as far upstream as transportation conditions permitted and suitable town sites were available, and later became the termini of railroad spurs and commercial centers for the mountain areas. The second wave of settlers was attracted by the agricultural possibilities of the broad fertile lowlands in the valley bottoms such as that shown in the foreground of the photograph. From W. W. Atwood and K. F. Mather, 1932.)

Chapter 10. The Power of the Purse, 1925–1928

The power over the purse is the power over liberty.

—Calvin Coolidge

The year 1925 has been called by one historian "the year that nothing happened." Calvin Coolidge was sworn in as President in his own right in March and as soon as the weather became better took an extended vacation. Federal expenditures were only a little more than $3 billion that year, less than half what they had been in 1920, and receipts were some $117 million more than expenditures so the national debt was being lowered, and that was good. The American Ambassador to Germany reported that German militarism was dead and that German ambitions were limited to economic rehabilitation. The Locarno Pact, which guaranteed the peace of the Rhine and called for arbitration of conflict among Western European nations, was signed so Americans could relax—they had not erred in rejecting Wilson's League because Europe was going to take care of its own problems. There were some minor problems at home. General Billy Mitchell claimed that air power would be all-important in the future wars and accused the War and Navy Departments of incompetency, criminal negligence, and almost treasonable administration of the national defense in not developing American capabilities, but he was found guilty of insubordination in a court-martial and resigned from the service. The boll weevil continued to eat its way through crops in the South, and in the summer of 1925 both the Southern and Western States were troubled by drought. Farming on the whole, however, was more prosperous than it had been since 1920. By and large the headlines that year recounted the plight of Floyd Collins, trapped in a cave in Kentucky, the real estate boom in Florida, the confrontation between religion and science at the Scopes trial in Tennessee, and the exploits of Babe Ruth, Bobby Jones, and Red Grange.

But 1925 was also the year in which Herbert Hoover, having achieved some of his goals in Government reorganization, espoused the cause of pure science. Hoover had been elected to the National Academy of Sciences in 1922 and was soon drawn into active participation in its affairs. In 1924, he served as a member of a committee on forest policy, along with Charles D. Walcott, Secretary of the Smithsonian Institution, and John C. Merriam, President of the Carnegie Institution of Washington. When a plan was proposed in 1925 to establish a research foundation under Academy auspices that would make funds available to investigators engaged in pure research, Hoover became chairman of the foundation's Board of Trustees. In a statement issued on February 1, 1926, the trustees declared their conviction "that the United States, which already occupies a leading position in industrial research, should rank with the most enlightened nations in the advancement of pure science; * * * that research in all branches of the mathematical, physical and biological sciences should be encouraged, because of the intellectual and spiritual value of adding to knowledge and because the greatest advances in science and industry often result from apparently useless abstract discoveries''; and ''that the funds now available for the support of research in pure science in the United States are far below what our population, education and material resources demand.'' In an address before the Society of Sigma Xi and the American Association for the Advancement of Science in December 1926, Hoover declared that

> **we must strengthen the first line of industrial advancement — pure science research. These men of pure science are the most precious assets of our country * * *. It is no fault of their own but it is the fault of the nation that it does not give to them and to the institutions where they labor a sufficient support. There is no price that the world could not afford to pay these men who have the originality of mind to carry scientific thought in steps or in strides.**

The Coolidge administration, however, held that the high degree of prosperity which the United States had achieved, and which seemed to be a harbinger of an era of perpetual prosperity, was the result of its policy of economy, elimination of waste, and raising the standards of efficiency in Government. Thus even in Secretary Hoover's Department of Commerce, where science it might be presumed would aid commerce and industry, the increase in funds for scientific research during his 8-year tenure was only $1.3 million.

The Federal appropriation for some items in the Survey program during this period was augmented by funds from other Federal agencies, States, and municipalities, which called on the Survey to make surveys and supply data in connection with their own programs. Thus engineering and the practical or applied sciences were encouraged, and the Survey's topographic mapping program and water-resources investigations were able to continue, even to grow, because they could supply what others needed. Congress eased the way by authorizing Federal agencies to transfer funds to the Survey before a project was begun, which the Survey could then use as its own, and by appropriating additional funds for topographic mapping and stream gaging for the specific purpose of, and limited to, matching funds supplied by the States and municipalities for cooperative projects.

Basic research, however, was regarded as a luxury item which the Federal Government could not afford. Cooperative funds were in general not available for basic research, one notable exception being the survey of the economic geology of Colorado, to which the Colorado Metal Mining Fund contributed a sizeable sum, and that at least had the aura of practicality about it. Yet basic research persisted in the Survey, especially in the Geologic Branch and the Ground Water Division of the Water Resources Branch. The new Conservation Branch engaged in some fundamental research and contributed to the support of work in the Geologic Branch and the Ground Water Division.

Much of the work of the Conservation Branch in its first year of existence was concerned with mineral lands, especially with the newly acquired responsibility for supervising mineral leasing operations on the public lands. Two significant changes were made, the delegation of more authority to the field offices and a major effort to reduce the size of the activity. A large decrease in personnel was made possible by the cessation of Federal operation of the Red River oil fields, which had been under receivership since April 1, 1920, at the end of November 1925. Then by discontinuing some lines of research and distributing the duties of employees who resigned among those who remained, in one year the staff was reduced from 139 to 89.

The new Homestead Division, which combined the functions of the former Division of Homestead Classification and Irrigation Section of the Land Classification Branch and the Division of Land Classification Investigations of the Water Resources Branch, made both detailed examinations of land for designation under the enlarged- and stockraising-homestead laws in all the public-land States west of the 100th meridian and broad areal studies in the

Herman Stabler (1879–1942), first Chief of the Conservation Branch of the U.S. Geological Survey, established in 1925 with responsibility for classification of the public lands according to their highest use, protection of the public interest in undeveloped mineral, water-power, and agricultural resources, and the promotion of efficient and economical development of mineral deposits in public and Indian lands. Stabler graduated from Earlham College in Indiana in 1899 and joined the Survey as an engineering aid in the Hydrographic Branch in 1903. With the exception of a year as an assistant engineer in the Reclamation Service, he remained with the Survey until his death in 1942. In his own professional work, which was chiefly concerned with water quality and utilization, he published reports on the prevention of stream pollution and purification of wastes and developed an early interest in the amount of sediment carried by streams. He maintained a broad interest in all phases of conservation, however, and also served as a director of the American Society of Civil Engineers. (From the files of the U.S. Geological Survey.)

northern Great Plains region, Colorado, Idaho, Nevada, Utah, and Washington. The work in Nevada included a reconnaissance investigation to determine the agricultural utility of the unreserved public land throughout the State. Substantial progress was made in the cooperative project with the Department of Agriculture on agriculture and land utilization in the northern Great Plains region, and, under authorization from the Secretary of the Interior for extension of the cooperation, work was begun in the central Great Plains region.

By 1925, the Survey's oldest branch, the Geologic Branch, had nearly recovered from its postwar trauma. The rate of exodus of staff had been slowed and even reversed in some instances. Nearly all its work had been reoriented toward research and the program was described as "the establishment of principles and the discovery of new generalizations and new laws of wide applicability; the reporting of new facts, in particular on geologic maps; and the preparation of economic reports describing in detail the character, quality, and position of mineral deposits."

The economic geology of metalliferous deposits had entered upon a new and more intensely active phase, and the issues of *Economic Geology* were replete with discussion of a variety of subjects. How important were theories of ore genesis in a report? One of the editors of the journal, E. C. Andrews of Sydney, Australia, thought that geologists should curb their tendency to venture into unknown realms of science—to shun "the romance of the unknown"—in giving opinions on ore genesis. Augustus Locke, consulting geologist, said economic geologists should get out into the field and go over every inch of the ground; the science was already overgrown on the speculative side. F. L. Ransome thought that the weak point in discussion of ore genesis was lack of information on the physical chemistry involved. One of the "prime necessities for progress" was the establishment of fundamental chemical and physical data by experimental work of the caliber of that done by the

Classification of the public lands according to their highest use was seldom achieved, for the mineral-land, power, and agricultural classifications were made and reported independently. For example, the Homestead Division since 1922 had been systematically classifying the public lands with respect to utility for agriculture in cooperation with the Department of Agriculture. Lands were classified as those on which crops could be raised by irrigation or by dry farming or suitable for grazing only. However, in an area in Rosebud County, Montana, in which the land was classified as primarily grazing land, Survey geologists found thick coal beds, estimated to contain nearly 11 billion tons of coal, suitable for strip mining when transportation facilities became available. The photograph shows a geologist examining coal beds in the area. (From N. W. Bass, 1932.)

Geophysical Laboratory on the origin of igneous rocks or by Professor P. W. Bridgman at Harvard on the effects of pressure on rocks. Ransome added

> **Without any suggestion that the use of the imagination should be discouraged or curtailed, writers on the problem of ore genesis may well be reminded that in the present state of knowledge, a modest realization of ignorance may well temper the enthusiasm with which some ideas are set forth and that suspension of judgment is not necesarily to be branded as timidity or aversion to real progress.**

C. K. Leith precipitated discussions of the meaning of "economic" in economic geology. The reports of the Committee on Industrial Preparedness of the American Institute of Mining and Metallurgical Engineers and the Committee on Foreign and Domestic Mining Policy of the Mining and Metallurgical Society of America were published in 1925 as a pamphlet entitled "International Control of Minerals." The AIME Committee proposed a program to create stockpiles of several of the deficient minerals. Leith, who had been a member of the AIME committee and chairman of the MMSA committee, led a round-table discussion of natural resources in international relations at the Williamstown Institute of Politics in the summer of 1925, taking the opportunity to acquaint economists and political scientists with the facts about the geographic distribution and international movement of minerals. Leith held that fixed environmental conditions provided the ultimate control of political arrangements and suggested that the balance of mineral resources was a powerful factor in determining the balance of political power. The conference received worldwide notice because Leith, in discussing mineral resources and production in the Far East, concluded they did not indicate that a first-class industrial power would develop in the region, and a reporter interpreted that statement to mean that Japan was not a war menace because of its weak steel industry.

Survey geologists were not publicly involved in these discussions, but the Metals Section nonetheless exhibited a new air of activity in 1925. In the early days of the Survey, Colorado had been the scene of pioneering work in mining geology, and S. F. Emmons' Leadville monograph of 1887 was accounted by many the most important publication of the Geological Survey in its first quarter-century. The latest report on Leadville, G. F. Loughlin's "Guides to Ore in the Leadville District, Colorado," marked the beginning of a new era in Colorado mining geology. Under the sponsorhip of the Colorado Metal Mining Fund, Loughlin, assisted by J. C. Beam and T. S. Lovering, studied the deep mines in the Cripple Creek district, and B. S. Butler and W. S. Burbank, after completing the field work and report on the copper deposits of Michigan, began preparations for an extensive study of the mining geology of the State to begin in the next fiscal year. Other field studies were continued in California, Nevada, Montana, and Idaho, and new projects were begun in west-central Utah, where Sidney Paige began mapping the Stockton-Fairfield quadrangles in the Oquirrh Mountains south of Bingham Canyon that included the abandoned gold mines of Mercur that J. E. Spurr had studied in 1894, and T. B. Nolan began a field study of the Gold Hill district in Juab County.

Although most of the metals projects were in districts where the major metals, gold, silver, copper, or lead, were the subject of investigation, some of the minor metals were also studied, either in conjunction with the major studies or alone. At Gold Hill, for example, Nolan found the deposits to be unusually varied, including not only gold and copper but also the important ferro-alloy minerals, molybdenite, which Butler had noted in his reconnaissance in 1912, and tungsten, which had been mined just south of the area during the world war. J. T. Pardee, who had previously examined the manganese ores of Washington, but found most of them to be the then unusable manganese silicate, went back after discovery of a high-grade manganese oxide was reported at Lake Crescent and was encouraged to believe that usable ore would be found. D. F. Hewett, who maintained an abiding interest in manganese minerals, completed field work in the Goodsprings quadrangle of Nevada and began a study of western manganese minerals and their origin. The Section of Iron and Steel Metals had dwindled to one major project, E. F. Burchard's study of the brown iron ores of Tennessee. Burchard had concluded that although a large proportion of the easily accessible ores had been mined, there remained an estimated reserve of 8.9 million tons. Future mining, he concluded, would be more expensive and its success would depend on the accessibility of transportation facilities and markets, iron prices, and improvement of the beneficiation process.

Responsibility for promotion of efficient and economical development of mineral deposits in public and Indian lands had been assigned to the Bureau of Mines after passage of the Mineral Leasing Act in 1920 and was transferred to the Geological Survey in 1925. In accordance with the instructions of the Secretary of the Interior, Government lessees were required to comply strictly with departmental orders and regulations developed to promote "conservation in its true sense, that is, use with minimum waste." Even in the 1920's, wells "going wild," such as that shown in the photograph, were among the most common oil and gas field wastes. (From T. E. Swigart and C. E. Beecher, 1923.)

The fundamental research projects seeking to learn the source and movement of petroleum were now beginning to produce some practical spin-offs. P. G. Nutting, in his study of the movement of fluids through porous solids, for example, found that a soda solution separated the oil from sand grains so effectively in the laboratory that there was full recovery of oil. Oil operators at Bradford, Pennsylvania, were interested in testing a modification of the water drive for secondary recovery, and the first trials promised success in the field as well. C. E. Van Orstrand's conclusion that temperature was related to subsurface structure interested some oil companies as a possible method of locating new oil fields.

Most of the Fuels Section geologists were engaged in areal mapping and stratigraphic studies in the public-land States of Colorado, Utah, Wyoming, and Montana, in part for purposes of mineral-land classification, and in northern Arkansas, Louisiana, and California. In addition to the mapping by the Fuels Section, other mapping and stratigraphic studies were also underway in New England, the Middle Atlantic States, the Gulf Coast, and New Mexico.

In 1925, the Survey became more deeply involved in basic research on natural catastrophes. On July 1, the Survey took over responsibility for the Hawaiian Volcano Observatory established by the Hawaiian Volcano Research Association in 1912. A few geologists were diverted from their mapping or other investigations for short periods to investigate some of the natural disasters that seemed unusually numerous in 1925. Arthur Keith studied the effects of the major earthquake of Febrary 28, that centered in the St. Lawrence Valley, in the Northeastern United States, as well as several small shocks in New England. W. C. Alden investigated the landslide of June 23 in the valley of the Gros Ventre River, about 35 miles south of Yellowstone Park. The slide had formed a dam about 225 feet high and half a mile long that completely blocked the river and produced a lake that submerged much of three ranches and a ranger station in the Teton National Forest. Alden concluded that heavy rains and melting snow had saturated a clay shale, interbedded with the Carboniferous sandstones and limestones, which slipped and caused the slide. J. T. Pardee studied two earthquakes in the same general area, the first only four days after the Gros Ventre slide. Nearly all Montana and parts of the neighboring States and Provinces were shaken and considerable damage caused, especially in the villages of Three Forks, Logan, and Manhattan by the June 27 earthquake. Pardee concluded that the region was likely to experience an occasional severe shock and suggested that the inhabitants take "at least a few simple precautions toward the prevention of future damage." Pardee also studied the effects of the earthquake of November 17 in the Big Horn Mountains of Wyoming. Survey geologists, however, were not involved in the study of the Santa Barbara earthquake of June 29, which focused attention on earthquakes in the United States and the damage they could cause. Studies of the Santa Barbara shock by well-known geologists, among them Bailey Willis, and engineers led to the first serious attempt to establish building codes.

The production of State geologic maps continued apace. The map of Alabama was in press by the end of the year, the maps of Oklahoma and New Mexico were ready for engraving, and progress was made on the map of Texas. C. W. Cooke prepared a geologic map of South Carolina as part of his report on the geology of that State and also cooperated with the State Geologist of Florida in revising the geologic map of that State. N. M. Bass, who was preparing a report on the oil and gas possibilities of Kansas, also cooperated with the State Geologist in preparation of a State map.

The geologic time classification used on the Survey's maps, however, was being questioned. That classification had been the source of lively controversy in the Survey's first quarter century, but little had been published on it for several years. The problems associated with Survey usage had not disappeared; in fact with the passage of time and the intensive study of the geology of the country, the problems had become very complex and the number of formation names had been greatly multiplied. Several geologists, among them T. C. Chamberlin and R. D. Salisbury, E. O Ulrich, Charles Schuchert, W. B. Clark, and A. W. Grabau, had proposed major changes in classification, and so several American classification schemes were then in use, as well as several European classifications that not only differed from the American usage but from each other. The Survey had meanwhile clung to essentially the classification adopted in 1903 for the Geologic Atlas, and the publication in 1925 of a bulletin, compiled by M. Grace Wilmarth, Secretary of the Survey's Committee on Geologic Names, entitled "The Geologic Time Classification of the United States Geological Survey Compared with other Classifications and Accompanied by the Original Definitions of Era, Period, and Epoch Terms" seemed to suggest, at least by its title, that the Survey classification should be the standard. T. W. Stanton, Chairman of the Geologic Names Committee, went so far as to suggest in the preface that the Survey had been "perhaps overconservative" in its classification. Schuchert, in a review of the bulletin in the *American Journal of Science*, called the Survey's classification "too simple" and "inadequate for modern needs."

The age of the Earth and length of the various time divisions were again being debated. The Wilmarth bulletin included estimates of the age of the Earth by H. S. Williams, W. J. Sollas, Charles Schuchert, and W. D. Matthew, which ranged from 48 to 94 million years, and by Joseph Barrell, of 1,240 to 1,710 million years. Only Barrell's estimate had included radioactivity as a factor in the calculation. In the latter part of the 19th century, before radioactivity was discovered, geologists had decried estimates based on physical data as being too short to account for geologic phenomena, but now many scientists considered the estimates based on radioactivity too long. In that respect, the Survey did not take a conservative view but maintained a wait-and-see attitude. R. C. Wells prepared a table of the ages of minerals and rocks based on radioactive changes for the first volume of the "International Critical Tables" and assigned an age of 1,540 million years to an uraninite from the Black Hills of South Dakota. Wells felt, however, that neither of the two methods then in use, the helium or the lead method, was satisfactory. The helium ratio gave minimum ages because of the loss of helium with time, and the lead ratio involved the assumption, subject to proof, that the lead was wholly of radioactive origin.

Although emphasis in the Geologic Branch was shifting from oil to metals, the Alaskan Geology Branch, under its new chief, continued the direct search for oil. P. S. Smith had been appointed Chief Alaskan Geologist on April 1, 1925. Smith had joined the Survey in 1906 and had spent the following nine seasons in Alaska, for the most part engaged in exploratory and reconnaissance surveys in unknown or little known parts of the territory. In 1915, he had been appointed Administrative Geologist of the Survey and for the period of George Otis Smith's service with the Coal Commission had been Acting Director. Gerald FitzGerald succeeded Smith in charge of the NPR–4 exploration and he and W. R. Smith mapped about 7,000 square miles, chiefly in the headwater region of the Colville River and some of the northern tributaries of the Noatak. Interviewed by the press on their return in the fall, the unusually laconic FitzGerald reported "One of the purposes of the expedition was to determine the extent of the oil area. This we accomplished." R. H. Sargent and R. S. Knappen surveyed 3,000 square miles across the full width of the Alaska Peninsula to assist in the development of oil resources. In addition to the investigations related to oil, F. H. Moffit continued his study of the mineral deposits of the Prince William Sound region, K. K. Landes continued to map the coal-bearing rocks of the Matanuska region, S. R. Capps began reconnaissance surveys on the northwest side of the Alaska Range, and J. B. Mertie, Jr., was off into the unknown once again, this time to make geologic surveys along the Yukon River between the international boundary and Circle.

The Survey's other two branches were supported in large part during the fiscal year that began July 1, 1925, by funds from other Federal agencies, States and municipalities, or Federal Power Commission permittees. The Federal appropriation was about 60 percent of the total available for the Topographic Branch but less than 30 percent for the Water Resources Branch. As a result, both programs were largely directed toward the particular needs of others rather than national needs.

By the mid-1920's it was becoming apparent that action must be taken to counter the effects of misuse of water. In the Roswell Basin of New Mexico, about 75 percent of the water supply for irrigation was directly of artesian origin and much of the rest was derived indirectly from the same source. C. A. Fisher of the Survey, who had studied the area in 1904 and 1905, pointed out that misuse of artesian water would have serious consequences. O. E. Meinzer remapped the area in 1916, by which time the artesian flow had decreased considerably, much land on the west side of the basin had been abandoned because of the increased pumping lift, and much land on the east side had become water-logged and had to be drained. The artesian head continued to decline because laws regulating the use of water were not enforced. In 1925, the Survey began a cooperative investigation which led to enactment of a model law. The illustration shows Survey equipment set up for a leakage examination. (From A. G. Fiedler and S. S. Nye, 1933.)

The topographic mapping program was diminished somewhat during the year because the amount of cooperative funds was less than expected, presumably because of confusion over the meaning of the Temple Act. The act had authorized an appropriation of $950,000 for the first year but of course no such appropriation had been made. The Federal appropriation for topographic surveys had, in fact, been reduced, in the expectation that the States would provide the same or more cooperative funds whereas the States offered less, apparently assuming that a large Federal appropration would be available. As a result, the area mapped was about 15 percent less than in the preceding year.

Surface-water studies remained the major element in the work of the Water Resources Branch, and examinations of streams and neighboring lands for classification with respect to their value for water power and irrigation continued to be important. New and more urgent water problems were developing, however, as the Nation's population increased, and the Survey was called on to extend its work beyond the availability of water for power and irrigation, which had occupied a large part of its resources for many years, to the availability and quality of water for urban and industrial use and to the menace of floods.

Ground-water studies became more numerous and more quantitative. In New Mexico, A. G. Fiedler and B. C. Renick began a cooperative investigation in the Roswell artesian basin where artesian flow had decreased alarmingly, to determine underground leakage, the quantity of water actually withdrawn from irrigation, the relation between draft and decline in head, and safe annual yield. A fundamental investigation was undertaken in Utah to determine the annual yield of ground water. In 1923, W. N. White and Depue Falck had made a ground-water and soil survey of the Escalante Valley for land classification purposes, in the course of which they had noted that in part of the valley alfalfa seed was being produced without artifical irrigation by subirrigation from ground water. As the Escalante Valley was a closed basin from which little or no water could escape and in which the ground-water recharge from mountain streams was about balanced by the average loss by evaportation from soils and transpiration from plants, Meinzer worked out a method to determine the annual yield; the Conservation Branch detailed W. N. White to make the field measurements. Urban water studies were expanded. David Thompson continued his work in New Jersey, and the Pennsylvania Topographic and Geologic Survey entered into an agreement with the U.S. Geological Survey for a cooperative study of the ground-water resources of that State. G. M. Hall began the work in the most urbanized area in southeastern Pennsylvania.

The 69th Congress which met for the first time in December 1925 was very Republican and very conservative. In his annual message, President Coolidge described the state of the Union as "one of progress and prosperity," and said that the budget law had been working well; departmental estimates for the next fiscal year were only $3,156 million, or $912 million less than for the year before the Bureau of the Budget was established. The conservation and development of natural resources were mentioned only briefly in the message. Coolidge stated that the Government was committed to a policy of reclamation and irrigation but wanted it established on a sound basis, that waterway development and the encouragement and development of water power should go forward, and he urged Congress to reconsider the report of the recent Coal Commission in an effort to resolve the "perennial conflict" in the coal industry. He also urged Congress to pass the reorganization bill as it would also be "of great benefit to the efficient and economical administration of business of the Government." Congress, however, showed little interest in going beyond what had been accomplished by the Executive orders of June 1925. It was much more interested in cutting taxes, which, after all, Coolidge said had

In 1925, the Survey began a systematic sampling of the sediment carried by the Colorado River at Grand Canyon, Topock, and Yuma, Arizona, using the sampler shown. Plans for the development and utilization of the river had to take into account the quantity of solid material carried by the river, much of which would be deposited in the proposed reservoirs, diminish their capacity, and decrease the effectiveness of flood control and river regulation, but observational data were scarce. C. S. Howard found that in the first 3 years of the investigation the annual load of suspended matter at Grand Canyon was considerably larger than that at Yuma, and for 2 of the 3 years it was larger than that at Topock. Howard also noted that for a considerable portion of the material a given weight required a larger volume than had been assumed. An accurate estimate of the volume of sediment to be deposited in reservoirs would require more quantitative data on the material carried in suspension and also a study of bed load, but the data on hand suggested that estimates in preliminary plans might well be too low. (From C. S. Howard, 1930.)

been the purpose of reducing expenditures. A new revenue bill, reducing income and inheritance taxes and removing many excise taxes, was passed in February 1926.

Congress passed two bills during the session that affected the work of the Survey to a degree, one resulting in extra work without additional funds, the other altering both the funding and the nature of work. The Sulphur Leasing Act of April 17, 1926, extended the Mineral Leasing Act of February 25, 1920, by authorizing the leasing of land in Louisiana and payment of royalties for production of sulfur. The Potash Act of June 25, 1926, authorized an appropriation for fiscal year 1927, and a similar amount for each of the four succeeding years to be expended as mutually agreed upon by the Secretary of the Interior and the Secretary of Commerce "for the purpose of determining the location, extent, and mode of occurrence of potash deposits in the United States and conducting the necessary laboratory tests incident thereto." The bill as originally filed and as passed by the Senate in April called for a cooperative project between the Bureau of Soils of the Department of Agriculture and the U.S. Geological Survey. The Department of Agriculture, however, did not actively support the bill; in the House of Representatives it was therefore referred to the Committee on Mines and Mining and became a "farm relief" bill, endorsed by Secretary Hoover, Secretary Work, and the Director of the Bureau of the Budget. The distribution of funds mutually agreed upon by the Secretaries of the Interior and Commerce provided $92,500 for the Bureau of Mines and $7,500 for the Geological Survey. The Bureau of Mines took responsibility for physical exploration, the Survey for site selection and laboratory tests.

On April 12, 1926, the Army Engineers and the Federal Power Commission transmitted to Congress their joint report on waterway development, authorized in the Rivers and Harbors Act in the spring of 1925. In it, they proposed investigations estimated to cost $7.3 million, among them investigations of stream discharge, capacity of power sites, location and capacity of reservoir sites, location and practicabilty of dam sites, and stream profiles, with all of which the Survey had many years' experience. The report referred to the Survey only in connection with streamflow data, however, and only by the suggestion that after the investigations were completed, the gaging stations should be continued and the Geological Survey's appropriation increased for that purpose. No action was taken on the report during the remainder of the session.

In the Department of the Interior appropriations bill, the items covering Survey activities had been modified. All administrative salaries were included in one item, and other items were then reduced by the amount that had been assessed for administrative salaries. The item for chemical and physical research, in the appropriations bills since 1888 but without an increase in funds since 1911, was combined with that for geologic surveys, so a single appropriation item would cover all the work of the Geologic Branch and the word "research" would be eliminated. The House Appropriations Committee made no objection to either change but then proposed a new appropriation item, not requested by the Survey. During an inspection trip in the previous summer, the committee members had met T. A. Jaggar in Hawaii, and Congressman L. C. Cramton had invited Jaggar to submit a plan for developing a division of volcanology in the Survey with a separate appropriation. Director Smith was somewhat less than enthusiastic about the proposal but conceded that perhaps to lend importance to the subject it could be given separate status for a year. The Committee then reduced Jaggar's proposed appropriation from $25,000 to $21,000 and described the work as "volcanologic surveys" not "research." For all major items, the Bureau of the Budget had recommended a smaller appropriation than the appropriation for the year underway, the committee approved some of their recommendations and cut others by small amounts.

Perhaps more important from the Survey's point of view, however, was the approval of new language with respect to transfer and cooperative funds. Under the law until this time, when the Survey made surveys or investigations on behalf of another agency it was reimbursed only when the work was completed, and Survey funds were used until such reimbursement was received. Survey funds were thus often unavailable for other purposes and as work on behalf of other agencies increased, problems had developed in financing Survey projects. The proposed new wording provided that: "During the fiscal year, 1927, the head of any department or independent establishment of the Government having funds available for scientific investigations and requiring cooperative work by the Geological Survey on scientific investigations within the scope of the functions of that bureau and which it is unable to perform within the limits of its appropriations may, with the approval of the Secretary of the Interior, transfer to the Geological Survey such sums as may be necessary to carry on such investigations. The Secretary of the Treasury shall transfer on the books of the Treasury Department any sums which may be authorized hereunder, and such amounts shall be placed to the credit of the Geological Survey for the performance of work for the department or establishment from which the transfer is made. *Provided*, that any sums transferred by a department or independent establishment of the Government to the Geological Survey for cooperative work in connection with this appropriation may be expended in the same manner as sums appropriated herein may be expended." With regard to cooperative work with a State, Territory, or political subdivision thereof, the amounts received by the Geological Survey "shall be used to reimburse the appropriation from which the expense of such work is paid."

Both the House and the Senate devoted considerable time and attention to the appropriation for topographic surveys. At the outset of the discussion in the House, Chairman Cramton stated that the purpose of the Temple Act was to expedite completion of the topographic survey of the United States through more extensive cooperation of the States and municipalities with the Federal Government. There had been a great deal of misapprehension on the subject, he said, and read the letter from the Association of American State Geologists to President Coolidge complaining that the Director of the Budget had ignored the provisions of the Temple Act in allowing the Survey only $477,000 for topographic surveys. The $950,000 authorized for the first year of the act, said Cramton, was nowhere near met by State offerings, and in any event it would be impossible for the Survey to staff up to that level in one year. Moreover, he said, the Director of the Survey agreed to this interpretation—the restriction of supplemental funds to the amount matching cooperative funds was "in accord with the spirit of the act." The Director of the Survey also agreed that cooperative work should have preference over purely Federal work. In order to take care of increases in State offerings, some for the fiscal year underway, Cramton proposed to reword the item for topographic surveys by increasing the amount to $525,000 with a proviso "that $445,000 of this amount shall be available only for cooperation with States or municipalities, and of this $73,700 shall be immediately available." Congressman Temple, for whom the act was named, promptly objected. The spirit of the Temple Act was not dollar-for-dollar cooperation but to bring the States up to a maximum, which was expected to be $700,000, and then pay for the rest of the work out of the U.S. Treasury. If money was not appropriated for purely Federal projects in this bill, then money would have to be appropriated to other agencies in other bills for such purposes as defense mapping or mapping the national forests. Money would be saved on the Survey appropriation, but the cost to the Treasury would be increased. The House, however, went along with Cramton's recommendation. The Senate also discussed the appropriation for topographic surveying at length and Senator Sam Bratton of New Mexico inserted in the record several letters and editorials criticizing the action of the Director of the Budget. All attempts to increase the appropriation for topographic surveys failed; Congress appropriated only $451,700 for topographic surveys in fiscal year 1927 in the Interior Appropriations bill and appropriated the additional $73,300 for mapping in cooperation with the States during the current fiscal year as part of a deficiency bill, establishing a precedent followed for several years in appropriations for topographic surveys.

The appropriations committee recommended a cut of about 20 percent in the funds for investigations of Alaskan mineral resources, a cut which Secretary Work protested, but the House went along with the cut after several Congressmen had a chance for humorous remarks about how much work was done in Alaska when the geologists and engineers spent most of their time in Washington. The committee's recommendation on the appropriation for preparation of illustrations was overruled. Director Smith had made a special plea for an increase in funds because preparation of illustrations had become the biggest bottleneck in publication—there were 49 reports ready for printing except for the illustrations—but the committee did not recommend an increase. However, when Congressman Addison T. Smith of Idaho read a letter from Francis J. Thompson, Dean of the School of Mines at the University of Idaho and Secretary of the Idaho Bureau of Mines and Geology, urging him to do something about publication of G. R. Mansfield's report on the geology and mineral resources of southwestern Idaho, the House voted to increase the appropriation from $18,000 to $25,580, but then agreed to a cut of 8 percent in the already inadequate printing funds.

In the end, the total appropriated for the Survey was $1,819,440, about 7 percent less than in the fiscal year already underway, and part of it was available only to match cooperative funds. However, the provision for transfer of funds made it less difficult for the Survey to undertake work for other Federal agencies, and the restriction of part of the appropriation to matching State contributions spurred several States to increase their contributions so in the end, the total available to the Survey was $2,864,127. The Federal appropriation was almost 64 percent of the total, a proportion that would seem sufficient to allow prosecution of a national program. In reality, however, some parts of the Survey became dependent on outside funds and thus more and more involved in meeting the particular needs of others.

The Water Resources Branch faced the greatest problem, for cooperative funds for water-resources investigations in fiscal year 1927 were double the direct appropriation and funds supplied by other Federal agencies almost equalled the direct appropriation. There was no possibility of dollar-to-dollar matching of cooperative funds, so most of the work of the branch had to be of the service variety. Most of the transfer and cooperative funds were for surface-water studies, primarily stream gaging, and the number of river measurement stations increased to 1,749 in 41 States and Hawaii. In the continuing appraisal of water-power resources, hydraulic engineers accompanied the topographic party that mapped the Little Colorado River from Tolchico to the mouth of the river and made surveys of all dam sites in that stretch. H. T. Stearns was diverted for a time from ground-water investigations to examine the geology of the Mill Creek and Elk Creek dam sites and the Round Valley reservoir in Mendocino County, California, and of 43 dam sites in the western part of Oregon.

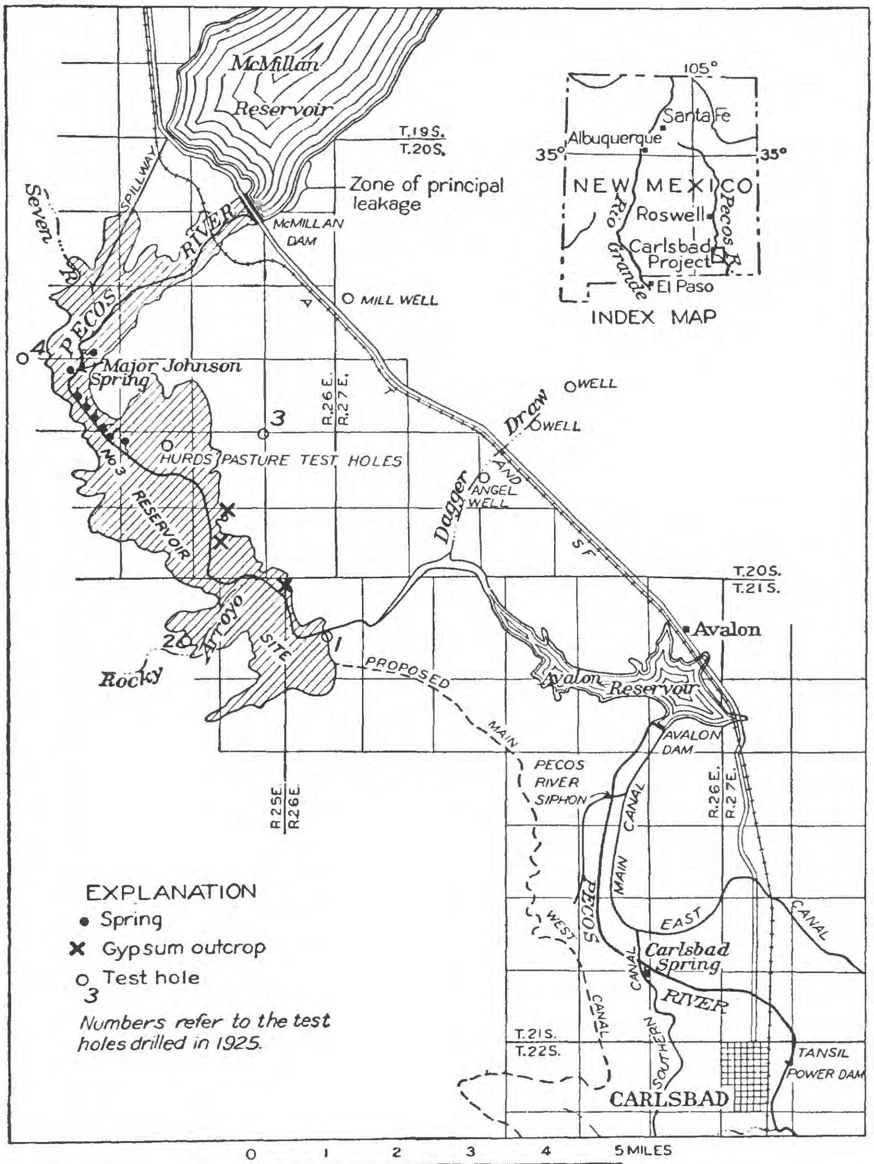
Cooperative ground-water investigations were continued in the urban areas of New Jersey and Pennsylvania, and in New Mexico, Utah, and Hawaii. A new investigation was begun in central California in cooperation with the East Bay Municipal Utilities District, whose Chief Engineer and Manager was Arthur Powell Davis, former Director of the Reclamation Service. Davis had proposed the building of a dam on the Mokelumne River. As ground water in the alluvial fan was being pumped for irrigation, it was considered wise to

In California, the East Bay Utilities District proposed a 325-foot dam on the Mokelumne River and a pipeline more than 100 miles long to provide additional water supply for the cities of Berkeley, Oakland, and Alameda, and called on the Survey to make surface- and ground-water studies to determine the quantity of water that could be exported without interfering with the rights of lawful appropriators and riparian uses of the natural flow of the Mokelumne, and also to what extent the ground-water reservoir of the area, which supplied 2,000 irrigation wells, depended on the Mokelumne for recharge. The aerial photograph shows the river between Lancha Plana, the site of the proposed dam, and Clements, the section in which the amount of ground-water recharge was important. The elongated land forms in the lower central part of the photograph are rows of gravel left by gold dredges. (From H. T. Stearns, T. W. Robinson, and G. H. Taylor, 1930.)

determine the effect of the diversion on ground-water supplies even though the dam was to be located at a place above that at which the ground-water reservoir in the fan was replenished and it was considered certain that there was a surplus of unappropriated water in the river. Stearns made the investigation in addition to his work on dam sites. Cooperation was continued with the North Dakota and Minnesota well drillers' associations, especially with their committees on specifications for class-A farm wells, and efforts to organize associations in other States were aided with a view to developing higher standards and better results in water-well drilling. The division was instrumental in bringing about a National Research Council conference on well drilling and well records, which led to the organization of a committee on conservation of scientific results of drilling and improvement of drilling methods and equipment as a committee of the National Research Council and the U. S. national committee of the International Well Drilling Congress.

The Topographic Branch laid aside its plans for a national mapping program, once Congress made clear its intent with regard to the Temple Act. Cooperative arrangements were made with 25 States and the Territory of Hawaii, which provided a total of $409,000, an amount equal to more than 90 percent of the Federal appropriation. An additional $44,000 came from other Federal units. Very little mapping was done unless other funds were involved, the most substantial amount being the 180 square miles in Nevada mapped for the Geologic Branch. Nearly 17,000 square miles were mapped, the bulk of it in the States east of the Mississippi River. The Chief Topographic Engineer told the American Mining Congress quite frankly in September 1926 that "The immediate future of mapping in the Western States is contingent upon State cooperation. If the mining industry in the Western States needs topographic mapping and wants to take advantage of the corps of trained engineers of the Survey, it will be necessary to arrange cooperation by the States through some official agency." In addition to the mapping, the Branch made plan and profile surveys, at the expense of the Conservation Branch, of the Little Colorado River, Clark Fork in Montana and Idaho, and the Middle Fork of the Willamette and Sandy Rivers, Oregon, in connection with power surveys. Very little was available in the way of funds for experimental work, and T. P. Pendleton, head of the Photomapping Section, resigned to join a private firm engaged in such work. J. H. Wheat succeeded him but also remained in charge of the Map Information Office.

The Conservation Branch had sufficient directly appropriated funds in the fiscal year beginning July 1, 1926, not only to carry on its own program of classification of the public lands and supervision of mineral leasing operations but to supply funds to the field branches of the Survey to make additional investigations and surveys to supply data for its programs. The cost of supervising mineral leasing operations by the Survey was turning out to be much less than expected when the leasing law was enacted, averaging about 2 percent of the aggregate rents and royalties involved, but royalties received were also declining. The royalty value of oil and gas, which provided by far the largest share of the total, had dropped in just one year from $8.2 to $6.0 million, chiefly from a decline in production in Wyoming. The Homestead Division was renamed the Agricultural Division and continued to work in cooperation with agricultural economists of the Department of Agriculture. Field work was carried on in the central Great Plains region in the States of Colorado, Kansas, Nebraska, and Wyoming, and the preliminary edition of an 8-sheet map showing the agricultural classification of lands in the northern Great Plains region was published. By this time the Department of the Interior had begun to lose



In 1925, the new Commissioner of Reclamation requested the Director of the Geological Survey to send geologists who had not previously examined the site to make a field investigation of a proposed reservoir site on the Pecos River north of Carlsbad, New Mexico, immediately downstream from the McMillan Reservoir, which leaked badly, and upstream from the Avalon Reservoir, which held water without appreciable loss. Three Survey geologists had made four investigations of the site between 1905 and 1923 and had, with some minor differences, agreed that the site was unsuitable with respect to water-tightness. From the 1925 investigation, which included drilling four test holes to determine depth to ground water, O. E. Meinzer, B. C. Renick, and Kirk Bryan also concluded that the risk due to probable leakage was too great to warrant construction of a dam to anything like the height proposed. The Bureau of Reclamation thereafter requested funds for enlargement of the Avalon Reservoir. (From O. E. Meinzer, B. C. Renick, and Kirk Bryan, 1927.)

all assurance that the Stockraising Homestead Act was working well and to fear instead that it was doing major damage to the livestock industry. Secretary Work in his annual report urged Congress to repeal the Stockraising Homestead Act and substitute a policy of leasing the grazing lands.

The Alaskan Branch was in somewhat straitened circumstances because of the cut in appropriation and the Navy's decision not to allot more money to surveys of Naval Petroleum Reserve No. 4. The pioneer spirit then came to the fore and as much work as was possible was accomplished by a variety of methods that ranged from some that resembled those used the Survey's earliest days in the 1880's to some that looked forward a decade or two hence. The Survey felt that many points concerning the geology of the Naval Petroleum Reserve required further examination before its task could be considered reasonably complete, so Branch Chief P. S. Smith and Gerald FitzGerald spent the season in the far North, traveling more than 700 miles by dogteam to reach the survey area. J. B. Mertie, Jr., and J. O. Kilmartin traveled by canoe or on foot to map in the wilds north of the Yukon just west of the Canadian boundary. S. R. Capps and K. W. Trimble used a pack train of 17 horses for their combined geologic and topographic survey of the Alaska Range, whereas F. H.

By passing the Temple Act in February 1925, Congress gave the Survey a mandate to prepare a topographic map of the United States. Congress did not, however, appropriate the requisite Federal funds to accomplish such a goal. Thus, although the Survey continued to experiment with the design of instruments and the development of methods of compiling topographic maps from aerial photographs, it relied heavily on cooperative funds to support its work and conducted most of its surveys by long-established field methods. The ambivalence was evident in the Survey's topographic instructions published in 1928, which defined the accuracy of a map as depending in part on the accuracy with which the field measurements had been taken and plotted but also suggested, in an extensive discussion of the compilation of maps from aerial photographs, that in some cases a photomosaic would be more useful than a map. (From C. H. Birdseye, 1928.)

Moffit had most of the facilities available to those who worked in the Western States in his investigation of the mineral resources of the Copper River area. Looking to the future, a Navy expedition made aerial photographs of a large part of southeastern Alaska using controls that would permit the Survey to prepare base maps for future geologic and topographic mapping from the photographs.

The financial resources of the Geologic Branch were far less than those of the Topographic and Water Resources Branches but 88 percent of its funds had been appropriated by Congress for the Survey. Thus no part of the Branch received its principal support from outside sources. In fact, no distinction could be perceived among projects wholly supported by Federal funds, partly supported by funds from outside agencies, and those in which Survey scientists joined scientists in other agencies and in the private sector in working on a problem. On July 1, 1926, the organizational structure of the branch was simplified. The divisions, the organizational units which stood between the section and the branch, were discontinued. The Division of Chemical and Physical Research became a section, of the same rank as the sections of the old Division of Geology and Paleontology. Volcanology did not become a separate division, as Jaggar had hoped, but a section, with headquarters at the Hawaiian Volcano Observatory. Sidney Paige, head of the Division of Geology and Paleontology and of the Section of Areal Geology, resigned from the Survey to enter private industry, and H. D. Miser returned from the Tennessee Geological Survey, where he had spent 10 months as State Geologist, to become head of the Section of Areal Geology. All distinctions between economic and general geology were also dropped at this time, and all investigations in the branch became simply "geologic investigations." In a very real sense, however, all projects had become geologic investigations although they ran the gamut from detailed mapping of mines to compiling the geologic map of the United States, from selecting drilling sites in the search for potash to determining the temperature distributions below the floor of the crater of Kilauea, or from the x-ray study of clay minerals to making a structure contour map of the northern Appalachians. Everything was grist for the "geological mill," but basic to all else was geologic mapping. In many ways the branch program was reminiscent of that when G. K. Gilbert was Chief Geologist, and not unexpectedly so as Gilbert had been in many respects Mendenhall's scientific mentor and Mendenhall's career after Gilbert's death in 1918 was often influenced by his memories of Gilbert. Mendenhall, however, unlike Gilbert, fully appreciated the importance of economic geology for the Survey and the Nation.

The Metals Section began a major project in 1926 in cooperation with the Colorado Metal Mining Fund, to study the mining geology of Colorado, the work to consist of resurveys of old districts in the light of new developments, detailed studies of districts not previously mapped by the Survey, and a general inspection of the metalliferous regions of the State. Resurveys of old districts were begun by G. F. Loughlin in the Leadville and Cripple Creek districts, and by B. S. Butler in the Breckenridge district, while F. C. Calkins began an appraisal of the adequacy of maps in the Mosquito Range, and the Tenmile and Alma districts. W. S. Burbank began a survey of the Bonanza district, and T. S. Lovering mapped the Montezuma quadrangle. Other members of the section were in the field in California, Utah, and Nevada. D. F. Hewett mapped the part of the Ivanpah quadrangle in San Bernardino County, California. The survey had been undertaken primarily because of the ore deposits but the region was also yielding structural data of significance and contained an exceptionally complete stratigraphic record. James Gilluly and T. B. Nolan continued mapping in western Utah, Gilluly taking over the Stockton-Fairfield project Sidney Paige had begun; L. G. Westgate and Adolph Knopf worked in and near the Pioche district in Nevada; and H. G. Ferguson, after two seasons in the field, devoted a large part of his time to a detailed study of the mineralogy of the veins in the Alleghany district of California, in the hope of determining the principal factors that controlled the deposition of the gold.

The mineralogy of the potash cores was also a subject of investigation. From the $100,000 appropriated by Congress for core drilling by the Bureau of Mines, $7,500 was allotted to the Survey for site selection. Cores from two of the test holes and selected portions of the core from a private test on the McNutt permit, all in Eddy County, New Mexico, were sent to the Survey for study and chemists found promising prospects in the McNutt permit. W. T. Schaller and E. P. Henderson identified polyhalite of remarkable purity in several strata as well as several other minerals, among them two found for the first time on the American continent.

A cooperative investigation of clay minerals was also begun. Clay minerals, which make up the fine-grained argillaceous rocks, had been difficult to study microscopically because of their incoherence, the small size of the constituent particles, and the extremely diverse chemical composition. Fine-grained argillaceous rocks were, however, extremely important in the geologic column and of economic interest because they were commonly thought to be the source beds of petroleum. Development of methods of study of minute crystal aggregates, including the x-ray powder methods, made it possible to obtain definite information from optical examination. In accordance with recommendations of the National Research Council, mineralogists of the Survey, the U.S. National Museum, and Columbia University, where x-ray facilities were available, undertook the study.

Fuels Section investigations in 1926 were again largely areal mapping and stratigraphic studies, and many of them in the public-lands States were supported in part by funds from the Conservation Branch which needed data for classification purposes. In California, H. W. Hoots resumed his work in the southern San Joaquin Valley while W. P. Woodring and P. V. Roundy continued work on the Elk Hills report. In the Colorado Plateau, A. A. Baker mapped in the rugged country adjacent to the Colorado River near Moab, Utah, an area largely inaccessible by automobile but one from which there had been many applications for oil and gas prospecting permits, while E. T. McKnight mapped across the river in the canyon-trenched country between the Colorado and Green Rivers, part of which had been traversed by John Wesley Powell in the 1869 expedition. North of these areas, D. J. Fisher mapped in the Book Cliffs area in Utah while C. E. Erdmann studied the coal and oil shale in an adjoining area along the Little Book Cliffs near Grand Junction, Colorado. W. H. Bradley continued to study the Green River Shale of Utah and Colorado. G. B. Richardson continued to map the coal, oil, and gas fields of the Appalachian area on a quadrangle basis, and compiled structure contour maps of parts of Pennsylvania, Ohio, and West Virginia as part of the investigation.

Stratigraphic studies in the Gulf Coastal Plain, though many of them were undertaken for scientific reasons only, were of value in the development of oil resources. L. W. Stephenson, Julia Gardner, and C. H. Dane studied the Cretaceous and Tertiary formations; Stephenson determined by examining core samples that the Eagle Ford Shale, a formation closely associated with the petroleum deposits of central Texas, was also present in Louisiana. Stephenson, H. D. Miser, and C. H. Dane visited several exposures of volcanic material in northeastern Texas to wind up the 4-year study of water-laid volcanic material that C. S. Ross had first identified in 1923 in specimens submitted to the Survey for identification. Their investigation demonstrated that the Woodbine Sand of Arkansas could be traced westward through Oklahoma into northeastern Texas where it passed into the typical Woodbine Sand of Texas, one of the producing oil sands.

In 1926, the Survey accepted the opportunity offered by William N. Beach, a sportsman and photographer of game, to join him in an expedition to the headwaters of the Skwentna and adjacent parts of the Kuskokwim Basin because the southern Alaska Range, even though it could be seen from Cook Inlet, was still largely unexplored. In the Beach expedition and two independent expeditions into the area in 1927 and 1928, Survey geologist S. R. Capps and topographers K. W. Trimble, R. H. Sargent, and Gerald FitzGerald mapped more than 4,000 square miles and outlined the major geographic features. The photograph shows Mount Spurr, named for one of the Survey's pioneer geologists in Alaska, a volcano in the Alaska Range that was mildly active in 1927. (From S. R. Capps, 1935.)

Fundamental investigations of petroleum were limited. P. G. Nutting continued his work in molecular physics, in particular on the physical properties of silts and sands related to the recovery of petroleum in spent fields. Because oil producers were greatly interested in the soda process, he prepared three general papers: one on the best field practice, one on the physical and chemical principles underlying the process, and one on the development of the process, the results of field tests, and the patent situation. David White, still on leave as Chairman of the Division of Geology and Geography of the National Research Council, was one of the members of the Council's Central Petroleum Committee, organized for cooperation between the Council and the American Petroleum Institute in connection with fundamental investigations into the physics, chemistry, and geology of petroleum. White had been largely responsible for obtaining gifts from John D. Rockefeller, Sr. and Universal Oil Products Company to finance the work for 5 years.

Areal mapping was continued throughout the country and steady progress was made in the production of State geologic maps. The geologic map of Oklahoma was published by the Survey and the map of Alabama by the State. The New Mexico map was well on its way toward publication and compilation of the Texas map was begun. G. W. Stose helped to compile the map of Pennsylvania then in preparation by the State, and the Survey contributed information and material for proposed maps of Arkansas and Colorado. Field investigations for the cooperative map of Virginia were continued, and work was begun on a new geologic map of Florida. The Topographic Branch completed the new base map of the United States and finally the day arrived when all these separate items led to the ultimate goal: Stose began compilation of the long-planned geologic map of the United States.

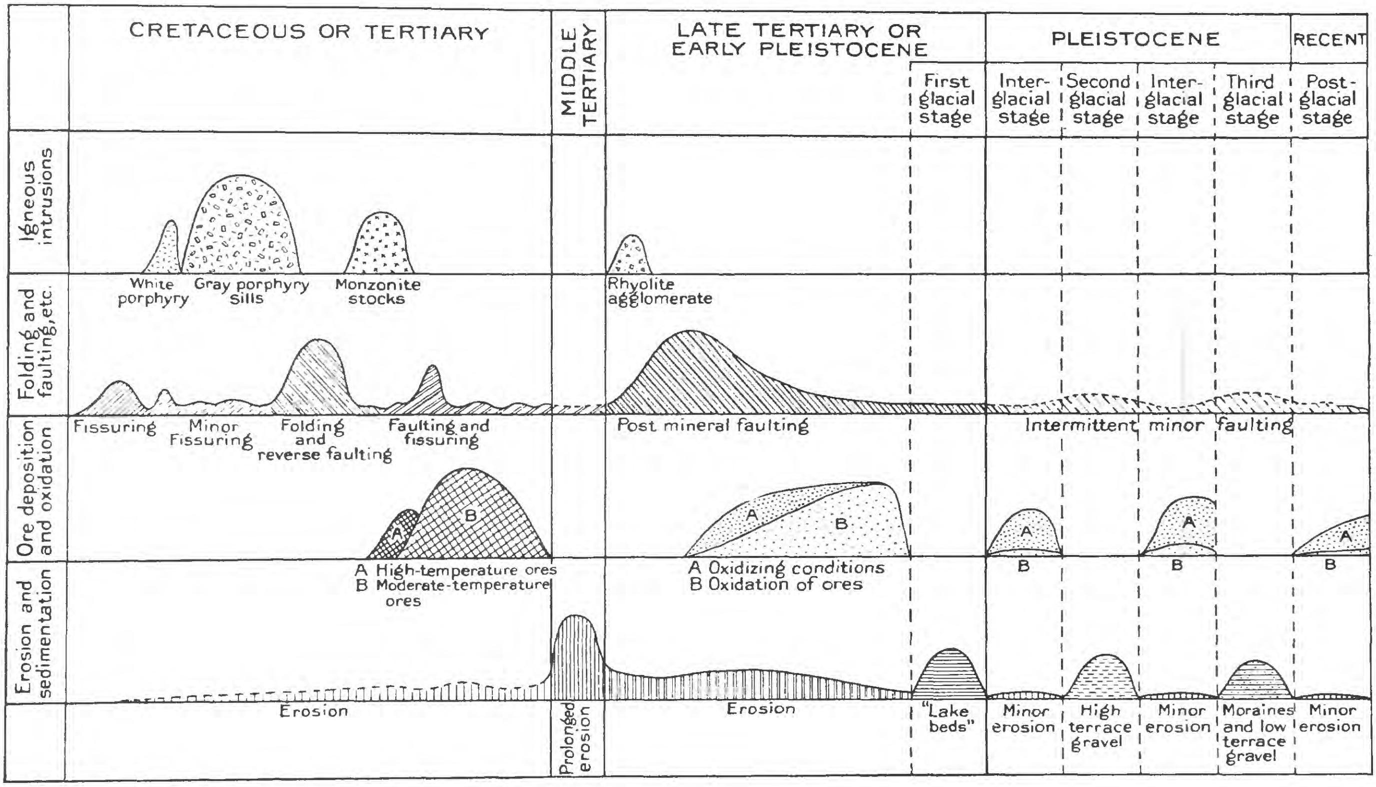
Three of the Survey's senior scientists were involved in special projects related to national parks in 1926. Both David White and F. E. Matthes contributed to a cooperative effort by the National Park Service, the American Museum Association, the National Academy of Sciences, and the U.S. National Museum to provide educational material at the Grand Canyon National

Park. Arthur Keith made a special field study in connection with the proposed Great Smoky National Park in western North Carolina and eastern Tennessee.

At the Hawaiian National Park, the Hawaiian Volcano Observatory maintained its watch on Kilauea. A set of borings was begun in the floor of the crater to study temperature distribution, and a precise-level line connecting tidewater at Hilo with the summit of Mauna Loa was run in cooperation with the Coast and Geodetic Survey. Using this line as a base, local level lines were extended from time to time to check any changes in altitude and the tilt in the land surface indicated by the seismographic records.

Vulcanism was one of the major topics under consideration at the International Geological Congress in Spain in 1926. Geophysics was even more extensively considered, and the International Congress voted that each country represented at the meeting should form an official committee on geophysical research to study the use of geophysical methods in investigations of structural geology or mineral deposits. From the Survey, H. G. Ferguson, Julia Gardner, Marcus Goldman, D. F. Hewett, and E. O. Ulrich attended but did not present papers although Hewett presided at several sessions. There was, in fact, a notable lack of American contributions to the technical sessions of the Congress, which undoubtedly reflected the nature of support of science in the United States at that time.

The whole world, it seemed, was in a state of ferment in 1926. Germany was admitted to the League of Nations and made a treaty of friendship and neutrality with Russia but its relations with Italy were tense. Italy made a treaty of friendship with Spain and Albania but Mussolini escaped three attempts to assassinate him. Greece alternated between military and civilian control, but the army overthrew the existing regime in Portugal, and General Joseph Pilsudski led a military revolt and became virtual ruler of Poland. Stalin eliminated his political opposition and became dictator in Russia, and the constitution was suspended after a coup d'etat in Lithuania. There was a 9-day general strike in Great Britain in May, and a financial crisis in midsummer toppled the French



In 1927, some 40 years after publication of S. F. Emmons' monograph on the Leadville district in Colorado and 20 years after the report by Emmons and J. D. Irving on the Downtown district of Leadville, the Survey published a major report on the Leadville district begun by Emmons and Irving and completed by G. F. Loughlin, then Chief of the Metals Section. Emmons' original finding that the contact between the Blue limestone and the White porphyry was the horizon in which the most productive deposits were found was still valid, and by far the greatest part of the total tonnage of ore had come from large bodies formed by the replacement of limestone, as Emmons' had concluded. The greater number and depth of mine workings had yielded data on the structural relations and complexity of faulting, identified the source of the ore solutions, and revealed a far more complex history. The illustration shows the sequence of events. (From S. F. Emmons, J. D. Irving, and G. F. Loughlin, 1927.)

Government. In the Near East, the Arab State was split up; Ibn Saud became King of Hijaz and Nejd, later known as Saudi Arabia, and Reza Shah Pahlavi took control in Iran. In the Far East, the Netherlands East Indies were in revolt, and civil war between local military dictators in China left the national government virtually without power. Nearer home, Panamanians opposed a treaty between the United States and Panama to protect the canal in time of war and prevented its ratification, and U.S. marines were sent into Nicaragua to quell an insurrection. Even the American electorate was restless; the Progressives gained and the Republicans lost seats in both houses of Congress in the November elections.

In the annual message to Congress on December 7, 1926, President Coolidge again extolled the economy, elimination of waste, and general increased efficiency in the Federal Government that had promoted prosperity in the United States. He also made the usual formal endorsement of conservation, but in addition to calling for the proper development of water resources and reclamation with incidental power development, he also proposed a survey of the relation of the Government grazing lands to the livestock industry. Coolidge did not endorse Secretary Work's recommendation that the Stockraising Homestead Act be repealed and a system of leasing instituted but instead suggested a plan of administration corresponding broadly to that already successfully applied to the national forests. Only one bill was filed regarding the grazing lands and it was not heard from again after being referred to the Senate Committee on Agriculture and Forestry. The Army Engineers were authorized on January 21, 1927, to formulate general plans for the improvement of streams for combined purposes of navigation, development of potential water power, flood control, and irrigation. The Department of the Interior Appropriations bill, approved 9 days earlier, was an austerity measure. It provided less for all Survey activities in the year ahead except topographic surveys and Alaskan mineral-resources investigations for which it provided an additional $58,500 and $10,000 respectively.

Although relations with both Mexico and Nicaragua were tense at the time, the President said little in his annual message about them beyond the statement that "in some quarters our diplomacy is vexed with difficult and as yet unresolved problems." The difficulty with Mexico was the result of a law passed by the Mexican Congress in December 1925 putting into effect an article of the 1917 Constitution, which stated that ownership of lands and waters in Mexico was vested in the nation. As oil and mining properties controlled by U.S. capital were affected, the State Department had protested but there had been no resolution of the problem. In Nicaragua, revolutions and counterrevolutions had been the norm since the Marines had been withdrawn in 1925. The United States had recognized General Adolfo Diaz as President, an action protested by various factions, and then at Diaz' request, had sent the Marines back to Nicaragua, only to be denounced throughout Latin America and Europe for the action. In the cause of world peace, Coolidge in February proposed a 5-power disarmament conference, and his Secretary of State Frank Kellogg and the French Foreign Minister Aristide Briand began collaboration on the development of an antiwar pact. After Congress adjourned, Coolidge sent Henry L. Stimson to "clean up that mess" in Nicaragua, and Stimson's efforts at negotiating a peace among the various factions succeeded in time to permit planting of new crops in June. The situation in Mexico, however, continued to fester.

While the Coolidge administration was concentrating on peace efforts, the Mississippi River went on a rampage. After an enormous snow and two weeks of rain along the entire watershed from Minnesota southward, water spread like an inland sea over an area 1,000 miles long and as much as 40 miles wide. More than 250 people were reported drowned, and at least 700,000 had to flee their homes. Six Governors in the stricken States requested Federal help, so Coolidge appointed Secretary Hoover chairman of a special Mississippi Flood Committee to coordinate relief for the disaster area. For several months thereafter Hoover made headlines.

The Survey made no special study of the Mississippi River floods. More than three-fourths of the funds for water-resources investigations were supplied by the States or other government agencies for specific purposes, so the Survey had very little leeway in initiating new projects. There were, moreover, only a few gaging stations in the flooded area to provide data. Surface-water investigations were again the major part of the program of the Water Resources Branch, and river measurements were made in 40 States and the Territory of Hawaii in cooperation with the States and in connection with the work of the Bureau of Reclamation, Office of Indian Affairs, National Park Service, Forest Service, Weather Bureau, Bureau of Mines, State Department, Corps of Engineers, and the Federal Power Commission. At the end of the year, 1,830 gaging stations were being maintained, but only 10 of them by the Survey alone.

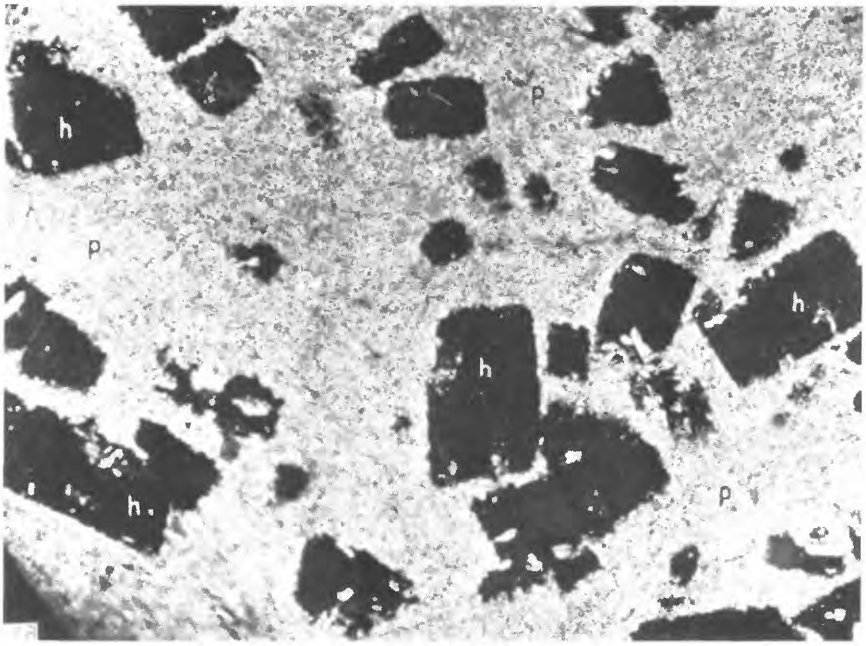
The ground-water program continued to expand as the need for water increased and the demands for information became more exacting. In the Grand Prairie region of Arkansas, rice growers had prospered because an abundant supply of water could be pumped from wells at moderate cost but now the annual withdrawal of water had become so great that the head in the wells was lowered and pumping costs increased. In the Willamette Valley of Oregon, rainfall during the greater part of the growing season was insufficient to mature certain crops, but if irrigation water were available in late summer, the valley would produce berries and fruits; ground water was the most feasible source. In the Mimbres Valley of New Mexico, about 6,000 acres were being successfully irrigated but there was fear of overdevelopment. Preliminary surveys were made in all three areas to determine feasibility and then arrangements were made for the Geological Survey to begin comprehensive investigations. In the Eastern States, R. M. Leggette continued the survey of the water resources of Pennsylvania and A. M. Piper and F. G. Wells began a new study in Tennessee in cooperation with the State. The division also assisted a growing number of State associations of water-well drillers. O. E. Meinzer himself helped organize the Illinois association and also acted as chairman of a committee to organize a national association.

In addition to his administrative and organizational work, Meinzer made "a splendid contribution of lasting value to the hydraulics of artesian regions" in a paper on the compressibility and elasticity of aquifers published in *Economic Geology*. Meinzer held that artesian water, especially in strata of sand or soft sandstone, supports part of the load of overlying rock and that the aquifers are compressed when the artesian pressure is decreased, expanded when it is increased. Although only very moderate amounts of contraction and expansion resulted from changes in pressure produced by operation of wells, the amounts were more than could be attributed to the elasticity or other volume change in the water itself and large enough to affect radically conclusions regarding recharge, movement, and discharge of water in artesian aquifers. If artesian water supplies were to be fully developed and utilized, Meinzer said, legal protection must be given to those who develop them and put them to beneficial use, but that could "be accomplished only as ground-water geologists and engineers establish a broad, secure, scientific foundation for determining ground-water conditions and estimating ground-water supplies."

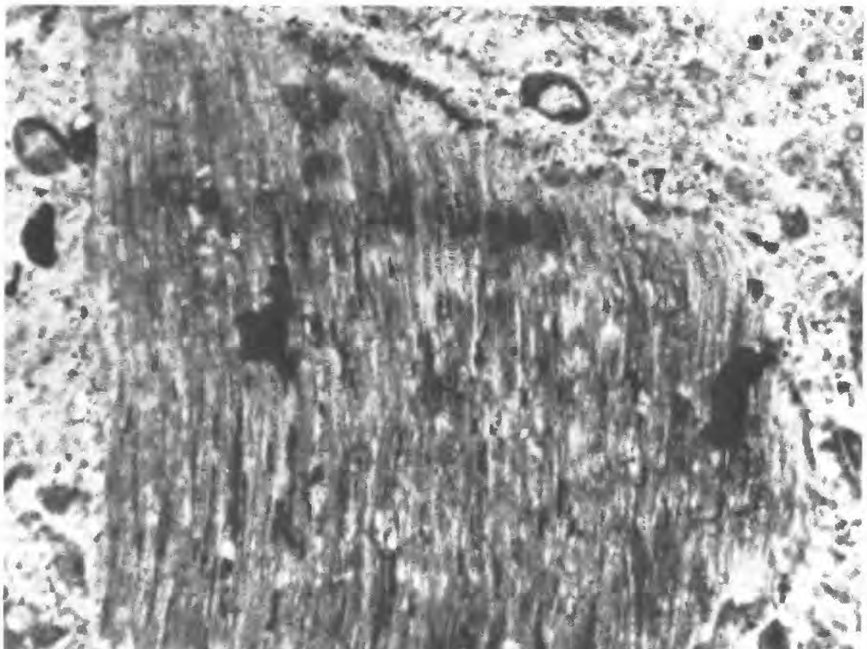
The Topographic Branch was unexpectedly able to do more mapping of the public lands in 1927 than for several years past because of a decline in State cooperative funds. A little more than half the mapping was done in States east of the Mississippi River but some of that was in the proposed Great Smoky and

Shenandoah National Parks. In the Western States, considerable mapping was done in the national forests for the Forest Service, and in California, Montana, Utah, and Wyoming for the Geologic Branch. Of the 17,721 square miles mapped for the first time, resurveyed, or revised, about 60 percent was at the scale of 1:62,500.

The Conservation Branch's own activities again shifted in response to changing conditions in the administration of the public lands and the second consecutive decrease in its appropriated funds. The latter also made it difficult for the branch to finance field work by the other branches to provide it with classification data. The low price of oil discouraged production from the public lands, and the royalties received from oil and gas declined still more. The administration of the Naval Petroleum Reserves had been transferred from the



A study of the mineralogy of drill cores and well cuttings from test holes in the potash fields of New Mexico and Texas, as part of the test drilling program authorized in 1926, revealed one reason why potash minerals had been so difficult to find. W. T. Schaller and E. P. Henderson discovered that the existing saline minerals were not the original minerals. Many had originated by the reaction of pre-existing saline minerals with potash-rich liquors while others were formed by reactions into which potassium did not enter. In many cases, Schaller and Henderson were able to determine the order in which the minerals were formed. The photomicrograph, for example, shows a fine-grained polyhalite (p) that has begun to replace halite (h), dividing some crystals into two parts, largely replacing a few, and corroding all of them. (From W. T. Schaller and E. P. Henderson, 1932.)



In the 4 years following C. S. Ross's laboratory identification of volcanic ash and tuff from the basal Gulfian (Upper Cretaceous) rocks from Arkansas in 1923, Ross, H. D. Miser, L. W. Stephenson, and C. H. Dane identified similar volcanic rocks in the field in an east-west belt about 150 miles long near the northern margin of the Gulf Coastal Plain in Arkansas, Oklahoma, and northeastern Texas. The volcanic tuffs had undergone very extensive alteration, some kaolinized, and some altered to bentonite. The illustration shows a thin section of bentonitic volcanic tuff. The large fragment, originally glassy pumice, has been completely altered to the clay mineral beidellite. (From C. S. Ross, H. D. Miser, and L. W. Stephenson, 1929.)

Department of the Interior to the Navy Department on March 17, 1927, after the Supreme Court had declared the Elk Hills leases invalid, but an agreement had been worked out whereby the Survey continued to supervise operations in accordance with the policy set by the Secretary of the Navy. The Agricultural Division, on the other hand, found itself hard pressed to review a sudden great increase in applications for enlarged and stockraising homesteads following the proposal that a leasing system be substituted. It managed, however, to continue its studies of land utilization in the central Great Plains region and to extend them into the Colorado Basin.

Field work in Alaska in the 1927 season was again limited by lack of funds. Gerald FitzGerald and J. B. Mertie, Jr., traveling by dog team, canoe, and on foot, accomplished 4,900 square miles of topographic mapping and 3,700 square miles of geologic mapping in previously unmapped parts of the Yukon Basin in northeastern Alaska. S. R. Capps and R. H. Sargent continued mapping in the Alaska Range and F. H. Moffit returned to his study of the geology and mineral resources of the Copper River region. During the off-season, Sargent completed a drainage map of part of the Hyder-Ketchikan region, an area of about 6,900 square miles, from the aerial photographs made by the Navy in 1926.

In the Geologic Branch, where area mapping and stratigraphic studies had become a major element of the program, several sections had become to some extent interchangeable. When W. T. Thom, Jr., head of the Fuels Section, resigned to join the faculty at Princeton University, H. D. Miser, head of the Areal Geology Section, succeeded him. The search for potash, which had occupied the Nonmetals Section for many years, was now primarily the province of the chemist and mineralogist, so G. R. Mansfield, head of the Nonmetalliferous Section, succeeded Miser and the Areal Geology and Nonmetals Sections were combined. Areal mapping and stratigraphic studies were underway in all parts of the country and progress was made in the compilation of the geologic maps of the United States and several individual States.

Of the three senior scientists who had undertaken special projects in national parks in 1926, only David White went back for a second season in the Grand Canyon, and there was more than a little nostalgia in that expedition. Charles D. Walcott, the former Director of the Geological Survey and Secretary of the Smithsonian Institution, died on February 9, 1927. As a young Survey geologist, Walcott had been sent into the Canyon in 1882 to seek fossils to determine the age of the beds and had gone on to become an authority on the fossils of the early Paleozoic and the Precambrian. In 1893, Walcott had given David White his first opportunity for independent scientific work in the Survey. The Carnegie Institute of Washington, of which Walcott had been a trustee for its entire 25 years of existence, supplied the funds for White's work. John C. Merriam, the president of the Carnegie Institution, said that "the definite contribution which he [Walcott] made to information concerning early stages of life and its environment constitute an element in the foundations of history which only the wrecking of our world of human thought could destroy." White relinquished the chairmanship of the Division of Geology and Geography of the National Research Council to another former Chief Geologist, Waldemar Lindgren, and went back to the Grand Canyon to extend his search for paleobotanical material "with the object of determining the age of the beds and gaining knowledge of the plant life history in this part of the continent during Paleozoic and earlier times." White's search was rewarded by the discovery of two or three possible fossils in the lower part of the Precambrian Unkar Group, one of them possibly an a invertebrate, as well as additional material, "belonging more or less directly to the type of algal deposit named, though apparently not published, by Doctor Walcott, *Chuaria.*"

Arthur Keith, who was president of the Geological Society of America that year, confined most of his field work to a study of the geology of the District of Columbia but also took time to make a special investigation of recent earthquakes in Maine. F. E. Matthes returned to California and a study of the physiography of the drainage basin of the San Joaquin River in the vicinity of Yosemite National Park. W. C. Alden spent the season, the first of five in the Northern Rockies, studying the physiography and glacial geology of the intermontane valleys in western Montana, Idaho, and Wyoming, while Frank Leverett studied the eastern glaciated area in Pennsylvania and New Jersey.

Fundamental research projects in cooperation with the National Research Council were continued in the laboratories—of analytical methods for lead, thorium, and uranium with particular reference to the determination of geologic age by R. C. Wells, and of clay minerals by C. S. Ross. Ross reported that research to date had disclosed that the number of important clay-forming minerals was not large and that many of those previously described were not valid mineral species.

The Fuels Section continued its investigations in California, where H. W. Hoots completed his field study of the eastern part of the Santa Monica Mountains and W. P. Woodring continued his study of the Elk Hills, and in the Colorado Plateau region where C. E. Erdmann spent a second season in the Book Cliffs region, E. T. McKnight and C. H. Dane mapped north of the area they mapped in 1926, and A. A. Baker and party mapped south of the area they mapped in 1926. Mapping in the coal fields of eastern Montana, suspended since the early 1920's, was resumed in McCone County and the Ashland coal field of Rosebud, Powder River, and Custer Counties in aid of public-land administration.

Both the research and the economic aspects of the economic geology of metalliferous deposits advanced along divergent ways in the spring of 1927. The Division of Geology and Geography of the National Research Council established a Committee on Processes of Ore Deposition. The American Institute of Mining and Metallurgical Engineers held a symposium on the resources and metallurgy of manganese ores, and in the wake of the latter, the War Department requested the AIME to reconstitute its special committee on manganese of the Committee on Industrial Preparedness to consider whether its previous report should be revised in the light of the world situation.

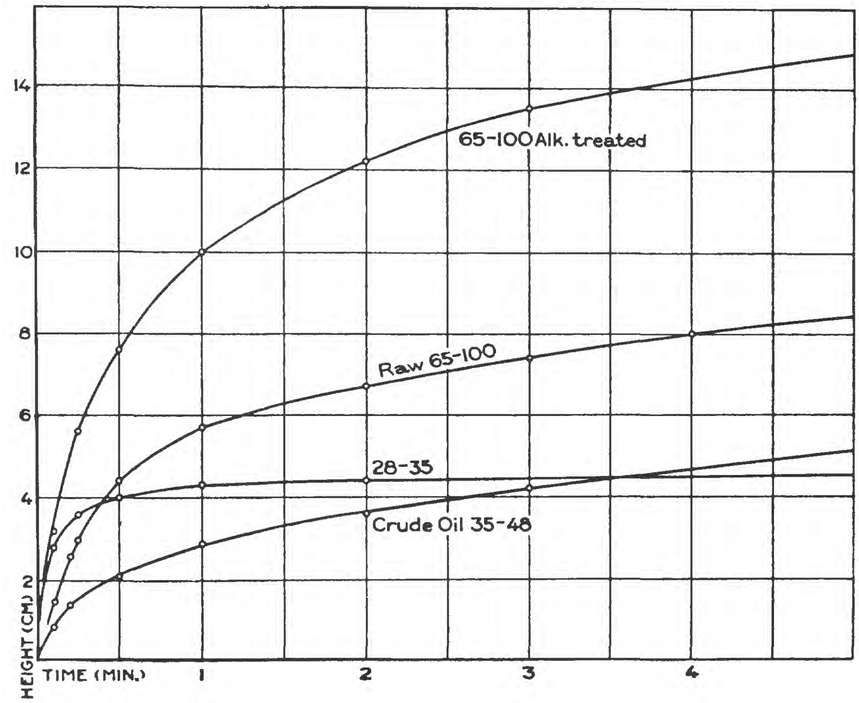
The NRC committee, under the chairmanship of Waldemar Lindgren and a membership drawn exclusively from the Survey or Survey alumni in the academic world or research institutions, emphasized the necessity of both geologic research for correlation and generalization, and physico-chemical studies. The committee also pointed out once again that individual efforts were not enough and that if important advances were to be made a more liberal and enlightened attitude was needed in both official bodies and the metal industries. F. L. Ransome, who was a member of the committee, seized on one of the recommendations for his presidential address to the Society of Economic Geologists in December 1927. For lack of basic chemical and physical data, he said, there had been little progress in economic geology in two decades. "Unless we remember that we are primarily scientific men we are likely to become content with the accomplishment of the particular job in hand and to lose sight of or become apathetic towards the broader considerations of our relation to scientific progress."

C. K. Leith, who had been co-chairman of the AIME meeting, countered Ransome's statement with a warning that economic geologists must not withdraw into the shell of pure science. The broader political and public aspects of economic geology, particularly those relating to mineral resources, should not be ignored.

The primary allegiance of the economic geologist is to pure science. Of necessity he must learn something of the economic field. The additional opportunity now opens wide before him to aid in the interpretation of his field for the public welfare.

Leith had clearly brought this point out in his own paper at the AIME meeting in which he stated that "the adequacy of total supply, its occurrence in a few large reserves far removed from centers of consumption, and the steady tendency to concentration of commercial control in the hands of consuming steel interests in countries other than those of origin" was causing a growing interest in the availability of future supplies of manganese. The great steel-producing countries, the United States, England, France, and Germany, were all natural exploiters of world resources of manganese in times of peace, but in the event of war they would be unable to obtain adequate supplies of manganese by developing domestic sources and the substitution of other substances for manganese was not then technologically feasible. Of the alternatives, Leith thought stockpiling of supplies was possible but politically unacceptable, and control of the channels of flow from source to consumer would require the improbable negotiation of foreign alliances.

D. F. Hewett, probably more than any other member of the Metals Section, epitomized the ideal economic geologist according to Leith. Hewett was the only geologist to serve as a member of both the NRC Committee on the Processes of Ore Deposition and the AIME Committee on Industrial Preparedness. In addition, he continued field work in the Ivanpah quadrangle and his investigation of dolomitization, and worked on the report on the Goodsprings quadrangle. In the Colorado project, G. F. Loughlin continued his work in the Cripple Creek area and T. S. Lovering mapped in the Montezuma quadrangle and did some underground mapping in the Breckenridge district. W. S. Burbank spent a second season in the Bonanza district and E. S. Larsen, Jr., returned briefly to the Creede district to assess new developments there. On the other side of the Colorado Plateau, T. B. Nolan and James Gilluly continued work in Utah and H. G. Ferguson continued mapping in Nevada. C. P. Ross and J. T. Pardee continued their investigations in



In his study of the structure of oil sands and the movement of petroleum and water through sand and rock, P. G. Nutting found that calculations of the movement of fluids in porous solids according to the laws supplied by theoretical physics were of little value because such laws pertain to uniform channels of simple form, whereas in nature the channels are neither simple or uniform. Nutting therefore began to develop methods for determining the effective pore section in a particular direction because once this was known, movements under specific heads, pressures, or capillary forces could be calculated. In these experiments, he found that pretreatment of the sand grains facilitated the movement of fluids—as the illustration shows. Pretreatment became the basis for a method of secondary recovery of petroleum. (From P. G. Nutting, 1927.)

Idaho and Montana. In addition to these continuing projects, Adolph Knopf made a field study of the copper deposits of Plumas County, California, and A. C. Spencer, whose work at the Santa Rita, New Mexico, copper deposit had not been completed returned to the field to provide aid to the State,which was beginning a study of the ore deposits of Socorro County. In essentially the only metals investigation in the East, E. F. Burchard was called on to prepare a report on ore reserves and iron production in the Tennessee River Basin for the Corps of Engineers.

President Coolidge's foreign-policy initiatives in the winter and spring of 1927 met with varied success. The disarmament conference in Geneva during the summer of 1927 was a failure; France and Italy refused to attend and the three other nations were unable to come to any agreement. The Stimson settlement in Nicaragua was widely misunderstood, and the administration was much criticized for interferring in Latin-American internal affairs, and in July one of the junior officers in the army of the Liberals, who had refused to accept the Stimson agreement, attacked the American marines and a band of native constabulary. In September, however, Coolidge scored an outstanding success in sending Dwight W. Morrow as Ambassador to Mexico with instructions only to "keep us out of war with Mexico." Morrow dealt so skillfully with the Mexicans that on November 17 the Mexican Supreme Court declared the limitation on concessions under the petroleum law unconstitutional, and on December 25, the Mexican Congress granted unlimited concessions on lands on which positive actions had been taken May 1, 1917. Then in January 1928, Coolidge himself went to Havana for the Sixth International Conference of American States. His address to the conference was very conciliatory in tone and made such an impression on the delegates that the American delegation successfully prevented passage of a resolution declaring that "no state has the right to intervene in the internal affairs of another."

Domestic policy, however, had not changed. President Coolidge had announced on August 2, 1927, that he did "not choose to run for President in 1928" but did not relax in the slightest his stand on domestic economy. In the annual message to Congress on December 6, he said "The country as a whole has had a prosperity never exceeded. Wages are at their highest range, employment is plentiful. Some parts of agriculture and industry have lagged; some localities have suffered from storm and flood. But such losses have been absorbed without serious detriment to our great economic structure." However, "without constructive economy in Government expenditures we should not now be enjoying these results." Flood control was, of course, a live issue but Coolidge said

> **The Government is not an insurer of its citizens against the hazards of the elements. We shall always have flood and drought, heat and cold, earthquake and wind, lightning and tidal wave. * * * The Government does not undertake to reimburse its citizens for loss and damage incurred under such circumstances. It is chargeable, however, with the rebuilding of public works and the humanitarian duty of relieving its citizens from distress.**

Coolidge cautioned legislators, however, to confine their attention to the problem of the lower Mississippi and await the results of the comprehensive survey authorized by Congress before enacting any general legislation.

The Interior Department's requested appropriation for fiscal year 1929 was about 12.2 percent less than its appropriation for fiscal year 1928. Secretary Work boasted to the House Committee on Appropriations that "After four years of effort in consolidating and coordinating activities, reducing the personnel to a point more nearly commensurate with the needs of the service, and discontinuing unnecessary activities, the department has become a more compact, efficient organization." For the Geological Survey, the proposed reduction in appropriation was even greater than the Department average, more than 16 percent, and the total proposed appropriation was only $296,000 more than the appropriation in 1908, the year after George Otis Smith became Director, and $285,000 of the 1929 budget was for supervision of mineral leasing which was not an item in the 1909 budget.

The House Appropriations Committee considered much of the Survey's work a luxury item. Director George Otis Smith told them that

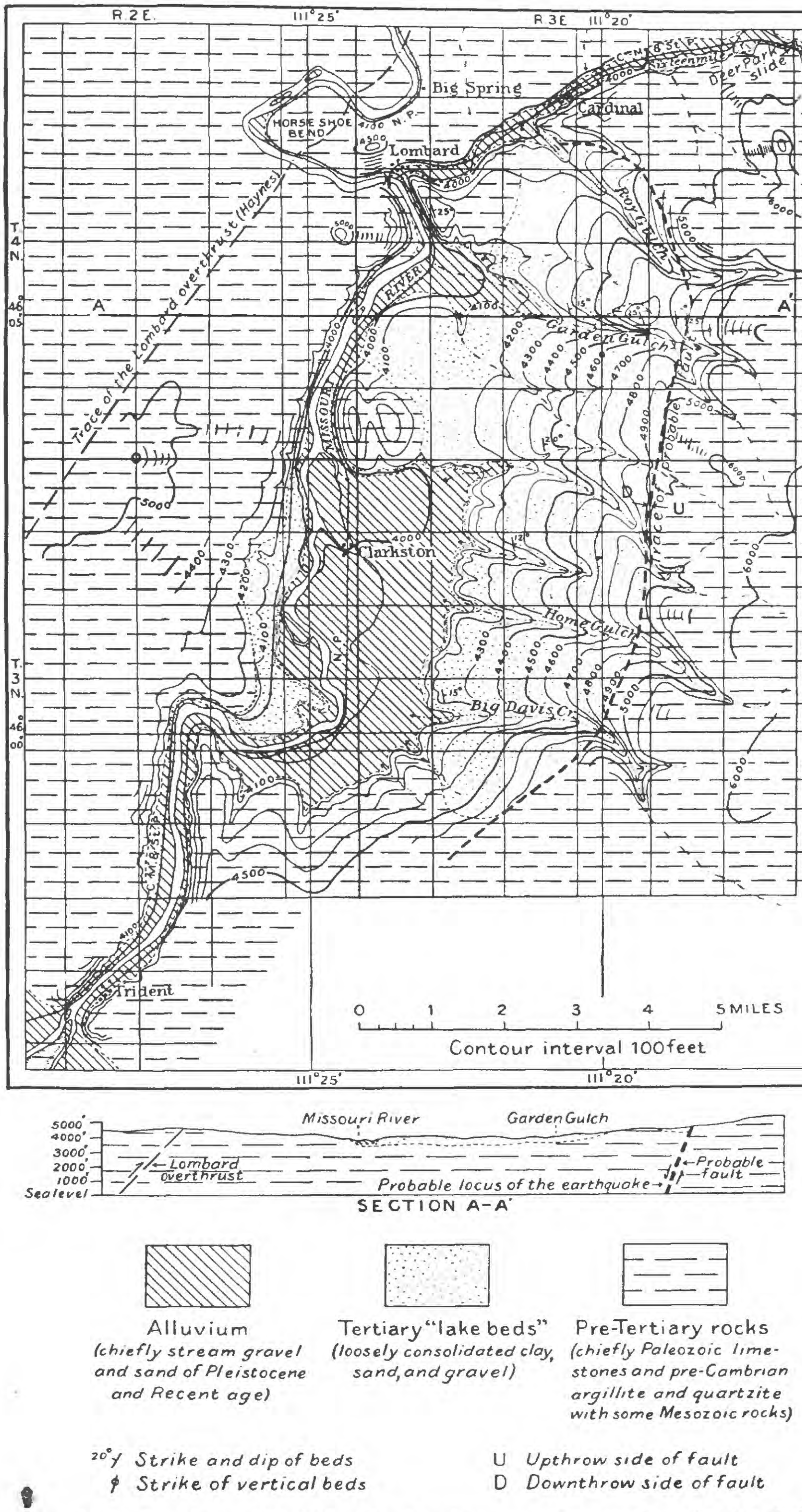
> **The basic idea of the Survey's work is the application of scientific methods by scientists to practical tasks for the general good. Its fact finding is a continuing inventory of natural resources—an aid to the discovery, development and wisest use of the nation's mineral wealth. The standards in useful geology, in useful topographic maps, in authoritative stream gagings, have all become higher as better methods have been developed. In the work it is necessary not only to apply the scientific principles already known, but also to carry on research so as to develop more knowledge and new principles for the use of future workers both in and outside the Survey.**

Chairman Cramton's reaction was "Of course, I want my youngster to have a good time on Christmas, but if he comes and wants me to get him a Rolls Royce, or even something he needs really, that I have not got the money for, he won't get it. This committee has not got the money to make large increases in these items." George Otis Smith, it might be noted, responded tartly: "Well, I was asked to express my ideas of the needs, not of the expectations."

Only in his plea for funds to match the offerings of the States for cooperative work in stream gaging did the Director get a favorable response from the committee, and that was a mixed blessing. During the fiscal year 1927, the States had contributed an amount that was 90 percent of the Federal appropriation for topographic mapping but more than twice the Federal appropriation for water-resources investigations. It was, the Director said, "unmistakable evidence of the growing spirit of cooperation between public officials," but the financing of cooperative efforts in the gaging of streams should be more equitably divided between State and Federal governments. The reasons for a dollar-for-dollar arrangement were similar to those recognized and adopted for topographic mapping. To this the committee agreed and recommended that the appropriation for stream gaging be increased from $147,000 to $197,000, with a proviso, similar to that used for topographic surveys "That no part of this appropriation shall be expended in cooperation with States or municipalities except upon the basis of the State or municipality bearing all of the expense incident thereto in excess of such amount as is necessary for the Geological Survey to perform its share of general water resources investigations, such share of the Geological Survey in no case exceeding 50 per centum: Provided further, That $125,000 of this amount shall be available only for such cooperation with States and municipalities." Rather than a solution, the appropriation with its attached proviso merely added a new dimension to the problem. Congress recognized the desirability of 50–50 cooperation, but did not supply funds to make it possible.

Senator Carl Hayden of Arizona was responsible for an additional increase in funds for water-resources investigations. The Colorado River Conference in September 1927 had resolved "that this conference respectfully request the Senators and Representatives of the Colorado River Basin States to obtain the necessary congressional action to provide for the collection of the needed river-flow data by the United States Geological Survey." The Survey estimated that $50,000 was needed but the Bureau of the Budget had allowed only $12,000. During the House hearings Congressman Edward Taylor of Colorado had questioned the adequacy of the estimate but neither the committee nor the House itself had made any change. In the Senate hearings, however, Senator Hayden elicited the information from Director Smith that the $12,000 would take care of the Lees Ferry station only, although other stations were needed. The Senate

Several of the strong earthquakes in various parts of the United States in 1925 were studied by Survey geologists to determine the cause of the shocks. J. T. Pardee concluded that the earthquake of June 27, which shook nearly all of Montana and parts of the neighboring States and Provinces, was caused by movement along a post-Miocene fault on the east side of Clarkston Valley, as shown on the geologic map. Pardee reasoned that if the fault was still active the region would likely experience an occasional severe shock in the future and residents should therefore take some simple precautions to prevent damage. The Santa Barbara earthquake of June 29, which caused extensive damage in a well populated area, persuaded Congress in 1926 to authorize a continuing Federal investigation of earthquakes, primarily the prevention or minimization of damage through the development of building codes and earthquake-resistant structures. (From J. T. Pardee, 1927.)



committee therefore added "and other base-gauging stations in the Colorado River drainage" to the item and raised the amount to $50,000. In the final version of the bill, the $50,000 was approved and the total appropriation for stream-gaging was $247,000.

The Appropriations Act made it clear that Congress preferred to base the appropriation for topographic surveys on the amount of cooperative funds offered by the States, even to the extent of making a deficiency appropriation later in the year if more cooperative funds were available than had been anticipated. Thus no plan for completing the topographic map of the United States could be made. Even with the unexpected increase in the appropriation for water-resources investigations, there could be no national planning, nor was there any leeway to undertake emergency programs without seeking funds specifically for that purpose. The work of classifying the public lands was still urgent and the work of administering the mineral leasing act was increasing. However, wells were being abandoned or shut in, royalty and other receipts were declining, and so Congress cut the appropriation. George Otis Smith had given the House Appropriations Committee a list of more than 30 recommended geologic investigations that could not be undertaken for lack of funds. None would be undertaken in fiscal year 1929, for the appropriation for geologic surveys was somewhat smaller than it had been—not even enough to maintain the status quo let alone provide for any advancement of science. The service aspects of the Survey program were further emphasized by Congressional actions or the lack thereof. On December 15, Representative Nicholas Sinnott of Oregon had introduced a bill, at the request of the Department of Commerce, to authorize the transfer of the geodetic work of the Coast and Geodetic Survey to the Department of the Interior. Included in the transfer would be the variation of latitude, gravity, and seismological observations as well. The bill was referred to the Committee on Interstate and Foreign Commerce and not heard from again. Among the many flood-control bills filed in this session of Congress was one by Congressman Temple to provide for topographic mapping and stream measurements in the valley of the Lower Mississippi River and in such other areas as had an immediate bearing on the solution of the flood problems of the Mississippi River Basin. Congress did not act on that bill but instead passed a flood control bill on May 15, 1928, authorizing expenditures of $325 million over a 10-year period for control of floods in the Mississippi Valley. The act stated that it was the "sense of Congress that the surveys of the Mississippi River and its tributaries authorized pursuant to the act of January 21, 1927, and H. D. 308, 69th Congress, 1st session be prosecuted as speedily as practicable." Even before the bill became law, the Corps of Engineers approached the Survey to arrange for stream gaging in connection with these surveys, and the Engineers and the Mississippi River Commission also called on the Survey for topographic mapping and river surveys. Thus, as the U.S. Geological Survey approached the fiftieth anniversary of its establishment for "the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain," most of its resources were being spent in topographic mapping and stream gaging in cooperation with States, Territories, or municipal agencies or on behalf of other Federal agencies.

Severe floods caused great loss of life and property damage in several parts of the United States in 1927. The spring flood of the Mississippi River, which drove 1 1/2 million people from their homes and destroyed 2 million acres of crops and thousands of animals received the most attention and sparked a massive relief effort under the direction of Secretary Hoover. Floods in November in parts of the five industrialized New England States caused great loss of life and extensive property damage to highways, railroads, industries, and municipalities. The photograph shows a road near Rutland, Vermont, after the flood. Survey engineer H. B. Kinnison pointed out that such damage naturally follows industrial development on flood plains and adjacent to river channels unless flood-control projects are concommitant and that similar disasters were inevitable in practically every intensely developed region without a plan for flood control. In the flood-control bill of 1928, however, Congress provided only for a program to control floods in the Mississippi Valley. (From H. B. Kinnison, 1930.)

Chapter 11.
Research: Source of Power, 1928–1930

> **No scientific organization, even though much of its energy must be devoted to the application of science, can continue to function long without continuing the study of principles. Research is to such an organization what fuel is to the engine or food for the body. It is the source of power.**
>
> **—W. C. Mendenhall**

The year 1928 was in many aspects a low point in the history of the Geological Survey. Research, which is essential to the functioning of a scientific organization, was limited by the meager financial support then available. Practical surveys and investigations were being made but most of them were supported at least in part by funds from other Federal, State, or municipal agencies and were directed toward filling the special needs of these agencies rather than part of a national program. Resource problems of many sorts existed—in utilization of land, production of oil and some metals, and of too much or too little water—but there was no national plan for their solution or even national consideration of most of them. Even when legislation existed, such as the Temple Act of 1925 calling for completion of a national topographic map in 20 years, Congress had not provided the means to accomplish the objective.

Within 2 years the situation was significantly better. The election of a Survey alumnus, Herbert Hoover, as President in November 1928 resulted in several changes in Federal policy that affected the Survey's work. More important, however, were the overall increase of nearly 40 percent in its appropriations and the approval of a special appropriation for fundamental research in geological sciences. The 71st Congress, elected with Hoover in 1928, also passed several measures for the conservation of natural resources, the development of water resources, and the establishment of new national parks. In December 1930, when President Hoover nominated the Survey's Director, George Otis Smith, as Chairman of the newly reorganized Federal Power Commission, Chief Geologist Walter C. Mendenhall, the Survey's most persistent advocate of basic research, succeeded Smith as Director. Having completed 50 years of service to the Nation, the U.S. Geological Survey looked forward to increased usefulness, only to find its future altered once more by a national emergency, the onset of the Great Depression.

The turnabout in Survey fortunes between 1928 and 1930 was rapid but it was clear even as the new fiscal year began on July 1, 1928, that a change was in the offing, for both major-party candidates for President were so different from the incumbent that change was inevitable. True, the nomination of Hoover reflected the continuing domination of the Republican party by business and industry, and Hoover held the orthodox Republican view that when business prospered the rest of the country was assured of prosperity. However, even though Hoover had accepted the Harding and Coolidge leadership and had not aligned himself with the progressive interests, he personally espoused many progressive views and he had, moreover, shown a strong commitment to the

Herbert Clark Hoover (1874–1964), President of the United States, 1929–1933. His was actually a rags-to-riches story. Orphaned at an early age, he was raised by relatives and worked his way through Stanford University as a member of the first class to graduate in 1895 and then achieved success as a mining engineer. Hoover first became acquainted with the Geological Survey as an undergraduate when he was employed as Waldemar Lindgren's field assistant. He renewed the acquaintance during World War I when he headed the Food Administration, which was housed in temporarily vacant space in the Survey's part of the new Interior Building, and served informally as adviser to the war minerals program. Hoover was a strong supporter of conservation and of science and an early advocate of the reorganization of the Federal Government to promote efficiency. His achievements have been overshadowed by the fact that the Great Depression of the 1930's began 6 months after he took office. (Courtesy of the Library of Congress.)

development of water resources, conservation of natural resources, and support of science in his administration of the Commerce Department. The nomination of Governor Alfred E. Smith of New York as the Democratic candidate reflected the increasing power of urban interests. Smith had been especially identified with the preservation of political, individual, State, and legal rights and with welfare legislation. During the campaign, he claimed that the much vaunted Republican prosperity was a myth but few believed him.

In the fiscal year beginning July 1, 1928, the Water Resources Branch of the Survey began to expand in size as problems caused by too much or too little water increased. In large part because of the Army Engineers' investigations related to flood control, the number of gaging stations increased from 1,830 to 2,238 and new district offices were established at Augusta, Maine, Tuscaloosa, Alabama, Topeka, Kansas, and Fort Smith, Arkansas. On behalf of the State Department, the branch was also involved in investigations of flood problems with international implications, and a new district office was established at Thief River Falls, Minnesota. Canadian landowners wanted to construct dikes along the Roseau River, which rises in Minnesota and flows into Canada, to protect their lands from frequent overflows, but on the United States side it was feared that construction of dikes would constrict the channel and aggravate flood conditions in Minnesota; a joint investigation was therefore arranged involving measurements of streamflow, a large-scale topographic map of the basin, and a detailed survey of the river channel. The State Department also sponsored an investigation of the Kootenai River in Idaho and Canada where a similar Canadian proposal to construct dikes along the river on the Canadian side to protect land from overflow raised similar fears about constricting the channel and increasing the river stages on the United States side of the boundary. R. W. Davenport, who had been detailed to the Federal Power Commission, returned to the Survey to become liaison officer with the State Department in addition to supervising projects for the commission.

The Survey's ground-water investigations were progressing rapidly into a quantitative stage and also being extended into more States. The statewide study of resources was continued in Pennsylvania, where R. M. Leggette established an observation well at Sligo, and in Tennessee, and begun in Alabama, in cooperation with the State, by W. D. Johnston, Jr. In August 1928, an office was opened in Minneapolis, which was then the center of well-drilling activities, and A. G. Fiedler, who had specialized in well-drilling methods, was assigned to undertake a comprehensive study of well-drilling methods and to cooperate with the various State associations of water-well drillers. Following up on the preliminary surveys in 1927, David Thompson, A. M. Piper, and W. N. White began studies of the source and quantity of ground water available for irrigation in the Grand Prairie region of Arkansas, the Willamette Valley in Oregon, and the Mimbres Valley of New Mexico. H. T. Stearns of the Ground Water Division and Lynn Crandall of the Surface Water Division began a quantitative study of ground water in the Snake River Plains of Idaho in cooperation with the Idaho Bureau of Mines and Geology and the Idaho Department of Reclamation. They endeavored to determine the direction of movement of ground water, the amounts of water contributed to the underground reservoir by seepage from the Snake River and tributary streams, from precipitation on the plain itself, and from irrigation water that percolated below the root zone. In December 1928, papers by Meinzer, Thompson, and White at the meeting of the Society of Economic Geologists brought to the attention of the geologic profession the basic research underway in ground-water hydrology.

The spectacular failure of several large dams and reservoirs, most notably the nearly new St. Francis Dam in California on March 12, 1928, focused attention on the relation of geology to dam- and reservoir-site engineering. Governor C. C. Young of California appointed a commission, including both F. L. Ransome and G. D. Louderback, to determine the cause of the failure of the St. Francis Dam. The commission found that "such a dam properly built upon a firm and unyielding foundation would be safe and permanent under all conceivable conditions, except perhaps faulting and earthquake shocks of tremendous violence" but "unfortunately in this case the foundation under the entire dam left much to be desired." The dam had been built on a mica schist, of thin and easily separable laminae, and a conglomerate of inferior strength, which, when wet, lost almost all characteristics of a rock. "With such a formation," the commission concluded, "the ultimate failure of this dam was inevitable, unless water could have been kept from reaching the foundation." No geologist had been consulted in selecting the site or during construction of the dam, and C. R. Longwell said "No competent geologist would have approved the dam site without serious reservation, and probably very few would have consented to construction of the dam in that place under any consideration."

Congress became sensitive to these construction problems and in May 1928 passed a joint resolution calling for the appointment of a board of engineers and geologists not previously associated with the project to examine the site and plans of the Boulder Canyon Dam. The Secretary of the Interior appointed Major General W. L. Sibert, Corps of Engineers (retired); engineers D. W. Mead of Madison, Wisconsin, and Robert Ridgway of New York; and geologists Charles P. Berkey of New York and W. J. Mead, of Madison, Wisconsin. The board was instructed to report by December 1 "as to matters affecting the safety, the economic and engineering feasibility, and adequacy of the proposed structure and incidental works." The report was satisfactory, and Congress approved the Colorado River project on December 21.

At a symposium on geology and engineering for dams and reservoirs at the February 1929 meeting of the American Institute of Mining and Metallurgical Engineers, Meinzer made a distinction between geology at dam sites and geology at reservoir sites. Dam sites, he said, were primarily the province of the engineer, who was concerned with the strength and stability of the rocks and their permeability and general behavior in the presence of water under pressure. Geologic investigations of reservoir sites, on the other hand, were concerned almost entirely with conditions that produce leakage or relative watertightness and were essentially ground-water hydrology, outside the normal training and experience of engineers. Kirk Bryan, who spoke on the geological examination of dam sites, admitted that geology had sometimes been overlooked or at best tolerated because of its inability to supply the quantitative information that the engineer needed without the use of test-holes, which the engineer regarded as his own province. Such problems as there were, he suggested, could be easily overcome if geology could progress more rapidly into a quantitative stage.

The role of geology in reservoir planning was recognized by Congress shortly before adjournment when it warily added to the appropriation for the enlargement of the Avalon River reservoir on the Pecos River at Carlsbad, New Mexico, a proviso that the funds would not be available until the "director of the U.S. Geological Survey shall have reported favorably on the foundation of the Avalon Dam and on the depth to which water may be stored in the proposed enlarged project." Director Smith promptly convened a special board of geologists and engineers who concluded that additional drilling was needed at special points. Kirk Bryan was sent to supervise the drilling by the Bureau of Reclamation; his report was reviewed by O. E. Meinzer, and by H. D. Miser and A. C. Spencer of the Geologic Branch, before clearance was given to proceed with the enlargement of the reservoir.

The Topographic Branch continued to be the Survey's largest branch, its total funds for the year being more than twice the direct appropriation for topographic surveys as the result of cooperative agreements and the transfer of funds from other Federal agencies, especially the Corps of Engineers and the National Park Service. For the Engineers, topographic engineers made river surveys in Illinois, Indiana, Kentucky, Arkansas, Mississippi, Oklahoma, and Texas along streams that flowed into the Mississippi or its tributaries in connection with the flood-control work of the Engineers. For the Park Service, surveys were made of the tentative boundaries of proposed new national parks in the Great Smoky Mountains and the Shenandoah Valley, and a topographic survey of Zion National Park was begun. Topographic surveys were made in 23 States and the Territory of Hawaii, and 17,190 square miles were mapped, about two-thirds of it at the 1:62,500 scale. Most of the mapping at the 1:62,500 scale was in the Eastern or Central States; about half of it in Maine, Illinois, Kentucky, and Oklahoma.

The work of the Conservation Branch continued to shift along the trends begun a year earlier as the movements to conserve the grazing lands and oil and gas gained strength. Applications under the Stockraising Homestead Act increased for the second year in succession; the Agricultural Division fell farther behind in its classification work but continued its areal studies in the Colorado Basin region. Oil prices continued to be low and production from the public lands continued to decline. After the Supreme Court had declared invalid the earlier leases of the Teapot Dome Naval Reserve, the Secretary of the Navy had

Ray Lyman Wilbur (1875–1949), Secretary of the Interior, 1929–1933. Wilbur and President Hoover had been friends since 1892 when Wilbur entered Stanford where Hoover was then a sophomore. After receiving his M. D. degree in 1900, Wilbur had divided his time between the practice of medicine and teaching until 1908 when he returned to Stanford to become, successively, clinical professor of medicine, chairman of the department, which amounted to being head of Stanford's new medical school, and president of the university in 1915. During World War I, he served as Hoover's assistant in the Food Administration in charge of the domestic campaign to save food. On becoming Secretary of the Interior, Wilbur declared that water conservation was the first priority in the administration of the public domain because of its importance in the everyday lives of the people, but the wise use of mineral resources, especially petroleum, was equally imperative from the national viewpoint. Wilbur, who was strongly committed to the ideal of research, looked on the Survey as a "fine example of the proper place of science in Government business" and was instrumental in obtaining the long-desired appropriation for fundamental research. (Photograph of an oil painting by Henry S. Hubbell, 1940, in the Department of the Interior.)

decided to suspend production and wells were shut-in in January 1928. The Federal Oil Conservation Board in its report in January 1928 had proposed the initiation of a conservation program, and the General Land Office had begun a campaign to cancel oil and gas leasing permits, the terms of which had had no compliance. Conservation Branch engineers were thus spending much of their time determining and reporting whether the physical conditions of a permit holding interposed any bar to development or if any land within the limits of the geologic structure involved was being drilled, so the General Land Office could make its decisions.

By 1928, the necessity of controlling the rangelands was being more widely accepted. Both the Geological Survey and the Department of Agriculture contributed to the discussion, the Survey with a series of five maps showing the agricultural utility of the central Great Plains region and the Department of Agriculture with a report by H. H. Bennett and W. R. Chapline of its Bureau of Chemistry and Soils that termed soil erosion a national menace. The report was concerned chiefly with the erosion resulting from the artificial disturbance of the vegetative cover and ground equilibrium by humans and domestic animals. The authors called for reestablishment of the vegetative cover and its protection against fire; use of artificial means to aid erosion control; and the regulation of grazing. By this time, even the American National Livestock Association was willing to concede the desirability of leasing the public grazing lands.

The oil conservation program was less widely accepted. When the Federal Oil Conservation Board proposed it, about half the total oil being consumed in the United States was used for fuel. The board deemed motor fuel and lubricants to be the most essential oil products, and noted that a program to increase the percentage of gasoline from crude at the expense of fuel-oil production was then feasible. Fuel oils could be replaced by coal, so it seemed desirable to begin a conservation program before further increases in crude-oil production encouraged increased consumption and made the inevitable later readjustment to a declining production more difficult. As far as Federal oil was concerned, the Secretary of the Interior decided that

> **With the present realization that the limit to be placed upon industrial progress is likely to be fixed by the amount of power available for doing man's work, it is a plain duty to safeguard the future with a business-like policy**

in developing the oil and coal in the public lands. The Federal Oil Conservation Board, however, went beyond the conservation of Federal oil by appointing a committee of nine lawyers and oil men which recommended enactment of Federal and State legislation to legalize agreements for the cooperative development and operation of single oil pools, and to permit curtailment of production in times of surplus supply. Such laws would, of course, be two-edged swords; while conserving oil and gas, they would also remove the oil industry from certain provisions of the antitrust law.

W. E. Wrather, a leading oil geologist, had a more optimistic outlook. Although domestic production had reached such proportions that he admitted to a "somewhat nervous speculation" as to how much longer it could be continued, he nonetheless said

> **We have never at any particular time in the past been in possession of sufficient detailed geologic information regarding our potential and untested oil-producing provinces to justify more than a very hazy and indefinite estimate of their future possibilities. Any estimate that fails to stress this point falls short of the demands of clear thinking.**

Although the Nation's oil resources were a finite quantity and at some time a peak would be reached after which the country would be faced with declining domestic production, Wrather did not "view with alarm" the approach of that inevitable day. Quantities of oil could still be produced by better methods of recovery, fuel could be obtained from oil shales and retorting or pulverization of coal when the day of real need arrived, and last, but not least, there was synthetic chemistry. There was also the possibility that before the necessity for synthetic fuel arrived, other sources of power "of which we little dream at the present moment" might be discovered. And who was to say that that could not happen? During the 19th century, coal had been the major source of energy and had played a leading role in industrialization, and it was only during the first three decades of the 20th century that fuel oil, gasoline, natural gas, and water power had become competitive. Now world production of petroleum was steadily increasing while the production of coal had been almost stationary since 1913, and the coal mining industries of both the United States and the United Kingdom were seriously depressed.

The Geologic Branch's fuel investigations in 1928 were either long-range fundamental research or field mapping in which the acquisition of specific data on coal or oil was only one objective. David White, who was guiding several of the projects sponsored jointly by the National Research Council and the American Petroleum Institute, resumed his study of the origin of petroleum and collected specimens in quarries and drifts made by the oil-shale companies in Utah. W. H. Bradley, who had been making a detailed study of the Green River formation, which included the oil shale, reported on the algal reefs and oolitic beds that made up an appreciable part of the formation, on the analcite and meerschaum beds, and on the varves and climate of Green River time. Data acquired in the last study enabled him to estimate the length of time to deposit the Green River as 5 to 8 million years and the duration of the Eocene as 13 to 33 million years, thus providing an independent check of estimates of age based on determinations using radioactive minerals. In another long-range project, P. G. Nutting continued his laboratory studies of granular solids, which encompassed far more than the movement of oil, getting into such matters as the filtration of oil, flotation of ores, deformation of rocks, and dam seepage. C. E. Van Orstrand measured temperatures in the oil fields of Texas, Oklahoma, and California; even more extensive investigations, however, were made by three research associates of the American Petroleum Institute using the apparatus devised by Van Orstrand.

A. A. Baker supervised a party mapping in southwestern San Juan County, Utah, between the San Juan River, the Navajo Reservation, the Colorado River, and the Arizona boundary, in part to obtain data for use in public-land administration. With H. E. Gregory and J. B. Reeside, Jr., he also made a reconnaissance of the geology of portions of northeastern Arizona. Baker and Reeside reported that the conditions of sedimentation during the Permian in this region had differed greatly between local areas at a given time and changed often with time, the net effect being to produce materially unlike sequences of deposits at now widely separated places—and thus also considerable differences of opinion about stratigraphic relationships and appropriate nomenclature. In other geologic mapping projects, W. P. Woodring remapped part of the Elk Hills, California, region on a new topographic base, C. H. Dane began mapping in the San Juan Basin, N. W. Bass and A. J. Collier resumed mapping in the coal fields of Montana, and G. B. Richardson continued mapping quadrangles in the coal areas of Pennsylvania.

Much of the Geologic Branch work was, in fact, geologic mapping, and Arthur Keith, who had headed the Areal Geology Section and the Geologic Names Committee for several years, was the man of the hour. In his presidential address to the Geological Society of America in December 1927, Keith, reflecting American skepticism in general, had challenged the theory of continental drift, arguing that the distribution of sediments and of folding on the North American continent confirmed the permanence of ocean basins and the "reasonable" permanence of continents. In April 1928, Keith was elected to the National Academy of Sciences and also chairman of the Division of Geology and Geography of the National Research Council, to succeed Waldemar Lindgren on July 1. Under Keith's aegis, three new committees were established, one on field data on earthquakes, which he himself chaired, and others on batholithic problems and State geological surveys.

In addition to the geologic mapping, several geologists prepared summaries for a volume on North America in the series *Geologie der Erde* being published by Gebrüder Borntraeger in Berlin. W. C. Alden continued his study of the glacial geology of the northern Rockies while Frank Leverett worked on reports and F. E. Matthes, after completing reports on the glaciation of the Sierra Nevada, began a study of the physiographic development of the Mississippi River in connection with problems of flood control. Volcanologic studies were continued in Hawaii, California, and Alaska.

In the laboratories, R. C. Wells began experimental work on ore deposition, investigating in particular dolomitization, in connection with D. F. Hewett's work, and the origin and replacement of minerals, and also began experiments on the diffusion of gases through rocks. R. K. Bailey, one of the eight chemists in the section, was sent to Roswell, New Mexico, to be close to the scene of the drilling for potash.

The Metals Section continued to operate on a somewhat broader basis than did the other sections in the Geologic Branch. Early in the spring of 1928, three senior geologists of the section, G. F. Loughlin, D. F. Hewett, and H. G. Ferguson, and Chief Geologist W. C. Mendenhall met with Professor Lindgren, R. A. F. Penrose, Jr., and Everett DeGolyer to formulate plans for an annotated bibliography of economic geology and to assure them of full Survey cooperation in the venture. During the summer, Hewett, accompanied by Loughlin, made a study of rock alteration in Nevada, then visited the Ely, Hamilton, and Eureka districts in Nevada and the Tintic district in Utah in connection with his study of dolomitization, and visited manganese mines in Arizona, California, Nevada, and New Mexico in connection with preparation of a new summary of the manganese deposits of the United States. In two papers published during the year Hewett explored the extreme ranges of the economic geology of metals, presenting to the Society of Economic Geologists a theory of ore genesis and to the American Institute of Mining and Metallurgical Engineers a review of metal production in Europe in the light of its geologic, economic, and political background to demonstrate that control of production provided more orderly advances and longer life to deposits.

Metals Section geologists were also in the field in New Mexico, Nevada, Idaho, Montana, and Colorado. Loughlin spent some time in New Mexico with A. H. Koschmann and V. T. Stringfield of the newly reorganized State Bureau of Mines and Mineral Resources who had been assigned to complete the study of the Magdalena district which Loughlin had begun in 1915 but had been

In 1928, the Survey began an investigation of the source, movement, and disposal of ground water in the Snake River Plain, a desert area in southern Idaho where about a million acres were under irrigation. Part of the strange landscape of black lava flows, drifting sand dunes, and bare lake beds had been set aside in 1924 as the Craters of the Moon National Monument, shown here in a view looking southeast from the summit of Big Cinder Butte. The Survey study indicated that only a small part of the total annual ground-water supply, estimated as 4 million acre-feet, was being utilized for irrigation, and a map was prepared from which could be predicted the depth necessary for a well to obtain water. To conserve the ground-water supply, it was recommended that future irrigation development be confined to the southeast side of the Snake River above Milner so seepage water might return to the river where it would be available for reuse. (From H. T. Stearns, Lynn Crandall, and W. G. Steward, 1938.)

unable to continue because of his assignment first to war work and then to administration. H. G. Ferguson continued mapping the Tonopah and Hawthorne quadrangles as part of the overall investigation of the Great Basin. The investigations in Idaho, Montana, and Colorado were all cooperative ventures. C. P. Ross spent a second season in the Bay Horse region of Idaho, and in Montana the study of the mining districts of the Greater Helena region was broadened through the cooperation of the city, enabling J. T. Pardee to investigate an area in the Belt Mountains between York and Confederate Gulches and F. C. Schrader to examine a large area south of the city. The cooperative project in Colorado, which B. S. Butler continued to supervise although he joined the faculty of the University of Arizona, was enlarged slightly. In the Front Range, T. S. Lovering remapped the Breckenridge district that F. L. Ransome had studied in 1909, and C. H. Behre began a resurvey of the outlying parts of the Leadville district which had not been studied since S. F. Emmons' classic work in the 1880's. In the San Juan Mountains, W. S. Burbank began mapping in the Ouray district to begin the study of the Ouray-Telluride-Silverton "triangle" where Whitman Cross had mapped near the turn of the century.

The Alaskan Branch, which depended entirely on Federal funds, was able to continue its pioneering investigations in 1928. R. H. Sargent used the first of the drainage maps compiled from the aerial photographs taken for the Survey by the Navy in 1926 as bases for his reconnaissance mapping in the Ketchikan district in southeastern Alaska, where conditions were particularly encouraging for mineral development. The mapping thus provided a test of the accuracy and cost of a base made by photographic methods in comparison with one made by conventional ground methods. In another pioneering survey, Gerald FitzGerald abandoned his dogteam for an airplane, and in company with S. R. Capps and a recorder flew from Anchorage to a survey site in the Alaska Range west of Mount Spurr, hitherto a blank on all authoritative maps of the Territory. The flight took one hour and twenty minutes whereas the pack train carrying their supplies took more than twenty days to make the trip. In an area like the Alaska Range, where the working season was limited to less than 100 days, the time saved was important; budget makers were satisfied as the saving in food and salaries almost compensated for the extra cost of transportation by air. Other surveys were made by F. H. Moffit in the Copper River region and R. K. Lynt, who made a detailed topographic survey of a small tract in the Juneau region urgently needed by the Forest Service in connection with its activities in aid of the development of the paper-pulp industry.

Although Herbert Hoover had been elected President by an overwhelming majority on November 6, 1928, his influence on the final session of the 70th Congress was negligible; the Coolidge philosophy prevailed to the end of his term. Coolidge's last annual address to Congress began on a euphoric note: "No Congress of the United States ever assembled, on surveying the state of the Union, has met with a more pleasing prospect." At home there was "tranquillity and contentment," abroad "peace, the good will which comes from mutual understanding." In late summer, 14 nations had signed the Kellogg-Briand Pact to outlaw war, and the State Department, attempting to build hemispheric solidarity, was about to repudiate the Roosevelt Corollary to the Monroe Doctrine, defining the Doctrine as "a case of the U.S. v. Europe, and not of the U.S. v. Latin America." Coolidge spoke also of the great wealth of the United States "created by our enterprise and saved by our economy." During its 3-month session, Congress did little more than pass the appropriations bills, exercising appropriate economy as they did so.

Given the prospect of a President committed to the expansion of scientific research, the Geological Survey made a strong plea for funds for research in the budget submitted in the fall of 1928, but to no avail. The plea was based on the rapidly increasing needs of American industry for raw materials which, in turn, meant the more rapid exhaustion of mines and wells. The Survey was being called on to take the lead in studies directed toward the finding of ore in order to forestall any serious decline in the supply of metals and other essential minerals with the inevitable slowing down of all industry. For this important work, Director Smith pointed out, the Survey's appropriation in 1929 had been, in dollars, about the same as the appropriation for 1913, but the 1929 dollar was worth only 60 cents. In an accompanying written statement, the Survey pointed out that some minerals were abundant but others were limited in quantity and definitely exhaustible. Consequently, the search for them was constantly becoming more intense, and that

> all of man's resourcefulness, all of the energy, and all of the science of which he is master are needed to find new supplies to satisfy modern needs. The trends of colonization and settlement, the issues of peace and war, have been vitally affected by the presence or absence of these mineral resources, and civilizations have waned as the supplies have diminished.

The mineral industry wanted the help that geologic maps, geologic research, and geologic understanding could give them, and "giving this aid constitutes the economic use of geology." The Government was properly "looked to, not to apply geologic principles to specific problems, such as digging coal or mining copper — that is the field of the practicing geologist and the mining engineer — but to establish the principles ready for application, to supply the general maps, to determine the rock succession, the broad relations and habits or ores, and the laws of their occurrence, and thus to guide exploration from hopeless into hopeful areas." The House Appropriations Committee, however, was not impressed with the argument. The appropriation for geologic surveys was not increased.

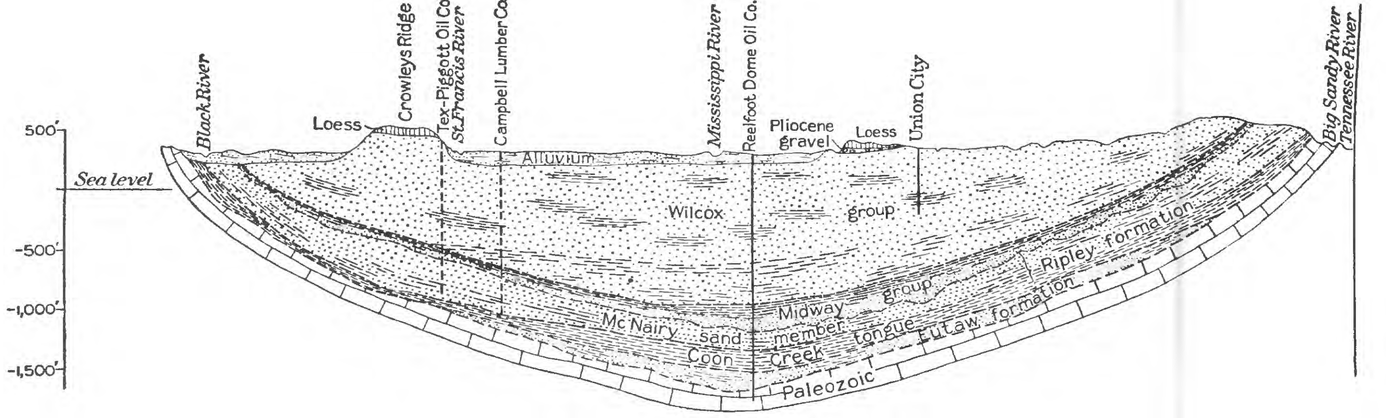
The only item Congress increased significantly was the appropriation for topographic surveys and in recommending that increase, to $635,000 of which $462,000 was limited to cooperative projects, the House committee was clearly more impressed by the greater cooperative offerings from the States than a resolution by the American Society of Civil Engineers urging the acceleration of mapping. The committee also authorized the Survey to contract with private firms for aerial photography. The War Department had insisted that the Survey contract with private firms when they were available to avoid War Department interference with private industry, but when the Survey tried to do so, the Comptroller General had ruled "that the making of topographic maps is one of the duties imposed by law on the United States Geological Survey to be performed by its authorized personnel, and contracting with an outside agency or individuals to perform a duty thus imposed was not authorized. Furthermore, the appropriations for the United States Geological Survey were made upon the basis of surveys by established ground methods and by the regular personnel of that service and that if it is desired to substitute an entirely different and new method such as aerial photography and by contracting with outside firms, the matter was one for presentation to the Congress for express authority to do so." The provision was carefully worded. It authorized the Secretary of War and the Secretary of the Navy to furnish aerial photographs if it would be economical for the Government and not interfere with military or naval operations. The Secretary of the Interior would reimburse the War or Navy Departments for the cost of making the photographs, the Department of the Interior would furnish copies of the photographs to cooperating agencies, and the Geological Survey would contract with civilian aerial photographic concerns if the War or Navy Departments were unable to furnish the photographs in time to meet the needs for which they were requested. Funds were also appropriated for the Survey to make surveys of the boundaries of the proposed Shenandoah and Great Smoky

As the importance of geology in the selection of dam and reservoir sites became more widely understood, Survey geologists were called on in the winter and spring of 1929 to study the geologic conditions that would affect the proposed Madden Reservoir in the Panama Canal Zone. The reservoir was intended to store flood water for use, mainly in the dry season, for lockages in the Panama Canal, for the possible development of hydroelectric power, and to aid in avoiding disturbing currents in the canal. Some of the rocks in the area were found to be permeable to water and others to be mechanically weak. Although it was clear that the reservoir would leak, the project was nonetheless favorably recommended because all the water except what was lost through evaporation or retained in the rock pores would find its way into Gatun Lake where it was desired. The illustration shows a diamond drill sinking a hole on the west side of one of the proposed dam sites. (From Frank Reeves and C. P. Ross, 1931.)

Mountains National Parks. The Sinnott bill, which proposed the transfer of geodetic work from the Coast and Geodetic Survey to the Department of the Interior, failed after the American Engineering Council announced its opposition.

Among the few other measures passed that were of interest to the Survey was the Boulder Canyon Project Act, which authorized construction of the largest dam in the world, a 75-mile-long canal to divert water from the Colorado River to the Imperial and Coachella Valleys in California, and a power plant to develop electric current from the falling water. Grand Teton National Park, proposed by C. D. Walcott in 1897, was also established in a bill approved on February 26, 1929.

The new Cabinet was announced after President-elect Hoover returned to Washington in January 1929 after a trip to Latin America to promote a good neighbor policy. As Secretary of the Interior, Hoover chose the President of Stanford University, Ray Lyman Wilbur, who, he said, "had been my constant friend of nearly forty years from my college boyhood. * * * His long background in public phases of the medical profession prior to his university presidency gave him a fine insight into social and educational forces so much needed by the Interior Department at that time. He was a great outdoor man and knew the West and its resources above most men." To succeed himself at the Department of Commerce, Hoover chose Robert P. Lamont, an engineer and business man, but one who, Hoover later said, had "no initiative and no imagination." The post at Agriculture was offered to Senator Charles McNary and others who declined it, and finally to Arthur M. Hyde, former Governor of Missouri. Wilbur was one of the three members of the Cabinet who most closely shared Hoover's views, the others being the Attorney General William D. Mitchell and Secretary of the Navy Charles Francis Adams, Jr. A new era was thus about to begin in the Interior Department.



In 1928, F. G. Wells began a survey of the western counties of Tennessee as part of a cooperative statewide study of the use of ground water to meet the growing need for water for municipal and rural supplies and industrial development. Favorable conditions were found in the region west of the northward reflex of the Tennessee River. Most of this region is within the Gulf embayment which, as the section shows, is a basin of Paleozoic rocks filled with unconsolidated sand and clay of Cretaceous and Eocene age. The thickness of the principal water-bearing beds, the Wilcox Group, the McNairy Sand Member of the Ripley Formation, and the Eutaw Formation, and the physical properties of the sands of which they are composed indicated that large quantities of ground water could be developed throughout the area, and chemical analyses of samples indicated that the water was of good quality for all purposes except for the presence of considerable iron. (From F. G. Wells, 1933.)

Seventeen days after his inauguration as the 31st President of the United States, Hoover helped the Geological Survey celebrate the 50th anniversary of its establishment. President and Mrs. Hoover received members of the Survey at the White House on March 21, 1929, the 50th anniversary of the nomination of Clarence King as the first Director. Hoover had his picture taken with them all, standing between Director George Otis Smith and Professor Waldemar Lindgren, whose field assistant he had been in 1895.

Hoover's interest in conservation, however, had brought about a change in the Survey's work even before that day. He recognized three urgent problems in the conservation of the public lands: overgrazing, which diminished the value of the lands and imperiled the water supply through destruction of the natural cover; the best method of applying a reclamation service in order to gain real and enlarged conservation of water resources; and the conservation of oil and gas resources. Only 8 days after being inaugurated, Hoover took action on the last-named, announcing on March 12 that henceforth there would be the greatest possible conservation of Government oil. On March 16, a Departmental order outlined the procedures under the policy announced by the President, and thereafter Conservation Branch activities with respect to oil and gas filings became for the most part the preparation of technical reports on the status of drilling operations on permit holdings or on the geologic structure affecting them that had been held for cancellation or were involved in pending applications. Then on May 14, another Departmental order required the Survey to report to the General Land Office the prospective value for oil and gas in certain types of nonmineral entries and filings in 20 States as a basis for the reservation or waiver of the Government's title to such deposits. President Hoover also proposed a plan, along the lines of the Colorado River Compact, for an interstate oil compact by which each of the oil states would agree to set up regulations to repress overdrilling of new pools and waste of gas pressure in collaboration with the others. Secretary Wilbur presented the plan at a meeting of the Governors of oil States and executives of major oil companies on June 20, but they rejected the plan.

Reclamation, in Secretary Wilbur's view, was but one phase in the conservation of water resources which was of first importance in the administration of the public domain because water affected the daily lives of the people living in the arid region. Reclamation had created a great wealth in land, and it was generally agreed that the engineering operations of the Bureau of Reclamation had been soundly conceived and well carried out. The economic principles and policies that should govern decisions on the feasibility of projects had, however, not been firmly established and so Wilbur instituted an economic survey of reclamation projects. There was, however, a larger problem.

From Nebraska west, water, and water alone, is the key to our future. We need the mountains and the hills and a great protective back country or we can not have sufficient water for our valleys. The cooperation and fair play that have made possible the successes of individual reclamation undertakings must be extended to the larger problem. Homestead thinking must be replaced with watershed thinking. There must be a great western strategy for the protection of our watersheds and the plant life on them, however undesirable and unimportant some of it may seem to be.

He warned that unless we cared for the land, the West would suffer from "man-made barrenness, floods, erosion, and decay." Meanwhile, on June 25, President Hoover issued a proclamation making the Colorado River Compact effective and Secretary Wilbur began negotiation of the power contract. Hoover also ordered the Bureau of Reclamation to prepare engineering plans for the Columbia River project and proposed to the Governor of California a joint commission to examine the engineering and economic phases of the Great Valley of California water storage and flood control project.

The problem of overgrazing came up in August 1929 when Hoover sent a message to a conference of western Governors stating his desire, among other things, "to work out more constructive policies for conservation in our grazing lands, our water storage, and our mineral resources" and proposing a study of the problems of the public domain. The governors endorsed the proposed study, and, on October 19, a Public Lands Commission was appointed under the chairmanship of James R. Garfield, Secretary of the Interior in the last 2 years of the Theodore Roosevelt administration.

In embarking on these policies, the Hoover administration was taking no dramatic initiatives as had the Theodore Roosevelt administration, although ardent conservationists in both the public and private sectors held divergent views on some of the issues, particularly on land utilization. The Division of

Oscar E. Meinzer (1876–1948) was one of the founders and first chairman of the Section of Hydrology of the American Geophysical Union, the first professional society devoted exclusively to hydrology. Meinzer joined the Survey as a geologic aid in 1906, succeeded W. C. Mendenhall as chief of ground-water investigations in 1912, and remained with the Survey until his retirement in 1946. He was author or coauthor of more than a hundred reports and papers on ground water and is credited with being the principal architect in the development of the modern science of ground-water hydrology. (From the files of the U.S. Geological Survey.)

Geology and Geography of the National Research Council had established a Committee on Statistics of Agricultural Land Utilization under the chairmanship of Professor Wellington D. Jones of the University of Chicago in an effort to gather pertinent information. In Washington, the Federated Societies on Planning and Parks issued a report prepared by a Joint Committee on the Bases of Sound Land Policy, chaired by Frederic A. Delano, which attempted to answer whether or not the land area of the United States would meet the demands of the population in the year 2000, and how to determine the best use of our land resources. Professor Benjamin Hibbard of the University of Wisconsin, who, with Henry C. Taylor, had established the profession of agricultural economics, stated that a national land policy to conserve land values would have the Federal Government halt further reclamation development, regain possession of much submarginal land, cease selling land of doubtful value and quality, and reforest some of the land withdrawn from cultivation and put other portions in wildlife refuges. The National Industrial Conference Board had undertaken a series of studies of world consumption and production of the various forms of energy on the premise that the first essential requirement for intelligent consideration and discussion of conservation is comprehensive information. The board's research staff, under the direction of Alfred G. White, who had been a member of the War Minerals Committee in 1917–18, prepared a detailed analysis of the factors that determine consumption and production of fuel oil, taking into consideration the various purposes for which fuel oil was used and the extent to which other sources of energy competed with the present and probable future supply of fuel oil. The board concluded that conditions were then favorable for undertaking an oil conservation program. In the oil industry itself, however, conditions steadily grew worse as the result of overproduction.

It was left to the private sector to initiate an effort for conservation of minerals other than oil and gas. The first overture came from the British Empire Mining and Metallugical Congress, which, in the fall of 1929, urged that a new and comprehensive study of the world mineral situation be made. In the spring of 1930, the Mineral Inquiry, under the chairmanship of C. K. Leith and sponsored by the American Institute of Mining and Metallurgical Engineers, was established in office space in the Brookings Institution in Washington. Aiding Leith as members of the Mineral Inquiry were H. Foster Bain, managing director of the Copper and Brass Research Corporation and former Director of the Bureau of Mines; G. Temple Bridgman, consulting mining engineer for Guggenheim Brothers; M. L. Requa, director of the Oil Division of the Fuel Administration during the World War and a friend of President Hoover; J. E. Spurr, who had served with Leith during the World War on the committee on mineral imports, and as chief engineer of War Minerals Relief; and William Rawles, one of Leith's students, as executive secretary. Although privately organized and funded, the Mineral Inquiry asked and received the cooperation of Federal agencies in the mineral field.

The work of the Conservation Branch of the Survey was inextricably linked with administration policies. Under the policy on oil and gas conservation initiated on March 12, 1929, the Survey prepared 4,533 reports on oil and gas cases outside Alaska for submission to the departmental committee to pass on claims. The number of oil and gas leases under supervision increased from 597 to 676 during the year, and royalties increased from $3.7 million to $4.1 million, but permits declined from 15,442 on June 30, 1929 to 6,482. The Agricultural Division continued its field studies of the agricultural utility of the land in the Colorado Basin region and acted on about 7,000 applications under the Enlarged- and Stockraising-Homestead Acts. Applications were beginning to decline, and cancellation of previous designations increased, so the total acreage designated under the Enlarged Homestead Act actually declined

By the late 1920's, the traditional policy of allowing unrestricted use of the unreserved public domain as a grazing common had ceased to be beneficial and in fact had become harmful by permitting overcrowding and overgrazing. The contrast between overgrazed and protected range lands is strikingly shown in the illustration; the pasture inside the fence line shows a good growth of palatable forage while practically all forage has been removed from the outside range. A plan of proper range management was needed not only to conserve a valuable natural resource but also to provide for livestock operations on a permanent economic basis. It remained to find a suitable formula for such management, which was achieved by passage of the Taylor Grazing Act in 1934. (From L. R. Brooks and others, 1933.)

during the year from 325 million acres to 318 million. Designations under the Stockraising Homestead Act increased slightly, from 120 million acres to 121.5 million acres. In addition to its regular work, the branch also prepared a report and a series of maps of the 10 principal public-land States for the Garfield commission.

The importance of the conservation of water resources led to still greater expansion of the Water Resources Branch during the year that began July 1, 1929. Most of these investigations were made by the Division of Surface Water, which carried on stream gaging in 47 of the 48 States and the Territory of Hawaii. The number of gaging stations increased to 2,426 and 2 new district offices were opened, at Hartford, Connecticut, and Charleston, West Virginia, because of the increased work in cooperation with the States.

Ground-water investigations were made in 26 States and the Territory of Hawaii. R. M. Leggette, F. G. Wells, and W. D. Johnston, Jr., continued the cooperative statewide surveys in Pennsylvania, Tennessee, and Alabama, and a new survey was begun in Texas under the general supervision of W. N. White. A. N. Sayre, a recent University of Chicago Ph.D., joined the Survey to begin work in Uvalde and Medina Counties, and two young engineers, S. F. Turner and T. W. Robinson, began work in Dimmit and Zavala Counties, all in southern Texas, where additional ground-water supplies were needed for irrigation. After making a study of the water resources of the Rosebud Indian Reservation in South Dakota for the Indian Service, A. G. Fiedler began work in Somervell County, in the northern part of Texas, where the artesian head at many wells had declined to a serious extent. Arrangments were made for a cooperative survey in the Territory of Hawaii by H. T. Stearns, and, pending completion of Stearns' Idaho project, K. N. Vaksik of the Territorial Division of Hydrography began collecting well records on Oahu. The special studies in the Mokelumne area of California, the Willamette Valley of Oregon, the rice-growing area in Arkansas, and the Mimbres Valley in New Mexico were continued, and S. S. Nye began a special survey of the occurrence, quality, and movement of ground water in Lea County, New Mexico, where dry farming had been supplemented in some cases by pumping from shallow wells. The Ground Water Division also continued to work with the eight State associations of water-well drillers and early in 1930 helped establish an American Association of Water Well Drillers. Both O. E. Meinzer and A. G. Fiedler were members of the Advisory Council of the national organization, Meinzer representing the National Research Council and Fiedler the Survey.

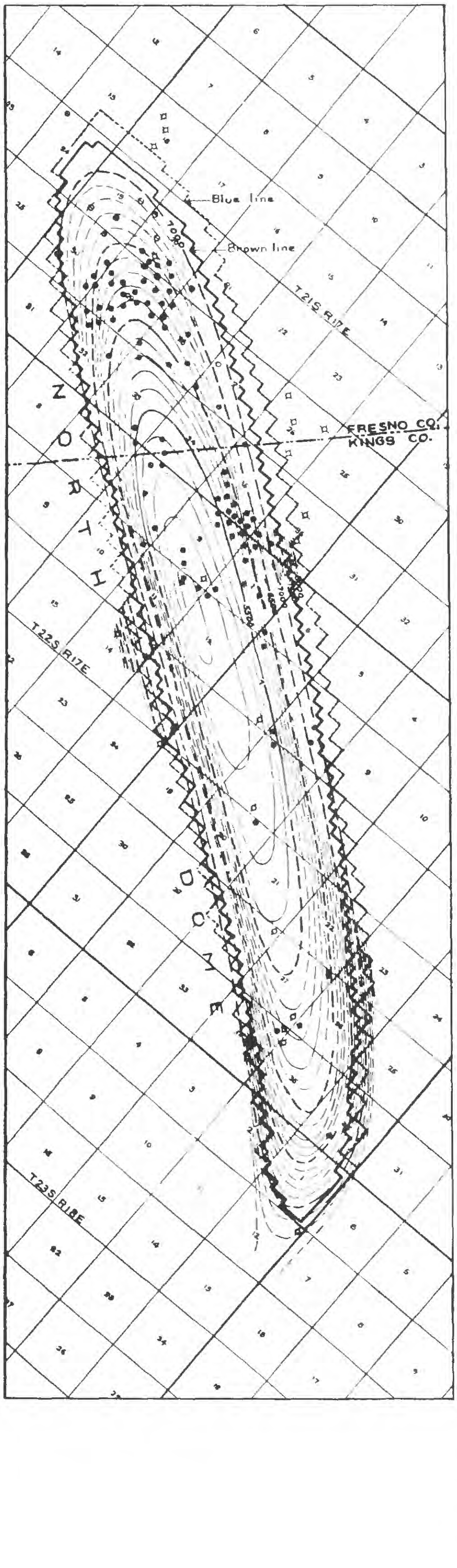
The Chief Topographic Engineer, C. H. Birdseye, resigned in September 1929 to become president of the Aerotopograph Corporation of America, which had been selected to make the surveys of the Boulder Dam region in preparation for construction of the dam. T. H. Pendleton, former head of the Phototopographic Mapping Section of the Survey and future Chief Topographic Engineer, was then Aerotopograph's Chief Engineer. There were other changes in branch administration as well. Glenn Smith, the Division Engineer in charge of the Atlantic Division and former head of the Division of Military Surveys and the Division of West Indian Surveys, who had frequently served as Acting Chief Topographic Engineer in Birdseye's absence, resigned on September 9. On September 10, the appointments of John G. Staack, then serving as Chief of the Great Lakes Section of the Central Division, to succeed Birdseye, and of Albert Pike to succeed Smith, were announced. Staack had been a member of the branch for 25 years, having joined the Survey immediately after receiving his B. S. from the University of Wisconsin in 1904. Pike was a 35-year veteran, having been appointed an assistant topographer on May 1, 1894, while still in his teens. In October, W. H. Herron, the Division Engineer in charge of the Central Division, died suddenly. He was succeeded by H. H. Hodgeson, who had been with the Survey since 1902.

Despite the significant increase in the appropriation for topographic surveys, total funds for the branch were about 7 percent less than the year before because of the decline in cooperative and other Federal funds. Nonetheless, more than 22,000 square miles were mapped, resurveyed, or revised, about 30 percent more than in the preceding year. The area mapped at 1:62,500, however, was very little more than the preceding year, and more than 7,000 square miles in eight Western States were mapped at 1:125,000 or 1:250,000 for the Forest Service or in preparation for geologic mapping.

The Alaskan Branch continued its experiments with aerial photography. The photographs made in 1926 had proved to be of such value to other agencies as well as to the Survey that the Forest Service had joined the Survey in asking the Navy to continue the work. The Navy, considering the training that the work afforded naval personnel as well as the needs of the bureaus, agreed to do so. R. H. Sargent was attached to the Navy's aerial expedition which photographed about 12,000 square miles in southeastern Alaska. Most of the branch efforts, however, were concentrated on exploration. S. R. Capps and Gerald FitzGerald teamed up to map more than 1,300 square miles of hitherto unsurveyed country in the Alaska Range. J. B. Mertie, Jr., completed field work for a revision of the geologic map of the tract lying between the Yukon and Tanana Rivers, mapping about 1,500 square miles in the area north of Fairbanks and west of Circle. F. H. Moffit made a geologic reconnaissance of parts of the area near the headwaters of the Copper River extending into the drainage basin of the Tok River.

The conservation policies of the Hoover administration had little effect on the work of the Geologic Branch which, in 1929, remained basically oriented toward geologic mapping, stratigraphic studies, and fundamental research yielding the maps, data, and understanding needed by industry. The purposes of these studies and the uses to which they were put, however, were increasing, and maps were being prepared of areas ranging in size from the entire United States to part of a mining district. G. W. Stose continued compilation of the geologic map of the United States; G. R. Mansfield was chairman of the Committee on Tectonics of the Division of Geology and Geography of the National Research Council, which began preparation of a tectonic map of the United States. The geologic maps of Arkansas and Kentucky were published, that of Pennsylvania was completed for publication, compilation of the maps of Texas and California continued, and field work was begun for a map of Georgia. Some quadrangle mapping was done but more mapping was special-purpose. L. F. Noble, for example, continued mapping the San Andreas Rift in California as part of the investigation of earthquakes in California, and also prepared a report for the Water District of Southern California to help it determine the

One of the first fruits of the Hoover administration's insistence on oil conservation was the passage of a bill authorizing unit operation or cooperative development of oil fields containing public lands. The concept of developing an oil and gas field as a geological unit as a means of conservation had been proposed as early as 1908 by David T. Day of the Survey, but not until it was realized, after the discovery well in the Kettleman Hills oil field in California was brought in in 1928, that unrestricted development of the field would be ruinous to the oil industry as well as waste natural resources was there any urgency to adopt such a measure. In the plan for unit operation of the North Dome in the Kettleman Hills field, one of the first approved, the "blue line" on the structure contour map of the top of the Temblor Sandstone was the first approximation of the limits of productivity and the outer boundary of participating acreage. The "brown line" is a redetermination of the productive acreage as of January 31, 1931, on the basis of drilling information. (From C. D. Avery and J. C. Miller, 1934.)



most geologically favorable place for proposed aqueducts from the Colorado River to cross the fault zone. W. C. Alden continued to map in the Northern Rockies as part of his study of the geomorphology and glacial geology of that area, and F. E. Matthes mapped along the Mississippi River in connection with flood studies. Howard Powers joined the staff of the Hawaiian Volcano Observatory and began mapping the Kona district as part of the volcanological studies.

Laboratory investigations followed the general pattern. Roger Wells continued his investigation of methods of age determination, and analyzed some samarskites and uraninites for lead, uranium, and thorium so the age of these minerals could be calculated. In conjunction with a determination by Professor G. P. Baxter of Harvard, Wells' results afforded a means of determining the rate of disintegration of thorium over a very long time. W. T. Schaller, E. P. Henderson, J. J. Fahey, and F. C. Calkins concentrated on petrographic examinations of drill cores obtained in drilling for potash deposits and found that they could detect the presence of the more commercially valuable but more soluble minerals such as carnallite, sylvite, and langbeinite. Thus petrography became a tool to aid future exploration for potash.

Field work of the Fuels Section was on the whole more related to coal areas than potential petroleum areas. The reexamination and mapping of the coal beds of the Mesaverde formation across the southern part of the San Juan Basin in New Mexico was extended. J. D. Sears resumed an investigation of the Gallup district where he had mapped in 1919 and 1920, assisted by T. A. Hendricks who later took charge of the mapping, while C. B. Hunt continued the mapping which C. H. Dane had begun in 1928, under Dane's supervision. In Montana, W. G. Pierce mapped the southwest part of the Rosebud field and A. J. Collier, with several assistants, mapped in the Rickey-Lambert field.

Coal was also the subject of M. R. Campbell's address as president of the Society of Economic Geologists in 1929. Campbell pointed out that eight stages could be recognized in the metamorphism of coal, but at least six of these stages left few if any marks on the composition or physical appearance of the sediments associated with the coal. Thus coal could be regarded as a recorder of incipient rock metamorphism. Two months later, Campbell and David White participated in a very practical symposium on the still live subject of classification of coals at the American Institute of Mining and Metallurgical Engineers meeting.

The Survey's oil studies were primarily stratigraphic and lithologic investigations which George Otis Smith said illustrated "the peculiar functions of a survey under governmental auspices in contributing to the technical work performed directly by the scientists employed by the industry." Such studies were underway in Pennsylvania, Texas, California, Utah, New Mexico, Colorado, and Wyoming. Fundamental research related to oil Smith described as "production studies from the geologic side." Among these were P. G. Nutting's comprehensive study of the relations between oil, silica, and water, which branched off into a study of the bleaching clays used for refining petroleum lubricants. Some bleaching clays were effective and some were not, and producers were reduced to cut-and-try methods as little was known about them.

David White, however, continued his research into the genesis of petroleum as well as early plant life. As a member of the Central Petroleum Committee of the National Research Council, he guided several of the 38 fundamental research projects funded by the American Petroleum Institute from the Rockefeller-Universal Products grant, and worked closely with Taisia Stadnichenko in an investigation of the effect of geologic time in the genesis of oil from buried organic debris suggested by the experimental work of C. G. Maier and Stuart Zimmerley in 1924. Maier and Zimmerley had found that the formation of bitumen depended on both temperature and time of heating, and in microthermal studies of some "mother rocks" of petroleum from Alaska, Stadnichenko found that differences in natural carbonization could be related to differences in composition and differences in composition were also related to differences in melting points and temperatures of volatization. In another API investigation, Parker Trask, API research associate, used the Maier-Zimmerley method on several recent sediments and found that the bitumen content of older rocks was several times greater than that of recent sediments of comparable organic content. That suggested to him that in older deposits some of the organic matter had been converted to bitumen and that the formation of bitumen was possibly an intermediate step in petroleum generation.

The Metals Section expanded in 1929 as the Colorado project was enlarged and new cooperative projects were begun in Oregon and Nevada. In addition, the cooperative projects in Idaho and Montana were continued, and informal cooperation between the Survey and the New Mexico Bureau of Mines and Mineral Resources sent G. F. Loughlin to New Mexico in the summer and brought Sam Lasky of the State Bureau to Washington for the winter to work on the report on the Magdalena district with Loughlin. In the Oregon project, D. F. Hewett restudied mines in the Sumpter quadrangle, adding new facets to his 1914 study, J. T. Pardee made a preliminary examination of the mining district in the western part of the State, and James Gilluly began mapping the Baker quadrangle and a detailed study of the copper deposits near Keating. Russell Gibson succeeded Pardee in Montana, mapping the Libby quadrangle in the northwest corner of the State, and C. P. Ross continued his work in Idaho.

B. S. Butler told the Colorado Scientific Society in June 1929 that the ore deposits of the southern Rocky Mountain region were concentrated in a narrow belt surrounding the Colorado Plateau and were associated with volcanic fields largely confined to the same belt. Structural and stratigraphic data indicated that the Plateau had long been a positive area undergoing erosion or moderate deposition while the surrounding area was a negative area of deposition. Ore deposits were formed as part of the igneous activity that accompanied the folding and faulting of the basins of deposition at the time of the Tertiary orogeny. Four young men were added to the staff: E. B. Eckel to work with W. S. Burbank in the San Juan Mountains, E. N. Goddard to work with T. S. Lovering in the Front Range, and Quentin Singewald and John W. Vanderwilt to work under Butler's supervision, Singewald in the Alma district and Vanderwilt in the Climax area.

An overview of ore deposits in Nevada, planned before the World War intervened, was provided by H. G. Ferguson. Ferguson found there were four

Nearly a quarter of a century after the Survey first began the study of western coal fields, J. D. Sears and other Survey geologists reexamined and remapped the coal beds across the southern part of the San Juan Basin in New Mexico and found relations between the Mesaverde Formation and the underlying Mancos Shale were not simple. At the western edge of the field, estuarine and fluviatile deposits in the lower part of the Mesaverde overlie marine shale of the Mancos Formation. Eastward through the field, however, some of the beds showed a progressive lateral change to rocks of littoral and marine types, and there was some interfingering of the two formations. Thus the Gibson Coal Member of the Mesaverde was split toward the east by the Hosta Sandstone Member of the Mancos, and the Hosta, in turn, was split by the Satan Tongue of the Mancos. The photograph shows the Hosta (upper two ledges) split by the Satan. (From J. D. Sears, 1934.)

W. H. Bradley's detailed and multifaceted study of the Green River Formation of Colorado and Utah, which he had begun in 1923 to resume the investigation instigated by David White and recessed during the World War and early postwar years, allowed him to determine the physical conditions under which the sediments had accumulated in ancient Uinta Lake. He also reconstructed the history of the lake and inferred that the oil shale of the formation resulted from the accumulation of organic ooze in the lower stagnant layer of water during stages when the lake was relatively broad and deep. The illustration shows one of the microorganisms that grew in the lake, the green alga *Eoglobella longipes* Bradley. (From W. H. Bradley, 1931.)

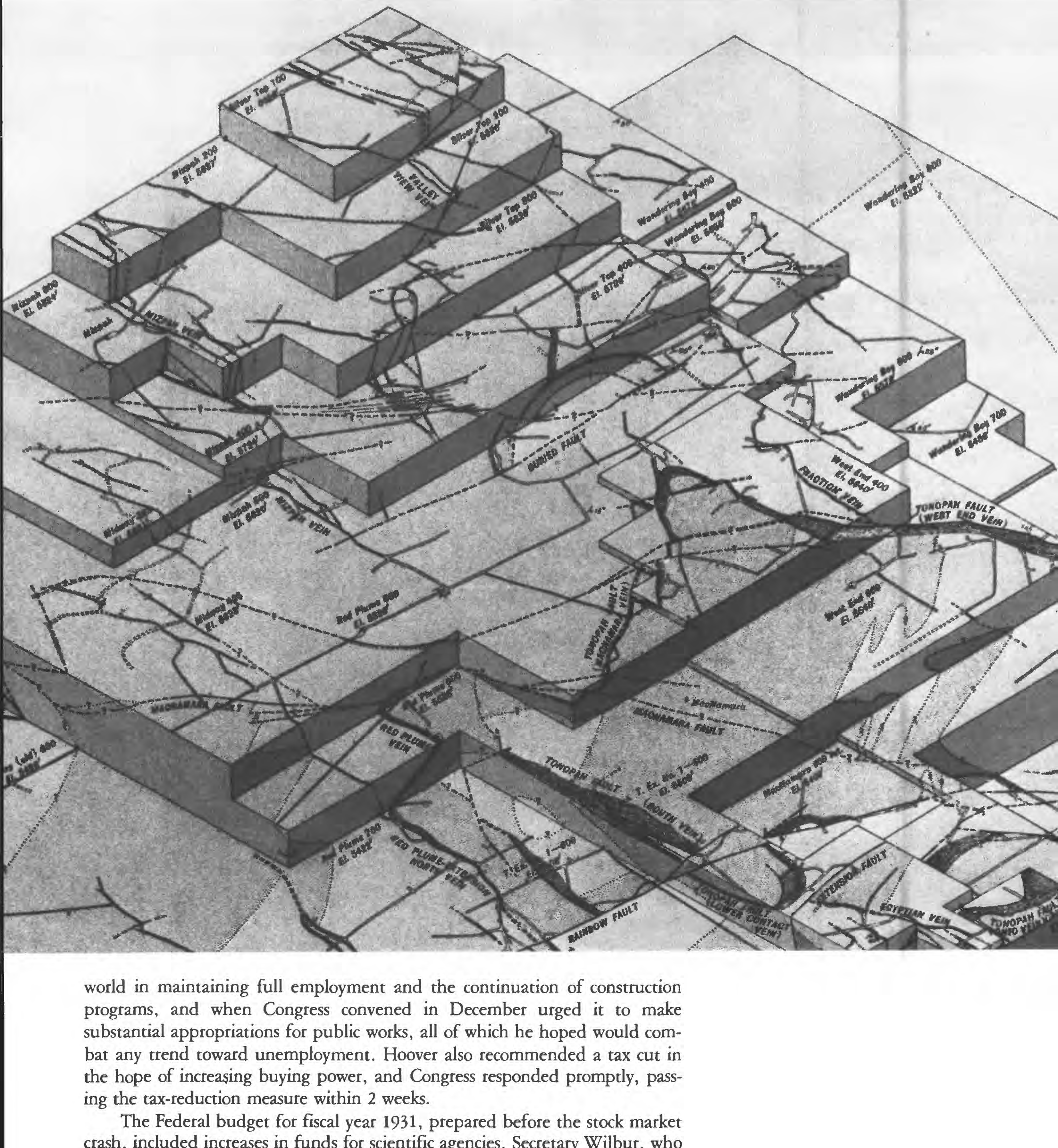
periods of deposition, the earliest associated with granitic rocks intruded near the close of the Jurassic in western Nevada, another associated with granitic rocks intruded at the beginning of the Tertiary in eastern Nevada, and two later periods associated with volcanic flows of Miocene and Pliocene age. He thought that the western argentiferous quartz veins offered little hope of important future production but that the eastern deep-seated deposits might continue to be important producers of base metals. Of the later deposits, the silver and silver-gold veins of the Miocene were likely to prove of more importance than the Pliocene gold-bearing veins. In cooperation with the State, T. B. Nolan, having completed the report on the Gold Hill district, began a resurvey of the Tonopah district which J. E. Spurr had studied shortly after the turn of the century, and soon found himself in disagreement with earlier workers in the area on interpretations of both stratigraphy and structure. The ore deposits, Nolan discovered, were associated with a unique compound fault, a recumbent crescent in cross section, and subsidiary faults. These findings provided a new basis for exploration and new hope for the district.

The Survey joined forces with the Bureau of Mines in preparing the United States report for the volume on the gold resources of the world of the 15th International Geological Congress which met in Pretoria, South Africa, in the summer of 1929. G. F. Loughlin and H. G. Ferguson, who were responsible for the final text, pointed out that gold production in the United States had been gradually declining since the World War, with only a slight reversal of the trend in 1923 and 1924 as a result of increased production of by-product gold from copper ores and the opening of new shoots of siliceous ore in old mines. The decline in production was attributed in part to the high cost of mining but also to the fact that many of the leading districts had reached or passed their maximum output of gold before the war began; increased production was considered likely in only a few States.

The Geological Congress had planned an appraisal of the gold resources of the world but differences in reporting made that endeavor impossible; countries reported reserves in ounces, in dollars or pounds, or in tons, and some did not report any figures. Among those countries that reported their gold reserves, South Africa clearly ranked first with an estimate of 1,000 million pounds sterling, but some of the Pacific nations also indicated the presence of large reserves.

Economists in the summer of 1929 were more concerned with government-held gold reserves than with gold resources. During the World War, most European nations had to abandon the gold standard. The increase in world price levels had enlarged the demand for gold in central bank reserves and threatened to cut the supply as rising costs pressed against the fixed price. For a time, following the League of Nations conference in 1922, foreign exchanges had been substituted for gold in reserve holdings but in 1925 Great Britain had returned to the gold standard and most other nations had followed suit. The United States' position as a creditor nation tended to set up a flow of gold toward it that threatened to unbalance the world distribution of gold and make an effective gold standard impossible. Partly to restrain this tendency, the U.S. Federal Reserve System held to an easy-money policy with low interest rates. Despite the policy, American gold stocks increased by more than $2 billion during the 1920's, and by 1929 gold losses in many countries signaled approaching distress. The Federal Reserve policy, meanwhile, had raised speculation in stocks to new heights at home.

In the fall of 1929, the inevitable economic crisis began. Stock prices began declining in September, and then, on October 24, the decline became a panic. By mid-November, the loss in paper values of stocks was almost $30 billion. Both business and political leaders were optimistic that the reversal would be short-lived. President Hoover sought the cooperation of the business



world in maintaining full employment and the continuation of construction programs, and when Congress convened in December urged it to make substantial appropriations for public works, all of which he hoped would combat any trend toward unemployment. Hoover also recommended a tax cut in the hope of increasing buying power, and Congress responded promptly, passing the tax-reduction measure within 2 weeks.

The Federal budget for fiscal year 1931, prepared before the stock market crash, included increases in funds for scientific agencies. Secretary Wilbur, who called the Survey "a fine example of the proper place of science in Government business," said that he expected to "see its activities strengthened and its work enlarged by increased funds and increased emphasis within the department," In 1929, more than a quarter of a century after J. E. Spurr first studied the Tonopah mining district in Nevada, T. B. Nolan remapped the area in cooperation with the State. Publications by Spurr and J. A. Burgess in 1915 had described the formations as essentially horizontal and implied that the bulk of the major faulting was later than the deposition of the ore. Nolan, however, making use of the more extensive exposures made available by development of the district, found that the formations were considerably tilted and that faulting was far more pronounced before mineralization than after. The apparent horizontal attitude of the formations in the older central part of the district was in fact largely the result of premineral faults. Nolan used a block diagram, part of which forms the illustration, to show clearly the relations between dominantly eastward-striking veins and northward-striking formations and thereby set a new trend in geologic illustration. (From T. B. Nolan, 1930.)

and approved large increases in appropriations for geologic surveys, topographic surveys, and water-resources investigations, and also $300,000 for a new item, fundamental research in geologic sciences. The Bureau of the Budget whittled away at these estimates but allowed increases for most items and approved $100,000 for fundamental research.

When the House Committee on Appropriations began hearings on the Survey appropriations, every one present seemed relaxed and confident about the future. The Director did not attend—he was in Tokyo at a World Engineering Conference—and Administrative Geologist J. D. Sears and Chief Clerk John J. Madigan met with the committee. The chairman, L. C. Cramton, confessed a little surprise at the request for $100,000 for fundamental research; he had seen in a recent magazine, he said, that "the Geological Survey has sort of outlived its usefulness." The committee, however, either accepted or increased the recommendations of the Bureau of the Budget, and the chairman, in presenting the bill on the floor of the House, said "The Geological Survey comes into its own under this scientific administration." The bill, enacted on May 14, 1930, provided $2.87 million for the Survey, an increase of more than 30 percent over the current-year appropriation.

Congress also responded favorably to Presidential initiatives on conservation. In his annual message on December 3, 1929, Hoover had described the conservation of national resources as "a fixed policy" of the Government. Three important questions bearing upon the conservation of the public lands, he said, had become urgent: conservation of oil and gas resources against future need; a major problem due to overgrazing; and reconsideration of reclamation policy. Hoover announced that he had appointed a commission to study these questions and asked authorization of funds to defray its expenses. He also asked for a reorganization of the conservation work in the Federal Government. Conservation activities were spread among eight agencies in five departments, and thus there was "no proper development and adherence to broad national policies and no central point where the searchlight of public opinion may concentrate itself." Hoover made no recommendation as to which department should house conservation agencies, that being less important in his mind than the fact of concentration. Congress, on April 10, 1930, appropriated $50,000 for the expenses of a commission on the conservation and administration of the public domain but it made no effort to reorganize conservation within the Federal Government.

Congress, however, passed a major conservation measure in amending the General Leasing Act of 1920 to permit cooperative plans of developing oil pools involving public lands. The act authorized continuation of leases beyond 20 years where such plans were in effect and gave the Secretary of the department having jurisdiction over the lands authority to modify the quantity and rate of production, and the Secretary of Interior authority to reduce the royalty when production was decreased below 10 gallons a day. The unit plan of development, by confining production to a minimum number of wells and eliminating offsetting, minimized waste and provided a means of controlling overproduction. As Secretary Wilbur pointed out, under the old system production at the Kettleman Hills field in California would flood the market with gasoline exceeding in quantity the entire California production and waste 450 million cubic feet of gas each day; the waste in energy from that one field was in fact more than twice the total expected annual electrical output at the Hoover Dam. The bill approved on July 3, 1930, was a temporary measure, to expire on January 31, 1931, but it was made permanent by a new bill approved March 4, 1931.

Congress also acceded to President Hoover's request for a reorganization of the Federal Power Commission. Since its formation in 1920, the Commission had been a part-time responsibility of the Secretaries of Agriculture, War, and the Interior; Hoover believed it should be the responsibility of full-time commissioners. The bill was passed and approved on June 23, 1930, providing for five full-time commissioners, no more than three from the same party, each to receive a salary of $10,000 a year.

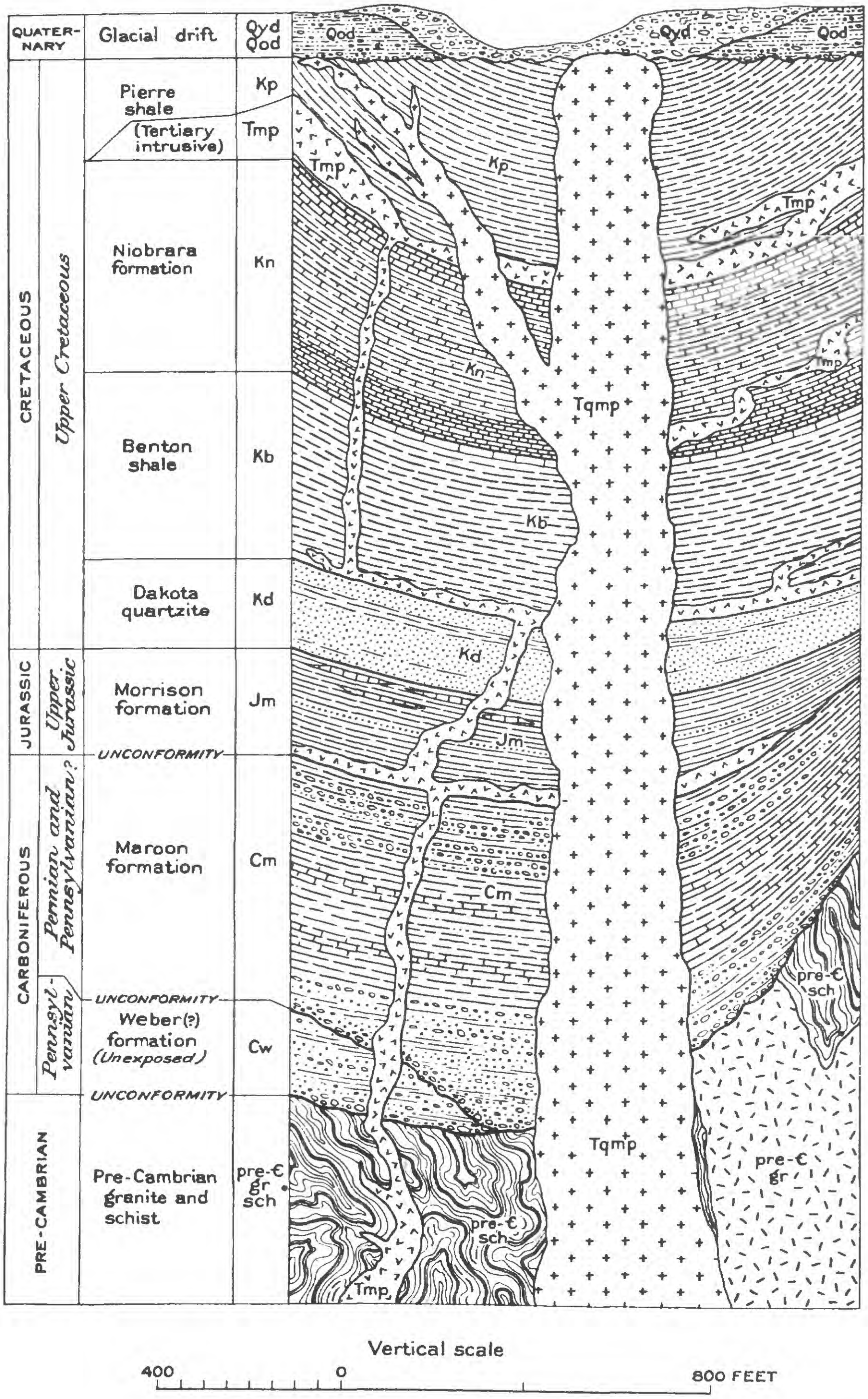
As the Geological Survey began its 51st year, it looked forward with renewed confidence to the future. The Federal appropriation for water-resources investigations had been almost doubled; the appropriation for geologic investigations had been increased by 40 percent, and part of the increase had been appropriated specifically for fundamental research; the appropriation for topographic mapping was up almost 20 percent; and the appropriation for Alaskan mineral resources had been restored to the 1925 level. The Conservation Branch had received no increase in funds but had asked for none; work in the Conservation Branch was expected to decline because of change in policy with regard to development of the mineral lands. For three of the branches, the year's work proceeded according to plan; the Topographic and Conservation Branches, however, had to cope with special conditions resulting from the failure of the national economy to rally.

The Water Resources Branch had more funds to work within fiscal year 1931 than any of the other branches and there was a net increase of 31 in the staff during year. Despite the great increase in the Federal appropriation, however, more than 60 percent of the branch's funds came from outside sources and so the program expanded without shifting emphasis. Surface-water investigations continued to outnumber all others; the number of gaging stations increased to 2,663 by the year's end (655 of them in connection with Corps of Engineers' projects), and 3 new district offices were established: at Ocala, Florida, and Indianapolis, Indiana, because of the increase in State cooperation and Engineers projects, and at Columbia, South Carolina, in connection with Engineers projects and Federal Power Commission requirements.

Ground water and reservoir sites were investigated in only 19 States and the Territory of Hawaii but there were 63 separate investigations. State-wide investigations were continued in Pennsylvania, Tennessee, and Texas, and new ones were begun in Florida and Nebraska. In Pennsylvania, R. M. Leggette completed his work in the northwestern part of the State and S. W. Lohman, a recent graduate of the California Institute of Technology succeeded him, beginning work in the northeastern part of the State. David Thompson took over general supervision of ground-water work in the Southeastern States. The Geological Survey of Alabama was unable to supply cooperative funds, so the ground-water survey was terminated and W. D. Johnston, Jr., transferred to the Geologic Branch. F. G. Wells also transferred to the Geologic Branch but C. V. Theis, after receiving his doctorate in geology from the University of Cincinnati, joined the Survey to begin the investigation of ground-water conditions in south-central Tennessee, and V. T. Stringfield, another newly appointed geologist, began a cooperative investigation in Florida, starting in Sarasota County. In Texas, W. N. White, Penn Livingston, and S. F. Turner began an investigation of ground-water resources in the Houston area where the increased draft had so lowered ground-water levels that concern was felt for the municipal water supply which came chiefly from ground water. The Nebraska Geological Survey had begun a statewide investigation of ground-water resources in 1929, beginning in the Platte Valley and the northern part of the upland to the south where the wide use of ground-water supplies for all purposes made imperative a better understanding of the geology and hydrology of the area. The State-sponsored survey became a cooperative project in 1930 and L. K. Wenzel of the U.S. Geological Survey was assigned to study the hydrology. In Oregon, the work in the Willamette Valley was suspended at the request of the State because of the urgent need for investigations in other parts of the State. A. M. Piper began field work in May 1930 in the vicinity of The

Dalles, where several hundred acres of orchards were cultivated chiefly by dry-farming methods; under his general supervision, T. W. Robinson and C. F. Park, Jr., began a study of the Harney Basin, a closed basin in the southeastern part of the State. H. T. Stearns arrived in Honolulu in July to establish an office and begin the study of the ground-water resources of Oahu.

A new stage in the professionalization of the science was reached when the American Geophysical Union organized a Section of Hydrology as a constituent unit and the American representative in the International Association of Scientific Hydrology, which had been formed by the International Union of Geodesy and Geophysics in 1922. The organizational meeting was held at the National



Twenty years after F. L. Ransome mapped the Breckenridge district in Colorado, T. S. Lovering remapped part of the district on a larger scale. With geologic data from the mining at greater depths in the intervening years and information gained from a study of the surrounding region, Lovering made a more detailed analysis of the stratigraphy and complicated structure of the region. His columnar section for the district showed Precambrian schist, granite, and granite gneiss underlying the sedimentary rocks, which were of Carboniferous, Jurassic, and Cretaceous age. All these rocks were intruded by monzonite porphyry (Tmp on the illustration) and quartz monzonite porphyry (Tqmp) of Eocene age. Lovering believed that the primary mineralization was related to the solidification of the deeper parts of the quartz monzonite porphyry, the latest of the porphyry intrusions, and that many of the deposits had been greatly modified by enrichment. (From T. S. Lovering, 1934.)

Research Council on November 15, 1930, and the first meeting of the section on May 1, 1931. O. E. Meinzer of the Geological Survey was elected the first chairman of the section. Meinzer, A. M. Piper, C. V. Theis, G. H. Taylor, and W. W. Rubey of the Survey all presented papers at the first meeting.

The Geologic Branch took on a new lease on life in 1930 with its increased funds. The $100,000 appropriated for fundamental research was divided among the Sections of Paleontology and Stratigraphy, Coastal Plain Investigations, Glacial Geology, Areal Geology, Chemistry and Physics, and Petrology. The additional $50,000 appropriated for geologic surveys and approximately the same amount in cooperative and transfer funds were used by the economic geology sections. The increase in funds permitted a modest expansion in staff; 2 reinstatements and 22 new appointments brought the professional staff to a total of 146 by the year's end: 134 geologists, some of them part-time, 9 chemists, and 3 physicists. Among the 22 newcomers were 11 assistant geologists and 7 junior geologists appointed to serve as assistants to some of the senior scientists.

Taking advantage of advances in optical methods for detailed study of minute crystal aggregates and the development of the x-ray powder method for studying fine-grained crystalline materials, scientists of the U.S. Geological Survey, the Smithsonian Institution, and Columbia University in the mid-1920's began a complete investigation of the clay minerals. The optical and x-ray studies together with chemical and thermal investigations indicated that instead of one kaolin mineral, as had been commonly assumed, there were at least three distinct species, which C. S. Ross and P. F. Kerr called kaolinite, nacrite, and dickite. The three minerals were presumed to have originated in different ways. The photograph shows a single coiled kaolinite crystal from Mexia, Texas, a form so fragile that any transportation would have destroyed it, so it must therefore have developed in place. (From C. S. Ross and P. F. Kerr, 1931.)

The Geologic Branch also assumed additional responsibilities to the profession. In the spring, Chief Geologist Mendenhall was named General Secretary and H. G. Ferguson chairman of the committee on excusions for the 16th International Geologic Congress which was to meet in the United States in 1932. Guidebooks for the excursions were planned and N. H. Darton, F. E. Matthes, M. R. Campbell, H. E. Gregory, Charles Butts, and A. B. Knopf were assigned to their preparation. Compilation of the various State maps and the U.S. geologic map continued and E. B. Knopf, A. I. Jonas, J. T. Gardner, C. W. Cook, W. H. Monroe, L. W. Stephenson, and R. C. Moore all did field work to aid in their completion before the International Congress. A committee on the stratigraphic nomenclature of formations that crossed State boundaries, first proposed by the Association of State Geologists, was also formed, including representatives of the American Association of Petroleum Geologists, the Geological Society of America, the Association of State Geologists, and the U.S. Geological Survey. Representing the Survey were T. W. Stanton, Chief of the Section of Paleontology and Stratigraphy and Chairman of the Geological Names Committee, H. D. Miser, Chief of the Fuels Section, and G. W. Stose, the Geologic Map Editor.

Among the field investigations that were begun or expanded in 1930 as a result of the new funds were a detailed study of the geology of the Afton quadrangle in southwestern Wyoming by W. W. Rubey and J. S. Williams, in part for the purpose of classifying the lands as to phosphate, and geologic studies of Death Valley by L. F. Noble, the Marathon Basin in Texas by P. B. King, and the Appalachian Valley of Virginia by Charles Butts. E. O. Ulrich undertook a study of early Paleozoic rocks in Iowa and Michigan, and R. W. Brown and K. J. Murata of the Fort Union and associated formations in North Dakota. E. S. Larsen, Jr., began mapping the Southern California batholith where he had first mapped in 1906 as an assistant to W. C. Mendenhall.

George Steiger retired as chief chemist to devote his attention to the development of spectrographic methods and techniques for the determination of beryllium. Recent work in metallurgy had resulted in the production of beryllium alloys of outstanding promise in industry. Roger Wells, who succeeded Steiger as chief chemist, continued his work on the development of methods of determining geologic age, and R. E. Stevens, a new chemist, began the experimental investigation of the genesis of some metallic ores.

Much of the field work by the Fuels Section geologists, as for several years past, consisted of mapping and stratigraphic studies of more immediate scientific than economic import. Mapping the coals of the Mesaverde Formation at the southern edge of the San Juan Basin was continued; J. D. Sears led one party and started another in the Mount Taylor region, which he then turned over to C. B. Hunt. T. A. Hendricks, who had worked with Sears in 1929, began mapping the coal field in Oklahoma, on which J. A. Taff had reported in 1899. This area was of interest as much because it contained one of the thickest known sections of Pennsylvanian rocks as for its coal. In Utah, E. M. Spieker mapped in the Wasatch Plateau, A. A. Baker mapped in the northern part of the Green River Desert, and W. H. Bradley spent 4 months mapping erosion surfaces on the north flank of the Uinta Mountains in an effort to resolve the history of Green River time. Other fuels investigations were underway in Montana, where W. G. Pierce and F. S. Parker mapped coal lands in the southeastern part of the State, in part for use in classifying the lands, and in Pennsylvania, where G. B. Richardson completed mapping the Somerset and Windber quadrangles in Somerset County for folio publications. In the only major oil-related field investigation, W. P. Woodring, Ralph Stewart, and Ralph Richards began stratigraphic and structural investigations in the Kettleman Hills area in California. Ralph Arnold had said in 1910 the petroleum possibilities in the area were good; the oil was deep, however, and the discovery well of the giant field was not drilled until 1928.

The demands of the oil industry for basic data on sedimentary rocks had led to the development of a new specialization in geology for which the name "sedimentary petrology" was chosen when a new journal was launched in 1931, and to that development the Survey had contributed. C. S. Ross of the Survey and Professor Paul Kerr of Columbia had established four groups of clay minerals in their joint investigation, and had found that kaolin was not a mineral but a group of minerals. At least three of them, kaolinite, nacrite, and dickite, had similar chemical compositions but different optical properties, x-ray diffraction patterns, and dehydration curves. These three minerals were stable at different temperatures and thus presumably were formed under dissimilar conditions. Ross and Kerr suggested that kaolinite, the most common mineral, was formed primarily by the weathering of feldspathic rocks whereas nacrite and dickite seemed to be hypogene minerals. W. W. Rubey used the advances in clay mineralogy and techniques of investigation in a comparative study of the mineralogy, chemical composition, and physical properties of the fine-grained argillaceous rocks which make up nine-tenths of the Upper Cretaceous rocks exposed on the northwest flank of the Black Hills. The fine-grained argillaceous rocks were of great scientific interest, being the most abundant but least understood of sedimentary rocks; they were also thought to be the source

Grand Teton National Park in Wyoming was established by act of Congress approved February 26, 1929, becoming the 21st national park. In 1898, C. D. Walcott, then Director of the Survey, had urged Congress to establish the park, saying the area "may be more truly called the Switzerland of America than can any other spot known to me." Secretary Wilbur echoed Walcott's thought at the dedication of the park on July 29, 1929, calling the Grand Teton Mountains, "one of the noblest and most spectacular in the world, probably being more comparable with the Swiss Alps than other American mountain ranges." (From R. L. Wilbur, 1929.)

beds of petroleum. Rubey found that the finer-grained noncalcareous shales accumulated more slowly and in deeper water than calcereous shales, and that the finer-grained rocks lost volume and were deformed internally by loading and tilting. He also found that the percentage of soluble bitumens in the rocks varied with tilt or shear but not with depth of load, which led him to suggest the possibility that folding might convert the organic matter in fine-grained sedimentary rocks into oil and then force it into adjacent beds. P. G. Nutting continued his investigation of the bleaching clays and was on his way toward identifying them as the less stable and less completely weathered clay minerals. A new investigation was begun, under the direction of C. S. Ross, by M. N. Bramlette who began a special study of the siliceous sediments of the Monterey Formation in California, one of the major oil-producing formations of the State.

The Metals Section continued to expand and diversify. Several young men were added to the staff, the cooperative projects in Colorado and Oregon extended their investigations, new projects were begun in New Mexico and California in informal cooperation with those States, and both G. F. Loughlin and D. F. Hewett undertook special resource investigations, Loughlin of the carnotite deposits in southwestern Colorado and southeastern Utah in response to a Congressional request, and Hewett, a continuation of his survey of manganese deposits, aided by G. R. Mansfield and J. T. Pardee in Idaho and Montana.

In the Colorado project, then in its fifth year, T. S. Lovering extended the study of the mineralized belt of the Front Range northeastward toward Jamestown. Field work in the Mosquito Range had been completed and preliminary reports prepared by C. H. Behre, Q. D. Singewald and B. S. Butler, and Butler and J. W. Vanderwilt; Vanderwilt then began mapping in the Snowmass area west of the Mosquito Range. In the San Juan area, W. S. Burbank and E. B. Eckel continued mapping in the Ouray-Telluride district and E. T. McKnight began geologic mapping in the Rico district where Whitman Cross had worked in the 1890's. A. H. Koschmann, with whom Loughlin had been working in New Mexico, joined the Survey to carry on the work Loughlin had been doing at Cripple Creek as time permitted. Work was also started toward a revision of the geologic map of western Colorado, making use of Lovering's mapping in the northern part of the Front Range and E. S. Larsen, Jr.'s, work in the San Juan Mountains. To this end, David White spent several weeks in Colorado studying special stratigraphic problems, J. B. Reeside, Jr., and J. S. Williams made a preliminary correlation of Mesozoic rocks, and Professor J. H. Johnson of the Colorado School of Mines and part-time Survey geologist, correlated the Carboniferous rocks.

In Oregon, J. T. Pardee had general supervision of investigations of gold, copper, and mercury resources in the western part of the State and individual studies were made by P. J. Shenon, F. G. Wells and A. C. Waters, and by Eugene Callaghan and A. F. Buddington. In eastern Oregon, James Gilluly had J. C. Reed and C. F. Park, Jr., to assist him in investigating mining districts in that part of the State and in mapping the Baker quadrangle, and R. W. Richards and B. N. Moore made a reconnaissance examination of nonmetallic minerals.

The informal cooperation in New Mexico and California did not involve transfer of funds but assistance by State personnel and supplies. In New Mexico, Sam Lasky, who had also been working with Loughlin, transferred from the State to the Federal survey and continued to map in the Central district. In California, W. D. Johnston, Jr., late of the Water Resources Branch, began a study of the underground geology in the Grass Valley district in the light of developments since Lindgren had mapped the area in the 1890's.

Projects were also continued in Nevada, Idaho, and Montana. In Nevada, H. G. Ferguson continued mapping the Hawthorne and Tonopah quadrangles with the assistance of S. W. Muller, and T. B. Nolan continued the resurvey of the Tonopah district with the assistance of Ian Campbell. Frank Schrader was sent to make a reconnaissance of the mining districts in the eastern part of Nevada. C. P. Ross and Russell Gibson continued mapping in Idaho and Montana.

The Alaskan Branch diverted some of its effort in 1930 from exploration to investigations on behalf of the Alaska Railroad. The completion of the railroad from Seward to Fairbanks in 1923 had been hailed as an historic event in the industrial development of Alaska but the railroad had not lived up to expectations. In 1929, the General Manager of the railroad had asked the Survey for aid in determining what could be done to stimulate mineral development that might contribute tonnage to the railroad but the Survey was unable to do much with the funds available. In 1930, a Senate Select Committee had been appointed to study means of decreasing the railroad deficit, and the Survey made three field studies in areas near the railroad. P. S. Smith examined some of the productive mining camps adjacent to the railroad between Seward and the Willow Creek gold lode districts, F. H. Moffit studied the Kantishna district and nearby country west of the railroad and part of the Bonnifield district east of the railroad, and S. R. Capps investigated the tract on the south side of the Alaska Range from the West Fork of the Chulitna to the Nenana. Gerald FitzGerald and J. B. Mertie, Jr., continued their explorations; FitzGerald mapped in southwestern Alaska north of Bristol Bay, one of the largest unsurveyed tracts in the Territory, and Mertie made a reconnaissance geologic survey of an area between the Yukon and Porcupine Rivers west of the international boundary that was not only unsurveyed but little visited even by casual trappers. In southeastern Alaska, R. H. Sargent mapped parts of Revillagigedo Island and the adjacent mainland, using a base map showing drainage and shorelines that he had compiled from aerial photographs. B. D. Stewart was sent to examine the Taku district east of Juneau to which prospectors had rushed in 1929 following announcement of the discovery of sulfide ores, but could spend little time there after being called as an expert witness in a trial in Seattle.

The Topographic Branch program in 1930 was, unexpectedly, altered by the deepening economic depression. The States were unable to offer as much as had been estimated in the way of cooperative funds, so part of the appropriation restricted to matching cooperative funds could not be used. Federal transfer funds increased, however, so the total expenditures for topographic mapping were about the same as in the preceding year. Unlike former years, when State cooperative funds declined, the amount of small-scale mapping in the Western States did not increase but decreased and the amount of large-scale mapping (1:62,500 or larger) was only slightly less than the year before. Approximately 60 percent of the large-scale mapping was done in the States east of the Mississippi River, in cooperation with the States, for the Corps of Engineers in connection with their flood-control projects, or in connection with the proposed Great Smoky Mountains, Shenandoah, and Mammoth Cave National Parks. Experiments with the photogrammetric compilation of maps were also continued; the map of the Upper Columbia River was completed and progress made on the map of Zion National Park.

The Conservation Branch found, contrary to expectations, that its workload in supervising mineral leasing operations in 1930 increased rather than decreased. Under President Hoover's oil conservation policy that had gone into effect on March 12, 1929, the number of prospecting permits had been reduced from about 17,500 to 5,094, and under Congressional authorization, permits had been extended with a requirement that there be no drilling or production until permitted or required by the Secretary of the Interior. However, both mines and wells were being abandoned and branch engineers were called on to prevent loss or damage to the minerals or mineral-bearing formations, to fight fires in abandoned coal mines, and to plug improperly abandoned oil and gas wells. A major accomplishment was the completion of the first unit plans of development, for the Kettleman Hills North Dome field in California and the Little Buffalo Basin gas field in Wyoming, before expiration of the temporary act on January 31, 1931. The Agricultural Division received fewer applications under the Enlarged- and Stockraising-Homestead Acts and so was able to continue its areal studies in the Colorado Basin region and to begin intensive studies of grazing in the Mono Lake and Owens Valley regions of California.

A deficiency in rainfall, especially in the humid States, added to the farmers' problems in the summer of 1930, and unemployment increased during the summer and fall. Still the election results in November 1930 suggested that the voters had not made up their minds that the Republican administration was wholly to blame for the growing economic plight. Although the Republicans lost heavily, the Democrats did not gain a majority in either house of Congress. The new Congress, however, would be so evenly divided—48 Republicans, 47 Democrats, and 1 Farmer Laborite in the Senate; 218 Republicans, 216 Democrats, and 1 Farmer-Laborite in the House—that the balance of power would rest with the insurgents, and deaths during the 13 months before the new Congress convened could completely alter the picture. In his State-of-the-Union Message on December 3, 1930, Hoover blamed the growing depression on world conditions beyond the control of the United States. "The origins of this depression lie to some extent within our borders through a speculative period which diverted capital and energy into speculation rather than constructive enterprise. Had overspeculation in securities been the only force operating, we should have seen recovery many months ago, as these particular dislocations have generally readjusted themselves. Other deep-seated causes have been in action, however, chiefly the worldwide overproduction beyond even the demand of prosperous time for * * * important basic commodities."

Among the nominations submitted to the Senate for confirmation on December 4 was that of George Otis Smith, Director of the Geological Survey, for a 5-year term as chairman of the reorganized Federal Power Commission. The nomination was confirmed on December 20, and Smith resigned as Director of the Survey on December 22, having served as Director for a few months short of 24 years, nearly half its life, nearly all its second quarter-century.

How had the Geological Survey fared under Smith's leadership? He provided an appraisal of his own stewardship in the introduction to the Survey's 50th annual report. Although Smith called it "A look ahead," it was a reflection on his experience as Director. A comparison of his view of the Survey with that of the Survey administration in 1904 in celebrating the 25th anniversary clearly shows what had happened to the Survey in its second quarter of a century.

The major change was "the degree to which the public domain is administered on a scientific basis," an item not mentioned in 1904. "In the 20 years beginning in 1907," Smith wrote, "approximately a million dollars was spent for geologic work in areas in which the Federal Government owns coal lands. Upon this investment of appraising its property the Government is now collecting between $400,000 and $500,000 a year in royalties from coal mines from Government leases. The Government oil and gas leases have been still more productive, although the chief contribution of this service to the public interest has been the conservation of the natural resources belonging to the people. Even more important, however, than the enforcement of the best economic practices by the Federal engineers is their contribution to the conservation of life and health, both the zinc and coal mines under Federal supervision showing better accident records than other mines in the same States. Larger attention to the Government's real-estate business in classifying the unused public lands and in supervising mining leases would pay good dividends."

In 1929, the Survey published the last of its great monographs, a series begun in 1882, and the last of the major reports on vertebrate paleontology planned by its first vertebrate paleontologist, O. C. Marsh. H. F. Osborn said that the study of the titanotheres of ancient Wyoming, Dakota, and Nebraska had transformed our knowledge of the early Tertiary geology of the Rocky Mountain region, resulted in the development of a method of attacking problems of vertebrate paleontology, provided a convincing demonstration that evolution seldom moves along a single line of descent, and afforded an opportunity to enlarge knowledge of the actual modes of evolution and to revise theories of the causes of evolution and of extinction. By the time the report was published, however, the major emphasis in paleontology had shifted from vertebrates to invertebrates and especially to microfossils. The illustration is a back view of the mounted skeleton of *Brontotherium hatcheri*. (From H. F. Osborn, 1929.)

In regard to topographic mapping, Smith said "The work that produced the small-scale reconnaissance type of map has given place to more and more detailed surveying, with a product that can be used in planning engineering projects. New standards and new methods are constantly improving these maps, which as yet cover less than half the area of the United States." In 1904, the Survey had reported that topographic maps of 26 percent of the country, including Alaska, had been completed and that the maps had proved useful in investigations of water supplies and in railroad and highway construction.

"The investigations of water resources," the Director said in 1930, "which at first sought simply the answer to the agricultural problem presented by the wide expanses of arid land in the West, now serve many purposes. Power furnished added incentive to accurate stream measurement, and the quality as well as the quantity of water available for industrial and municipal use is now found an absolutely necessary subject of study in all parts of the United

States.'' In 1904, the investigations of water resources were still relatively new. The Survey then merely claimed that it had assembled 15 years' data on river discharge for study in relation to precipitation, had studied the physical characteristics of river basins to determine runoff, had stimulated the development of water power by gathering data on streamflow, had gathered data on the irrigable public lands, and was helping to plan the construction of large-scale irrigation projects. Some of the studies projected in 1904 were still, in 1930, in the future.

Smith made no claim for advancements in geology. In 1904, the Survey had stated that the value of its work to the people was best shown by the aid extended in developing the Nation's mineral resources and in forwarding important engineering projects, citing in particular the Leadville investigations, the Lake Superior iron studies, the Appalachian coal-field studies, and the collection and publication of mineral statistics. Perhaps the most revealing statement Smith made was his comment with reference to economic geology that ''It is significant that the demand for intensive study of ore possibilities is most active today in the same mining States, Colorado and Nevada, where the first mining work of the Geological Survey was done, the production of the epoch-making monographs on Leadville, Eureka, and the Comstock, which had as their purpose to meet the anxious desires 'of miners as well as of students of geology and economy.' ''

Smith foresaw a long future for the Survey. ''The present accumulation of unanswered requests for needed work, the embarrassing abundance of untouched problems, and the broad expanse of unoccupied fields afford little basis indeed for any feeling that the activity of the Geological Survey will soon reach any state of diminishing returns.'' The Survey was, according to Smith, ''a fact-finding agency, collecting and presenting the information regarding the country's natural resources necessary for the formulation of a national plan'' and the demand for facts would continue as long as people continued to ''carry on commerce and industry by a more intensive conquest of nature.'' Resources, however, must be used more wisely than in the past ''in the light of better science and better engineering'' and the prospects for winning a more general and more firmly established prosperity would furnish an incentive for applying science to national welfare. In short, he concluded, ''the one hundredth report of the Director of the United States Geological Survey may be expected to be simply a report of progress.'' That confidence that there would be a Geological Survey in 1980 may have been George Otis Smith's greatest contribution to the organization.

President Hoover was committed to the appointment of heads of scientific bureaus from within the Civil Service, and pending submission of a formal nomination, Chief Geologist Walter C. Mendenhall was named Acting Director on December 22, 1930. His nomination as Director was submitted to and confirmed by the next session of Congress. Since becoming Chief Geologist in 1922, Mendenhall had been the Survey's most persistent and outspoken advocate of fundamental research. The change of directors would thus mean a change in direction in more senses than one.

Chapter 12.
Research: Useful to the Social Organism, 1931–1933

> **The normal and proper objective of the research of tax-supported geologic institutions is to acquire facts or establish principles to apply in ways that are useful to the social organism.**
>
> **—W. C. Mendenhall**

Walter Curran Mendenhall became Director of the United States Geological Survey on December 22, 1930, at what, given one set of circumstances, must have seemed the best of times, and given another, close to the worst of times. It was midway in a year when the Survey had received more financial support for its work than ever before, and Congress was about to pass a bill with a still larger appropriation. Ten days before, however, the Bank of the United States in New York City, with 400,000 depositors, closed its doors, and even the most optimistic had to admit that the Nation's economic situation was getting worse rather than better.

Mendenhall was the same age as his predecessor, born in Ohio on February 20, 1871, 2 days before George Otis Smith was born in Maine. Both men had joined the Survey in the 1890's, and both had served first as summer field assistants before becoming full-time geologists. Both had long been involved in Survey administration; Smith had become head of the Section of Petrology in 1906, and Mendenhall took charge of ground-water investigations in 1908. Their greatest differences were perhaps in George Otis Smith's insistence on the practical nature of the Survey's work and Mendenhall's equally urgent stand on the necessity of basic research as the foundation for practical work. There were, however, also differences in temperament. Smith was inclined to be reserved and aloof in manner. He was known as "Dr. Smith" and few there were who dared called him by his given name. Mendenhall had a well-developed sense of humor. He had been one of the original members of the Survey's Association of Ambitious Assistants (which later became the Pick and Hammer Club), and had been a frequent target of their humor because of his interest in golf and prolonged bachelor status. As Director he was always addressed as "Mr. Mendenhall" but otherwise was almost universally known as "Mendy."

In accepting the appointment, Mendenhall wrote to the Secretary of the Interior

> **Insofar as my part in Survey affairs may be effective, it will be directed toward fostering closely coordinated team work, to the end that the products of Survey activities shall continue to be of high quality—since quality is essential to permanent value—and as useful in the public service and in the advancement of geologic and engineering science as we can make them. We hope that our ideals will continue to be what we hope they are now, sane and practical ideals; that we shall not dissipate energy pursuing perhaps temporarily attractive, but impracticable dreams. We shall hope * * * to continue to devote our energies to the advancement of useful knowledge and the permanent welfare of our fellow citizens through our scientific and engineering services.**

He was never deterred from these ideals, and thus, during his administration, despite the depression and the beginning of World War II, the Survey was gradually molded to his vision.

The first 3 years of Mendenhall's directorate were undoubtedly the most difficult. The depression steadily worsened, and the Survey's funds were slashed from a high of $3.1 million to $2.0 million, of which only 70 percent could be used. Cooperative and transfer funds also declined and the Survey faced compulsory furloughs or reductions in force. With the advent of the Roosevelt administration in 1933, Mendenhall himself faced the possibility of being replaced, but expressions of support from outside the Survey forestalled that action. More and more endorsements of the Survey as a research organization were received, and more and more emergency funds were funneled to it, until Mendenhall found that "its specialists and their specialized knowledge in problems of water supply, mapping, geology, engineering, and land classification" were "in embarrassing demand."

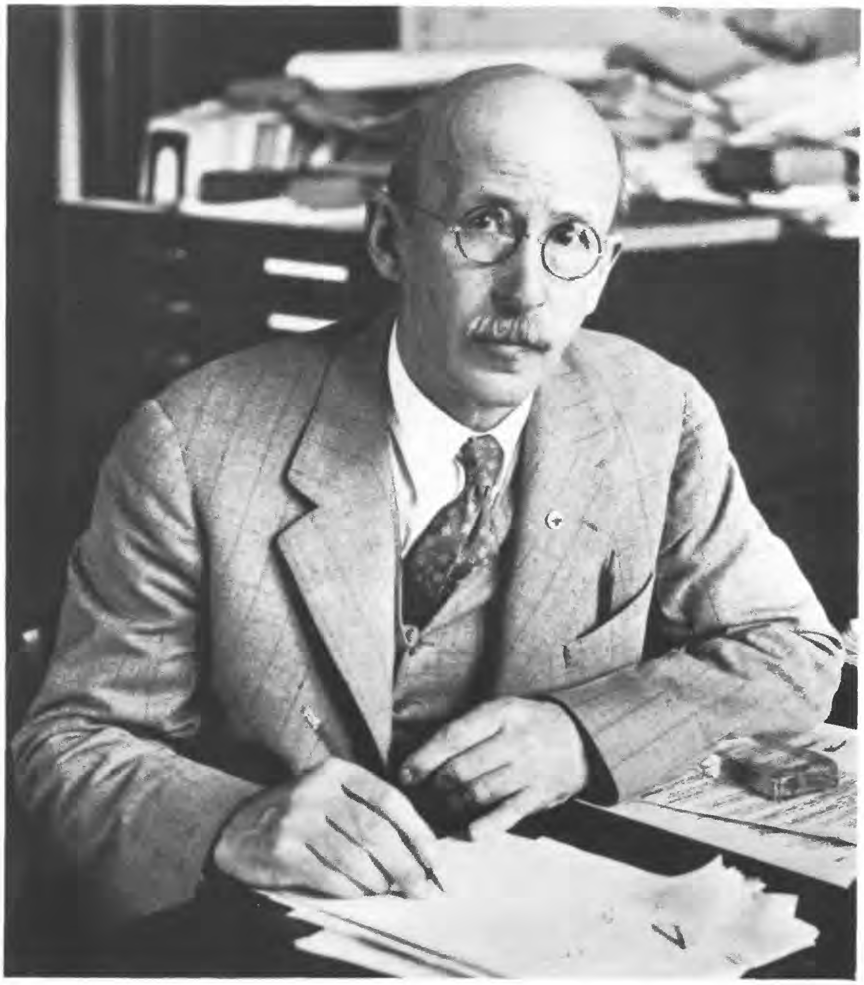
The Interior Department Appropriations Act, providing funds for the Survey's first full year under Mendenhall as Director, was passed on February 14, 1931. The appropriation of $3,141,740, the largest to that date, included a substantial increase for water-resources investigations to enable the Survey to continue the gaging stations being operated in connection with the Army Engineers' investigations that were scheduled to end by October 1, 1931. The Bureau of the Budget had recommended an appropriation of only $650,000, with $575,000 of that amount limited to matching cooperative funds, and $50,000 for the Colorado River gaging stations. The House Appropriations Committee, however, asked the Survey to prepare a revised estimate, dividing the stations scheduled to be discontinued into two groups, those that should be continued as purely Federal stations and those that could be continued on a cooperative basis. The revised estimate of $720,000, with $552,000 limited to cooperative investigations, $48,000 for the Colorado River gaging stations, $45,000 for 120 Federal gaging stations that could not be included in cooperative agreements, and $75,000 for general noncooperative work, was approved by the committee and the Congress. The appropriation for purely Federal investigations placed the program on a new basis after several years of domination by cooperative and repay studies. The new bill also included a 10 percent increase in the appropriation for classification of public lands, a substantial increase for publications, and a proviso that the cost of publishing topographic maps prepared as part of cooperative surveys be borne by both parties.

The general mood in Congress that session, however, could be best described as fractious, and the Survey's former director, George Otis Smith, was one of the bones of contention. His appointment as Chairman of the Federal Power Commission had been confirmed by the Senate, although many senators had opposed it because he was known to favor private development of power while the law required the preference be given to municipal development. The debate had been prolonged and the vote to confirm was 38 to 22, with 35 not voting. The new commissioners were sworn in on December 22, 1930, and on the following day, Chairman Smith and two of the other four commissioners met, notified all employees that their positions had been abolished by termination of the old Commission and all but the general accountant and the solicitor, both of whom had clashed with the executive secretary over what they considered his unduly friendly attitude toward private power interests, that they would be given temporary appointments and would probably be retained. In effect, the three Commissioners fired the general accountant and the solicitor. When Congress reconvened on January 5, 1931, after the Christmas recess, Senator Thomas Walsh of Montana called for reconsideration of the appointments. The Senate voted to reconsider Chairman

Smith's appointment and asked President Hoover to return the resolution of confirmation. This he refused to do, so the Senate put the nomination back on the calendar anyway, voted on February 4 to reject it, and on February 5 asked the District Attorney to institute proceedings to test Smith's right to hold office.

The upcoming International Geological Congress was a victim of the prevailing mood in the U.S. Congress. Traditionally the meeting had been subsidized by the host country, and in answer to President Hoover's request for funds, Senator Hiram Johnson of California had introduced a resolution which the Senate had passed. In the House, however, the resolution was reported out on February 16 and referred to the Committee of the Whole but never placed on the agenda before Congress adjourned on March 4. It was therefore necessary to ask for a postponement of the Geological Congress in order to seek another source of funds.

The Water Resources Branch became the Survey's largest and richest branch in the fiscal year that began on July 1, 1931, with total funds of about $1.5 million and a staff of 285. Several changes were made in branch organization in anticipation of the expanded program. John C. Hoyt became a technical adviser to the branch, and on March 16, 1931, C. G. Paulsen, who had headed the Boise, Idaho, district office was named Chief of the Surface Water Division. On April 8, the Division of Water Utilization was reestablished, its mission to investigate the utilization and control of water and to supervise field administration of power-resource investigations, in particular to take responsibility for international operations and investigations for the Federal Power Commission.

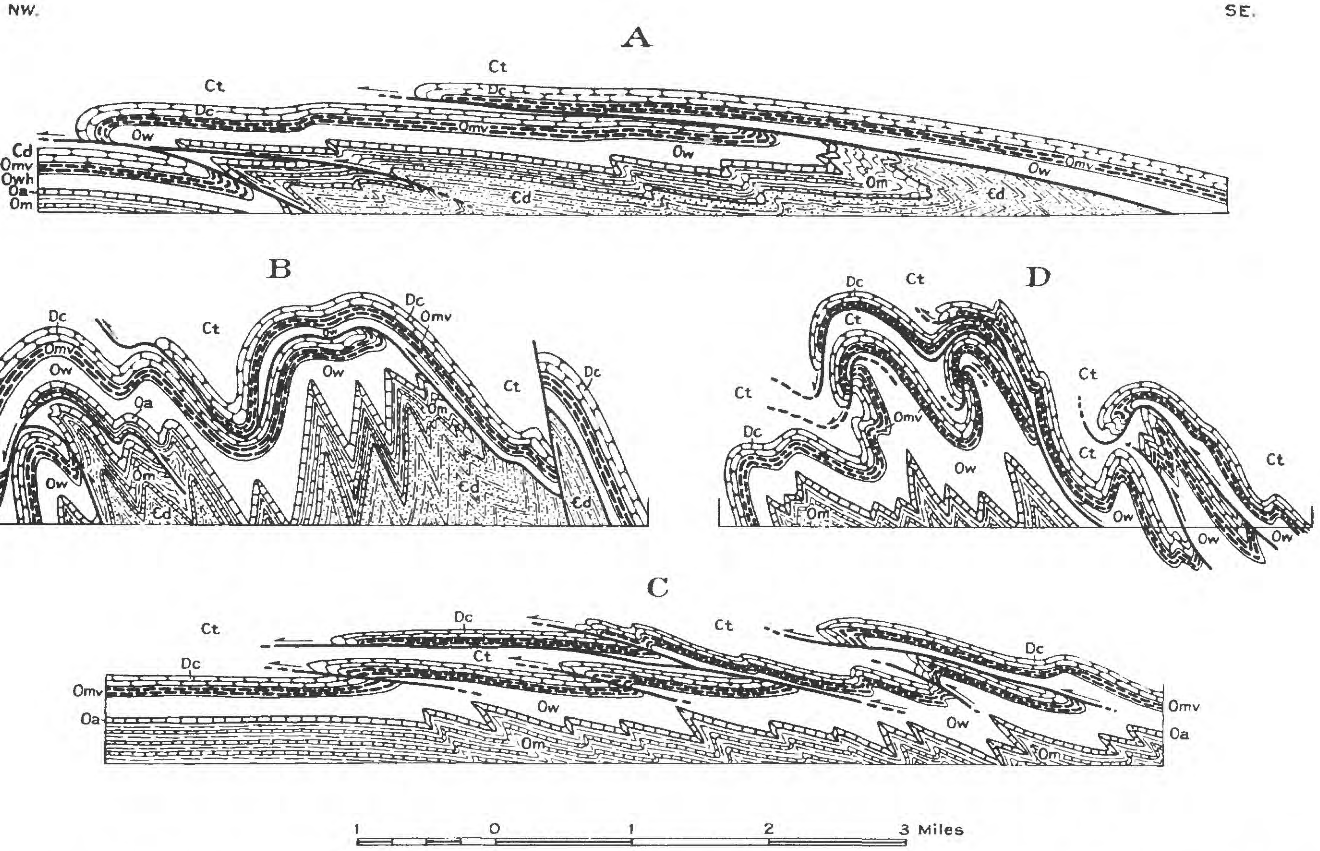


Walter Curran Mendenhall (1871–1957), Chief of the Land Classification Board, 1911–1922; Chief Geologist, 1922–1930; Director of the U.S. Geological Survey 1930–1943. Mendenhall was first associated with the Survey as a volunteer assistant in 1893, became one of the pioneer Alaskan geologists in 1898, and a pioneer in ground-water geology in 1903. He was a strong advocate of fundamental research and his directorate was pivotal in the history of the Survey. Following his retirement in 1943, the *Engineering and Mining Journal* aptly summarized his career: "To have combined outstanding achievement in science with a long record of devoted public service is an accomplishment worthy of any man's respect. To these attainments, Dr. Mendenhall has added another: he provided for the men who have worked under his direction an environment in which scientific research, technical integrity, and practical skill could flourish, to the enrichment of all mankind." (Courtesy of the Library of Congress.)

R. W. Davenport, who had actually been performing these duties since his return to the Survey in 1928, was named head of the new division.

The biggest expansion was in surface-water investigations, and 683 new gaging stations were established. New district offices were opened in Santa Fe, New Mexico, and at Harrisburg, Pennsylvania, as a large cooperative program began with that State. Collection of hydrologic data needed for the forecasting of floods was part of the Pennsylvania program. The Harrisburg office also established four stations in Delaware on streams entering the Delaware River and Bay when industrial interests along the lower Delaware became concerned about the encroachment of salt water. Thus for the first time, the Survey was making measurements in all 48 States as well as in the District of Columbia and the Territory of Hawaii.

Drought and depression altered the ground-water program in 1931, particularly in the Eastern or Humid States, where the drought had been most severe in 1930. Acute shortages in the water supplies of several communities in New York State induced the State Legislature to appoint a Joint Legislative Committee and to appropriate funds to obtain expert assistance. Arrangements were made for the Geological Survey to begin a cooperative investigation on Long Island. A. G. Fiedler started the work pending the arrival of David Thompson. New Jersey resumed formal cooperation with the Survey, and the investigations which had been carried on before were expanded. Pennsylvania suspended the regular survey in favor of a statewide program of observation wells to monitor ground-water levels. In Virginia, where the drought had been especially severe, R. C. Cady, in his second year as a Survey geologist, began a cooperative investigation of ground-water resources in the northern tier of counties nearest Washington. North Carolina began an observation-well program and called on O. E. Meinzer for advice. C. V. Theis completed the field work in south-central Tennessee but that survey was then discontinued for lack of cooperative funding. V. T. Stringfield continued the investigation near Sarasota, Florida. In Nebraska, L. K. Wenzel continued field work in the Platte Valley, drilling a line of test holes and selecting observation wells for periodic measurements. A. N. Sayre began a survey of the ground-water resources in Duval County, Texas, and their relation to the artesian waters in nearby Brooks, Kleberg, and Willacy Counties, and W. N. White and S. S. Nye began a study of the Balmorhea area in western Texas to determine if the withdrawal of ground water for irrigation would reduce the flow of springs that were the chief source of the surface water being used for irrigation. Theis, after completing the field work in Tennessee, returned to his native New Mexico to begin a survey of the ground-water resources in Roosevelt and Curry Counties, immediately north of Lea County where Nye had been working. Most of those counties were either cattle range or farmed without irrigation; in Portales Valley, however, water was pumped from wells, and a considerable increase in pumping made it essential to determine the amount of available ground water. R. M. Leggette and G. H. Taylor began an investigation in cooperation with Salt Lake City to determine the possibility of increasing the municipal water supply from a nearby artesian area, and David Thompson began a new project in cooperation with the Idaho Department of Reclamation, studying the ground-water resources of Malad and Curlew Valleys in Oneida County, across the State line north of Great Salt Lake to determine the possibility of obtaining additional ground water for irrigation and of storing surplus surface water in small reservoirs. A. M. Piper continued to supervise the work in the Harney Basin in Oregon and also took on supervision of the Mokelumne project in California. There it had been decided that additional geological information was needed, and H. S. Gale returned to the Survey and H. E. Thomas transferred from the Geologic Branch to obtain it.



As part of the Survey's newly funded program of fundamental research in the geological sciences, P. B. King mapped the geology of the largely unknown Marathon region in trans-Pecos Texas, on the edge of the Mexican Highlands province where it merges into the Great Plains. He found that structurally the region was a broad dome of Cretaceous rocks, from whose central part the Cretaceous cover had been stripped away, leaving an area of low country in the center in which strongly folded Paleozoic rocks were exposed. The folds, trending northeast and overturned to the northwest, were broken by numerous thrust faults, some of which had displacements of several miles and were themselves folded. The illustration shows his restoration of structural features in the younger rocks of the Dagger Flat anticlinorium, sections A and B in the southwestern part and C and D in the northeastern part. A and C represented the probable structures of B and D after the first folding and overthrusting in the region but before the last folding. (From P. B. King, 1937.)

The Topographic Branch, although its total available funds were about 10 percent less than the year before, mapped more than 29,000 square miles during the fiscal year, the largest area covered in one year since 1912. Even though nearly 40 percent of that area was mapped at the smaller scales of 1:125,000 and 1:250,000, the area mapped at 1:62,500 and larger scales was larger than ever before. Most of the larger scale mapping was done in States that supplied cooperative funds or in connection with the flood control work of the Army Engineers. For the National Park Service, work continued on the photogrammetric compilation of maps of Zion National Park and Bryce Canyon National Park. Planimetric maps of about 3,200 square miles in Michigan and Louisiana were also compiled from aerial photographs, and an experimental project was undertaken, in cooperation with the Army Air Corps, on the use of a new 5-lens camera at high altitudes, which promised to reduce the amount of control needed for photogrammetric work. Both Glenn Smith and C. H. Birdseye, who had left the Survey in September 1929, returned to the Survey. Smith came back in December 1930 to take charge of the Central Division and H. H. Hodgeson was transferred to the Pacific Division to replace T. G. Gerdine, who died on October 31, 1930. Birdseye returned in February 1932 to become a special assistant to the Director.

The most extensive Survey project in Alaska in 1931 was part of an "investigation of mineral and other resources of Alaska to ascertain the potential resources available which will affect railroad tonnage" for which Congress had made a special appropriation of $250,000 in the Interior Department Appropriations Act. Secretary Wilbur assigned the investigation to the Survey, S. R. Capps was put in charge of the project, and several geologists from the Geologic Branch were transferred temporarily to Alaska, among them R. W. Richards, G. A. Waring, C. F. Park, C. P. Ross, F. G. Wells, J. C. Reed, and, during part of the field season, D. F. Hewett as a special consultant.

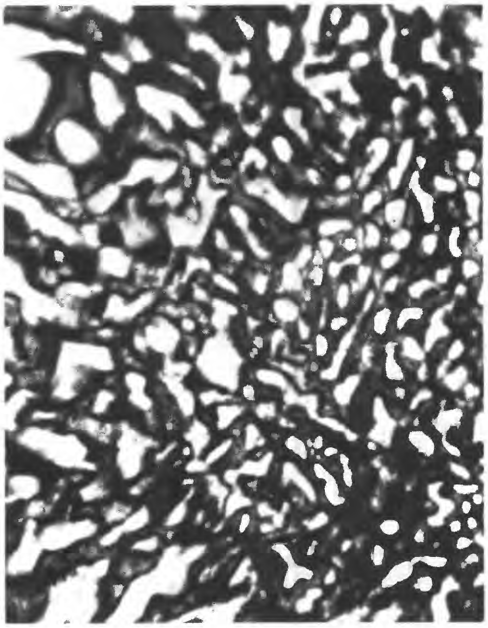
Director Mendenhall, who had been one of the pioneer geologists in Alaska at the turn of the century, joined P. S. Smith in his annual reconnaissance of recent mining developments in the Territory. Other mineral-resources investigations were made in the Yukon region by J. B. Mertie, Jr., in the Taku district by B. D. Stewart, and in the Copper River Valley by F. H. Moffit. Gerald FitzGerald and junior geologist P. A. Davison made a combined topographic and geologic reconnaissance of part of the Nushagak region of southwestern Alaska, and C. F. Fuechsel mapped in the practically uninhabited and undeveloped part of the Copper River Valley, while R. H. Sargent, using the drainage base he had compiled from aerial photographs, mapped in southeastern Alaska. Through the courtesy of the Bureau of Mines, C. W. Wright and H. F. Reid made geographic and geologic investigations in the vicinity of Glacier Bay to complete the work begun many years before by the Wright brothers before they left the Survey for the Bureau of Mines and the Geophysical Laboratory.

Director Mendenhall, like Director Walcott, tended to act as his own chief geologist at the beginning of his directorate. Thus there was little change in the Geologic Branch program when T. W. Stanton, Chief of the Branch of Paleontology and Stratigraphy, became Acting Chief Geologist. Because of a decline in cooperative funds, some readjustments were necessary but on the other hand several economic geologists were needed in Alaska to investigate the mineral resources of the Railroad Belt. Fundamental investigations begun the year before were continued and, despite the disappointment of the postponement of the International Geological Congress, a considerable effort went into production of the geologic map of the United States and the preparation of guidebooks.

The Metals Section continued cooperative investigations in Colorado, Nevada, Idaho, Oregon, and New Mexico. In Colorado, priority was given to field work leading to the preparation of a geologic map of the State. T. S. Lovering continued his study of the tungsten and gold deposits of the Front Range and prepared a paper and map showing their relation to faults in the region that was issued by the Colorado Scientific Society as an aid to prospecting and mine development. B. S. Butler, Q. D. Singewald, and J. W. Vanderwilt mapped on the west side of the Front Range and C. H. Behre in the mines at Leadville. Burbank concentrated on the State geologic map. In Idaho, the cooperative project was limited to P. J. Shenon's mapping in the drainage basin of the South Fork of the Clearwater River and south of the divide between that stream and the Salmon River, which included the Elk City, Orogrande, Buffalo Hump and Tenmile districts. In Oregon, B. N. Moore began the detailed study of the nonmetallic resources of the eastern part of the State, Eugene Callaghan and A. F. Buddington did further work in the mineralized areas of the Cascade Mountains, and J. T. Pardee examined the gold and platinum placer deposits of the southern coast, which were again of interest because of the uncertain economic conditions. Pardee also spent some time in Montana, examining the gold placers in the Pioneer district near Helena, manganese deposits near Philipsburg, vermiculite near Hamilton, and phosphate areas in Granite and Powell Counties. Russell Gibson continued his work in the Libby quadrangle in Montana, giving special attention to the gold quartz veins. In California, W. D. Johnston, Jr., spent a second season underground in the Grass Valley district, and in New Mexico, S. G. Lasky spent 5 months in the field in the Bayard area of the Central mining district.

In the eastern part of the country, L. W. Currier completed a study of the structural relations of the lead and zinc deposits in southwestern Virginia in cooperation with the State, and C. S. Ross, Chief of the Section of Petrology, who had become interested in southern Appalachian ore deposits while looking for sources of pyrite during the World War, continued his investigations of

To test N. L. Bowen's recently proposed thesis that albite granites were of hydrothermal origin, James Gilluly studied in some detail the albite granite near Sparta, Oregon, in connection with his study of the mineral deposits of the eastern part of the State. Field relations, microscopic studies, and chemical analyses led him to conclude that the Sparta albite granite had been formed by late magmatic and postmagmatic replacement of an almost completely solidified diorite by solutions probably derived from deeper levels in the mass and in large part guided by brecciated zones in the diorite. In this process, albite replaced andesine and orthoclase, a soda amphibole replaced hornblende, and large quantities of a deep blue quartz were introduced. The photograph shows a brain-coral myrmekite, recognized as a replacement product, in which the dark areas are albite and the light areas quartz. (From James Gilluly, 1933.)



Petrologist C. S. Ross, who had developed an interest in the copper-bearing pyrrhotite deposits of the Ducktown type in the southern Apppalachian region during the war-mineral investigations, attacked the problem of their genesis by the use of petrographic methods. W. H. Emmons had concluded (see page 255) that the deposits at Ducktown, Tennessee, are partly replaced limestone lenses but Ross concluded that they are hydrothermally deposited veins, formed in a series of distinct stages each of which was characterized by a distinct group of minerals, and that the minerals of each successive stage replaced those of the preceding stages. In the photomicrograph, magnetite (dark gray) cuts across remnants of a crystal of pyrrhotite (light gray), showing that the magnetite is later than the pyrrhotite, and the straight parallel boundary lines of the enclosed pyrrhotite indicate that replacement had proceeded along crystallographic directions. (From C. S. Ross, 1935.)

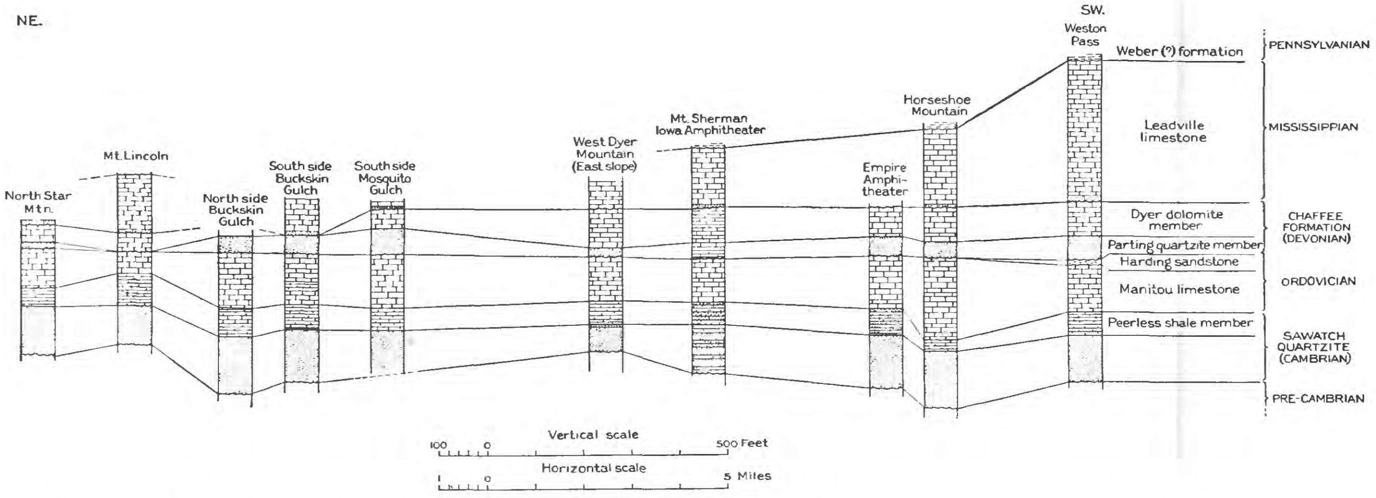
southern Appalachian ore deposits, one of his principal objectives being the maximum use of petrologic methods in connection with field studies in the investigation of ore deposits.

D. F. Hewett was engaged in a special study of the manganese deposits of the United States. The Manganese Subcommittee of the Committee on Industrial Preparedness of the American Institute of Mining and Metallurgical Engineers had been reconvened to bring the conclusions of its 1924 report up to date in accordance with a request from the War Department. In a report submitted to the War Department in February 1932, the committee reaffirmed its earlier conclusion that a war-reserve of manganese ore was vital to insure national defense but increased its estimate of the amount necessary from 600,000 to 680,000 tons. The committee was convinced that circumstances combined against the probable commercial development of the low-grade deposits and (or) complex beneficiation processes. Processes applicable to large low-grade reserves might be developed that would be technically sound but noncommercial in normal times although applicable in times of stress and resulting high prices, such as in a war emergency. The investigations of such processes and their demonstration on an operating scale was obviously not an undertaking for private enterprise but its importance to national defense was unquestionable. The committee therefore definitely recommended concrete research by the proper government agencies to the end that fully demonstrated methods supported by detailed designs and plans be actually in hand on the eve of a war emergency.

The search for another strategic mineral, potash, was successfully concluded in 1931. During the 5-year test drilling program, the Government had drilled 24 test holes, and in 17 had found more than 50 intersections of polyhalite beds of possible economic interest. In 12 holes, the presence of the commercially more desirable sylvite, carnallite, or langbeinite had been detected, and in one a 5-foot bed of sylvite and halite containing more the 30 percent K_2O overlain by a 5-foot bed of halite containing enough sylvite to yield 8.8 percent K_2O. Two other tests had penetrated beds of similar but lower-grade salts that were of possible but more remote commercial interest. Perhaps even more important, the program had made the oil companies and the public in general potash conscious and had stimulated private exploration. The United States Potash Company was already making regular shipments of potash salts from its shaft in Eddy County, New Mexico. Moreover, the cost of preliminary exploration had been greatly reduced by the discovery that careful petrologic study could detect the presence of the commercially more desirable minerals in well cuttings even though they were so soluble that it had seemed improbable that they would be preserved in well cuttings in sufficient amounts to provide a basis for prospecting.

The Fuels Section continued its geologic mapping and stratigraphic studies, for the most part in Western United States. C. H. Dane and W. G. Pierce began mapping the Tertiary and Upper Cretaceous formations of the High Plains of eastern Colorado between the Platte and Arkansas Rivers, while A. A. Baker continued mapping in the Green River Desert-Cataract Canyon region of Utah, E. M. Spieker in the Wasatch Plateau, and C. B. Hunt in the Mount Taylor region of New Mexico. T. A. Hendricks and C. B. Read mapped coal deposits in part of the southeastern Oklahoma coal field and F. S. Parker mapped coal fields in Custer County, Montana. W. P. Woodring and his colleagues continued their intensive investigation of the middle and south domes of the Kettleman Hills field in California, and, in a new venture, N. W. Bass began a cooperative investigation of shoestring sand bodies and related oil pools in Greenwood County, Kansas.

After the 5-year grant of private funds to the American Petroleum Institute expired at the end of June 1931, the Survey took over support of Parker



In the resurvey of the Mosquito Range in Colorado, more detailed stratigraphic studies, made to determine the amount of displacement along some of the notable faults and the depth to strata that had contained valuable ore deposits in the larger mining districts, demonstrated the existence and widespread distribution of rocks of Devonian age and led to a revision of the stratigraphic column in central Colorado. The illustration shows the lateral relations and variations in thickness of the pre-Pennsylvanian Paleozoic formations. Here the Parting Quartzite, named by S. F. Emmons in 1882 and considered by him to be Silurian, and the lower part of the Leadville Limestone, which he had called the Blue Limestone and Carboniferous, was assigned to the Chaffee Formation of Devonian age as its Parting Quartzite and Dyer Limestone Members. The upper part of the Leadville (Blue) Limestone was found to be separated from the lower part by an unconformity and to be of Mississippian age. (From J. Harlan Johnson, 1934.)

Trask's study of source rocks of petroleum, and Taisia Stadnichenko joined the Survey to continue work with David White on the origin of petroleum. P. G. Nutting continued his investigations of the porosity and permeability of oil sands, thermal dehydration of minerals, and the absorptive power of clays as a factor in their capacity to bleach or clarify oils.

The volcanologic program in Hawaii expanded in 1931. Topographer E. W. Wingate established four new permanent triangulation points as a base net for observations at Halemaumau and three temporary points on the rim of the pit for map control. Work was begun on a 1,000-foot contour map of the ocean floor around the entire Hawaiian ridge. A. E. Jones constructed a seismologic laboratory at the Volcano Observatory, and Howard Powers completed the detailed mapping of the lava flows of Hualailai Volcano and began petrographic studies. T. A. Jaggar contributed a chapter on the mechanism of volcanoes of the "Physics of the Earth" volumes published by the National Research Council. The only other Survey contibution to the first four volumes published in 1931 was a reprinting of C. E. Dutton's 1889 paper "On some of the greater problems of physical geology."

In the Conservation Branch, the supervision of oil and gas operations became so different from supervision of mining operations that at the beginning of the fiscal year the Mineral Leasing Division was divided into two units, a Mining Division under H. I. Smith and an Oil and Gas Leasing Division under H. B. Soyster. Soyster was a graduate of the University of California in 1922, who had joined the Bureau of Mines as a petroleum engineer in 1924 and then been transferred to the Survey in 1925. The Mineral Leasing Division supervised operations under 341 leases, 451 permits, and 91 licenses on coal, potash, sodium, phosphate, and oil shale lands that produced minerals valued at $7.88 million during the year. The division also supervised mining operations on Indian lands, chiefly in Oklahoma. Under the Hoover administration's oil-conservation policy, production from the public lands had declined as the number of wells shut in increased, fewer wells were completed to production, and permits were cancelled or relinquished. The crude-oil industry was in a state of shock because of the discovery of 27 major oil fields between 1928 and 1930, and State authorities were grappling with the problem of controlling overproduction when the East Texas field was discovered in October 1930. The discovery well had a daily initial flow of only 300 barrels but large gushers were completed in succeeding months in neighboring areas so that by the summer of 1931 the daily flow was about 900,000 barrels and the potential flow was greater than world demand. Much of the oil was sold for 10 cents a barrel, some for only 2 1/2 cents. In August 1931, following a strong statement by President

Hoover, the Governors of Oklahoma and Texas closed the Oklahoma City and East Texas fields, the latter under martial law, and in September, the Governors of Oklahoma, Kansas, and Texas signed the oil compact. An Oil States Advisory Committee called for an interstate agreement, with the creation of a joint Federal-State fact-finding body to forecast demand, recommend crude-oil production, and allocate it among producing States and imports. Secretary Wilbur designated the Survey as the Federal representative. The Mineral Classification Division was swamped by a 30 percent increase in the number of classification cases, most of them concerned with oil and gas lands, while the Agricultural Division received 18 percent fewer classification cases and was able to continue its studies of agricultural utility and grazing conditions. The Power Division made river surveys in Arizona, Oregon, Montana, and Wyoming and examined dam sites in Oregon, Washington, and Montana in connection with power projects.

The report of the Garfield Committee on the Conservation and Administration of the Public Domain was submitted to the President on January 16, 1931, but was not sent to Congress until the new Congress met in December. The general conclusions of the committee were as follows: (1) "All portions of the unreserved and unappropriated public domain should be placed under responsible administration of regulation for the conservation and beneficial use of its resources; (2) Additional areas important for national defense, reclamation purposes, reservoir sites, national forests, national parks, national monuments, and migratory bird refuges should be reserved by the Federal government for these purposes; (3) The balance of the public domain, valuable chiefly for forage should be given to the States if and when they were prepared to accept it and provide administrative control of use; (4) In States not accepting such a grant of the public domain responsible administration or regulation should be provided." The committee also recognized that

> **the Nation is committed to a policy of conservation of certain mineral resources. We believe the States are conscious of the importance of such conservation, but that there is a diversity of opinion regarding any program which has for its purpose the wise use of those resources. Such a program must of necessity be based upon such uniformity of Federal and State legislation and administration as will safeguard the accepted principle of conservation and the reclamation fund.**

The committee further concluded that when such a program was developed and accepted by any State or States, those resources should be transferred to the States, except when lands were reserved for national defense or other purposes by the Federal Government. The committee went on record that the "present conservation policy of reclamation should be continued."

In November 1931, a month before the report went to Congress, a National Conference on Land Utilization met in Chicago, called by the Secretary of Agriculture at the suggestion of L. C. Gray of the Division of Land Economics of the Bureau of Agricultural Economics. Gray, who had a doctorate from the University of Wisconsin, was close to Henry C. Taylor and Benjamin Hibbard who had been so influential in developing agricultural economics as a field of professional specialization and public service. The conference disagreed with the recommendations of the Garfield Committee on the subject of forage lands and reclamation. Agricultural experts were then trying to find a way to deal with farm surpluses and were skeptical of further expansion of agriculture by reclamation of arid lands at high cost.

In December 1931, however, Congress was far more concerned with the economy than with conservation. The United States was then going into the third, and perhaps the most cruel, year of the Great Depression. There were anywhere from 8 1/2 to 17 million unemployed, depending on the statistician, and for most of those who were still working, salaries and wages had been sharply reduced. In September 1931, England had gone off the gold standard and several other nations soon followed suit. The American banking system was seriously affected, especially those banks which had invested heavily in foreign securities, and in September and October more than 800 banks had closed. Gold was being hoarded in increasing amounts and it seemed possible that the United States would also be forced to abandon the gold standard.

In the 13 months between the election of November 1930 and the convening of the first session of the 72d Congress in December 1931, several members had died; in the special elections to fill the vacant seats the Democrats reversed the results of the 1930 election and achieved a small majority in the House. The Senate, however, remained at least nominally Republican. John Nance Garner of Texas, a member of the House since 1903 and the ranking Democrat on the House Ways and Means Committee in the 71st Congress, was elected Speaker. The organization of the House by the Democrats also meant a change in committee chairmen. The new chairman of the House Interior Appropriations Subcommittee was 73-year-old Edward Taylor of Colorado, who had been elected to the House in 1908 as an avowed opponent of "Pinchot conservation" and who by seniority had become the most influential member of the House from the public-land States. Taylor had maneuvered the Stockraising Homestead Act through the House and had opposed the Mineral Leasing Act, and, in fact, all efforts for Federal management of natural resources. The new chairman of the House Public Lands Committee was John M. Evans of Montana, a former judge of a police court, one-time Land Office registrar and mayor of Missoula, who had been elected to the House in 1912. Sam Rayburn of Texas, also elected to the House in 1912, became chairman of the House Committee on Foreign and Interstate Commerce, which, under Hoover's influence, had handled much of the legislation concerning topographic mapping. Evans served only one term as chairman of the Public Lands Committee, failing to be renominated in 1932, but Taylor and Rayburn both served in the House until their deaths, Taylor in 1941 and Rayburn in 1961.

The Senate received the nomination of Walter Curran Mendenhall as fifth Director of the Geological Survey shortly after it convened and confirmed it on December 21, 1931. A day later, it received with equanimity the news that its suit to prevent George Otis Smith from serving as Chairman of the Federal Power Commission had failed. Beyond that and the always essential appropriation bills, however, there was little that directly affected the Survey. A bill to provide for Federal mangement of the public rangelands was passed by the House but failed to pass in the Senate, and both houses passed the bill authorizing reorganization of the Executive Branch.

Director Mendenhall made his first appearance before the House Appropriations Subcommittee on the Interior Department on January 5, 1932. In a departure from previous custom, he brought with him the Chief Topographic Engineer, the Chief Hydraulic Engineer, and the Chief of the Conservation Branch as well as the Chief Clerk and a 60-page justification of the Survey's requested appropriation. Secretary Wilbur, in an earlier appearance before the committee, had already stated that "The Geological Survey performs important functions as a unit of the Interior conservation organization. It is the Federal geological authority. * * * It is the recognized authority on the facts about available water supplies, both surface and underground, essential to any well planned development, but becoming more widely recognized as necessary in the settlement of the country and the growth of cities. * * * It has to do with industrial and domestic water supply, flood control, irrigation, water power, and so on. * * * So geology is coming into its own, whether it is building a dam, putting in a mine, or controlling a flood."

A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., who mapped several thousand square miles and measured numerous sections in the Colorado Plateau region of Utah, Arizona, New Mexico, and Colorado in connection with the classification of the public lands, made a more definitive interpretation of the Jurassic stratigraphy of that region in which earlier correlations had diverged widely because distinctive fossils were rare and formations were deceptively similar in lithology. The photograph shows the three members of the Glen Canyon Group near the head of Indian Creek in Utah: the massive Wingate Sandstone at the base, the Kayenta Formation, with its distinctive bedding, in the middle, and the massive Navajo Sandstone forming the high dome. The name Kayenta was used for beds previously correlated with the Todilto Limestone of New Mexico, which was younger than the Navajo at its type locality. Although the Survey designated the age of the Glen Canyon Group as Jurassic(?), the authors suggested that the Wingate and Kayenta might ultimately prove to be Triassic, a suggestion confirmed during the uranium exploration of the 1950's. (From A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., 1936.)

The appropriation requested for the Geological Survey for the fiscal year beginning July 1, 1932, was $2,904,000, or $237,740 less than the appropriation for the year underway. The largest single reduction was $164,000 in the appropriation for topographic surveys restricted to matching cooperative funds. It was expected that $152,000 of the funds restricted to cooperative topographic surveys in the year underway would be unallotted at the end of the year, not so much because of lack of cooperative funds from States but because of the requirement in the 1932 act that the cost of engraving and printing maps be included in cooperative projects. The cost of engraving and printing ordinarily was not incurred in the same year as the field work; moreover, cooperative agreements already in effect had not included such costs, and there was no way of knowing whether State legislatures, which did not all meet annually, would agree to the extra costs. As the Survey could not by law spend more than 50 percent in a cooperative survey, it had solved the problem by undermatching cooperative funds by an amount equal to the costs of engraving and printing, which were then paid from general funds. The other large reductions were in publication funds. For the other items, the requested appropriation was the same as the current-year appropriation although already there were problems apparent with regard to the appropriation for water-resources investigations. At the time of the hearings, the States had already offered $35,000 more in cooperative funds than the amount provided in the appropriations request. Moreover, the Corps of Engineers had asked the Survey to revive and maintain some of the 200 abandoned gaging stations from which it wanted records in connection with its work on flood control and navigation. The Corps was willing to transfer funds for that purpose but the Survey thought it had made an agreement with the committee to sever relations with the Corps. This committee, however, had no objection to the Survey's accepting the transfer funds.

The House Appropriations Committee recommended that the Survey appropriation be cut $624,500 below the estimate because of "a marked decrease in requests from States for cooperative work in connection with topographic surveys and stream gaging," which was contrary to the facts presented to the committee, and because of "the belief of the committee that investigation, research, and classification work should be reduced to a minimum under present economic conditions." The major reductions proposed were $250,000 for topographic surveys, $119,500 for stream gaging, $50,000 each for geologic surveys and fundamental research in geologic sciences, but no item escaped the knife. The committee concluded that a careful examination of the various items for the Geological Survey convinced the committee that the service would not be crippled by the reduction."

Congressman Temple attempted to obtain an increased appropriation for topographic surveys while the Survey appropriation was under consideration in the House, noting that more cooperative funds were available than had been expected. The justification for fundamental research, however, had attracted the attention of other members of the House. The justification stated that the subject for investigation might be closely connected with the problems of industry, giving promise of immediate practical results, or "utterly remote from the business world, such as tracing the ancestry of the modern horse back through the ages to the little 5-toed creature of Eocene time." It also pointed out that "while no one can predict the importance of the results * * * past experience justifies the confidence that something of value will come" and pointed out that scientific research had revolutionized industry and the American style of living. Nonetheless the "little 5-toed creature of Eocene

In a reconnaissance examination of a large area of the High Plains of eastern Colorado, C. H. Dane, W. G. Pierce, and J. B. Reeside, Jr., recognized some of the finer divisions of Cretaceous stratigraphy identified by N. W. Bass and others in their oil and gas investigations in western Kansas. The Cretaceous formations of Colorado had originally been defined in 1862 by F. B. Meek and F. V. Hayden as the Niobrara and Benton. The Fort Hays and Smoky Hill Members of the Niobrara had been recognized in Kansas in 1893 and 1896, but G. K. Gilbert's stratigraphy of 1896, in which he replaced the Benton with the Graneros, Greenhorn, and Carlile Formations, had been generally accepted in Colorado. The photograph shows the contact (about 2 feet above the hammer) between the Fort Hays Member of the Niobrara and Bass's Codell Sandstone Member of the Carlile. (From C. H. Dane, W. G. Pierce, and J. B. Reeside, Jr., 1937.)

times" became the symbol of "useless" science in 1932 that "birds with teeth" had been in the days of John Wesley Powell. Congressman John Ketcham of Michigan concluded that inasmuch as the rocks had been there for thousands or even millions of years, the Survey's geologic investigations were not pressing. The House accepted the recommendations of its Appropriations Committee.

The Senate Appropriations Committee recommended restoration of part of the cuts in topographic surveys and water-resources investigations. The Senate itself, however, rejected its committee's report and demanded an overall 10 percent cut in the House bill so an additional $98,500 was cut from the appropriations for administrative salaries, geological surveys, fundamental research, volcanologic surveys, Alaskan mineral resources, and mineral-leasing enforcement. Secretary Wilbur protested in vivid if somewhat unscientific terms that the Senate cut was "just as if you took a chicken and pulled out all of its wing and tail feathers and expected it to fly" when the House had already damaged the Survey "so that it would just creep." Despite his protest, the bill, approved on April 11, 1932, provided only $2,181,000 for the Survey, less than 70 percent of the appropriation for the year that would end in about 2 months.

A few days later the National Academy of Sciences expressed a somewhat different view of the Survey. Its Director, W. C. Mendenhall, was elected one of the 15 new members permitted by the rules, Arthur Keith was elected Treasurer, and David White was awarded the Mary Clark Thompson Medal for most important service to geology and paleontology.

Secretary Wilbur reaffirmed his support of the Geological Survey after passage of the Economy Act of June 30, which called for further reductions, compulsory retirements, impounding of 8 1/3 percent of salary funds, and restrictions on filling vacancies, including written authorization from the President himself. The Economy Act also permitted transfers between appropriations to permit retention of employees and Secretary Wilbur transferred $284,000 from the appropriation for road and trail construction in national parks to the Survey.

Conditions were grim as the Survey began its 53d year, and in many ways were reminiscent of those that prevailed in 1894 when Charles D. Walcott succeeded John Wesley Powell as Director. In 1894, with a depression only about a year old, Washington had been besieged by 17 armies of the underprivileged

After two seasons reexamining and mapping the coal beds across the southern part of the San Juan Basin in New Mexico, C. B. Hunt made a brief reconnaissance of the geology of the Mount Taylor volcanic region, part of the southern flank of the basin, which C. E. Dutton had studied in 1884. Hunt found that the first eruptions were probably those of Mount Taylor Volcano itself in Miocene time. Those eruptions were followed, probably in the Pliocene, by a large number of basalt sheets erupted by small volcanoes distributed around Mount Taylor on erosion surfaces cut around the Mount Taylor cone, most of them after Mount Taylor had become quiescent. Streams have since cut downward nearly 2,000 feet so lava sheets now cap high mesas and in some places the old volcanoes are marked only by isolated necks. The photograph is a view looking northeast, across an erosion surface in Lobo Canyon, toward Mount Taylor. (From C. B. Hunt, 1938.)

In 1931, Congress appropriated funds to assist the struggling Alaska Railroad by an investigation of natural resources that would affect railway tonnage. The Secretary of the Interior assigned the investigation to the Survey. Ten projects, selected on the basis of Survey knowledge of the area, were undertaken because they promised to disclose valuable mineral deposits that, if found, would attract private enterprise for development in the near future, and would likely afford considerable tonnage to be hauled by the railroad. Five of the 10 projects involved examinations of areas likely to be principally valuable for gold. Among them was the Willow Creek gold lode district, which included the Lucky Shot mine and camp and the War Baby mine shown in the photograph. (From J. C. Ray, 1933.)

seeking relief, and the largest had been dispersed after its leaders were arrested for walking on the Capitol grass. In 1932, veterans of the World War came to Washington at the end of May with the announced intention of remaining until Congress authorized full cash payment of veterans' bonuses. Most of them left in mid-June after the Senate defeated the measure. When Washington police tried to evict the remainder, four persons were killed and President Hoover called out Federal troops and tanks to complete the eviction. In 1894, the Democrats, after only a brief and partial return to power, had been turned out of office in the midterm elections. Similarly, the Republicans had lost heavily in the 1930 elections although they were not turned completely out of office. But there the resemblance ended. By the Presidential election in 1896, after 3 years of depression, the economy had begun to improve, the Republicans claimed the credit, and the Republican candidate was elected President. In 1932, however, there had been no change in the downward trend of the economy and there was little hope of a Republican victory in November. The Republicans nominated President Hoover for a second term; the Democrats chose Governor Franklin D. Roosevelt of New York. Both party platforms called for a sharp reduction in government expenditures, a balanced budget, and U. S. participation in an international monetary conference.

In the fiscal year beginning July 1, 1932, the Conservation Branch of the Survey, which had received the smallest cut in funds, was able to adjust to the reduced appropriation as the number of land-classification cases received declined by almost 19 percent from the preceding year. In fact, the Mineral Classification Division made progress in reducing its backlog, and the Agricultural Division was able to complete its field studies in northeastern Nevada, to continue its intensive studies of grazing lands in the Mono Lake and Owens Valley regions in California, and to prepare a land classification report and map for western Colorado showing irrigated and dry-farming land, range types, and aggregate forage resources as compared with livestock population. The Power Division continued its river surveys in Oregon and Washington and examined several dam sites, determining depth to bedrock at two of them by geophysical methods. The Mining Division supervised operations in an increased number of properties, but the production of coal and phosphate declined, and only that of potash increased. The Oil and Gas Leasing Division was preoccupied with the development of unit plans; departmental approval was obtained for the unit plan for the Pitchfork field in Wyoming and work was begun on a plan for the Middle Dome of the Kettleman Hills field in California.

The program of the Water Resources Branch was not unduly affected by the cut in appropriation for its total funds for the year were almost the same as those for the preceding year. Stream gaging was done in 48 States, the District of Columbia, and the Territory of Hawaii, and the number of river-measurement stations increased to 2,801 at the year's end. Ground-water investigations in 19 States and the Territory of Hawaii included some new objectives. In Michigan, for example, ground water was needed to fight forest fires. The Michigan Forest Fire Experiment Station had developed power equipment for fighting forest fires, which were becoming more hazardous as the drought continued. The equipment consisted primarily of a truck-mounted water tank that could be filled or emptied by using a small reciprocating pump driven by a gasoline engine. The water to fight fires was obtained from wells put down by jetting with water from the tank. The Michigan Geological Survey sought the cooperation of the U.S. Geological Survey in determining where water in sufficient quantities could be found at depth of 20 feet or less in regions subject to forest fires, and S. W. Lohman spent the summer surveying conditions in Roscommon County. In Utah, R. M. Leggette began an investigation of ground-water conditions in Ogden Valley in relation to the flow of the Ogden River as the basis for settlement of conflicts between those who used surface water for irrigation and the city of Ogden, which obtained nearly all its municipal water supply from artesian wells in the valley. The conflicts arose because during the summer and fall of most years the flow of the river was augmented by ground water returned to its tributaries from the sediments in the valley and by water that seeped into its channel as the river passed through Ogden Canyon. Regional ground-water investigations were continued in New York, where David Thompson and Francis Wells of the Geologic Branch began work; in Virginia, where R. C. Cady began work in the Shenandoah Valley; and in Florida, where V. T. Stringfield completed work in the Sarasota area and A. G. Fiedler supervised the exploration of artesian wells to determine the location of leaks and of water-bearing zones yielding salt water and water of the highest quality. Lohman, after completing work in Michigan, began an investigation near Elizabeth City, North Carolina, which obtained its water supply from the Pasquotank River but also wanted a ground-water supply. In Texas, W. N. White and A. N. Sayre began work in the San Antonio area to determine the capacity of the reservoir in the Edwards Limestone and the amount of water that could be withdrawn annually without serious depletion, and Penn Livingston began work in Kleberg County where ground water was the only trustworthy source of water supply and, although deep artesian wells in all parts of the county yielded fresh water, the artesian head was declining and good water could be obtained from above or below the artesian fresh-water horizon in only a few places. C. V. Theis continued the investigation in Curry and Roosevelt Counties, New Mexico, and extended it into Lea County where S. S. Nye had previously worked. On the Pacific coast, A. M. Piper made a reconnaissance of the Walla Walla Basin in preparation for a new project while the field work in the Harney Basin was completed, and in Hawaii, H. T. Stearns completed field work on Oahu.

Field work in the Geologic Branch was limited owing to the decline in Federal and State funds, but except for the retirements of M. R. Campbell, E. O. Ulrich, and F. C. Schrader under the provisions of the Economy Act, the staff was maintained, and a record number of reports and maps were in preparation. Eighteen members of the Branch contributed to a volume on the ore deposits of the Western States published by the American Institute of Mining and Metallurgical Engineers to honor a former Chief Geologist, Professor Waldemar Lindgren, on his 70th birthday, and others, notably David White, contributed to the second edition of the highly regarded "Treatise on Sedimentation," sponsored by the National Research Council, and edited by Professor William Twenhofel. Work continued on the geologic map of the

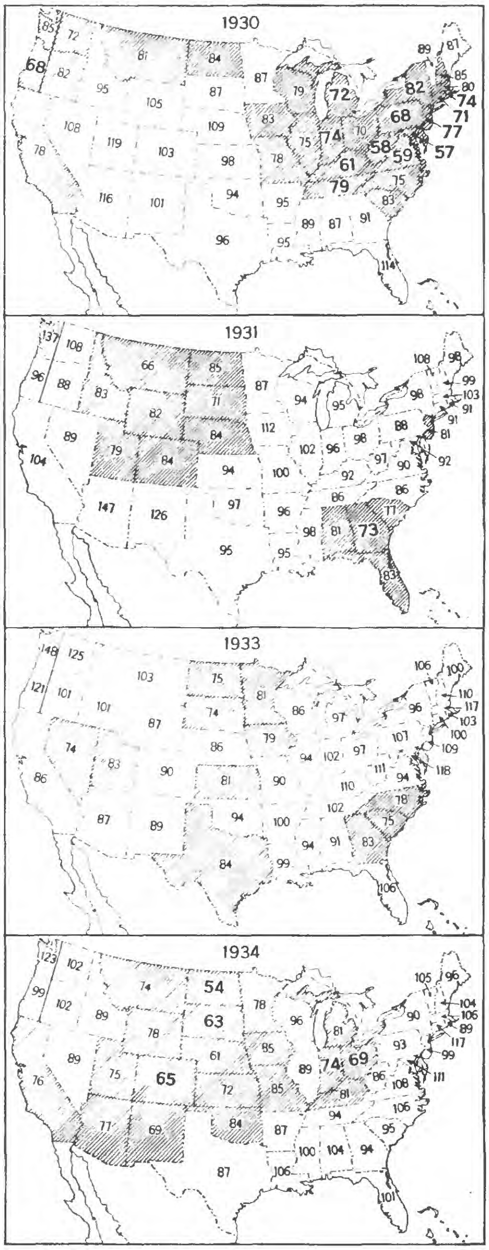
United States and guidebooks for the International Geological Congress, rescheduled for July 1933, and Arthur Keith began compilation of a geologic map of Maine, to be published by the State.

One of the most significant events of the year was the adoption of a report on the classification and nomenclature of rock units, prepared by J. B. Reeside, Jr., and W. W. Rubey under the supervision of H. D. Miser, by the joint committee of the American Association of State Geologists, the American Association of Petroleum Geologists, the Geological Society of America, and the U.S. Geological Survey. The new stratigraphic code was the first attempt since the turn of the century to deal with the subject in a comprehensive fashion. The code was published under the authorship of of 14 geologists, the 12 members of the joint committee and Reeside and Rubey, listed in alphabetic order, and became informally known as the Ashley code. It excited far less controversy than had earlier attempts. As the authors noted, uniform procedure in stratigraphic practice was essential, the greatest aid to uniformity was regulation, and although regulation would restrict an individual's freedom of action, general acceptance would be beneficial.

Much of the field work of the Geologic Branch in 1932 was done by the Metals and Fuels Sections. James Gilluly began a study of the geology and ore deposits of the Ajo district in southern Arizona. The district was known chiefly for its importance as a producer of copper but the district and its surroundings offered unusual opportunities for geologic investigations of many kinds. T. B. Nolan began a resurvey of the Eureka district in Nevada, one of the three great districts chosen for special study by the Survey's first Director in 1879 but not restudied since that time. Several smaller mining districts in Nevada were also studied, the Tuscarora and Mountain City by Nolan, and the Chief, Delamar, and Searchlight districts by Eugene Callaghan. The cooperative program in Colorado was continued although curtailed owing to the decrease in funds. In Idaho, P. G. Shenon and John C. Reed mapped in the Buffalo Hump, Elk City, and adjoining districts, and L. W. Currier spent 2 months in the Yellow Pine district in the Boise Basin. The Fuels Section had field work underway in Arkansas, Montana, Colorado, Utah, and California but none for extended periods. In Arkansas, H. D. Miser continued his studies of the Ouachita Mountains. In Montana, F. S. Parker extended the detailed mapping of the coals beds of Custer County and W. G. Pierce and C. B. Hunt made a reconnaissance survey of parts of Hill, Chouteau, and Liberty Counties. C. H. Dane and Pierce completed their mapping in the High Plains of Colorado, and in Utah, A. A. Baker did the field work necessary for preparation of a preliminary structure contour map of southeastern Utah, and E. M. Spieker some additional mapping of part of the Wasatch Plateau with special reference to coal. In California, W. P. Woodring and his colleagues began mapping in the San Pedro Hills and did some additional work in the Kettleman Hills area.

The most intense earthquake in Western United States in many years and probably the second most severe shock in Nevada since its settlement occurred near Cedar Mountain on December 20, 1932. The shock was perceptible over an area of 400,000 square miles but did very little damage. It did, however, provide considerable geologic information because the pattern of faults and displacements indicated the direction of earth movement. Fortunately, Eugene Callaghan was still in the field in Nevada at the time and was able to begin a field investigation within a few days. Unfortunately, heavy snows forced suspension of the field investigation after a few weeks.

Despite the drastic cut in its appropriation, the Alaskan Geology Branch was able to undertake a close-to-normal field program in 1932. Investigations on behalf of the Alaska Railroad were continued, by Ralph Tuck and C. P. McKinley in the Curry district, where gold-bearing veins had been discovered, and in the Moose Creek area, where G. A. Waring supervised core drilling of



The growing need for information on water was made more evident by the droughts of the early 1930's. Between 1930 and 1934, a serious drought occurred over some broad region of the United States in each year except 1932. Survey hydrologist John C. Hoyt pointed out that because droughts are caused by deficient and poorly distributed precipitation, high temperatures, and hot winds, which in turn depend on other natural phenomena over which humans have no control, little can be done to modify their occurrence. It is possible, however, to alleviate the economic losses resulting from water shortages by conservation of available water supplies, efficiency in all uses of water, and adjustment of activities that depend on water to available supplies and variations in supplies. To exercise any of these controls, however, complete information is needed about available supplies, their fluctuations, and the possibilities of conservation. (From J. C. Hoyt, 1936.)

coal deposits. S. R. Capps accompanied an expedition organized by the Navy for the main purpose of making an aerial reconnaissance of the shorelines of the Alaska Peninsula and Aleutian Islands. The area was difficult of access and little was known of its geology. Capps was unable to make trips ashore but was taken along on several flights that enabled him to gain some understanding of the region as a whole. Of the other members of the branch, only J. B. Mertie, Jr., did not go into the field, instead beginning preparation of a comprehensive report on the large area west of the international boundary between the Yukon and Tanana Rivers. F. H. Moffit returned to the Copper River Valley to make a reconnaissance geologic map of the Tonsina district which Fuechsel had mapped in 1931, and Fuechsel moved on to map in the headwater region of the Copper River Valley and at points along the Richardson Highway. Gerald FitzGerald began reconnaissance mapping on Kodiak Island, southeast of the Alaska Peninsula, and R. H. Sargent continued reconnaissance mapping in southeastern Alaska.

The Topographic Branch was most severely hurt by the cut in appropriation; its total funds were less than 80 percent of the preceding year's funds, and the area mapped in the field was considerably less than in the preceding year. Only 8,762 square miles were mapped at a scale of 1:62,500, and more than half of that was in Maine, Illinois, and Missouri in cooperation with State agencies. An additional 7,192 square miles were mapped at 1:125,000 and 2,654 square miles in Nevada were mapped at 1:250,000. However, the amount of planimetric mapping prepared from aerial photographs increased significantly, as maps of nearly 8,000 square miles in Michigan, Montana, and Louisiana were compiled. Photogrammetric methods were used to compile maps of 425 square miles in California.

Science became somewhat of a political issue in the waning days of the presidential election campaign when President Hoover declared that progress in the last generation had been due to scientific research, and that if the American system was not destroyed and if scientific research was stimulated, future generations would enjoy the same opportunities as the present generation. Republican hopes of victory had been raised when business seemed to improve in the summer of 1932, the gold drain was reversed, the rate of bank failures slowed, and the stock market showed signs of reviving. But hard times had settled in again by early fall, and in November 1932 Governor Roosevelt was elected President and the Democrats became the majority party in both houses of Congress.

Some people interpreted the results of the election as a repudiation of Hoover's scientific policies as well as his economic policies. Some agreed that research might eventually benefit the economy but thought it should be postponed until the emergency was over. Others thought that a slowing up of research might be a good thing, giving scientists time to assess the meaning of discoveries already made and especially the applications of discoveries. Yet others suggested that scientific and technologic progress offered a basis for prosperity that could not be realized because of the financial system. These proponents of "technocracy" proposed that the price system be based on energy and that scientists and engineers be put in charge of the economy. The idea became very popular in the month following the election but, like Jonah's vine, the idea grew and as quickly withered.

In his last annual message to Congress on December 6, 1932, Hoover reiterated his stand on the importance of maintaining the American system of free enterprise in the future progress of the Nation, particularly in the light of what scientific research might produce. The "continued existence and adequate functioning" of the Government depended on the "maintenance of State, local, institutional, and individual sense of responsibility." The Government should "allow free play of social and economic forces as far as will not limit equality of opportunity and as will at the same time stimulate the initiative and enterprise of our people'' but could ''permit of no privilege to any person or group;'' it should ''act as a regulatory agent and not as a participant in economic and social life.''

> **With the free development of science and the consequent multitude of inventions, some of which are absolutely revolutionary in our national life, the Government must not only stimulate the social and economic responsibility of individuals and private institutions but it must also give leadership to cooperative action amongst the people which will soften the effect of these revolutions and secure social transformations in an orderly manner.**

Congress was more concerned with economy than philosophy. The Federal budget called for a total appropriation of $4.2 billion, a reduction of $0.58 billion below that for fiscal year 1933, and the budget message urged limitation of expenditures in the interest of ''the already heavily burdened taxpayer'' and the ''very integrity of the finances of the Federal Government.'' The proposed cuts were selective rather than across the board.

The budget estimate for the Geological Survey for the fiscal year beginning July 1, 1933, was $2,384,900, some 9 percent more than appropriated for the year underway, but still less than received because of the transfer from national park funds. The estimate posed more than the usual number of problems with respect to cooperative funding because the impoundment by the Treasury of 8 1/3 percent of salary funds, as required by the Economy Act, had reduced the Survey contribution in some investigations to less than 50 percent. (The Comptroller had also ruled that the impoundment applied to State funds deposited with the Treasury for disbursement by the Survey; that decision had been appealed but not as yet resolved.) For topographic surveys, the Bureau of the Budget had approved a total appropriation of $512,000, of which $316,500 was restricted to cooperative surveys, but almost $345,000 had been received in cooperative funds during the year underway and $340,000 was in prospect for the next year. For water-resources investigations, the Bureau of the Budget had approved a total appropriation of $621,400 of which $482,300 was restricted to cooperative investigations. The Water Resources Branch had cooperative funds in the year underway of $580,000, but had had to decline some offers as the amount offered exceeded the total appropriation. Little if any decrease in the next year was expected. Despite the evidence, the House Appropriations Committee, under great pressure to reduce expenditures, cut the appropriations for topographic surveys by $62,000 and for stream gaging by $81,400 because ''existing economic conditions will undoubtedly result in severe reduction in cooperative funds.'' A total reduction of $457,400 below the Bureau of the Budget figure was achieved by the elimination of funds for fundamental research and Alaskan mineral resources, and reductions in other items ranging from 42 percent in the item for classification of the public lands to about 10 percent in funds for geologic surveys and supervision of mineral leasing.

Attempts to increase Survey funds during the House debate were all met with the statement that the amounts provided by the committee were as much as or more than the Survey had in 1927, a statement that was manifestly in error. Finally, Congressman Taylor stated that the committee ''is very sympathetic with the Geological Survey and nearly all of its work, and there is no disposition among the members * * * to cripple or seriously impede or delay their services. But, with all due respect, it sometimes seems to me personally that that bureau has less disposition to properly recognize the serious financial condition of the country and the depleted condition of the Federal Treasury and the absolute necessity of reducing expenditures in this department as well as other departments than it should have. The members of this committee are persistently beseeched to make no reduction for this bureau, and we have not made any that we feel are unjust." The House then approved the committee report as far as the Survey appropriation was concerned.

The Senate took a less rigid stand on the Survey appropriation. The delegate from the Territory of Alaska protested the complete elimination of an appropriation for Alaskan-mineral-resource investigations and the Senate restored an appropriation of $30,000. The Senate also increased the appropriations for supervision of mineral leasing and for publications. To all these changes the House agreed. Senator Hayden also tried to convince the Senate to increase the appropriations for geologic surveys and fundamental research, pointing out the value of geology to the mining industry and noting that Russia and Mexico, "two countries that are supposed to be backward in many respects," spent more on fundamental research than did the United States, but to no avail. The Interior appropriations bill, approved on February 17, 1933, provided the Survey with a total appropriation of $1,992,500, about 9 percent less rather than 9 percent more than the appropriation for the year underway that had been requested.

President Hoover's long-cherished dream of reorganizing the Executive Branch, which had seemed close to fulfillment when Congress passed the Executive Reorganization Act of June 30, 1932, in the end came to nought. The proposed reorganization was contained in a series of Executive orders submitted to Congress on December 9, 1932. They included the establishment of a Division of Public Works in the Department of the Interior, comprising the Survey, the Bureau of Reclamation, and several agencies to be transferred to Interior, such as the Office of the Supervising Architect, the Bureau of Public Roads, and most of the nonmilitary activities of the Corps of Engineers. The General Land Office was to be transferred from Interior to the Department of Agriculture where it and the Forest Service would form a Division of Land Utilization. The Federal Oil Conservation Board was to be abolished and its functions given to the Bureau of Mines. Another transfer of interest was that of the Navy Hydrographic Office to the Coast and Geodetic Survey.

The proposed transfers, especially those of the General Land Office and Engineer activities, were not well received. To become effective, the Executive orders had to be approved by joint resolution; some members of Congress went one step further and filed resolutions to disapprove the orders. It was pointed out that the original jurisdiction granted by law to the Secretary of the Interior could not be transferred by Executive Order to the Secretary of Agriculture and that there would therefore be some extraordinary maneuvers with regard to public-land administration if the Geological Survey were in Interior and the

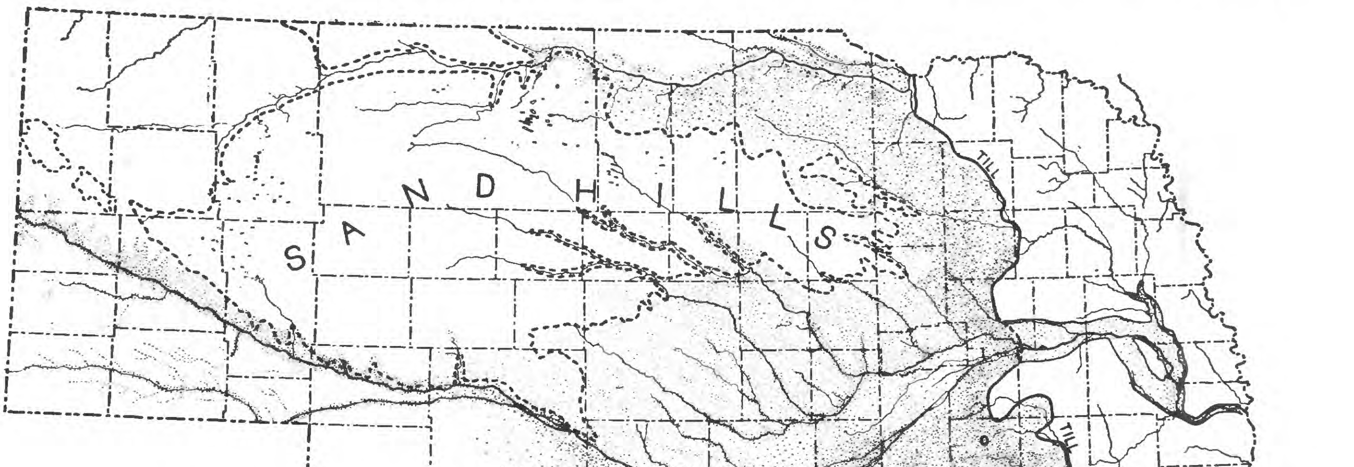
In northeastern Pennsylvania, a cooperative investigation of ground-water resources begun in 1930 indicated that anthracite coal mining, at that time by far the most important industry in the region, and the development of ground water for domestic use or industrial supplies were incompatible. Outside the coal basins, ground water was used for domestic and small municipal supplies, but within the coal basins surface water from the Delaware or Susquehanna River (shown in the photograph in Luzerne County) was used for almost all municipal, industrial, and domestic supplies. The region's coal beds and associated formations contained considerable water but the continual pumpage of mine water had lowered the ground-water level in the coal basins and most of the little water that remained within the reach of wells was highly acidic and unfit for ordinary use. The mine water was used for washing coal and then discharged into the streams. (From S. W. Lohman, 1937.)

General Land Office in Agriculture. L. C. Cramton, the former chairman of the Interior Appropriations Subcommittee who had become a Special Assistant to the Secretary of the Interior following his defeat in the 1930 election, suggested that the Forest Service logically belonged to Interior, not Agriculture. Senator Sam Bratton, Democrat of New Mexico, promptly filed a bill to establish a Department of Development and Conservation by combining the Departments of Agriculture and Interior. None of these proposals was acted on, however, and at the last minute Congress attached to the Treasury appropriations bill a provision calling on the President to reduce expenditures and in order to accomplish this and to increase efficiency to "group, coordinate, and consolidate" executive and administrative agencies according to their major purposes, thus transferring the authority to the incoming President.

The economic situation became progressively worse during the winter of 1932–1933. Banks continued to fail and by mid-February the American banking system had given way completely, and the economy was a disaster. By the morning of March 4, when Franklin D. Roosevelt was to be inaugurated as the 31st President, nearly every bank in the United States had been closed by State proclamation. There were ominous developments in other parts of the world as well. On January 30, Adolf Hitler had become Chancellor of Germany, the Reichstag building had been burned on February 27, and emergency decrees had suspended the constitutional guarantees of free speech and free press in Germany. Japan had rejected the League of Nations report condemning its actions in Manchukuo and continued its march southward.

The new Cabinet was hastily confirmed and sworn in on March 4 with the state of the economy the first order of business. It was a mixed group—one historian called it "a strange assortment"—composed of Republicans and Democrats, progressives and conservatives, party war horses and independents, inflationists and anti-inflationists, nationalists and internationalists. Cordell Hull, conservative Senator from Tennessee, was Secretary of State; William H. Woodin, an industrialist of orthodox economic views, Secretary of the Treasury; Homer S. Cummings, seasoned Connecticut politician, Attorney General, a last-minute choice after the sudden death of Senator Thomas J. Walsh; George H. Dern, mining executive and Governor of Utah, chosen first for Secretary of the Interior and then as Secretary of War; Claude A. Swanson, Virginia's courtly Senator, Secretary of the Navy, and, at 71, the oldest man in

In the south-central part of the semiarid State of Nebraska, where ground water was almost universally used for domestic, municipal, and industrial supplies, the increasing development of irrigation with ground water in the Platte River Valley made imperative a better understanding of the geology and hydrology of the valley. In a 5-year cooperative investigation by the U.S. and State geological surveys, A. L. Lugn and L. K. Wenzel found that part of the ground water had percolated into the area from the sand-hill region of north-central Nebraska and another part came through seepage from streams entering the area from the west and northwest. They concluded that for most parts of the area the ground-water supply was ample and that irrigation by ground water could be further developed in the Platte Valley and in the valleys of some of the smaller streams. Development of large irrigation projects on the plains to the south, however, was not feasible because the ground-water supply in that area was limited chiefly to percolation from the Platte Valley. (From A. L. Lugn and L. K. Wenzel, 1938.)



the Cabinet; Daniel C. Roper, one-time political lieutenant of Woodrow Wilson, whose views made him acceptable to business, Secretary of Commerce; Frances Perkins, State Industrial Commissioner of New York under both Governor Smith and Governor Roosevelt, Secretary of Labor and the first woman to serve in a Cabinet position.

Two of the most unorthodox members of the Cabinet were the Secretary of Agriculture and the Secretary of the Interior, and thus the long-standing rivalry of those departments was enlivened. For the post in Agriculture, Roosevelt chose Henry A. Wallace, son of Harding's Secretary of Agriculture. Wallace, at 45 the youngest man in the Cabinet, had been a Republican until 1928. He had been editor of the family magazine, *Wallace's Farmer*, a practicing agriculturist who had pioneered in the development of new breeds and strains of chicken, corn, and strawberries, and an agricultural economist, who had forecast the farm-price collapse of 1920 and had chaired the Agricultural Round Table in 1927 and the International Conference on Agricultural Economics in 1929. Harold L. Ickes, Chicago lawyer, former Bull Moose Republican and self-styled curmudgeon, became Secretary of the Interior. Ickes had become a Progressive because of a stand against political corruption rather than any great interest in conservation, and had hoped to be appointed Commissioner of Indian Affairs but was chosen for the Secretary's post when difficulties arose in filling it. Although Ickes was later described as "the most fanatical conservationist of his generation," at the outset he considered the functions of the Interior Department to be "sociological and scientific" and placed "the protection and enlargement of life" ahead of the conservation of natural resources as its first concern. Almost immediately, however, he was confronted with problems in the management of mineral resources. Curtailment of the overproduction of oil came up at the Cabinet meeting on March 14, and a conference of Governors or their representatives was hastily called. While committees of the Governors and oil industry representatives, who had also convened in Washington, were meeting to try to work out a program, Ickes was summoned to the President's office for a conference on legislation to cure some of the outstanding problems of the coal industry. By mid-April, Ickes was jousting with Wallace on the proper home of the National Park Service and the Forest Service.

The new Congress was called into special session on March 9 and in a little more than 3 months passed dozens of measures to stimulate the economy or provide relief. An emergency banking bill was brought up in the House while the new members were still seeking their seats, passed by both houses in the record time of 8 hours, and approved the same day. The Economy Act, fulfilling a platform pledge to reduce the cost of government, was passed on March 20. The Civilian Conservation Corps was established on March 31 to give unemployed young men useful work in such projects as reforestation, flood control, soil-erosion control, and road construction. On May 12, the Federal Emergency Relief Act appropriated $500 million for direct relief to States, cities, towns, and counties, and the Agricultural Adjustment Act provided financial aid to farmers. On May 18, the Tennessee Valley Authority was established "to improve the navigability and to provide for the flood control of the Tennessee River; to provide for the reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for the agricultural and industrial development of said valley; to provide for the national defense by the creation of a corporation for the operation of Government properties at and near Muscle Shoals in the State of Alabama." Finally, on June 16, came the National Industrial Recovery Act, designed to revive industrial and business activity and reduce unemployment. Under Title I of the act provision was made for codes of fair dealing for industries; under Title II, $3.3 billion was appropriated for public works.

None of the emergency legislation, with the possible exception of the National Industrial Recovery Act, seemed destined to help Federal bureaus such as the Geological Survey, and some made matters worse. The Economy Act proposed to balance the budget by reducing the salaries of Government employees as much as 15 percent, reducing veterans' pensions, and reorganizing Government bureaus to achieve economy. The Tennessee Valley Act terminated the investigations of the Army Engineers in that area, which included the operation of about 100 gaging stations by the Survey. The National Industrial Recovery Act included the conservation and development of natural resources among the public works for which the appropriation was made, but it was widely believed that construction was the main purpose of the program and no one knew if or how Federal bureaus would be involved. To make the situation even more difficult, on June 6 a cash withdrawal limitation was imposed on appropriations so that only 70 percent of the appropriation could be used. Thus the funds available to the Survey for fiscal year 1934 would be about half those available in 1933. At the beginning of the fiscal year, therefore, field work was curtailed, administrative furloughs were imposed, and some were separated from the service.

Under these gloomy conditions, visitors began arriving in Washington for the 16th International Geological Congress. The technical sessions were scheduled for the week of July 22, but excursions to points of geologic interest, two of them transcontinental, would precede and follow those sessions. Director Mendenhall of the Survey was General Secretary of the Congress; H. G. Ferguson and Marcus Goldman of the Survey, the Assistant Secretaries. The technical sessions of the 16th Congress were largely devoted to such fundamental research topics as the measurement of geologic time; batholiths and related intrusives; major divisions of the Paleozoic era; geomorphic processes in arid regions; fossil man and contemporary faunas; and orogenesis. Sessions were also devoted to zonal relations and metalliferous deposits, the geology of petroleum, and the geology of copper deposits. The 16th Congress devoted its major resource appraisal to copper. James Gilluly of the Survey was a member of the committee responsible for the publication to which a dozen and a half other Survey geologists contributed. The four major known sources of copper in the world at that time were, in order of importance, the Rocky Mountain and Great Basin area of the United States, the west slope of the Andes in Peru and Chile, the central plateau of Africa in the Belgian Congo and Northern Rhodesia, and the Precambrian shield area in central Canada and its extension into northern Michigan. Arthur Notman estimated the world reserves as of the order of 100 million tons of copper, which would last, at the average consumption for the preceding 13 years, for 69 years even if no more copper were found. He also pointed out that no important copper-producing area in the world had yet been exhausted although production had ceased in some districts because the metal could not be produced in competition with more favorable areas. Gold was of far greater interest than copper to those outside the profession, and when T. B. Nolan of the Survey was awarded the Spendiarov Prize as the most promising young geologist of the host country, he soon received an inquiry from an Idaho prospector asking for information on his special method of "determining where to look for favorable places for gold."

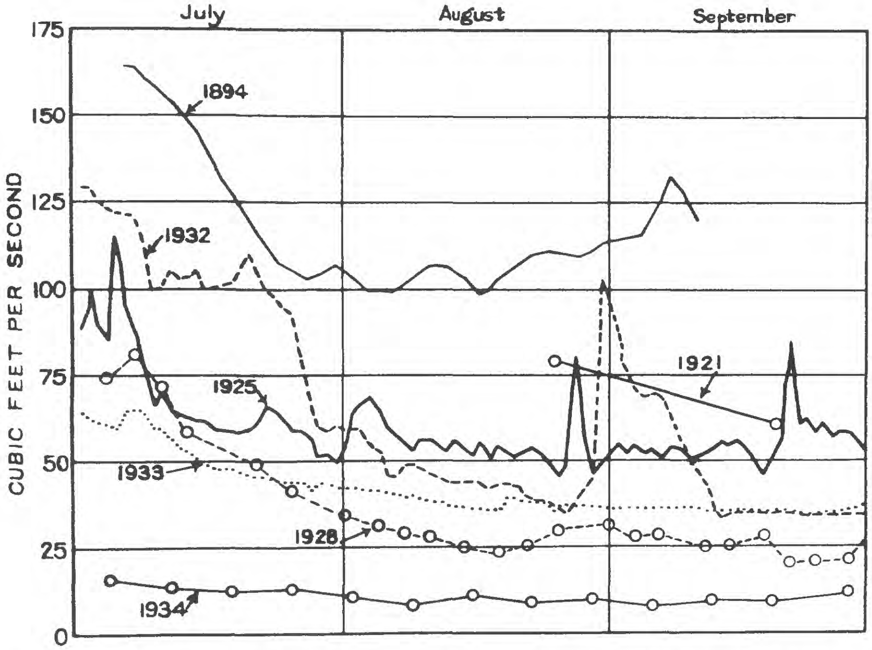
While Director Mendenhall was occupied as General Secretary of the Geological Congress, the administration of the National Recovery Act was set up. Title I was made the responsibility of a Cabinet committee headed by the Secretary of Commerce, and the National Recovery Administration was lodged in the Department of Commerce, with General Hugh Johnson as Administrator. Title II was the responsibility of another Cabinet committee headed by Secretary Ickes, and the Public Works Administration was placed in the Department of the Interior. Secretary Ickes was designated Public Works Ad-

In Duval Country, Texas, where cattle raising, farming, and oil production were the principal industries, A. N. Sayre's study of the ground-water resources, made in cooperation with the State Board of Water Engineers, indicated that there was little possibility of using ground water for irrigation. Except in the extreme southeastern part of the county, the quality of the water was unfavorable or the water level was so low that the lift necessary to raise the water to the surface would make the cost prohibitive. The illustration shows a ledge of the Goliad conglomerate, the principal water-bearing formation of the area. (From A. N. Sayre, 1937.)

ministrator. A National Planning Board was named on July 20 to aid Ickes in formulating a comprehensive plan of public works: Frederic A. Delano, city and park planner, and incidentally President Roosevelt's uncle, chairman; Charles E. Merriam, Professor of Political Science at the University of Chicago, and an old friend of Secretary Ickes; and Wesley C. Mitchell, Professor of Economics at Columbia University. So many applications were received for water projects in the Mississippi Valley that a special Mississippi Valley Committee was set up to review them.

On July 31, as the Geological Congress members enjoyed their excursions following the technical sessions, the President established by Executive order a Science Advisory Board "with authority, acting through the machinery and under the jurisdiction of the National Academy of Sciences and the National Research Council, to appoint committees to deal with specific problems in various departments." The Economy Act had called for reorganization of Government bureaus to achieve economy, but even before that was passed some Cabinet members, notably the Secretary of Agriculture and the Secretary of the Interior, had been coveting the others' bureaus and making plans on the basis of the authority in the Treasury Appropriation Act. Early in July, Secretary Wallace had asked the National Research Council for advice on the reorganization of the Weather Bureau. Isaiah Bowman, the Chairman of the National Research Council, found that the Council had no means of acting upon the request except by appointing a special committee, and suggested that instead a general board be established that could appoint committees to deal with specific problems. President Roosevelt then agreed to issue an Executive order appointing nine members of the National Academy of Sciences as a Science Advisory Board: Karl T. Compton, President of the Massachusetts Institute of Technology, chairman; W. W. Campbell, President of the National Academy of Sciences; Isaiah Bowman, Chairman of the National Research Council; Gano Dunn, President of J. G. White Engineering Corporation; Frank B. Jewett, Vice-President of American Telephone and Telegraph Company; Charles F. Kettering, Vice-President of General Motors Corporation; C. K. Leith, Professor of Geology at the University of Wisconsin; John C. Merriam, President of the Carnegie Institution of Washington; and R. A. Millikan, Director of the Norman Bridge Laboratory of Physics at the California Institute of Technology.

The Science Advisory Board, in addition to dealing with specific problems presented to it by Secretaries Wallace, Roper, and Ickes, undertook a study of the general problems of science and on September 15 submitted to Secretary Ickes, as Public Works Administrator, a "recovery program of science



In the Ogden Valley of Utah, where surface water had been used for irrigation since shortly after the first settlers arrived in 1847, and the city of Ogden had obtained its municipal supply from the ground-water reservoir in the upper valley since 1914, a considerable variation in total surface-water outflow had been observed over the years and the summer flow was generally inadequate to supply all demands. Conflicts arose among the water users because part of the river flow in the lower valley consisted of seepage of ground water into the channel. From an investigation of ground-water conditions in the valley and their relation to stream flow, made under a cooperative agreement between the Survey and the city of Ogden, R. M. Leggette and G. H. Taylor concluded that the city's use of the reservoir had resulted in a somewhat greater seasonal lowering of water levels than would otherwise have occurred and therefore that stream flow from seepage had been diminished. On the other hand, ground-water recharge during the winter and spring had been increased over what it would otherwise have been because of the lower water levels at the beginning of the recharge period. (From R. M. Leggette and G. H. Taylor, 1937.)

progress." The program, which carried the endorsement of officers of 33 major scientific and engineering organizations, proposed an appropriation of $16 million over a period of 6 years in support of research in the natural sciences and their applications, in the belief that

> **scientific research is an essential element of any far-sighted and comprehensive program for planning and improving the national prosperity, and * * * failure to nourish and encourage American scientific activity will result in failure to realize the nation's best economic advantages and standards of living.**

Among the fields of research eligible for support from this fund they included investigations that might reasonably be expected to lead to improvement or extension of public works; study and survey of natural resources in their economic, social and political relations, and particularly in regard to conservation; determination of physical and chemical properties of materials which might be useful in industry and engineering; research in biology, medicine and food technology directed ultimately toward public health and comfort; research in fields that might lead to "knowledge applicable to the satisfaction of human desires, the creation of new industries or the extension and improvement of established industries"; and research on mechanization in relation to employment and costs.

Secretary Ickes gave the board to understand that he was personally convinced of the value of the proposal but believed that public-works funds could be expended only for construction. By mid-September, however, the Public Works Administration had already made several grants that could easily be construed as support of science. On August 12, the PWA had allocated $500,000 to the Geological Survey for rehabilitation of river-measurement stations, and shortly thereafter another $70,000 for the establishment and operation of new river-measurement stations on the Colorado, Mississippi, and Ohio Rivers where only a few measurements had been made because of the great cost of installing and operating the special equipment needed on such large streams. Then on September 3, the Public Works Administration allocated another $100,000 to the Survey for investigations of ground-water problems in five areas for which no cooperative funds were available and in which Federal interests were sufficient to justify the use of Federal funds. In September also, the

PWA allocated $2,400,000 for topographic surveys in the United States and $25,000 for topographic surveys in Puerto Rico, and in succeeding weeks allocated more than $628,000 for plugging wells, safeguarding mine openings, and controlling fires in the public lands. By November 1, 1933, the total of PWA allocations to the Survey was $3,741,074. These were 2-year funds, available for use until June 16, 1935. The Survey estimated that $1.97 million would be spent in fiscal year 1934, about the same amount as had been appropriated directly for the Survey but $0.6 million more than it was authorized to spend under the Economy Act. Thus at least in some parts of the Survey the gloom of July had been dispersed.

Funds continued to be funneled into the Survey for stream gaging and topographic mapping. In November, the Weather Bureau, which had received an allotment for rehabilitation of the river stations it maintained for flood forecasting, turned over $112,000 to the Survey for the work, and the Tennessee Valley Authority completed arrangements for a program of stream gaging that replaced and in fact enlarged the program the Survey had carried on for the Corps of Engineers. In December, the Public Works Administration, on the recommendation of the Mississippi Valley Committee, allocated another $280,000 to the Survey for construction, repair, and replacement of equipment and maintenance of river-measurement stations on the Colorado River, tributary streams of the Mississippi, and at 805 existing stations in the Mississippi Valley, and the Tennessee Valley Authority made a cooperative agreement with the Survey to supply its needs for topographic maps. When the House Appropriations Committee met on December 19 to begin hearings on the Survey appropriations for the fiscal year beginning July 1, 1934, the Survey had received in addition to its Federal appropriation sufficient additional funds to

In the Harney Basin in southeastern Oregon, where the rivers drain into three lakes that have no outlet to the sea, discharge ranges from several thousand second-feet in some spring freshets to complete failure in some autumns so that between 1895 and 1930 the aggregate water surface of the lakes varied repeatedly from about 125 to about 2 square miles. The photograph shows Harney playa in a period when the lake surface was small. The Survey's investigation of the ground-water resources indicated that the 800 square miles of alluvial plains in the low central area contained arable land that could be irrigated economically by pumping from wells. The plains were underlain by shallow water-bearing beds, although near the center of the basin the water might be very alkaline, and received water largely by percolation from the Silvies River all along the stream during spring freshets. In the northwestern part of the central plain, deep permeable beds supplied several irrigation wells but recharge was restricted to a small area. In the marginal area, the temperature of the water in bedrock ranged from 52° to 154° F. (From A. M. Piper, T. W. Robinson, and C. F. Park, Jr., 1939.)

assure full programs in the Topographic and Water Resources Branches in the year underway and the promise of a busy and productive year ahead.

The Geologic, Alaskan, and Conservation Branches still faced difficult fiscal problems and the appropriations recommended by the Bureau of the Budget for the coming year offered no relief. The recommended appropriations for geologic surveys, Alaskan mineral resources, and classification of the public lands were essentially the amounts allowed under the cash withdrawal limitation during the year underway, too small to maintain the staff let alone do any productive work. The recommended appropriations for topographic surveys and water-resources investigations posed special problems even for those branches because they did not provide sufficient funds to match the cooperative funds being offered by the States. The recommended appropriation for topographic surveys was only $112,140; the States were already offering $208,000. The recommended appropriation for water-resources investigations was $337,650; the estimated cooperative offerings for the next fiscal year were already $530,000. Chairman Taylor was unsympathetic. He complained that the Survey had been "growing like a mushroom for a long time," disapproved of the methods by which the lands were classified, in fact stated that the need for such work had declined as fewer homestead entries were being made, and dismissed the notion that there had been any great increase in work with respect to mineral lands. The House committee then cut $19,130 from the appropriation recommended by the Bureau of the Budget, and the House on January 19, 1934, voted the Survey an appropriation of $1,303,060. Secretary Ickes asked the Senate to restore the cuts, and in the final bill, the House and Senate compromised on a partial restoration so that the total appropriated for the Survey was $1,313,500. Nearly half the 1934 funds unexpended because of the cash withdrawal limitation were reappropriated as well. Congress later appropriated funds for restoration of salary cuts so in the end the Survey received $1,631,138.

By the time the appropriations bill was approved on March 2, 1934, however, geologists who had been desk-bound or on furlough had hastily gathered their field gear and some were already in the field. In January 1934, the Public Works Administration made grants totalling $276,000 to the Geological Survey for geologic investigations of mineral resources in 19 States east of the Rocky Mountains and grants of $248,000 for classification of the public lands; an additional $10,000 had been transferred to the Survey from the Bureau of Reclamation for a field study of the mineral resources of the Boulder Dam region.

Responsible at least in part for the changed outlook was a report of the Science Advisory Board, which on December 7, 1933, 2 weeks before the House Appropriations Committee met, had given Secretary Ickes a ringing endorsement of the U.S. Geological Survey and its work. Soon after the Board was formed, the Secretary had asked it for advice about consolidating the Survey and the Bureau of Mines, and on September 5 a committee of C. K. Leith, chairman, F. M. Becket, Past President of the American Institute of Mining and Metallurgical Engineers, and F. A DeWolfe, State Geologist of Illinois, had advised against consolidation, and had in fact recommended the establishment of a third organization to concentrate and strengthen the work on mineral statistics and mineral economics then scattered through several departments. The full report stated that the organization of the Survey "is well designed as to branches, divisions and sections of work to be done" and that its "scientific and technical standards are high and the work of the Survey has been marked by conspicuous honesty," but that its work had been inadequately supported and the conditions under which its scientists were required to work were intolerable.

The Leith committee also concluded that while all the current activities were "desirable and justifiable," the "balance and emphasis" was unsatisfactory. It recommended that supervision of mineral leasing activities be returned to the Bureau of Mines, which had had the responsibility before it was transferred to the Department of Commerce in 1925. It also recommended that the geophysics program that had been developed in the Bureau of Mines be transferred to the Survey as it "has to do with the finding of ore, which is a function of the Survey, and not with extraction and technology of ores, which are primary functions of the Bureau of Mines." The committee also took note of a proposal then being actively advocated to transfer the Topographic Branch to a proposed new Bureau of Surveys and Maps but concluded that it was doubtful that the new bureau would receive larger funds, use them more effectively, or make any other great improvement over the existing arrangement.

The committee devoted most of its attention to the geologic work of the Survey, describing the Geologic Branch as "the core of the Survey responsible for the fundamental research for which the Survey was created the branch which in the main has given the Survey its high scientific reputation." Classification of the public lands was also a "vital part of the Government's resource program." Neither activity was receiving adequate support. While the Topographic and Water Resources Branches were both busy as a result of the cooperative funds and emergency Public Works allotments, the Geologic Branch was furloughing men for substantial periods. The committee suggested that, inasmuch as hundreds of geologists and engineers who had previously been engaged by the mineral and petroleum industries were without work, the Secretary "invite the Director of the Geological Survey to propose a plan for the useful employment of these men in connection with land classification and the study of mineral resources under an emergency allotment. The work could probably be supervised by members of the Geologic Branch and the results could be counted on to be of public benefit." The Science Advisory Board, in the person of C. K. Leith, had also had a hand in the transfer from the Bureau of Reclamation. The Director of the Bureau, Elwood Mead, had asked for advice on a geologic and economic survey of the Boulder Dam region, in response to which Leith had submitted a plan for a survey of mineral resources with respect to tonnage and grade; an estimate of costs and feasibility of mining, milling, and transportation; and an analysis of the results with regard to general economic and market conditions to ascertain the advantages or disadvantages of undertaking the development of the resources. The plan was an opening wedge into the field of mineral economics.

In conclusion, the committee stated

> **The Geological Survey has played an important part in the development of our mineral resources for more than fifty years, and mineral resources have been a leading factor in our material advancement. New questions of intelligent public planning, now looming, call for strengthening and wider use of the services that only the Geological Survey can perform.**

Chapter 13.
The End of the Pioneering Period, 1933–1936

We have reached the end of the pioneering period of go ahead and take. We are in an age of planning for the best of everything for all.
—Harold L. Ickes

A quarter of a century before Franklin D. Roosevelt became President, the National Conservation Commission appointed by Theodore Roosevelt reported that the Nation was entering a third stage in its growth and development of natural resources. In the third stage, said the Commission, enterprise would be "collective and largely cooperative, and should be directed toward the larger benefit of communities, States and the people generally." In the third stage, wise and beneficial uses of resources would be essential, and the checking of waste absolutely demanded. The conservationists of 1908 had been unduly optimistic about entering the third stage. The conservation program of the first Roosevelt aroused strong opposition and progress was made but slowly. The major effort of the Taft administration to give the Roosevelt program the force of law met with but little success. The Wilson administration gave conservation a lower priority, and after the onset of the World War conservation efforts were to a large extent disorganized until the advent of the Hoover administration, which was deeply committed to both conservation and science.

Franklin D. Roosevelt also had a strong commitment to conservation, and so, while most of his administration's first actions were designed to relieve unemployment and promote economic recovery, some of the emergency programs, such as the Civilian Conservation Corps and TVA, were two-edged; they provided employment and helped stimulate the economy, and they also aided in the physical rehabilitation of the countryside or the development and control of natural resources. Conservation programs were also carried forward or modified from those initiated in the Hoover administration—the construction of big new dams in the West, legislation to control the grazing lands of the public domain, and the creation of new national parks.

Unlike Hoover, Roosevelt was not pro-science, but neither was he against science. The hopes and expectations of scientists in the Federal service were lowered and raised by events rather than administration policy. Early in the first term, scientists were encouraged when Roosevelt resubmitted the nomination of Lyman Briggs as Director of the National Bureau of Standards after the Senate had failed to act on Hoover's recommendation and by his appointment of a Science Advisory Board. Secretary Ickes, however, as Public Works Administrator, declined to fund the Science Advisory Board's recovery program for science progress.

The Roosevelt administration made extensive use of boards and commissions for planning purposes and both science and conservation were included. One of the first, the National Planning Board, was set up by Secretary Ickes, at about the same time as the Science Advisory Board was established, to advise him on the feasibility and desirability of public works projects. The Planning Board was succeeded at the end of June 1934 by a National Resources Board, a

Cabinet-level board under the chairmanship of Secretary Ickes, and in June 1935 by a National Resources Committee, which took over planning for both the physical and social sciences. Although Americans were in general suspicious of any governmental planning and some of the planning aroused strong opposition from the more conservative members of Congress, by the end of Roosevelt's first term, economic and social planning by the Federal Government was an accepted fact.

Natural-resource planning, or at least its translation into legislation, was complicated by the division of responsibilities among several agencies and departments and to some extent by the rivalry among them. Both the Secretary of Agriculture and the Secretary of the Interior, for example, sought to promote conservation and research and incidentally to gain control of one or another of the other's bureaus. Significant advances were made in land and water utilization but the conservation and development of the nonrenewable resources proved to be as intractable a problem as ever. The nonrenewable resources, however, presented not a single problem but a whole variety of problems for which no single policy could probably be devised although a few dedicated individuals persisted in efforts to establish a national policy.

Among the nonrenewable-resource problems facing the Roosevelt administration in its first months in office were the overproduction of oil and the depressed state of the coal industry, and then the reappearance of the precious metals in the political arena. The United States, in effect, went off the gold standard on March 6, 1933, when President Roosevelt issued a proclamation prohibiting the export of gold and the redemption of currency in gold. The Emergency Banking Act of March 9 confirmed these actions, and authorized the Secretary of the Treasury to call in all gold and gold certificates in the country. In late summer, as economic recovery still lagged, Roosevelt, who had been impressed with a relation between the prices of gold and agricultural products postulated by an agricultural economist, decided he would like to buy gold in the open market at more than the prevailing price in an effort to raise commodity prices. On September 8, the domestic price of gold was raised from \$20.67 an ounce, which it had been for most of the preceding century, to \$29.92 an ounce. The results were at first satisfactory but then prices again began to drop. In October, therefore, the Reconstruction Finance Corporation was authorized to buy newly mined domestic gold, and later to buy and sell gold on the world market, at prices that were successively pegged higher and higher, from \$31.36 an ounce on October 25 to \$34.06 an ounce on December 16. Experiments in the massive purchases of silver began in December under an amendment to the Agricultural Adjustment Act. Silver was purchased at 64.64 cents an ounce (about one-half of \$1.29, which was 1/16 of \$20.67, the March 1933 price of gold). About the only accomplishment of the precious-metals program, however, was the arousal of sound-money Democrats into open conflict with the administration and increased pressure from inflationists for silver legislation. On January 25, 1934, Roosevelt sent a special monetary message to Congress, which promptly passed the Gold Reserve Act. On January 31, the dollar was stabilized at 59.06 cents and the price of gold fixed at \$35 an ounce. In June, Roosevelt yielded to pressure from the silver bloc and submitted a bill, also quickly passed, authorizing the purchase of domestic or foreign silver until the price reached \$1.29 an ounce or the Treasury's silver holdings were one-third its gold holdings. The move aided silver producers in the United States but had disastrous effects on the monetary systems of China and Mexico, which were on a silver standard.

The problems of the oil and coal industries were attacked under the National Industrial Recovery Act. The Code of Fair Competition for the Petroleum Industry was approved by President Roosevelt on August 19, 1933.

Franklin D. Roosevelt (1882–1945), President of the United States, 1933–1945. Roosevelt's political career began in 1910, the same year as that of Woodrow Wilson, with an unexpected victory as a candidate for the New York State Senate, where he became identified with the interests of upstate farmers and with progressive legislation and reform in general. A strong supporter of the conservation program of his cousin, Theodore Roosevelt, much of his knowledge of the land was based on the family estate and how it fared. In the New York State Senate, he served as chairman of the Committee on Fish, Forests, and Game and the Committee on Agriculture. President Wilson appointed him Assistant Secretary of the Navy in 1913, a post he held until he was nominated for Vice President in 1920. As Governor of New York from 1929 to 1932, Roosevelt experimented with methods that were later used in New Deal legislation. As President he hoped to achieve a national policy for the development of land and water resources. (Courtesy of the Library of Congress.)

It provided for a required daily production of 2,338,500 barrels to balance consumer demand and allocated the production among the petroleum-producing States, the largest amount, 965,000 barrels to Texas, and more than 1 million barrels to the States of Oklahoma, California, and Kansas. The code for the coal industry took somewhat longer and Roosevelt had to call operators and miners to the White House before agreement was reached. Then in the second session of the 73d Congress, beginning in January 1934, Senator Elmer Thomas of Oklahoma introduced a Department of the Interior bill for unrestricted and permanent control over the oil industry. This was followed by a House resolution for an investigation of "the production, importation, storage, transportation, refining, purchase, and sale of petroleum, and its products, for the purpose of determining whether there is an excessive supply of petroleum and its products; whether such excessive supply, if it exists, injuriously affects commerce in petroleum and its products and has the effect of rendering unprofitable the operation of wells of small but settled production and will cause their abandonment before the maximum yield is obtained."

The need to formulate a national mineral policy was called to the President's attention by C. K. Leith, who, with the approval of the Executive Committee of the Science Advisory Board and Secretary Ickes, wrote to Roosevelt on February 8, 1934, that

The United States has by far the most outstanding mineral resources of any country on the globe, and owes much of its material advancement to them. Its annual mineral output reaches nearly half of the value of agricultural products. Mineral development has been left almost exclusively to private initiative. There has been no unified national mineral policy other than that of laissez faire. Broadly speaking, the mineral industries are now passing from a period of exploitation to one of surplus, involving public and social considerations and the necessary introduction of some measure of public planning.

Leith suggested that coordinated national planning for the conservation of mineral resources would involve the restriction of mineral development and production to balance consumption, and "the first step, the very cornerstone of planning" was the preparation of estimates of future consumption. Effective methods of curtailment to meet consumption estimates must then be chosen as the mineral industries, with few exceptions, had no legal way to act jointly without violating antitrust laws. Mineral codes should then be reviewed to bring them into accord with the chosen method of curtailment. National defense needs, including the procurement of war stocks of certain key minerals not adequately produced in the United States, should also be taken into account. International exchanges of minerals should be considered in connection with treaty negotiations and tariff revisions. The Federal Government should develop the general principles for conservation into which the laws and practices of the different States could be brought into accord. Finally, Leith said, the use of marginal sources should be discouraged and mineral supplies obtained from the best developed, best organized, and cheapest sources.

The mineral industry had meanwhile been considering what help it wanted from the Government. Reno Sales, the Chief Geologist of the Anaconda Copper Mining Company and one of the chief spokesmen for industry at a symposium on relations between Government surveys and the mining industry at the February 1934 meeting of the American Institute of Mining and Metallurgical Engineers, agreed in part with Leith's sentiments, at least to the extent that "The position of our mining industry in relation to wealth produced, and number of people employed, is an extremely important one. Of vital moment also is the factor of metal supply in time of war. Prolonging the life of this most important and essential industry, therefore, becomes a matter of national concern. The bugbear of overproduction and excess productive capacity in our mining industry, of which so much has been heard in the past four years, should not be interpreted as proof that there are inexhaustible reserves, within the United States and its territorial possessions, of oil, ores of iron, copper, zinc, lead, or other useful metals. The facts are quite to the contrary." Sales, however, said "that there are undiscovered mineral deposits in the United States of great value, no one will deny. To make these resources available, every reasonable effort must be put forth to reduce as far as possible the financial risks involved."

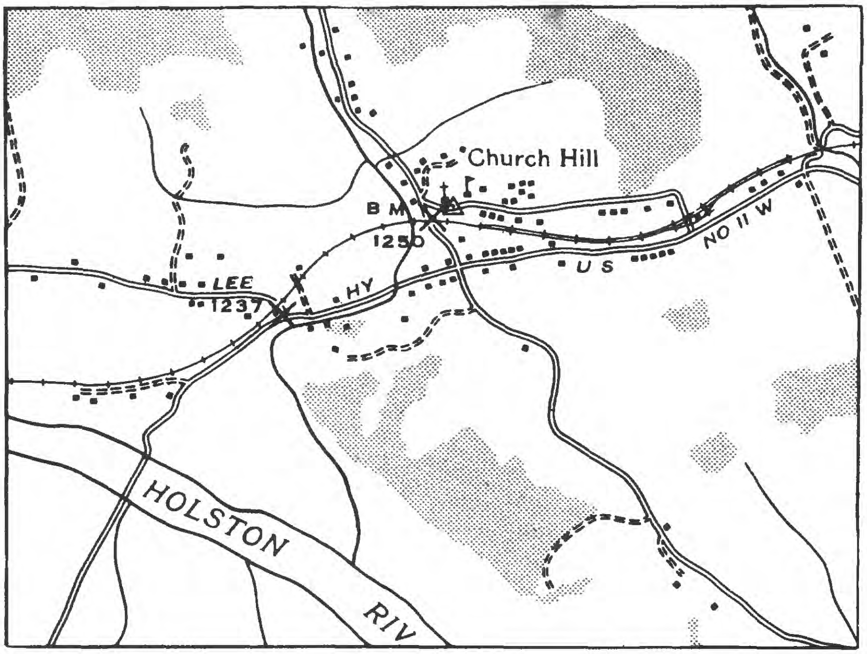
As a most important part of that effort, the industry wanted geologic help. The Government, Sales said, had early recognized its obligation to the mining industry by the formation and maintenance of the Geological Survey, and through that organization invaluable aid had been received. In fact, the "present-day application of geological knowledge of mine operations owes much to Survey activities" but the appearance of the mine geologist in industry had in no way lessened the need of intensive field and research work by the Survey and related organizations.

Because of increasing difficulties in maintaining ore reserves, it should be the policy of the Survey to work unceasingly to establish sound geologic principles for the guidance of human effort in the search for useful metals.

Sales, however, questioned the trend of recent Survey work. Despite the declaration by Emmons that the primary object of Survey work was to determine the general laws governing the formation of deposits, there had been a tendency to examine regions of new discoveries and partly developed areas and to devote less attention to well developed districts. While no one objected to Survey activities in frontier regions, whether there was a proper balance between the scientific side and the practical was a question deserving careful consideration by those in charge. Sales believed that older districts should be reexamined at sufficiently frequent intervals to keep pace with significant geological developments. Comparison and correlation of data on ores and ore deposits of similar mineral composition and geologic setting would also lead to progress, although the study of geologic units rather than geographic units as in the Professional Papers on the ore deposits of New Mexico and Utah would be more profitable and moreover would tie the work of the economic geologist more closely to that of the scientist working on the broader problems of geology. In any event, "The Government should provide funds upon a much more liberal scale than in the past, to enable the Survey to perform this useful and much needed service."

Following the AIME meeting, several congressmen from mineral-producing States and some of the leading mineral men from New York and

Harold LeClair Ickes (1874–1952), Secretary of the Interior, 1933–1946, Administrator of Public Works, 1933–1939, and Petroleum Administrator (under various titles), 1933–1946. Ickes, a Chicago lawyer, was a Republican associated with reform politics and an original Bull Mooser in 1912, but in 1920 and again in 1928 and 1932 he supported the Democratic ticket. After Roosevelt's victory, Ickes hoped to become Commissioner of Indian Affairs but instead became Secretary of the Interior. Although Ickes was a member of the Roosevelt inner circle, he was always wary of the New Dealers and hewed to his own course. Arthur Schlesinger, Jr. described him as "a defiant and fractious servant and a high-handed and mistrustful master—yet a superb public servant * * * who maintained vigorous standards of honesty and efficiency, who never flinched from battle." (Courtesy of the Library of Congress.)



The receipt of substantial funds from the Public Works Administration and the Tennessee Valley Authority had a profound impact on the Survey's topographic mapping program. PWA funds were used primarily for 1:62,500-scale mapping in public-land States; TVA funds made practicable the development of photogrammetric methods. TVA needed a contoured map on a scale sufficiently large for detailed planning, but the time involved and the funds required precluded such a choice. Instead, a planimetric map on a scale of 1:24,000, comprising 766 full or fractional 7 1/2-minute sheets, was made by using aerial photographs and developing special compilation methods. The map shown is a section of one of these maps, showing woodland (shaded), drainage, and culture. Once this assignment was completed, the Survey began compilation of contour maps by photogrammetric methods. (From T. P. Pendleton, 1935.)

Washington met with Congressman James Scrugham of Nevada and Director Mendenhall to discuss ways and means by which a mineral consciousness could be developed in the Government and something done for the mining industry. Congressman Scrugham, a member of the AIME, had been elected to Congress in 1932 following a distinguished career as an engineer, professor of engineering and dean of the Engineering School at the University of Nevada, State Engineer, Governor of Nevada, and Special Adviser to the Secretary of the Interior on Colorado River development. The group drew up a plan including the appointment of a new Assistant Secretary of the Interior for Minerals and the reorganization of the mineral services. Leith dismissed the plan as too narrow, failing to take into account foreign trade or national defense, and urged them to delay submission of their proposal to Secretary Ickes until a decision was reached on another plan which he had discussed at high levels.

President Roosevelt shortly thereafter approved Leith's plan and asked Secretary Ickes to form a planning committee and to serve as its chairman. On April 7, 1934, the following were appointed as members of the committee: C. K. Leith, Vice-chairman; Herbert Feis, representing the Department of State; J. W. Furness, the Department of Commerce; Colonel C. T. Harris, the War Department; Leon Henderson, the National Industrial Recovery Administration; W. C. Mendenhall, Director of the Geological Survey; F. A. Silcox, Chief Forester of the Department of Agriculture; Wayne C. Taylor, Special Assistant to the Special Adviser to the President on Foreign Trade; W. L. Thorp of the National Emergency Council, and Scott Turner, Director of the Bureau of Mines, who was later replaced by John W. Finch when he succeeded Turner as Director of the Bureau of Mines.

While plans were being discussed for the development of a mineral policy, Congress spurred the administration into action on the development of a water policy. On February 2, 1934, the Senate passed Senator George Norris' resolution requesting the President to provide a comprehensive plan for the improvement and development of the rivers of the United States that would give Congress the information needed to guide legislation to provide a maximum amount of flood control, navigation, irrigation, and the development of hydroelectric power. Roosevelt referred the resolution to the Secretaries of the Interior, War, Agriculture, and Labor, and they in turn divided the country into six regions, appointed six technical subcommittees, and gave them six weeks to draft a statement. The technical subcommittees, drawn from the professional staffs of the Interior, Agriculture and War Departments, included N. C. Grover, C. G. Paulsen, O. E. Meinzer, A. M. Horton, and A. W. Harrington of the Geological Survey.

In forwarding the report to the President on April 17, the Cabinet committee stated that

> **The basis of a comprehensive plan for water policy lies in (1) adequate facts, maps, and general information in easily accessible and comparable form; (2) continuous study and refinement of plans for the full development of river basins with coordination of present agencies in elements of the work; (3) agreement upon a statement of principles to govern the division of responsibility and costs among Federal, State, municipal, and private bodies, for various kinds of projects and combinations of projects; (4) agreement upon a statement of principles to govern the extent to which various kinds of projects shall be charged to the users and on methods of apportioning such charges; and (5) agreement upon a statement of the social, economic, physical, and geographical criteria for choice and priority of projects and units.**

Basic information on which the water policy must be based, however, was "fragmentary and scattered," and the committee considered it essential that the organization which prepared the study continue to develop more specific plans and that a definite planning body be established. President Roosevelt forwarded the document to Congress in June but suggested that Congress regard it as a preliminary study and wait until the next session for a comprehensive plan to be pursued over a long period of years. Among other reasons, he pointed out, many interrelated subjects must be considered in a comprehensive plan—erosion, stream pollution, fire prevention, reforestation, afforestation, and marginal lands, among others.

The urgent need for land planning persuaded the Secretaries of Agriculture and the Interior to form a committee on land planning in the summer of 1933, in an effort to bring to an end the disagreements between the two departments. The Director of the Survey, W. C. Mendenhall, was one of the three representatives of the Department of the Interior. In October, the Soil Erosion Control Service was established in the Department of the Interior with a $10 million grant from the Public Works Administration, its mission "to demonstrate that the impoverishment and destruction of our remaining areas of good agricultural land by continuing erosion can be largely controlled; and to lay the foundation for a permanent national erosion-control program of adequate scope to meet the acute land crisis created by wasteful methods of land utilization." Hugh H. Bennett, who a few years before had termed soil erosion a national menace, was persuaded to leave the Department of Agriculture to head the new program. The need for this program was demonstrated dramatically less than a month later as the first of the great dust storms of the 1930's swept across South Dakota on Armistice Day and spread eastward, darkening the sky in Chicago on the following day and Albany, New York, on the day after that.

In the fall of 1933, the Science Advisory Board, acting on its own initiative and in the belief that a study of the land problem from a distinctly scientific standpoint would be helpful, appointed a Land Use Committee of Isaiah Bowman, chairman, C. K. Leith, John C. Merriam, and Carl O. Sauer, Professor of Geography at the University of California. The board then engaged W. L. G. Joerg, of the staff of the American Geographical Society, to make a study and analysis of methods and principles that had been used for land classification and Professor Sauer to write a report designed to be of broad benefit to all agencies concerned in land use. Professor Sauer's report on "Land

Resources and Land Use in Relation to Public Policy," dated April 26, 1934, pointed out the need for a reintegration of land research. In the 19th century the Federal Government had sponsored scientific inquiries into the characteristics of the land as Americans moved westward, and these investigations had been a great stimulus to the growth of scientific knowledge. However, the generation of pioneer investigators had been succeeded by more and more specialized workers, Government bureaus had become involved in administrative and technologic services, and universities had taken over investigations formerly expected of the Government. It was time, he suggested, for land specialists of all kinds to focus their individual knowledge on the entire range of land problems "as a matter of national welfare that depends on a balanced relation between the people and their land." He proposed a program of inquiry that would proceed from the physical sciences, in which he included mapping as well as geology and hydrology, through the social sciences, to an examination of regions, defined as the different complexes formed by man and nature, and the relation of these regions to each other and to the country as a whole, and finally to public policy and a determination of "whether we have appropriated the land wisely or unwisely to our present needs and whether we have made proper provision for the future."

In an effort to get such a program underway, the Science Advisory Board committee invited representatives of 16 agencies in the Department of the Interior, Department of Agriculture, the Tennessee Valley Authority, and the Federal Relief Administration to meet in conference on June 14, 1934. Herman Stabler, Chief of the Conservation Branch of the Survey and J. F. Deeds, Chief of its Agricultural Division were among those attending. The conference heard reports on the land-use programs of the several agencies and statements on the scientific and administrative aspects of the problems of land use as seen by the Government, discussed the Sauer report, and agreed on the need for another conference in a few months. In the meantime, a concerted effort would be made to define further the scientific elements of the problems involved, establish priorities among such problems and elements, and keep the many agencies concerned in closest practicable association.

By June 14, 1934, however, Congress had already passed the Taylor Grazing Act, which, according to Rexford G. Tugwell, the Under Secretary of Agriculture, "laid in its grave a land policy which had long since been dead and which walked abroad only as a troublesome ghost within the living world." Congressman Edward Taylor of Colorado, long noted for his opposition to Federal control of the public lands, filed a bill on January 5, 1934, the third day of the session, "to stop injury to the public grazing lands by preventing overgrazing and soil deterioration, to provide for their orderly use, improvement and development, to stabilize the livestock industry dependent upon the public range, and for other purposes." A month later, even before the bill was reported out of committee, President Roosevelt issued an Executive order withdrawing certain public lands in Utah "from settlement, location, sale, or entry, and reserving them for classification in aid of legislation, for conservation and development of natural resources and for use as grazing land." The order was accompanied by an opinion from the Solicitor of the Department of the Interior that legal authority for the action existed under the Pickett Act of 1910 and that no special legislation was necessary. Mindful of the uproar that ensued when Theodore Roosevelt had withdrawn public lands nearly three decades earlier, the administration also supported passage of the Taylor Act. During the House debate, Congressman Taylor observed that the Western States had fought reservation of the public lands by Theodore Roosevelt because they considered the action a "high handed, outrageous, and infamous invasion of our vested rights," but that now "nobody would think of having the public domain thrown open to a brutal free-for-all scramble again." That was an exaggeration but the bill passed the House by almost 3–1 and the Senate without a division, and was approved on June 28, 1934. Although Taylor had stated that it did not matter whether the Department of Agriculture or the Department of the Interior administered the act, Congress, and the livestock industry which had had to deal with the Department of Agriculture in regard to grazing in the national forests, preferred the Department of the Interior. The Taylor Act provided for the segregation of a maximum of 80 million acres of vacant unappropriated and unreserved lands to be organized into grazing districts under the control of the Secretary of the Interior. The Secretary was also authorized to initiate measures to protect, regulate, and improve the lands within the districts, to issue permits for use of the range, determine fees and the number of livestock to be permitted in each district. The Act was amended in 1935 to increase the acreage to be included in grazing districts, and Executive orders in November 1934 and February 1935 effectively closed the public domain to entry.

The Grazing Service was established in the Department of the Interior to administer the Taylor Act and, as there was no appropriation for its work, the Agricultural Division of the Survey's Conservation Branch was "loaned" to the Department to organize the new bureau, prepare regulations, and conduct public hearings in the West to explain the purposes of the act and the procedures of grazing-district organization. Then on March 21, 1935, by Departmental order, the work of agricultural and grazing classification was formally transferred to the Grazing Service. Farrington R. Carpenter, a Colorado livestock man, was chosen to head the Grazing Service; J. F. Deeds, chief of the Survey's Agricultural Division, became the Administrative Assistant of the Service (the title today would be Assistant Director for Administration.)

For the rest of the Geological Survey, the first 16 months of the Roosevelt administration could easily be described in terms of the elastic rebound theory of earthquakes. First came the strain of accommodating itself to the reduced budget of the latter part of the Hoover administration, then the sharp shock of the first few months of the Roosevelt administration, and finally the recovery as PWA and other funds were channeled to the Survey, providing not only for needed work but also opportunity for new research that advanced the Survey to a new position in the world of science and engineering.

The Conservation Branch experienced perhaps the most radical change during this period, only part of it the spin-off of the Agricultural Division to form the Grazing Service. A Secretarial order on September 13, 1933, transferred to the Survey the duty of receiving rents, royalties, and license fees for transmission to the General Land Office and of maintaining accounts on these funds. In the fiscal year then underway, these funds amounted to almost $4 million, about twice the appropriation for the entire Survey. At the same time, the Oil and Gas Leasing Division began receiving an increasing number of plans for unit operation of oil fields for technical review and the Mining Division revised procedures to comply with a Departmental order restricting issuance of coal prospecting permits to localities whose needs could not be feasibly served by existing mines. These added duties could only be undertaken at the expense of the existing responsibilities which had fully engaged the staff. Some temporary assistance was received in the form of PWA funds to protect the public lands by putting out outcrop fires resulting from irresponsible trespass on coal lands or plugging abandoned wells, but these did not aid the regular work. PWA funds also enabled the Power Division to undertake long deferred surveys of power resources of important streams in 10 Western States but the Mineral Classification Division, which performed the original function assigned to the Survey, was unable to do field work for lack of funds.

The substantial allotments of funds from the Public Works Administration and the Tennessee Valley Authority began a revolution in topographic mapping in the Survey. The area mapped for the Public Works Administration and in cooperation with the States in fiscal year 1934 was 21,534 square miles, only 7 percent more than in the preceding year, but the area mapped at the mile-to-the-inch or larger scales was 174 percent of that in the preceding year, and a considerable amount of it was done on public lands where previously smaller scales had been used. The area covered by topographic surveys in fiscal year 1935 was 30,924 square miles, almost half again as much as in 1934. Mapping was done in all 48 States and in Puerto Rico, 77 percent of it at 1:62,500 or larger scales. The Survey's topographic mapping program became clearly a national mapping program. For the TVA project, a total of 766 maps on a scale of 1:24,000 was needed, and the need was urgent. As it would take many years to prepare the maps by conventional methods, the agreement stipulated that planimetric maps would be prepared first and then replaced by topographic contour maps. The maps, it was agreed, would be prepared by photogrammetric methods. T. P. Pendleton returned to the Survey to take charge of the work. The Survey's one aerocartograph was slow and expensive to use, so studies were begun immediately of new stereophotogrammetric plotting machines of German manufacture. Pending completion of the study, the planimetric maps were compiled in the office, using 3-lens aerial photographs and the radial line method, and given an overall check in the field. The stereoplanigraph obtained from Germany was no less complicated or expensive than the aerocartograph the Survey already owned. Multiplex projectors, however, were small, comparatively simple, and not expensive, but not as accurate as the stereoplanigraph. Permission was therefore obtained from the Zeiss Company to redesign the Multiplex for finer work, and Russell K. Bean was assigned to the task.

The interest in photogrammetry led to the establishment of a professional and technical society, the American Society of Photogrammetry, in 1934 to advance knowledge in the science and to act as a clearinghouse for the exchange of information. Bean was one of the founders of the new organization and C. H. Birdseye its first president. Within the Survey, the new interest led to a considerable increase in the area outside the Tennessee Valley covered by planimetric maps and in the use of aerial photographs as bases for topographic mapping.

PWA allotments broadened the program of the Water Resources Branch. The first allotments were used to rehabilitate existing river-measurement stations or to establish new ones on certain large streams. Then, in January 1934, the Survey was given $150,000 to establish and operate stream-flow measurement stations and to obtain records of sediment at the eight erosion-control projects of the Soil Erosion Service in North and South Carolina, Missouri, Kansas, Oklahoma, Texas, Wisconsin, and Washington. For each project, two adjacent similiar areas were selected and experimental methods of erosion control used on one; the effectiveness of the experimental methods was measured by the amount of sediment carried by the streams. Rain gauges were also operated on each project, and 213 observation wells were selected by R. M. Leggette for systematic observation of ground-water levels. An engineer was detailed to each project on 24-hour call as measurements were most important during floods, which were of short duration and often occurred at night.

In February 1934, the Public Works Administration allotted funds to the Survey for a compilation of data showing flood magnitude and frequency and a study of the relation between rainfall and runoff. Engineers generally agreed that much of the flood destruction in the United States could have been prevented if sufficient information had been available on river characteristics to serve as a basis for establishing control measures or for adjusting human activities, but for some rivers data on stages and flows of floods had never been compiled. Nor had available climatic and hydrologic data ever been adequately

In a survey of the geology and ground-water resources of the valley of the Gila River and San Simon Creek in Arizona in 1934, made under PWA auspices, M. M. Knechtel observed some of the extensive channel trenching of lands in Southwestern United States. Pictured is the steep-walled gully in the floor of San Simon Valley. Historic evidence indicated that the trenching, which had been described at length by J. L. Rich in 1911 and named the "epicycle of erosion" by H. E. Gregory in 1917, began after the arrival of white settlers. Most investigators attributed the trenching to the introduction of livestock and the consequent decrease in vegetative cover and formation of trails that promoted rapid runoff and increased the rate of erosion. Some geologists, however, favored a recent change in climate as the cause of the accelerated erosion and a few favored regional tectonic activity that brought about a differential warping of the earth's surface. The cause of the erosion was a matter of practical importance if appropriate measures were to be taken to prevent further encroachment of the channels on existing property. (From M. M. Knechtel, 1938.)

analyzed to deduce useful information. Both these studies were made in the Water Utilization Division. R. W. Davenport supervised the compilation of flood data by a working group composed in part of employees of the Survey or other Government agencies and in part by persons appointed by the Secretary of the Interior from PWA lists of eligibles. W. G. Hoyt, working under Davenport's supervision and aided by L. L. Harold and R. C. Cady, made the study of the relation between rainfall and runoff. The American Society of Civil Engineers' Committee on Flood Protection Data, headed by Gerard H. Matthes, the principal engineer of the Mississippi River Commission, and a committee appointed by the Section of Hydrology of the American Geophysical Union under the chairmanship of Wesley W. Horner, consulting engineer, of St. Louis, acted as advisers.

The Ground Water Division had been able to undertake a considerable amount of field work in the summer of 1933 although adjustments had to be made as projects were suspended for lack of cooperative funds. T. W. Robinson began an investigation of the Walla Walla Basin of Washington and Oregon on May 1, and was later joined by H. E. Thomas. The project, which was supported in part by funds from the States of Oregon and Washington and the County Court of Umatilla County, Oregon, stemmed from a suit brought by the State of Washington against the State of Oregon. A considerable part of the flow of the Walla Walla River then seeped into the ground on the alluvial plain at the base of the foothills; some of it reappeared as springs in Oregon and Washington and was used in both States for irrigation. In Oregon, irrigation was also carried on by gravity diversions from the river and by pumping ground water. Contending that irrigators in Washington were not receiving a fair share of the water, the State of Washington brought suit against the State of Oregon to determine the rights of each State to the water. Both States agreed to an investigation by a disinterested party and the Survey was asked to make it. The project in Michigan survived because O. E. Meinzer had recognized the possible advantages of cooperation with the Civilian Conservation Corps, and during the summer of 1933 there were eight parties in the field, each consisting of six or seven CCC men, headed by a Survey geologist. At the suggestion of A. G. Fiedler, double-acting hand-operated pumps were substituted for the relatively expensive power pump used in 1932, and the equipment was successfully used not only for drilling wells but for fighting 14 forest fires. In the Eastern States, the cooperative projects were continued in New York and New Jersey, and on a reduced scale in Virginia. The cooperative project in North Carolina was suspended at the end of June for lack of cooperative funds, but the ground-water program in Pennsylvania was resumed and S. W. Lohman began the investigation of the 14 counties in the south-central part of the State. V. T. Stringfield continued the investigations in Florida until the end of the fiscal year and was then detailed to Michigan. Cooperative projects were also continued in Nebraska, Texas, New Mexico, and Utah, although on a somewhat reduced scale, and the investigation in the Mokelumne area in California was completed at the end of June except for the investigation of rainfall penetration. In Hawaii, H. T. Stearns and Howard Powers began a study of the geology and ground-water conditions on the island of Maui.

When a PWA allotment of $100,000 was received on September 3, 1933, the Ground Water Division turned to the Geologic Branch, where geologists were being furloughed, for assistance. The first project to get underway was a reconnaissance by C. V. Theis, assisted by H. P. Burleigh and H. A. Waite, of an area of about 70,000 square miles in the High Plains in parts of Kansas, Colorado, Oklahoma, Texas, and New Mexico where practically all water, except along the Arkansas River, was pumped from wells, making vital a greater knowledge of its availability and quantity. Beginning in October and continuing through late fall and winter, geologists G. A. Waring of the Alaskan Branch, and M. M. Knechtel, D. A. Andrews, M. A. Harrell, and E. B. Eckel of the Geologic Branch investigated five areas in the High Plateaus of Utah, Colorado, New Mexico, and Arizona to determine the available water supplies from wells and springs and the prospects of developing additional supplies from deep-seated artesian basins. D. F. Hewett of the Geologic Branch headed a combined geologic-hydrologic investigation of a group of warm springs in the west-central part of Georgia being used in the treatment of infantile paralysis. In November, V. T. Stringfield returned to Florida from Michigan and began a regional study of artesian conditions in the Florida peninsula and early in 1934, M. A. Pentz, under the supervision of A. G. Fiedler, began an experimental investigation of the possibility of obtaining water supplies from shallow wells in the Coastal Plain.

In 1934, the Ground Water Division continued an extensive field program with the assistance of cooperative and PWA funds and also began a program of systematic observation of water levels and artesian pressure in wells. The Survey had been making measurements of ground-water levels in wells since Mendenhall began the practice in southern California in 1903 and Arthur Veatch, later that year, made measurements in connection with the Long Island investigations. Periodic measurements in connection with quantitative ground-water investigations had become an established practice in the Survey by 1930. The serious drought of that year in the Humid States made it clear that a more thorough knowledge of ground-water supplies was important, and in 1931, Pennsylvania had temporarily recessed the regional ground-water investigations to begin a State-wide program of observation wells to study fluctuations of the water table in cooperation with the U.S. Geological Survey. North Carolina began a similar program with Survey advice. By the beginning of January 1933, about 3,000 observation wells were being measured periodically by either the Ground Water Division or cooperating parties, most of them, of course, in areas of intensive ground-water development. Then early in 1934, a program of observing wells was set up in connection with the erosion-control projects of the Soil Conservation Service, and later in the year V. T. Stringfield and L. K. Wenzel assisted the State surveys in Michigan and Nebraska in selecting wells for statewide observation-well programs. In October 1934, O. E. Meinzer appointed a committee, under the chairmanship of R. M. Leggette, to promote the proper and systematic development of a broad program of observation wells and to establish uniform field and office methods. Leggette's committee, which included L. K. Wenzel, R. C. Cady, S. W. Lohman, V. T. Stringfield, R. W. Sundstrom, and S. F. Turner as members, developed a more or less standard procedure for establishing and maintaining observation wells, recommended that the records be published, and prepared a preliminary manual of methods which was issued in May 1935.

PWA grants revitalized the Alaskan Geology Branch which had been unable to do much field work in the 1933 season. In 1933, J. B. Mertie, Jr., working alone, had made a reconnaissance of the mining camps in the Ruby-Kuskokwim region, and R. H. Sargent had done some reconnaissance topographic mapping in southeastern Alaska; on behalf of the Alaska Railroad, S. R. Capps and Ralph Tuck had made a reconnaissance of the potential lode resources in the Willow Creek-Kashwitna region, and in cooperation with the U.S. Navy, Gerald FitzGerald had begun detailed topographic mapping in the Aleutian Islands. Seven projects were begun in 1934. F. H. Moffit and FitzGerald resumed the geologic and topographic mapping on the northeast side of the Alaska Range. J. B. Mertie, Jr., made a reconnaissance survey of the Kaiyuh Hills, southeast of the Yukon River in west-central Alaska, an uninhabited and little known region about which little information was available. Mertie did not discover any mineral deposits of great value but considered that his discovery of small bodies of silver-lead ore and traces of alluvial gold justified further prospecting. Capps began the geologic mapping of Kodiak Island, living on a boat and proceeding from point to point along the shore. Kodiak was the site of the first Russian colony in Alaska and it was believed by some to have been a stopping point during the migration of early people from Asia to North America, so archeologists were also investigating the island. In southeastern Alaska, Sargent mapped an extensive tract of Admiralty Island and adjacent parts of the Juneau district, and John C. Reed began geologic work near Ketchikan. On behalf of the Railroad, Tuck investigated the coal fields near Eska, in the Matanuska district.

The Geologic Branch had also been financially handicapped in 1933, but funds from several sources made a great variety of field work possible in 1934. In 1933, the branch had put only four small parties in the field for brief periods, to survey phosphate and oil-shale lands in Wyoming, oil in the San Pedro Hills of California, and coal on the east side of the San Juan Basin in New Mexico. With the aid of cooperative funds, work was also continued in the metal-mining districts in Colorado and New Mexico; in Idaho, increasing interest in placer gold mining resulted in a new cooperative project to evaluate the gravel deposits of the north-central part of the State.

Grants from the Penrose Fund of the Geological Society of America enabled members of the Geologic Branch to resume field work, some beginning in the fall of 1933, more in the 1934 field season. Penrose Fund grants went to Eugene Callaghan for a study of recent faults in the western part of the Great Basin; to James Gilluly, for a study of the structure, stratigraphy, and geomorphology of the Little Ajo Mountains in Arizona; to W. D. Johnston, Jr., for a study of the structure of the granodiorite of Nevada City; to T. S. Lovering, for a study of the physiography of the Front Range in Colorado; to L. F. Noble, for a study of the general stratigraphic and structural relations of a region including the Death Valley depression; to H. G. Ferguson, for a study of pre-Tertiary structural features in the western Basin Range region; to P. B. King, for a study of the Permian rocks of trans-Pecos Texas; to K. E. Lohman, for a study of diatoms in Maryland and California; to L. W. Currier, for a study of the metamorphism of Cambrian and Ordovician rocks on the east side of the Green Mountains; and to Parker Trask, for a study of the calcium carbonate content of fine-grained clastic sediments of California. A grant was also made to Julia Gardner for a study of the Tertiary faunas of northern Mexico. Grants to W. H. Bradley, T. B. Nolan, W. G. Pierce, and Ralph Stewart were "cancelled without prejudice" when the services of these geologists were needed on PWA projects.

The PWA projects employed geologists who had previously been engaged in the mineral and petroleum industries but were now without work under the supervision of Survey geologists, as had been proposed by the Leith Committee. Under these terms, some long-neglected investigations of mineral resources in the States east of the Rocky Mountains were undertaken. These included a much needed review of the gold resources of the southern Appalachian region, which had also been a target during the gold crisis of the 1890's; an examination of tin prospects in Alabama and adjacent States; an intensive survey of the Tri-State lead-zinc district in Oklahoma, Missouri, and Kansas; an investigation of bauxite deposits in Arkansas and other Southern States; surveys of quicksilver deposits in Arkansas and Texas; a geophysical survey of fluorite-bearing areas in Illinois and Kentucky; an investigation of the bleaching clays and other high-grade clays in several Southern States; prospecting of public land in Florida withdrawn for classification as phosphate lands; a survey of the oil and gas fields in New York, Kansas, Oklahoma, Arkansas, and Texas; and a survey of coal fields in Kentucky, Arkansas, Kansas, North Dakota, Oklahoma, and Texas. A few other surveys were made that were needed either locally or as part of the inventory of national resources. Some of these projects were continued on Survey funds after the PWA funds ran out, and nearly all resulted in a Survey publication at a later time. The experience gained by Survey geologists in these projects proved valuable in later years, particularly during World War II, and some of the PWA geologists later joined the Survey.

An allocation of $10,000 from the Bureau of Reclamation resulted in the assignment of six geologists, chosen because of their training and previous experience, to an appraisal of the mineral resources of the Boulder Dam region to determine their availability as the basis of industries that would consume power generated at Boulder Dam. B. N. Moore appraised the nonmetallic mineral resources; W. W. Rubey and Eugene Callaghan, the magnesite and borate deposits; W. T. Schaller, the borate minerals of the Kramer district; T. B. Nolan, the nonferrous metal deposits; and D. F. Hewett, the ferrous metal deposits. Field work began in February 1934 and the preliminary report was transmitted to the Bureau of Reclamation in January 1935. The complete report was published by the Survey in 1936.

In addition to these projects, some field work was continued in 1934 in the mining regions of Colorado, Idaho, and New Mexico, in cooperation with the States. In Colorado, geologists were also called on to make investigations with reference to a proposed deep drainage tunnel at Cripple Creek, to the adequacy of the artesian water supply at Englewood, at the request of the Public Works Administration, and of the Douglas Creek diversion tunnel at the request of the State Engineer.

During the summer of 1934, the Geological Survey also produced a major document on the geology and occurrence of petroleum in the United States for the House Committee on Foreign and Interstate Commerce in its investigation of the oil industry. David White contributed a paper on the early history of the use and development of petroleum and its origin in which he concluded that

although the expansion of oil production was greatly stimulated by the demands imposed on producers during the World War, and by competition among the companies in leasing new territory after the estimates of 1916-22 as to the available oil remaining in the ground, the long-continued overproduction from which the industry has suffered is due chiefly to the development by geologists and the adoption by producing companies of scientific methods of exploration for oil and the consequent great rapidity with which new oil fields in large number have been located and, owing to prevalent methods of production, too promptly exploited.

A. A. Baker, N. W. Bass, C. W. Cooke, C. H. Dane, H. D. Miser, O. C. Postley, R. W. Richards, G. B. Richardson, W. W. Rubey, L. W. Stephenson, and Ralph Stewart prepared summaries on the various petroleum-producing States. The reserves of recoverable oil from known fields in the United States were estimated as 13,360,000,000 barrels, a not inconsiderable gain over estimates of the late 1920's as the result of new discoveries.

David White's contribution to this document was reprinted in the April 1935 issue of the *Bulletin of the American Association of Petroleum Geologists* in order to make it more widely available to the profession. A month later, his last paper, completed a few days before his death on February 7, 1935, was published. Entitled "Metamorphism of organic sediments and derived oils," it was a rethinking of his earlier work on the carbon ratio in the light of 20 years of additional experience. He found that in many regions, the "oil dead line" fell in a far narrower range than previously supposed.

Not since the death of S. F. Emmons in 1911 had the death of a Survey geologist called forth so many tributes from all parts of the world. Professor Charles Schuchert of Yale summed up his career in the following words: "David White came to the United States Geological Survey in 1886 as a draughtsman; he left it in 1935 as America's foremost authority on Paleozoic stratigraphy based on fossil plants, as her leading expert on the origin and evolution of those two plant products, peat and coal, and as the author of a theory of oil distribution that is basic to the petroleum industry. In addition, he achieved notable success as an administrator in the Survey and in the National Research Council, and he found time, withal, to be mentor and friend to hundreds whose affection for him found abundant and constant expression. As Mendenhall has so well said, 'His was a career that came to full and happy fruition.'" Mendenhall, in his annual report, also pointed out that David White's career was "a striking example of the type of leadership at the service of the American people in the scientific establishments at Washington. Recognized and honored the world over as a scientist of the highest standing, whose research and administrative work had direct practical applications of great value; repeatedly offered by commercial organizations salaries several times greater than the Government paid him—he nevertheless remained in the service throughout his career and devoted his rare abilities and his limitless industry to the Government and the people of the United States."

On June 30, 1934, shortly after sending to Congress the preliminary report on river development, President Roosevelt created by Executive order a National Resources Board "to prepare and present to the President a program and plan of procedure dealing with the physical, social, governmental, and economic aspects of public policies for the development and use of land, water, and other national resources, and such related subjects as may from time to time be referred to it by the President." Secretary Ickes was chairman of the Board; the other members were Secretary of War Dern, Secretary of Agriculture Wallace, Secretary of Commerce Roper, Secretary of Labor Perkins, Relief Administrator Harry Hopkins, and the three members of the former National Planning Board, Frederic Delano, Charles Merriam, and Wesley C. Mitchell, which was discontinued when the new Board was formed. The staff was enlarged, and a Technical Committee, divided into six sections concerned with

To provide engineers the data they needed to develop flood-control measures, the Public Works Administration allotted funds to the Survey for the compilation of data on the magnitude and frequency of floods. On New Year's Day 1934, a flood in La Cañada Valley near Los Angeles, California, moved more than 800,000 cubic yards of debris from the mountain area to the foothills region and valley floor, devastating buildings, citrus groves, vineyards, villages and highways. The extent and depth of the debris is indicated in the photograph by comparison with the sizes of the steam shovels and trucks brought in to remove it. The flood water and debris came mostly from the mountainous tributary area north of the valley that had been almost completely denuded of its vegetative cover by a forest fire in November 1933, and this denudation was one of the principal causes of the enormous debris movement in a flood that followed two December storms. (From H. C. Troxell and J. Q. Peterson, 1937.)

land, water, minerals, power, industry, and transportation, was established. The Mississippi Valley Committee, which was also discontinued, became the Water Committee, the Leith committee on mineral policy became the Minerals Committee, and the joint Agriculture-Interior land planning committee became the Land Committee. Director Mendenhall was a member of both the Land and Minerals Committees, which were composed, with the exception of Leith, of Government experts. The Water Committee, by contrast, was composed of experts from outside the Government with the single exception of the Chief of the Army Corps of Engineers.

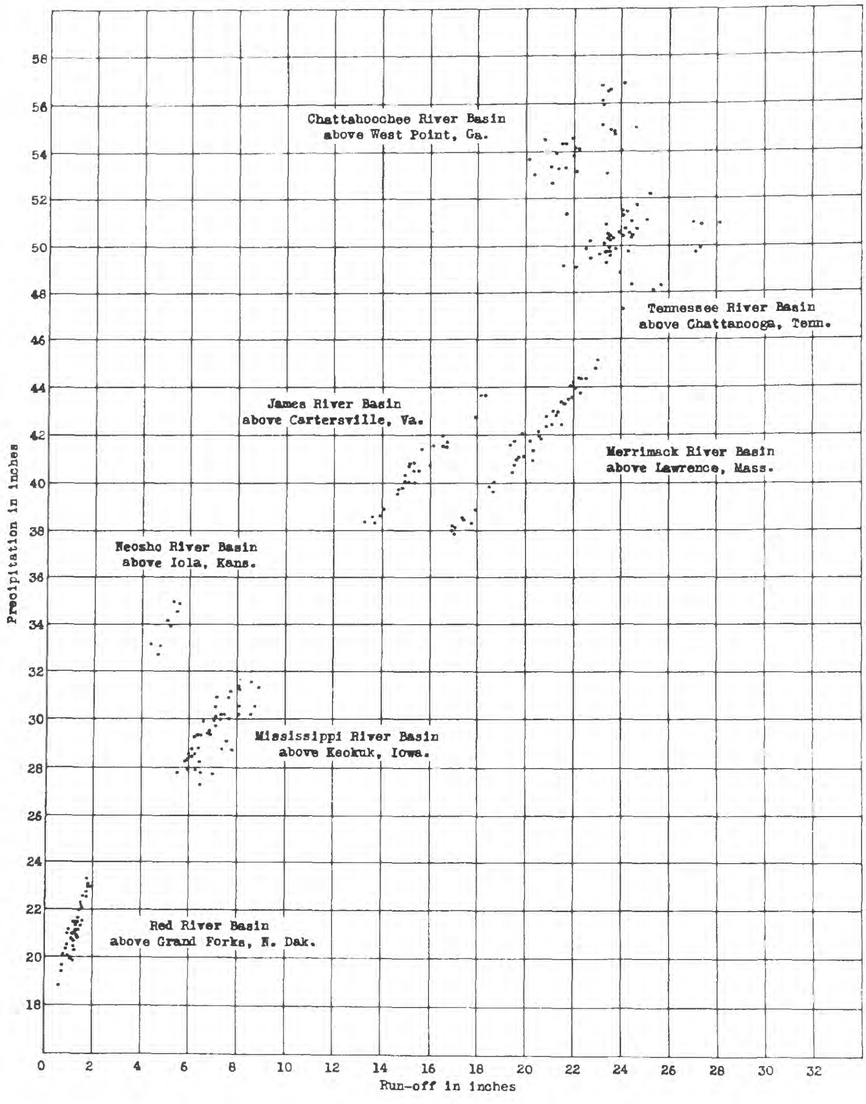
In November 1934, the National Resources Board gave the President a 455-page "Report on National Planning and Public Works in Relation to Natural Resources and including Land Use and Water Resources with Findings and Recommendations." Unlike the Science Advisory Report on Land Resources, the NRB report on land planning did not call for specific research. It categorized the land area of the United States into four classes: agricultural, 52 percent; useful nonagricultural (forest, woodland, and grazing), 41 percent; nonagricultural nonforest (urban, parks, roads, railroad rights-of-way, bird and game refuges, and swamps), 3 percent; and land of little or no use, 4 percent. The report projected need for an additional 47 million acres of arable land in the next 25 years, and proposed the retirement of some 25 million acres of crop land, an increase in Federal ownership of forest lands, and an increase in recreational areas.

The report on water planning called for establishment of a national advisory planning agency for coordinating the use and control of water resources because

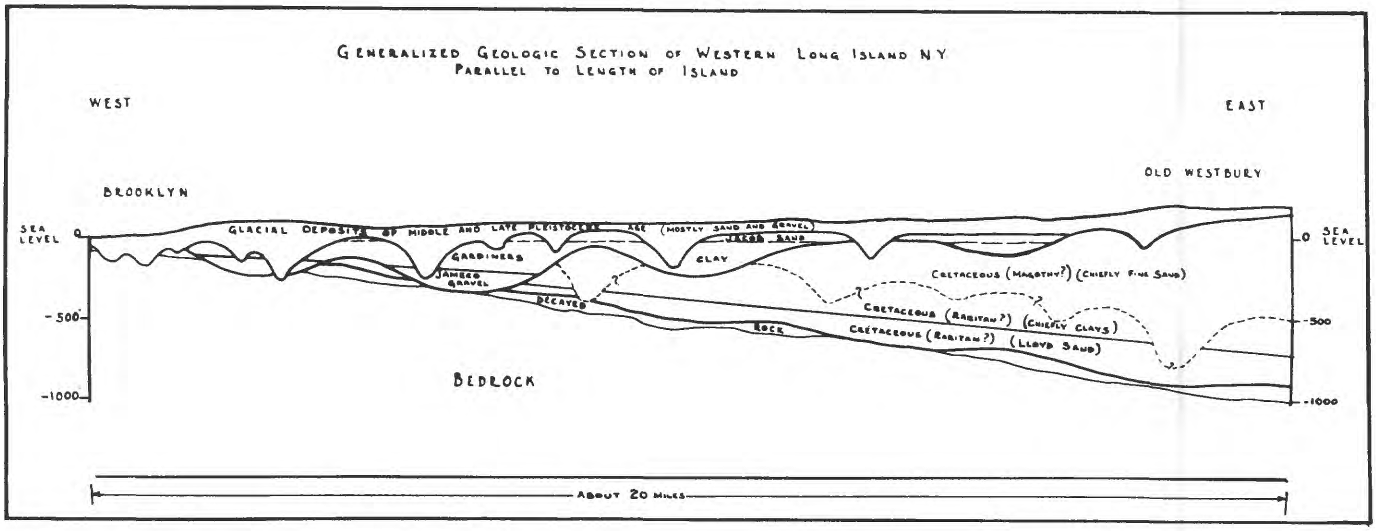
> **it is no longer possible to regard either water or land as purely private property, unaffected with a public interest. Whatever the legal rights, no owner has a moral right to waste a natural resource or to put it to uses which are generally harmful.**

The proposed agency would cooperate with and utilize existing and special Federal and State agencies to accomplish objectives which the committee defined as: to develop the more productive uses of water resources, such as pure water supply, navigation, power, irrigation, and recreation; to eliminate, modify, or neutralize harmful influences of waters, such as floods and erosion; to eliminate, modify, or neutralize man's harmful handling of waters, including pollution and waste through irrational promotion of runoff and drainage; and to accomplish these purposes effectively from the point of view of technology, geographical conditions, existing public agencies, and the good will of citizens.

The report also called for increased effort in or extension of "surveys, inventories, and records of conditions fundamental for the use and control of water resources," including among them the topographic mapping of the United States, the system of permanent gaging stations on rivers, the systematic inventory of water resources of the Nation, and systematic studies of ground water. It also called for an exhaustive study of legislation needed to permit effective cooperation between Federal, State, local, and regional agencies in the conservation and effective utilization of water resources, and for surveys, studies, and experiments in planning in selected unit areas in the 12 basins and districts into which the United States was divided.



As part of an investigation of the relation between rainfall and runoff commissioned by the Public Works Administration, the Survey studied the relations between precipitation, temperature, evaporation, transpiration, runoff, and infiltration as a basis for quantitative analysis of the hydrologic cycle over broad areas. In the 10-year progressive annual precipitation and runoff for selected drainage basins shown in the illustration, a change of 1 inch in annual rainfall is reflected by a change in runoff of about 0.3 inch in the Red River basin, 0.5 inch in the Mississippi River basin, and 0.7 to 0.9 inch in the basins of the James, Merrimack, Tennessee, and Chattahoochee Rivers. Evidently the annual average precipitation in the preceding 10 years had been less than the normal demands of transpiration and evaporation in the Red River basin but had exceeded those demands in the James, Merrimack, Tennessee, and Chattahoochee basins. (From W. G. Hoyt and others, 1936.)



In 1932, the Survey began a new study of the ground-water resources of Long Island, New York, which had been among the first it had studied in the early 1900's, because of concern that too great a draft on the ground-water supply would allow the infiltration of salt water. New data from wells drilled since the first study indicated that certain clay beds (the Gardiner clay of the cross section), which A. C. Veatch had believed were discontinuous lenses that retarded downward movement of water to lower beds but did not greatly reduce recharge, are in fact so widespread and thick that they more likely had originally covered the whole area and their absence in some wells was due to erosion rather than nondeposition. The erosion channels permitted only restricted recharge of underlying beds in some parts of the island. (From D. G. Thompson, F. G. Wells, and H. R. Blank, 1937.)

The Planning Committee for Mineral Policy defined conservation as "orderly and efficient use in the interest of national welfare, both in war and peace, without unnecessary waste either of the physical resources themselves or of the human elements involved in their extraction." The problem in conservation was not to prepare for the day when all fuels and metals would be gone but to minimize the adjustment to the stage of increasing cost of resources as the rich and accessible deposits were depleted. Waste must be eliminated and mineral technology improved, and for that purpose, better coordination of private and public effort was needed. An economic organization of the mineral industries should be encouraged to minimize the waste of resources and the business losses of destructive competition. Tax, tariff, and public-land policies should be reviewed in the light of their effects on resource use and conservation. The States should be encouraged to use their constitutional authority to prohibit waste by the exercise of police power. The arts of exploration, mining, and metallurgy should be fostered to offset the progress of exhaustion of resources and the increasing difficulties of their extraction. The liberties, health, and living standards of mine workers should be guarded as a primary obligation.

In specific recommendations, the committee called for preparation of consumption forecasts by the Bureau of Mines, working in cooperation with the Geological Survey and the Bureau of Foreign and Domestic Commerce; encouragement of the development of minerals in deficient supply in the United States by the methods that had made available supplies of potash, helium, and magnesium rather than by use of tariffs; extension of leasing laws to all minerals on public lands except in Alaska; physical stockpiling of reserves of certain deficient minerals and prohibiting the export of the scrap of metals for which the United States depended largely on foreign sources.

Both scientific research and better engineering practices were necessary to achieve these goals, the committee added, the most obvious being the extension of topographic and geologic mapping, specific studies of mineral occurrences and mining districts, more thorough inventories of mineral reserves, fundamental research in geology to improve methods of finding new mineral supplies, improvements in the techniques of exploration, mining, and metallurgy, and studies of changes resulting from improvement in transportation. The principal scientific, technical, and statistical services should be in the Department of the Interior, but the fact-finding agencies should be separated from the administration of mineral codes or production controls to insure independence of scientific inquiry.

The committee concluded that

> **The exhaustibility of minerals warrants special emphasis on scientific and technological investigations by the Government. The value of minerals produced annually is about 50 percent of that of agricultural products derived from the soil. Notwithstanding the importance of the mineral problem to our national welfare in comparison with agriculture, the total appropriations for Government mineral services are only a fiftieth part of the appropriations given to similar scientific and technological services in agriculture. Minerals, in short, from the standpoint of public attention have been a neglected natural resource.**

The report of the National Resources Board also included a plan for completion of the topographic map of the United States in 10 years. The plan, which had been prepared by the Federal Board of Surveys and Maps at the request of the National Resources Board, established three categories of mapping. For all unmapped and inadequately mapped agricultural lands in the Eastern and Southern States where farms were small and irregular, and other areas of extreme economic importance, an area estimated as about 300,000 square miles, planimetric maps would be compiled from aerial photographs and published at a scale of 1:24,000, followed by preparation of contour maps to be published as advance sheets at 1:31,680 and in final form at 1:62,500. For agricultural lands in States where the farms were large and regular and other areas of moderate economic importance, an area estimated as 1,216,000 square miles, planimetric maps would be compiled and published at 1:31,680, followed by preparation of contour maps to be published in advance form at 1:48,000 and in final form at 1:62,500. Maps of the remaining 700,000 square miles would be published only as topographic contour sheets, in advance form at 1:96,000 and final form at 1:125,000. All mapping, except for primary control by the Coast and Geodetic Survey, would be done by the Geological Survey. The total cost was estimated as $117 million.

The Science Advisory Board had also become interested in the surveying and mapping services of the Federal Government through discussions with the Bureau of the Budget and had appointed a committee that issued a report at about the same time. The SAB committee consisted of Douglas Johnson, Professor of Physiography at Columbia University, chairman; W. L. G. Joerg, Research Editor of the American Geographical Society; Robert H. Randall, President and Chief Engineer of R. H. Randall Co., geodetic and topographic engineers; C. C. Williams, Dean of the College of Engineering at the University of Iowa, along with Isaiah Bowman, C. K. Leith, and Frank DeWolf of the earlier committee on the Geological Survey, which had considered but not recommended a proposed new Bureau of Survey of Maps. The larger committee reversed that recommendation. It found that there had been unnecessary duplication of effort and waste of public funds because different Federal agencies covered the same territory with successive surveys, each adapted to its own needs rather than to the general needs of the Federal Government and the public, and also because of "structural defects" in certain bureaus. Production of the standard map could be expedited and major economies effected only by placing the primary surveying and mapping of the lands and adjacent waters of the United States and its territorial possessions under the unified control of a central surveying and mapping agency.

The SAB committee concluded that the central surveying and mapping agency should preferably be placed directly under the President, with the Department of the Interior or the Department of Commerce as alternatives. In each case, however, the Coast and Geodetic Survey would be the nucleus of the new mapping service and units or parts of units from other agencies would be transferred to the new agency; and the system of commissioning properly qualified personnel, mandated by law in the Coast and Geodetic Survey, would be extended to those transferred. The committee recommended that the Topographic Branch and the Division of Engraving and Printing of the Geological Survey be transferred to the new agency; the Topographic Branch it found, "owing to defects of organization" had not been "sufficiently alert in testing, inventing, developing and perfecting new methods and instruments," and its "total past production" and "present pioneering activities" were not "commensurate with what they might have been and should be under the stimulus of inspiring expert direction." The committee, exhibiting a certain amount of naivete about Government operations, proposed that the central mapping agency be financed by transferred funds. Each agency requiring mapping services would present its needs to the Bureau of the Budget and to Congress, secure appropriations to meet those needs, and then transfer the funds to the central mapping agency.

In other recommendations, the committee stated that the first objective of the national mapping plan should be completion of the standard topographic map of the United States at 1:62,500, or 1:125,000 if necessary to complete mountainous areas already far advanced at that scale, and that "where urgent Federal needs require the central agency to undertake topographic mapping on scales greater than 1:62,500 such work should so far as practicable be assimilated to the scale which can best be made the next objective of a more detailed survey of the national terrain." The policy of cooperative mapping should be reviewed, for cooperative surveys could retard the progress of the overall plan by calling for departures from national standards or result in a program determined too little by national needs and too much by the ability to pay of certain States. Other recommendations dealt with such fine points as engraving on glass and the use of stereoscopic methods in plotting. In conclusion, the committee stated that consolidation had "in principle" been approved by the Coast and Geodetic Survey and by the U.S. Section of the International Boundary Commission, and that "influential elements in the Topographic Branch and in the Division of Engraving and Printing of the Geological Survey have long advocated some form of consolidation of mapping activities, or separation from the Geological Survey to form an independent topographic mapping unit."

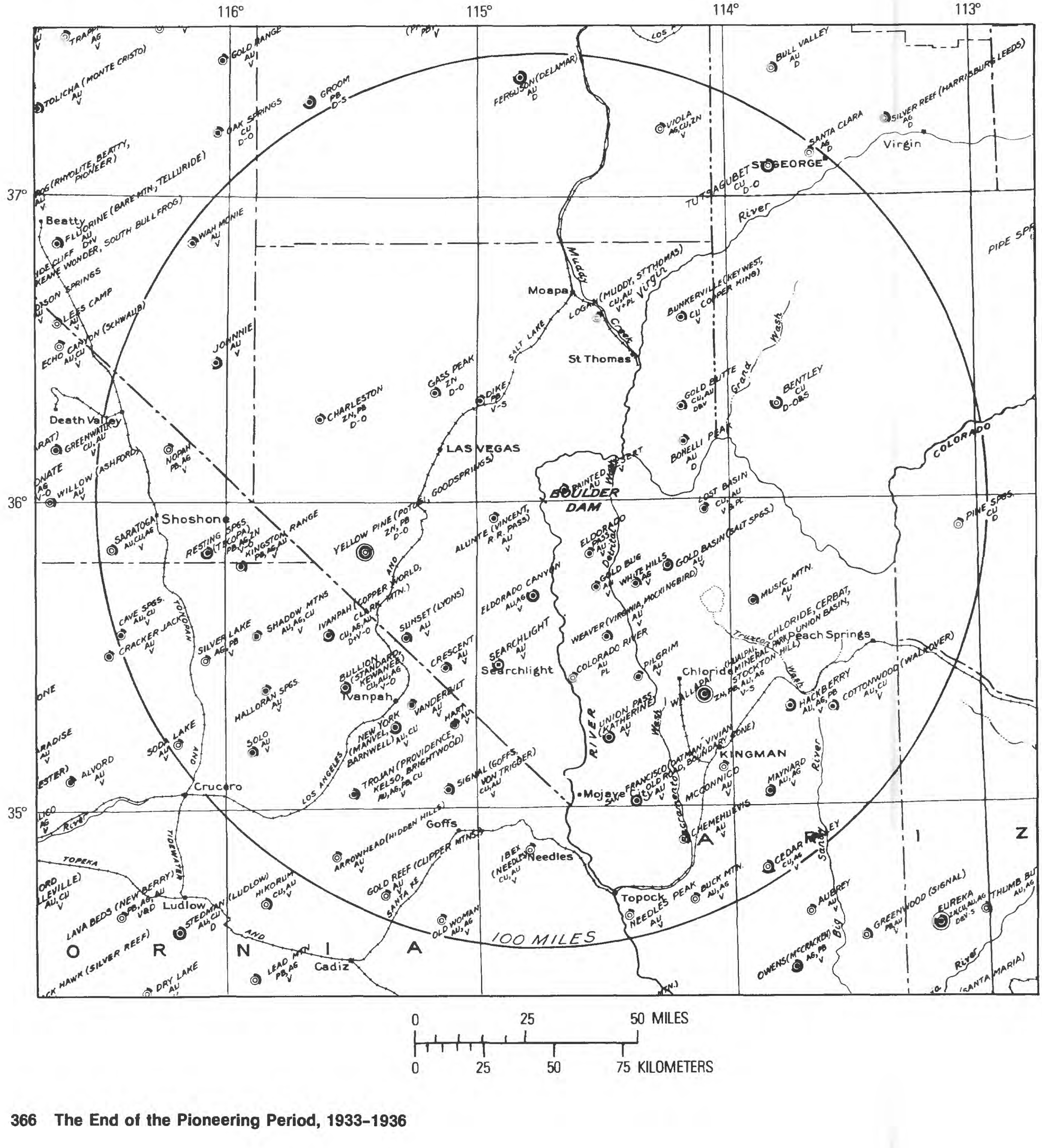
The Director of the Bureau of the Budget sent the report of the Science Advisory Board committee, together with drafts of three alternative Executive orders to set up the central mapping agency, to Secretary Ickes for comment. Ickes was never one to view lightly any dismantling of his department, however slight. Moreover, he had in hand the report of the Federal Board of Surveys and Maps on the subject, and, secure in the knowledge that powerful elements in the National Academy of Sciences were dismayed by some of the activities of the Science Advisory Board, was already on a collision course with the Science Advisory Board. In his reply to the Director of the Bureau of the Budget, which had been prepared by the Director of the Geological Survey, he opposed the creation of the central mapping agency and proposed, as an alternative, that the Division of Geodesy of the Coast and Geodetic Survey, which was not a mapmaking group although its work was related to mapmaking, be transferred to the Topographic Branch of the Geological Survey, "the major mapping organization of the country," and that the remainder of the Coast and Geodetic Survey be combined with the Hydrographic Office of the Navy. Accompanying the letter was a draft of an Executive order for the transfer of the Division of Geodesy.

The attempt to form a single mapping agency was no more successful than those that had preceded it in the years since the National Academy of Sciences had suggested it in 1878. No Executive orders were issued, and the Geological Survey and the Coast and Geodetic Survey each retained its integrity and autonomy. The Mendenhall-Ickes letter, however, achieved a degree of enduring fame, being placed for the record in Congressional documents, by suggesting that the mapping activities of the Government fell naturally into two great groups which required different kinds of training and experience, one "a landsman's job, the other * * * essentially a seaman's job," and concluding that it would not be sensible, nor would it contribute to economy or efficiency "to place our land mapping activities under a coast, harbor, and sea surveying organization because both involve some forms of engineering" and thus put "ensigns and commanders and captains in charge of surveying the plains of Kansas or the Mojave Desert."

The Science Advisory Board met with no more success with its new version of a program for science, which was completed at about the same time. The new science program called for allocation of 0.5 percent of the Public Works emergency appropriations for scientific and engineering research; formulation of programs of research both within and outside the Government by the National Academy of Sciences, the National Research Council, and a new Science Advisory Board; the appropriation of $5 million annually for support of scientific and engineering research outside the Government; and maintenance of the scientific bureaus of the Government with adequate personnel and appropriations. President Roosevelt delegated the task of evaluating the program

Charles Kenneth Leith (1875–1956), Geologist, U.S. Geological Survey, 1895–1905; Professor of Geology, University of Wisconsin, 1902–1945; mineral adviser to the Federal Government in World Wars I and II. Leith was one of the first members of the Science Advisory Board appointed in 1933, served as chairman of its subcommittee on the Geological Survey and the Bureau of Mines, prepared the plan for the geologic and economic survey of the Boulder Dam region, and proposed the mineral policy planning committee that later became part of the National Resources Board. He was cited by the University of Wisconsin in 1956 as "At once perceptive scholar and practical man of affairs, he has played a decisive role in the development of our national policy on mineral resources." (Courtesy of the University of Wisconsin Archives.)

to Secretary Ickes who, in turn delegated it to the Advisory Committee of the National Resources Board. At the end of January 1935, Secretary Ickes wrote to the President suggesting that the Science Advisory Board be abolished, that the planning function be placed with a Science Committee, which would include the social sciences and education as well as the physical sciences, under the National Resources Board. He urged that adequate Federal appropriations be made to finance specific research projects and provide generous support for the scientific work carried on by the Government but opposed any appropriation for unspecified projects to be determined by any science research committee.



The Ickes plan for a Science Committee was quickly approved and the National Academy of Sciences, the Social Sciences Research Council, and the American Council on Education were asked to nominate members of the new Science Committee. The Federal Government was willing to seek advice about scientific research but it intended to keep control of what was done.

In his annual message to Congress on January 4, 1935, President Roosevelt in referring to the National Resources Board said that its

> **study of our national resources, more comprehensive than any previously made, shows the vast amount of necessary and practicable work which needs to be done for the development of our national wealth for the enjoyment and advantage of our people in generations to come. The sound use of land and water is far more comprehensive than the mere planting of trees, building of dams, distributing of electricity, or retirement of submarginal land. It recognizes that stranded populations, either in the country or in the city, cannot have security under the conditions that now surround.**

Most of the message was devoted to a program of social reform with three major goals: security of livelihood through better use of national resources, security against the major hazards and vicissitudes of life, and security of decent homes. Among the few specific recommendations was the renewal and clarification of the National Industrial Recovery Act due to expire at the end of the fiscal year. The budget message on the following day proposed a budget of $8.52 billion that was balanced except for expenditures for relief and to provide work for the unemployed.

The National Resources Board had called for increased Federal spending on many conservation and research programs, and the Bureau of the Budget had approved a substantial increase in the Survey appropriation, especially for topographic surveys, water-resources investigations, Alaskan mineral resources, and classification of the public lands. Congressman Scrugham of Nevada, a new member of the Appropriations Committee, was in charge when Director Mendenhall and his usual entourage appeared for hearings on the Survey appropriations. The atmosphere was noticeably less formal than in the sessions when Congressman Taylor was in charge, Mendenhall was teased about running up the cost of government with his $500-a-year raise, which he disclaimed as "without solicitation or expectation," and the famed Mendenhall sense of humor was given free rein. The House committee concerned itself particularly with the appropriations for topographic surveys, geologic surveys, and water-resources investigations. The recommended appropriation for topographic surveys was $400,000, much larger than that for the year underway but less than the amount being offered by the States and a far cry from the annual appropriation of $11–12 million recommended by the National Resources Board. Although Scrugham urged that the Federal Government assume the entire responsibility for topographic surveys, the committee accepted the recommendation of the Bureau of the Budget. For geologic surveys, the Bureau of the Budget had recommended a small increase to $325,000. Scrugham took the lead in a discussion of mineral inventories, such as the one around Boulder Dam which the Survey had made for the Bureau of Reclamation. Mendenhall said that such inventories would be especially valuable in areas of potential power development, but in answer to Scrugham's inquiry whether one would be made in the Columbia River area, said "Not on this money." Scrugham was also interested in a resurvey of the Comstock, which Mendenhall also agreed should be made but again said could not be made "on this money." The committee then voted to increase the appropriation for geologic surveys to $335,000. For water-resources investigations, the Bureau of the Budget had recommended $630,000, which would provide $425,000 for cooperative investigations, $52,000 for Colorado River stations, $88,000 for Federal river-measurement stations in the Mississippi, Columbia, and Colorado River basins

◀ With PWA funds allocated to the Bureau of Reclamation and transferred to the Survey, six Survey geologists made a field study in the region of Boulder Dam, then under construction, primarily to appraise the mineral resources of the region with respect to their probable availability as the basis of industries that would consume power generated at the dam. The illustration is part of the map of nonferrous metal districts included in the report. Gold, silver, copper, lead, and zinc deposits were indicated by their chemical symbols, and the type of deposit by letters: V, vein; D, irregular body; PL, placer; O, oxidized ore; and S, sulfide ore. The circular symbols indicate whether the district had been recently examined by the Survey, whether or not production had been recorded, whether the reserve was undetermined or small, or noteworthy. The arc on the outer rim indicated the value of production for the period 1902–1932. (From D. F. Hewett, Eugene Callaghan, B. N. Moore, T. B. Nolan, W. W. Rubey, and W. T. Schaller, 1936.)

for which PWA had originally allocated the funds, and $65,000 for administration and noncooperative investigations. The committee cut the recommended appropriation for Federal stations to $75,000. The House approved the recommendation of its Appropriation Committee, which was only $3,000 less than that of the Bureau of the Budget.

The Senate increased the appropriations for several items so that in the end the Survey received $175,000 more than the amount recommended by the Bureau of the Budget. By the time the Senate committee hearings were held, it was clear that funds in the new Emergency Relief bill could not be used to supplement regular funds as NIRA funds had been. The Senate committee had also received a barrage of letters and telegrams complaining that Congress was not appropriating sufficient funds to match State offerings for cooperative investigations of water resources and a resolution from the American Mining Congress urging an annual appropriation adequate to maintain the Survey at an effective level. The Senate committee recommended increases over the House bill of $150,000 for water-resources investigations, $115,000 for geologic surveys, $60,000 for Alaskan mineral resources (or a restoration of the $100,000 appropriation of pre-World War days), and $25,000 for supervision of mineral leasing. No explanation was offered for the recommended increases and the Senate approved them without question. The conference committee accepted the Senate figure for geologic surveys and the House figure for supervision of mineral leasing, and compromised on the other proposed increases, allowing $30,000 for Alaskan mineral resources but only $20,000 for water resources. Thus in the final version of the bill, approved on May 9, 1935, the appropriation for geologic surveys was the largest in Survey history to that date, although $50,000 less than the combined appropriations for geologic surveys and fundamental research in fiscal year 1931; the appropriation for water resources was about 15 percent more than in 1931, for Alaskan mineral resources, about 7 percent less; and for topographic surveys only a little more that half what it had been in 1931.

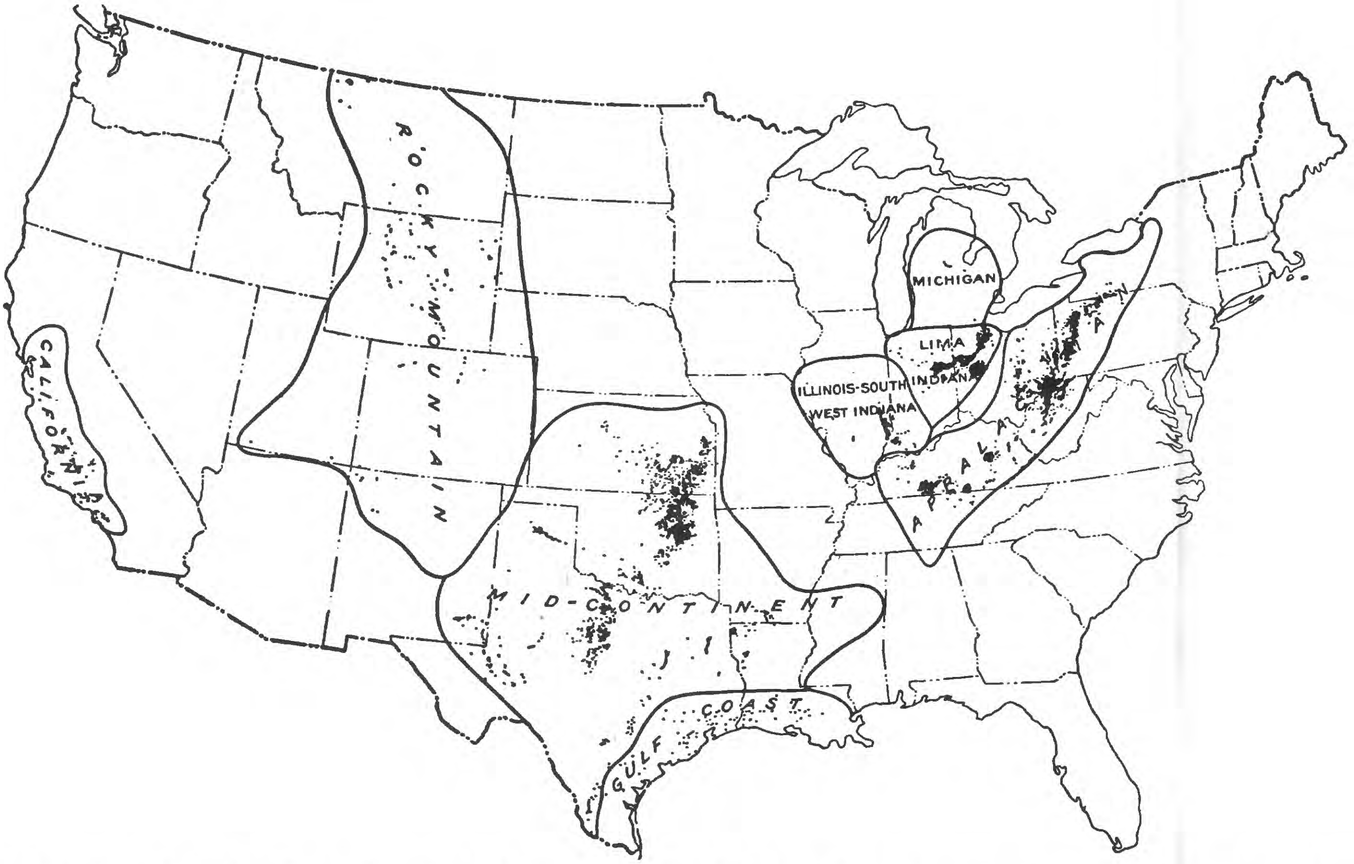
Legislation to renew and clarify the National Industrial Recovery Act was filed in both houses, but before any action was taken the Supreme Court, early in January 1935, struck down the provision in the NRA Petroleum Code that authorized the President to prohibit the transportation in interstate and foreign commerce of oil produced or withdrawn from storage in violation of State law on the grounds that it was an improper delegation of legislative authority. The oil industry had by this time concluded that Government control was to its advantage. Congress very quickly passed the Connally "Hot Oil" Act, approved February 22, 1935, which prohibited the shipment of contraband oil in interstate or foreign commerce for a period of 2 years. (The act was renewed in 1937 and 1939 and eventually made permanent.) Congress also authorized an Interstate Compact to Conserve Oil and Gas. Depending on one's viewpoint, these actions either enabled the oil industry to "avoid the twin horrors of competition and antitrust action" or provided a means of conserving oil by avoiding the waste generated by unrestricted or unregulated competition. In April 1935, C. K. Leith told the Senate Finance Committee while it was considering the renewal of the National Industrial Recovery Act the prevention of waste was one of the prime tenets in the conservation of nonrenewable resources. The Mineral Policy Committee believed that there should be some measure of production, capacity, or price control for exhaustible resources even after the National Industrial Recovery Act expired. Not only exhaustibility but unequal geographic distribution of minerals, and not only conservation but also national defense requirements made it important to prevent waste.

Secretary Ickes had by this time begun to consider the Department of the Interior the principal Federal agency of conservation. He was thus more than a little irritated when the Soil Erosion Control Division was transferred from In-

With funds allotted to the Survey by the Public Works Administration for investigations of mineral resources east of the Rocky Mountains, most of the known gold deposits in the Piedmont region of Virginia, North and South Carolina, Georgia, and Alabama were examined in 1934 and 1935. Gold mining in the area, which had begun in 1799 but almost ceased during World War I and the period of high costs that followed, was showing signs of revival. J. T. Pardee and C. F. Park Jr., found that both lodes and placers were being mined although in many places there was no definite separation between residual placers and the lodes from which they were derived, and thus the classification of a given deposit sometimes depended on the method by which it was worked. The photograph shows a steam dragline and a portable machine for recovering placer gold operating in Goochland County, Virginia, where the gravels were said to contain about 0.011 ounces of gold per cubic yard. (From J. T. Pardee and C. F. Park, Jr., 1948.)

terior to Agriculture at the end of March 1935 by Executive order. The order anticipated passage of legislation to establish a Soil Conservation Service in the Department of Agriculture but followed a complaint from Secretary Wallace to President Roosevelt that the Department of the Interior was interfering in agricultural matters. Secretary Ickes told the President then that he would like to be relieved of all responsibility for the works program and have all conservation activities in Interior. As this would require legislation, Ickes was told to canvass sentiment on the Hill, and on April 10 he was given authorization to go ahead with a bill. Two weeks later the bill was ready, proposing to change the name of the Department of the Interior to Department of Conservation and Works and to give the President the power for 2 years, subject to review by Congress, to transfer bureaus to and from Interior. When the bill was filed, newspaper correspondents immediately read into it a conflict between the Departments of Agriculture and Interior for control of the Forest Service, and Ickes confided to his diary, "they are not far wrong at that." When the Senate hearings were held in mid-May, representatives of the Forest Service appeared in opposition to the bill although their opposition had to be on general grounds as there was nothing in the bill itself to bring up the question of a transfer of the Forest Service.

All of this was overshadowed by the announcement by the Supreme Court on May 27, 1935, that the National Industrial Recovery Act was unconstitutional because Congress had exercised power beyond the scope of the interstate commerce clause and had delegated too much power outside its own reach. Four days later, in a press conference, President Roosevelt noted that the implications of this decision carried to their logical conclusion would exclude Federal jurisdiction over construction, mining, manufacturing, and agriculture, or four of the five major economic activities of the Nation. Almost immediately after the decision was announced, C. K. Leith suggested to Secretary Ickes that the Mineral Policy Committee draft a general enabling act covering all natural resources to replace the codes covering the mineral industries, but Ickes held



Oil became so plentiful in the early 1930's that Congress made an extensive investigation of the petroleum industry in 1934 as background for the development of legislation for regulation of the industry. As part of the investigation, Survey geologists prepared a comprehensive summary of U.S. reserves, calculating that as of December 31, 1933, recoverable oil amounted to 13.16 billion barrels. The map shows the producing fields and areas known at that time. The Survey considered it reasonable to assume that productive fields would be discovered in the future, some possibly as prolific as any then producing, but probable that the number of new fields would be less than the number already found. (From U.S. Congress, 1935.)

that the committee should not frame legislation unless the President specifically requested it to do so. Leith then attempted to bring the matter to the President's attention but the other members of the Mineral Policy Committee refused to endorse his letter.

Administration officials debated on a course of action in response to the Supreme Court decision but on June 4 the President announced his post-NRA policy. He recommended a program looking not to central control of the economy but the the patrolling of separate sections by separate laws, and called for passage of the Wagner bill, of a law enforcing wages, hours, and anti-child-labor provisions on public contractors, and of the Guffey bill to replace NRA in the coal industry. Again Roosevelt took the initiative and during the summer prodded Congress into action. The stream of legislation that followed was reminiscent of the first hundred days of the administration. Among the laws enacted were the Guffey-Snyder Act which, in effect, reenacted the bituminous coal code of the NRA and created the Bituminous Coal Labor Board and the National Bituminous Coal Commission to administer it, and an act requiring the development under unit plans of oil pools on public lands under lease.

As the newly revived administration swung into action, Roosevelt had issued an Executive order on June 7 abolishing the National Resources Board, which had been set up under the National Industrial Recovery Act, and reestablishing it as a National Resources Committee in the enlarged form earlier proposed by Secretary Ickes. The Technical Committee was expanded to include two new sections on urbanism and science. The Science section was composed of nine members, three each named by the National Academy of Sciences, the American Council on Education, and the Social Science Research Council. The National Academy of Sciences nominated its president, F. R. Lillie, Professor E. B. Wilson of Harvard, both zoologists, and J. C. Merriam, President of the Carnegie Institution of Washington, a paleontologist. The

Land Section of the Technical Committee continued with much the same membership, but the Water Section was new, composed largely of Federal experts including the Survey's Chief Hydraulic Engineer N. C. Grover, the Commissioner of Reclamation Elwood Mead, and H. H. Bennett, head of the Soil Conservation Service. The Minerals Committee was continued but without any clear sense of purpose and with some disagreement among the members about its future course; early in January 1936, it was disbanded and its functions were taken over by the National Resources Committee. In anticipation of the demise of the Minerals Committee, Leith arranged for a thorough study of mineral conservation under the auspices of the Brookings Institution in Washington. The Science Advisory Board, due to expire on June 30, 1935, was also given a 6-month extension in order to give the National Academy of Sciences time to provide some means for carrying on its work. This the Academy did through a reorganized Committee on Governmental Relations, its Executive Committee dominated by former members of the board, and newly renamed The Government Relations and Science Advisory Committee.

The Geologic Branch in the fiscal year beginning July 1, 1935, was almost back to normal. It had the largest appropriation it had had to that time for geologic surveys, some PWA funds were still available, cooperative funds were available from Colorado, Idaho, and New Mexico, and the National Park Service provided funds for physiographic and geologic studies in Yosemite, Sequoia, and Zion National Parks. Fifty field parties were at work in 35 States. The branch was also under new management. T. W. Stanton retired as Chief Geologist and was succeeded by G. F. Loughlin, Chief of the Metals Section. D. F. Hewett, who for many years had been closely associated with Leith, became the new Chief of the Metals Section.

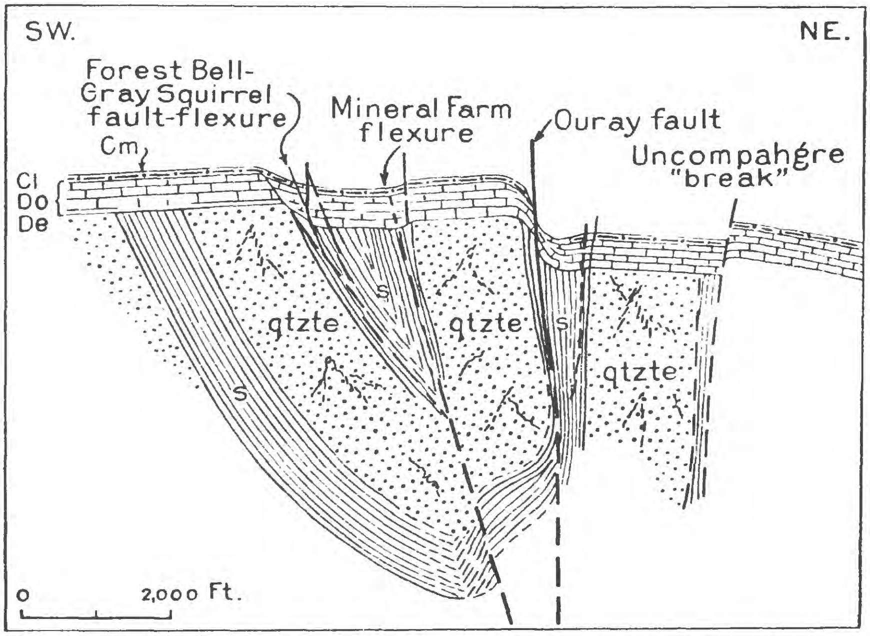
The Metals Section undertook investigations not only in the Western States but also in the Mississippi Valley and the Southern Appalachian States. In Colorado, Wilbur Burbank returned to the San Juan region and E. B. Eckel to the La Plata region; T. S. Lovering and E. N. Goddard were in the Front Range; A. H. Koschmann back at Cripple Creek; and C. W. Behre in the Mosquito Range. In Idaho, P. J. Shenon continued field work in the Coeur d'Alene district, J. C. Reed in the Florence and Warren districts of Idaho County, and C. P. Ross in the Boise Basin. In New Mexico, S. G. Lasky continued his field study of the Little Hatchet Mountains. In other areas, the Survey aided the State Survey of Arizona in mapping the Tombstone area by supplying the services of B. S. Butler, H. G. Ferguson resumed mapping the Hawthorne-Tonopah quadrangles in Nevada, F. C. Calkins began a resurvey of the Comstock district, E. T. McKnight continued detailed areal and underground mapping in the Tri-State area of Oklahoma, Missouri, and Arkansas, and J. T. Pardee and C. F. Park continued mapping in the Southern Appalachian gold region.

Fuels Section geologists resumed work in California, Utah, Wyoming, Kansas, and Oklahoma, and also continued the investigations begun under PWA auspices in New York. In California, W. P. Woodring gathered additional data on the Kettleman Hills oil and gas fields, and studied the oil resources and subsurface structure and stratigraphy of the Mountain View and Edison fields near Bakersfield. C. B. Hunt began a field study of the geology and oil and gas resources of the Hanksville-Cainsville area in Utah that was later extended to a study of the Henry Mountains. W. G. Pierce and D. A. Andrews made field studies of the geology and fuel resources of an area on the western margin of the Big Horn Basin in the north-central part of Park County, Wyoming. T. A. Hendricks made field investigations of the petroleum possibilities, structure, and stratigraphy of the Black Knob Ridge and adjacent areas in the Ouachita Mountains of Oklahoma, and N. W. Bass resumed the cooperative investigation in Kansas, studying the limestones of Mississippian age found in deep wells in the eastern and southeastern part of the State. W. H. Bradley continued the field investigations of the gas resources and structure in south-central and western New York, begun under a PWA grant, and found 10 domes considered suitable for drilling.

The Alaskan Geology Branch also had a full field season in 1935. F. H. Moffit and Gerald FitzGerald mapped in the Alaska Range between the Copper and Tanana Rivers, FitzGerald, as had become customary, in an area previously unmapped even in an exploratory way, little known and rarely visited except by prospectors, hunters, or native Alaskans. J. B. Mertie, Jr., completed the geologic investigation in the Nushagak region of southwestern Alaska begun by P. A. Davison in 1931. S. R. Capps returned to Kodiak Island to map the southern and central part, and R. H. Sargent continued mapping in the Admiralty Island area. Stephen Taber joined the branch temporarily to begin a special investigation of the effect of permanently frozen ground on mining developments in central and western Alaska, especially in the Fairbanks and Nome districts.

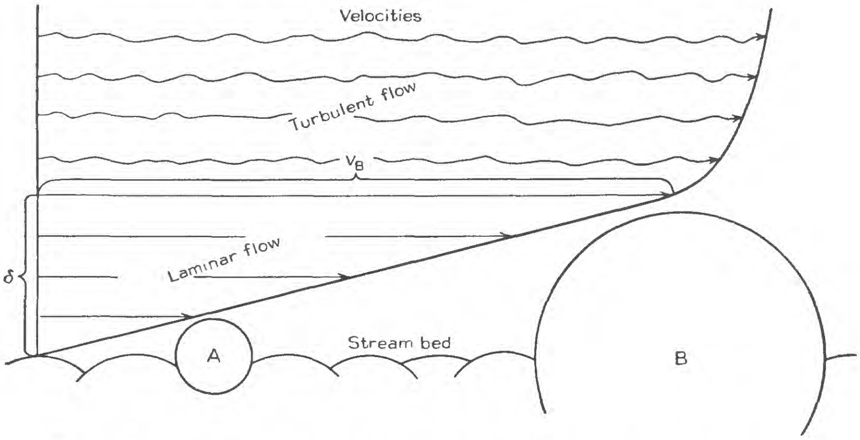
The Conservation Branch was severely handicapped by lack of funds in the fiscal year beginning July 1, 1935. The Power Division was able to continue its field investigations because of the extended availability of PWA funds but the Mineral Classification Division was restricted to the office and even there delayed by lack of geologic information as the result of limited field work. In the leasing divisions, field engineers had to be assigned to Washington because of the great number of unit plans submitted for technical review, with consequent sacrifice of field duties, omission of inspections, and loss in resources and revenue.

The Water Resources program expanded in the year beginning July 1, 1935, an expansion clearly in line with the call of the Water Planning Committee of the National Resources Committee for the extension of surveys, inventories, and records of conditions fundamental for the use and control of water resources but also the result, at least in part, of the many problems caused by the disastrous drought in 1934 and the increasing drain on ground-water resources. Stream-flow records were obtained in all 48 States, the District of Columbia, and the Territory of Hawaii, and at the year's end the number of stations in operation had increased to 3,163. Most of these measurements were related to such long-standing purposes as irrigation, municipal supply, or power.



In the Uncompahgre district of Ouray County, Colorado, W. S. Burbank found that the principal ore deposits were closely associated with laccolithic intrusions and local uplift of late Upper Cretaceous and early Eocene age but their location was largely governed by structural trends and axes of uplift established in late Paleozoic time that in part renewed and accentuated structural lines of late Precambrian time. An idealized section of the southern part of the district shows the relations of the main faults and folds in the Precambrian basement to faults and folds in the immediately overlying Paleozoic limestone. Two main structural axes crossed near the center of eruptive activity and divided the district into four sections in which, because of different relations to the structural axes and the intrusive rocks, the conditions of mineralization were different and prospectors must use different criteria in the search for ore. (From W. S. Burbank, 1940.)

To test various theories of the force required to move particles on a stream bed, W. W. Rubey reexamined the data from G. K. Gilbert's laboratory experiments on the transportation of debris by running water (see page 131) and found that the classic 6th-power law was valid for large particles such as coarse sand and gravel. In the idealized velocity gradient very near a stream bed shown in the diagram, the velocity within a film of laminar flow increases greatly with distance from the stream bed to a "bed" velocity at the boundary between that film and the main mass of turbulent water above it. The forces acting on a particle immersed within the film increase greatly with the dimensions of the particle or the height to which it stands above the stream floor, hence the forces acting on particle B to push, drag, and lift it may be enough greater than those acting on particle A to move B without moving A. The steepness of the velocity gradient is the controlling factor but the start of movement depends at least in part on surface drag or hydraulic lift. (From W. W. Rubey, 1936.)



Ground water, however, was being used in new ways, such as in air conditioning and industrial applications, in some areas and was increasingly being turned to in other areas for irrigation and public water supplies. The quantitative investigations that the Survey had been conducting became even more important under such circumstances. The Survey's ground-water investigations in 1935, in 21 States and the Territory of Hawaii, were concerned with a variety of problems. In the Humid States east of the Mississippi River, systematic ground-water investigations were continued in Connecticut, in New York, where R. M. Leggette took charge of field work, and in New Jersey, Pennsylvania, and western Florida. In Indiana, where more than 80 percent of all municipalities obtained their water supplies from ground water, R. C. Cady made a reconnaissance of the northern part of the State and selected 87 observation wells to begin a cooperative program. In the semiarid and arid regions most of the investigations were drought-related. In South Dakota, T. W. Robinson measured the depth to the water level and artesian pressure in about 75 artesian wells west of the Missouri River and A. N. Sayre investigated the ground-water conditions in the valleys of the James and Cheyenne Rivers where the Army Engineers were attempting to determine the extent of the shortages in water supply. In Nebraska, L. K. Wenzel, with the assistance of H. A. Waite, selected 350 observation wells in Keith County where the construction of large reservoirs in connection with the Platte Valley and Central Nebraska irrigation districts made information on ground-water resources very important. Wenzel also arranged informal cooperation with the city of Grand Island, Nebraska, where a depression in the water table had been noted earlier, and 55 observation wells were constructed there. In Texas, a statewide inventory of water wells and water-table and seepage studies were begun with the aid of a PWA grant sponsored by the State. A statewide program was also begun in Utah where the increasing number of disputes between owners of nearby wells had persuaded the legislature to enact a ground-water law and appropriate funds to begin the investigation as the basis for administration of the law. The State Engineer arranged for cooperation with the U.S. Geological Survey and G. H. Taylor and H. E. Thomas began the program on July 1. In the first season, 230 observation wells were selected where data on the position and fluctuations of ground-water levels could be obtained as the basis for later investigations to be extended throughout the State. The Oregon State Water Resources Department also arranged for cooperation with the Survey to begin an observation-well program in the semiarid region east of the Cascade Mountains.

In the spring of 1935, C. V. Theis had presented to the American Geophysical Union an important new formula for use in such quantitative investigations, the nonequilibrium formula for determining the drawdown of the water level in the vicinity of a discharging well, taking into account the removal of water from storage. The formula was called "nonequilibrium" because it did not depend on the hydraulic system's reaching a state of equilibrium. In nature, the hydraulic system in an aquifer is in balance; discharge and recharge are equal and the water table is more or less fixed. When discharge through wells is superimposed on that system, water levels are lowered in the vicinity of the wells and a new equilibrium must be established. For many years, the lowering was considered a local phenomenon and the reestablishment of equilibrium a short-term process, but evidence had been accumulating that at least in artesian areas a much larger area and longer time were involved than had been believed. Theis based his formula on the assumption that Darcy's law is analogous to the law of flow of heat by conduction and thus that the mathematical theory of heat conduction is largely applicable to hydraulic theory. Later development and use of the formula indicated that well discharge may affect the whole aquifer and the draft on storage may continue for several generations, even though at a distance these effects may be small.

The Topographic Branch, like the Conservation Branch, had a problem with inadequate funds. Most of its PWA funds had been spent, and the appropriation of only $400,000 limited the amount of cooperative funds that could be accepted. As a result, expenditures for topographic mapping were only about 70 percent of those in the preceding fiscal year, and field mapping for standard contour maps covered only 18,555 square miles. Although the amount of mapping declined, the program remained national in scope, as mapping was done in 43 States, and 70 percent was done at the 1:62,500 scale in accordance with the national mapping plan. In addition, planimetric maps of 31,654 square miles in 8 States were made from aerial photographs and given a field check. The bulk of the planimetric mapping was in the Tennessee Valley, and the 766 maps needed by TVA were completed by the end of the year.

Congress adjourned on August 26, 1935, and the President left Washington for several weeks, beginning with a train trip across the country in September, with a stop for the dedication of Boulder Dam, followed by a leisurely cruise on the *Houston*. It was a peaceful interlude, but a short one. In October, Italy invaded Ethiopia. Although Roosevelt quickly invoked the Neutrality Act, which Congress had passed shortly before adjournment, and representatives of 51 nations voted in the League of Nations Assembly to impose sanctions on Italy, which went into effect in November, the Italians continued their advance. In December, the French and British foreign ministers agreed to a partition of Ethiopia.

In his annual message to Congress, which he delivered personally before a joint evening session on January 3, 1936, Roosevelt spoke of the increasing tension in Europe and Asia. As a matter of policy, he said, the United States was following "a two-fold neutrality toward any and all Nations which engage in wars that are not of immediate concern to the Americas. First, we decline to encourage the prosecution of war by permitting belligerents to obtain arms, ammunition or implements of war from the United States. Second, we seek to discourage the use by belligerent Nations of any and all American products calculated to facilitate the prosecution of a war in quantities over and above our normal exports of them in time of peace."

On January 6, 1936, the Supreme Court challenged Federal jurisdiction in another area by declaring the Agricultural Adjustment Act of 1933 unconstitutional. The Court based its decision on the processing tax which the majority decided was not a tax but part of a system for regulating agricultural production. Secretary of Agriculture Wallace, who had already had some doubts about the processing tax, had new legislation ready to be submitted, and the Soil Conservation and Domestic Allotment Act became law only 54 days later, enabling the Government to continue the restriction of agricultural output by providing benefit payments to growers who practiced soil conservation by not planting soil-depleting crops.

The implications of the Supreme Court decision were far reaching, for this time in presenting its case the Government had invoked the clause giving Congress power "to lay and collect taxes, duties, imports, and excises, to pay the debts and provide for the common defence and general welfare of the United States." The general-welfare clause, the Government argued, should be construed broadly to include anything that was conducive to the national welfare. The Court declared, however, that agriculture was not a national problem and that it did not help "to declare that local conditions throughout the nation have created a situation of national concern; for this is but to say that whenever there is a widespread similarity of local conditions, Congress may ignore any constitutional limitations upon its powers and usurp those reserved to the States." The problem with respect to agriculture had been eased, but the nagging question remained: if agricultural problems did not affect the general welfare of the United States, what other Federal activities might be challenged?

On February 17, the Court upheld the dams built under TVA as a legitimate exercise of the Federal Government's power to control navigable streams and to provide for the common defense, but 3 months later, on May 18, declared the Guffey Coal Act was an infringement of states' rights and therefore unconstitutional. In the Guffey case, a stockholder had asked the Court to enjoin the Carter Coal Company from collaborating with the system of bituminous coal regulations established the year before to replace the NRA coal code. His lawyer argued that coal mining was just as much a local activity as farming or manufacturing, and therefore not subject to Federal regulation, although the company in question shipped most of its coal outside the State where it was mined. Seven coal-producing States supported the Government

After Congress authorized cooperative development of oil fields including public lands, the Survey began an investigation of the geology of the Kettleman Hills in central California, which included a considerable acreage of public lands, primarily to provide data to aid public-land officials in cooperating with the leaseholders and holders of private lands to conserve and utilize the resources to the greatest possible advantage. In working out the stratigraphy and structure of the area, Woodring and his coworkers paid particular attention to the zonal paleontology of the Pliocene section that crops out in the Kettleman Hills. Sand dollars of the genus *Dendraster* were among the most abundant of the stratigraphically important fossils in the San Joaquin and Etchegoin Formations. The type specimen of *Dendraster coalingaensis macer* Stewart, from the Etchegoin Formation, is shown. (From W. P. Woodring, Ralph Stewart, and R. W. Richards, 1940.)

case with briefs stating that the act did not endanger States' rights and that Federal regulation was the only solution for the coal industry. A majority of the Court found that the labor provisions of the Guffey Act, which had yet to be put into effect and were not in issue, were unconstitutional, and therefore that price stabilization and fair-trade practices, which were in issue, must also be unconstitutional. The decision ignored the stipulation in the act that if any provision of the statute were to be held invalid, the other provisions would not be affected thereby. The decision, according to A. M. Schlesinger, Jr., was "a staggering blow against the whole idea of national power."

The second session of the 74th Congress was a relatively short one, it being a presidential election year, and it provided few new major legislative enactments beyond the appropriations bills. President Roosevelt's plan to establish a National Resources Board was bottled up in committee in both houses and Secretary Ickes' bill for a Department of Conservation languished in a House committee. Nonetheless, Ickes continued to emphasize the role of the Department of the Interior in conservation, and in December 1935 told the House Committee on Appropriations that

> **Expediency in dealing with our natural resources can no longer be justified as Federal policy. * * * Careful and concentrated thought must be devoted to their protection and development through wise use.**

For the fiscal year beginning July 1, 1936, the Department had approved a Survey budget of $3,398,000, larger than any appropriation the Survey had received before that time but about the same amount as the combined PWA and directly appropriated funds for the year then underway. The largest increases were proposed for topographic surveys, water-resources investigations, and supervision of mineral leasing activities on the public lands. A smaller increase was proposed for geologic surveys, in part to support the geophysical activities being transferred from the Bureau of Mines to the Survey. The justification for geologic surveys stated the funds were needed "not only for the surveys of districts not previously studied in detail but for the periodic resurvey of leading mining districts," a recommendation of the AIME symposium in 1934, and "for the mineral inventories long recommended by the Geological Survey itself and now by the Mineral Policy Committee of the National Resources Committee." Somberly, the statement added

> **Obviously much more concentrated attention 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.**

The Bureau of the Budget slashed the requested appropriation for the Survey by 30 percent and recommended to Congress an appropriation of only $75,000 more than the current appropriation. The Department had requested $1,000,000 for topographic surveys; the Bureau of the Budget recommended $400,000. The Department requested $800,000 for water-resources investigation; the Bureau of the Budget approved $660,000. The Department requested $538,000 for geologic surveys; the Bureau of the Budget said $488,000. The Department asked $315,000 for supervision of mineral-leasing activities; the Bureau of the Budget recommended $225,000. Then to make up for the fact that it had approved increases of $113,000 in these four items, the Bureau of the Budget recommended that the appropriation for classification of the public lands, for which no increase had been asked, be cut from $150,000 to $100,000.

Although economy was probably the chief reason for the reductions, for economy and a balanced budget were being fervently promoted in some circles, the effect was nonetheless to cripple national work. Congressman Scrugham continued to favor the proposition that topographic mapping was a purely

Federal responsibility, but funds for topographic surveys, including transfer and cooperative funds as well as the appropriation, would not even provide for the salaries of the permanent staff and related activities. State offers of cooperative funds for water-resources investigations had surpassed the $596,000 mark by December 1935, so clearly the Bureau of the Budget figure would allow little if any purely Federal work. The recommended appropriation for geologic surveys allowed for the added expenses of the geophysical work but not for strategic-mineral investigations.

The House committee was most concerned about the amount of money that was being spent in Washington, and thought perhaps the whole Survey should be transferred outside the city to some point that would be more central to its operations. Director Mendenhall thought that the idea of being central applied equally well to the Capital, and in any event that the Survey should not be separated from the Department and other national functions. The committee did not press the idea of transferring the Survey outside Washington but it was unable to understand how administration, laboratories, the library, computations, drafting, and report writing in Washington had anything to do with field work. In the end, the House committee accepted all Bureau of the Budget recommendations except those for water-resources investigations and Alaskan mineral resources, from which it trimmed an additional $60,000 and $10,000 respectively, while voting to reduce the amount that could be spent in the District of Columbia for topographic and geologic surveys, Alaskan mineral resources, and supervision of mineral leases. The House went along with the committee's recommendations.

The Senate Appropriations Committee raised the appropriation for water-resources investigations to $791,317 (almost the $800,000 originally approved

The end of the pioneering period in the Yukon-Tanana region of Alaska was noted by J. B. Mertie, Jr., in a report published in 1937. It had begun in 1896 when J. E. Spurr headed the first Survey expedition into the area. Systematic study of the geology and mineral resources had begun when the Division of Alaskan Mineral Resources was established in 1903, and by the early 1930's the general types and distribution of the major geologic units had been fairly well determined. Henceforth, detailed and semidetailed mapping in selected areas would be needed to solve important problems. The red beds of the Tindir Group, shown here along the Tatonduk River, of uncertain age but roughly equivalent to the Belt series, Mertie believed merited more field and petrographic study. (From J. B. Mertie, Jr., 1937.)

by the Department) and for supervision of mineral leasing to $315,000 (again close to the Department estimate.) For topographic surveys, the committee proposed an appropriation of $650,000 and added a proviso that the Secretary of the Interior submit to the next session of Congress a program for expediting the topographic mapping of the United States in an economical manner, together with the estimated cost. That proviso was later dropped from the bill and made the subject of a resolution, proposed by Senator Hayden, and passed on April 17. More modest increases were recommended for geologic surveys and Alaskan mineral resources, $12,000 and $10,000 respectively. In the final bill, which was approved on June 11, the more generous Senate figures prevailed except for Alaskan mineral resources, which received only the $60,000 allowed by the House. The total appropriated for the Survey for the fiscal year beginning July 1, 1936 was $2,807,817.

At least part of the Survey appropriation can be accounted as congressional acceptance of national responsibility for natural-resource investigations, but a clear statement of Federal responsibility was made in the Flood Control Act of 1936, passed in the wake of the floods that devastated the Northeastern States in the spring of 1936 and approved on the same day as the Interior Department Appropriations Act. In the Flood Control Act, Congress stated as a principle that flood control on navigable waters or their tributaries was a Federal responsibility, in cooperation with States and smaller political subdivisions, and allocated to the War Department responsibility for Federal investigations and improvements of rivers and other waterways for flood control and allied purposes, and to the Department of Agriculture responsibility for investigations of watersheds and measures for retardation of runoff and waterflow and for prevention of soil erosion. Both departments were enjoined not to interfere with the investigations and river improvements incident to Bureau of Reclamation projects. As the 1936 election campaign began, an ideological confrontation among the three branches of the Federal Government was developing.

Chapter 14.
Astatic World, 1936–1939

If we were known to be dealing with a static world in which our knowledge regarding all available materials and of man was approximately complete, it would be possible to formulate plans which, with slight variation, might operate almost indefinitely. It is, however, clear that by whatever means we view the history of science and research we are seen to be dealing with almost continuously changing conditions to which adjustments must be made.

—John C. Merriam

At the outset of the election campaign in 1936, the issues seemed clearly defined. The Republican National Convention had condemned the New Deal, accused the President of usurping the power of Congress, charged that regulated monopoly had displaced free enterprise, and nominated for President the Governor of Kansas, Alfred M. Landon, a businessman and independent oil producer with little experience in politics. The Democratic National Convention had made its stand on the administration's record and nominated Franklin D. Roosevelt for a second term. In accepting the nomination, Roosevelt had challenged the opposition with an attack on the "economic royalists" who had "created a new despotism and wrapped it in the robes of legal sanction." Most of the newspapers and large numbers of businessmen supported Governor Landon, and Roosevelt's defeat was widely predicted. As the campaign progressed, the preservation of peace became an issue after other countries began to intervene in the Spanish Civil War, which began in mid-July, making Spain the battleground of rival ideologies. Most Americans, according to contemporary polls, sided with the Loyalists although many who feared the spread of communism more than fascism supported Franco and the Insurgents. Roosevelt came out on the side of peace while the businessmen supporting Landon were accused of being on the side of the warmakers. On November 3, Roosevelt was reelected President of the United States, winning 60.7 percent of the popular vote and the most overwhelming electoral majority since Monroe's victory in 1820. The Democratic majorities in both House and Senate were increased substantially.

The landslide victory naturally gave the administration renewed confidence to pursue a program of domestic reform, and plans were made to attack a wide variety of social problems. Increasing turmoil in the world, however, gradually forced the administration to devote more attention to foreign policy and national defense. Roosevelt's efforts to reform the judicial system, in particular the Supreme Court, split the Democratic Party, a recession in late 1937 added further complications, and in the 1938 elections, for the first time in 10 years, the Republicans made notable gains. Most of the New Deal's conservation programs to protect and develop the land and water were simply carried over from the first administration; a proposal to create regional conservation authorities, however, was opposed with a fervor reminiscent of earlier decades. Proposals for an accelerated mapping program and for mineral inventories in aid of domestic development received little support and even when their importance for national defense was recognized funds were not readily forthcoming. Funds for basic scientific research were meager, less than one percent of the budget, and economy and a balanced budget were considered most important.

By 1936, the Geological Survey, in no small part owing to the skillful administration of its Director, had regained its stability after the trauma of the early depression days and had also achieved new standing in the world of science and engineering. Director Mendenhall was president of the Geological Society of America that year, D. F. Hewett was president of the Society of Economic Geologists, C. E. Dobbin was vice president of the American Association of Petroleum Geologists, and O. E. Meinzer was president of the Washington Academy of Sciences. C. S. Ross had just completed his term as president of the Mineralogical Society of America, and C. H. Birdseye, after completing his term as president of the American Society of Photogrammetry, had been elected a councilor of Section E of the American Association for the Advancement of Science. Survey geologists were serving as associate editors of national scientific journals, Survey scientists and engineers were serving on committees of the National Resources Committee and the National Research Council, and Meinzer and R. W. Davenport of the Survey were appointed chairman and vice chairman of the Research Council's committee to prepare the volume on hydrology for the *Physics of the Earth* series.

It was an exciting time to be a geologist, perhaps less exciting, Mendenhall suggested in his presidential address, than the days of some of the great philosophic battles of the past, between Neptunists and Plutonists, over the meaning of fossil shells found on mountain tops, or Darwinian evolution, although he found discussion of some current topics equally interesting. He thought it

> **safe to say that what is now known about the earth and its development, about the origins and evolution of life, including man himself, and about earth processes is infinitesimal by comparison with what will eventually be known.**

Moreover, he believed that the contributions of the scientists of 1936 to the advancement of science would be as sound and as permanent as "those past contributions that we often refer to with awe as the products of the masters."

Desirable lines of research in geology and geography, the National Research Council found in response to a poll of more than 300 scientists in the

Gold placers had attracted the earliest settlers to Colorado but had long since ceased to be of much interest until the price of gold was increased in 1934. In a special field study of placers in northwestern Park County, Quentin Singewald combined his knowledge of the bedrock geology, including the location of lode deposits, and physiography of the region to determine the geologic environment of the gold placers and the probable distribution of gold in the unconsolidated deposits. Large areas of promising outwash gravel and morainal deposits were found from which private enterprise produced some $4 million in gold between 1939 and 1942. The photograph shows a close-up of the productive gravel in the Alma placer. (From Q. D. Singewald, 1950.)

spring of 1936, covered a broad spectrum, some familiar topics, some very new problems, and many of them couched in language that would have puzzled an earlier generation. Research was proposed in the concept of rhythm or cycles in geologic processes, the permanence of continents and ocean basins, the causes of magmatic differentiation, the geology of the Precambrian, the structure of the Earth's crust, the geology of the ocean bottom, the application of model theory to geologic processes, and the orientation of unequidimensional particles in moving fluids, to list but a few. So many problems were suggested in the borderland fields between geology, chemistry, and physics that the NRC set up an interdivisional committee to consider them, with the Survey's T. S. Lovering as chairman and W. W. Rubey among its members.

The Geological Survey, as a tax-supported organization, had less freedom to pursue basic research than endowed institutions, as Mendenhall conceded. He still held, however, to the familiar axiom that there can be no applied science unless there is science to apply, and as the Survey's fiscal situation stabilized, long-range and fundamental research programs were revived or inaugurated. With the beginning of World War II, the Survey's work was once more gradually reoriented to meet new national needs.

In the fiscal year that began on July 1, 1936, the Geologic Branch put 59 parties in the field and made investigations in 33 of the 48 States. The program remained weighted toward economic geology, but some of the economic geologists began making substantial contributions to basic science, and some fundamental research, suspended in earlier years, was resumed. The laboratory began giving more attention to the determination and compilation of the physical properties of rocks and to the correlation between physical properties of minerals and their chemical composition. The branch gained a new capability in geophysics through transfer of the Geophysics Section of the Bureau of Mines, as the Science Advisory Board had recommended in 1934. In another change of organization, the Coastal Plain Section was formally combined with the Section of Paleontology and Stratigraphy under J. B. Reeside, Jr.

The major metals field investigations were in the Rocky Mountain or Great Basin States. In the cooperative program in Colorado, field work was continued in the San Juan and La Plata regions, the mineral belt of the Front Range, and the Mosquito Range. T. S. Lovering devoted considerable attention to the problems of heat conduction in rocks, and W. S. Burbank found evidence from his studies of granodiorite porphyries in the Ouray district of a potential internal source of heat energy in crystallizing magmas that could explain the rise of magmas in the crust, concentrations of metals, and the manner in which materials were transported from the magma to the surrounding rocks. James Gilluly began a field study of the geology and ore deposits in west-central Cochise County, Arizona, and delivered a paper on the water content of magmas before the Harvard Tercentenary Conference on Arts and Sciences and one on the physiography of the Ajo region to the Geological Society of America. Eugene Callaghan began a survey of the Marysvale district, requested by Utah citizens in the hope that sufficient reserves of alunite would be found to attract industry to the region. Alunite had been discovered in 1910 and developed as a source of potash during and after the World War when potash prices were high; in 1936 there was a possibility that alunite could serve as a source of aluminum with potash as a byproduct. In Idaho, P. J. Shenon began mapping in the silver belt of the Coeur d'Alene district and J. C. Reed completed his work in the Florence mining district before leaving for Alaska. C. F. Park began a study of the areal geology and mineral resources of the Metaline quadrangle in the extreme northeastern corner of Washington.

A few metals investigations were made in the South and Midwest. Thomas Kesler, who had been a PWA geologist with the Survey in 1934, returned as a regular Survey employee to begin a study of the geology and mineral resources of the Cartersville district, 40 miles northwest of Atlanta, Georgia, where C. W. Hayes had mapped near the turn of the century, and E. F. Burchard continued mapping in the Russellville district in eastern Alabama. E. T. McKnight continued work in the lead-zinc districts of the Tri-State area and L. W. Currier completed in cooperation with the State an investigation of the fluorspar deposits of Illinois begun in 1935 as a PWA project.

The Fuels Section continued field investigations in California, Utah, Wyoming, and the Midcontinent region and began a new field project in Montana, an investigation of the mineral resources of the Little Rocky Mountains by M. M. Knechtel. Other new projects included Ralph Stewart's study of the structure, stratigraphy, and oil resources of the lower Tertiary strata of Reef Ridge in the Coalinga district in California where some of the Survey's earliest petroleum geology had been done, and A. A. Baker's mapping of the Strawberry Valley quadrangle in Utah with special reference to classification for oil, oil shale, gas, coal, and phosphate. Parker Trask concluded from his continuing investigation of the source beds of petroleum that petroleum originates mainly from the organic matter in marine sediments that is derived chiefly from the remains of planktonic organisms in the overlying water. Sedimentary petrology studies were extended in the fall when C. S. Piggott of the Carnegie Institution invited a group of Survey geologists to study the deep-sea cores from the North Atlantic Ocean and W. H. Bradley, M. N. Bramlette, J. A. Cushman, L. G. Henbest, K. E. Lohman, and Trask took up the task.

In other fundamental investigations, E. S. Larsen resumed his study of the Southern California batholith, with assistance from Harvard; W. C. Alden resumed his study of the physiography and glacial geology of western Montana and adjacent areas; and L. F. Noble resumed his study of Death Valley and its exceedingly complex structure. F. E. Matthes continued work in the national parks of the Sierra Nevada in cooperation with the National Park Service, and H. E. Gregory, after several years of "vacation studies" began a general geologic reconnaissance of the plateau country of southern Utah, including Zion Canyon National Park. N. H. Darton, before retiring after nearly 51 years in the Federal service, prepared a report on the structure of the northern anthracite coal basin in Pennsylvania on the basis of well data, bringing up to date work that had been in limbo since 1913 when he had completed an investigation for the Bureau of Mines of the relationship between structural features and the emanation of explosive gas in coal mines.

The Alaskan Geology Branch, with the exception of J. B. Mertie, Jr., had a normal field season in 1936. Mertie started for Alaska in the spring to make a geologic map of the valley of the Porcupine River in interior Alaska. On the way, however, the steamboat on which he was traveling up the Yukon River was wrecked and sank with all his instruments and field equipment. There being neither time nor funds to replace what had been lost, the field party was disbanded but Mertie proceeded to Fairbanks where he purchased new clothes, borrowed instruments from the University, and then, with authorization from Washington, spent the field season examining mining operations in the Fortymile, Eagle, and Circle districts. F. H. Moffit and Gerald FitzGerald continued their geologic and topographic mapping in the Alaska Range region, S. R. Capps returned to the railroad belt to study the principal mining camps along the route, and in southeastern Alaska, R. H. Sargent continued the topographic mapping of Admiralty Island, and in August John C. Reed began a geologic study of Glacier Bay. With the sense of emergency relaxed, P. S. Smith devoted some time to studying the route of early man from Asia and North America and at the Fifth Pacific Science Congress discussed the geologic and geographic evidence for a route across the Bering Strait rather than up the Aleutians.

In the mid-1930's, Survey geologists began a new investigation of the Oklahoma coal field where J. A. Taff had worked in the late 1890's and from which samples had been furnished for the coal-testing program of 1904, which, it was hoped, would lead to a scientific classification of coal. In a survey of the Howe-Wilburton district, T. A. Hendricks was not only able to establish a correlation between the formations of the Oklahoma and Arkansas coal fields, which had been differently defined near the turn of the century, but also to describe the coals according to the classification of coal by rank that had been adopted by the American Society for Testing Materials and the American Standards Association in 1937. The photograph shows the contact between the shale immediately above the lower Hartshorne coal and the overlying sandstone. Fossil tree trunks extend across the contact. (From T. A. Hendricks, 1939.)

The Water Resources Branch in 1936 furnished an excellent example of Director Mendenhall's ideal for Survey work—closely coordinated teamwork, useful in the public service, and leading to the advancement of science or engineering. The Surface Water, Ground Water, and Quality of Water Divisions joined forces with each other and with other Federal agencies to acquire the facts needed to resolve the interstate dispute over the allocation of the waters of the Rio Grande; the Division of Water Utilization acquired added duties with respect to flood investigations as a series of record-breaking floods in all parts of the country awakened public support for obtaining the basic data needed to design control measures; and the compilation and publication of data on power production, a task which the Survey had performed since the World War although it was only peripheral to Survey work, was transferred to the Federal Power Commission. In the regular ongoing program, stream-flow records were obtained in 48 States, the District of Columbia, and the Territory of Hawaii, and the number of gaging stations increased to 3,379 at the fiscal year's end. Ground-water investigations were carried on in 30 States and the Territory of Hawaii, the observation-well program was extended, and the use of geophysical exploration techniques in the search for water was investigated.

The Rio Grande Joint Investigation was under the general direction of the National Resources Committee, which had been asked by the Rio Grande Compact Commission to arrange for an investigation of the water resources of the basin above Fort Quitman, Texas, where the last major tributary joined the river. The States of Colorado, New Mexico, and Texas had signed a temporary compact in January 1929, not to allocate the waters but to obtain data by maintaining key gaging stations and exchanging the records, to bar Colorado and New Mexico from impairing the water supply in the Rio Grande by additional diversions or storage in Colorado except under specified conditions during the duration of the compact, and to convene a commission to conclude a permanent compact. When the Compact Commission found it difficult to reach agreement on a permanent compact it turned to the Federal Government for assistance; Federal interests were involved because the delivery of Rio Grande water to Mexico was guaranteed by treaty and because Rio Grande water was needed for irrigation projects on public and Indian lands. The Public Works Administration allotted funds for the investigation on condition that the States and certain Federal agencies also contribute funds, and the investigation was divided among the Bureau of Agricultural Engineering and the Bureau of Plant Industry of the Department of Agriculture and the U.S. Geological Survey, which was to make measurements of stream flow, drainage, waste, and diversions, and study the ground water including its chemical quality. The Surface Water Division established and maintained 76 gaging stations in Colorado and

144 in New Mexico; C. V. Theis supervised the ground-water investigations, and C. S. Howard was responsible for thousands of water analyses, including some which the Department of Agriculture laboratory was unable to make. Results of the joint investigation were used as the basis for negotiating the interstate compact that was approved by the three States and by the U.S. Congress.

Most of the flood investigations were made by engineers of the Surface Water Division in the districts in which the floods occurred under the guidance of the Division of Water Utilization; the Division of Water Utilization prepared the reports or supervised their preparation. With funds allotted by PWA, the floods of March 1936 in Eastern United States, floods of unusual magnitude in July and September 1936 in Texas, and the floods on the Ohio and Mississippi Rivers, the greatest known since the arrival of Europeans in the area, were investigated and reports prepared. Reports were also prepared on the floods in central New York State in July 1935, on the Republican and Kansas Rivers in May and June 1935, and in La Cañada Valley, California, on January 1, 1934. The study of the Texas floods indicated that long-time records of stream flow as well as flood records were needed for the economic and safe design of dams, reservoirs, levees, and other controlling works because Texas rivers had long periods of exceedingly low flow but during floods might have greater maximum rates of discharge than rivers in areas of comparable size elsewhere in the United States. Investigations of the floods on the Ohio and Mississippi Rivers included a special study of flood deposits by G. R. Mansfield of the Geologic Branch to aid in establishing criteria for the development of towns and construction of public works that might be affected by flooded rivers. The flood in La Cañada Valley pointed up strikingly the relation between rising flood damage and increasing human occupation of river banks and river valleys. Much of the damage of that flood was caused by the movement of massive amounts of debris from the mountains to the foothill region and the valley floor. Movement of material eroded from mountain areas into the valley was a natural process that had been going on for a long time without affecting or being affected by man's activities, but most of the debris during this flood came from an areas north of the valley which had been denuded by a forest fire in November 1933.

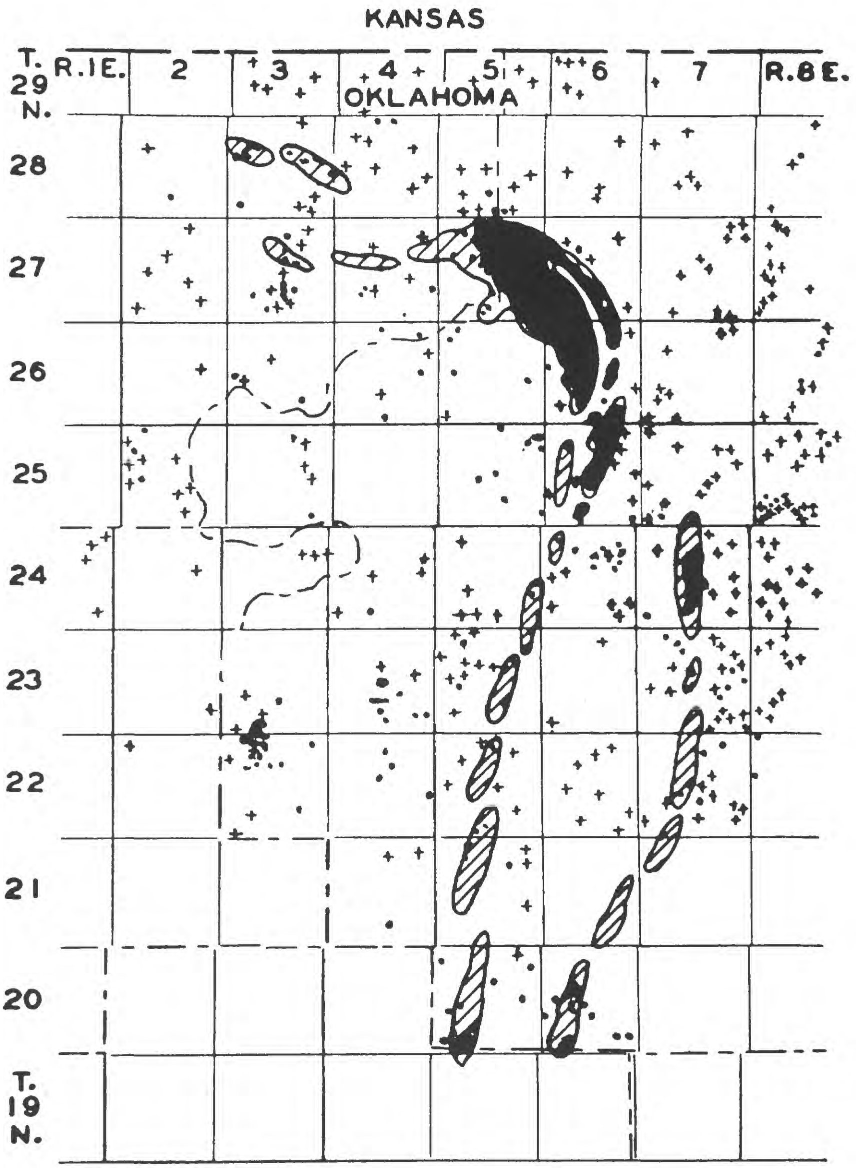
The Topographic Branch reached a turning point in its history in 1936 as work began in earnest in the compilation of topographic contour maps by photogrammetric methods. The Tennessee Valley Authority offered to set aside space for photogrammetric equipment if the Survey would furnish the instruments and personnel to operate them, and the offer was accepted. R. K. Bean was put in direct charge of a unit in Chattanooga, six topographers, two each from the three topographic divisions, volunteered for the experiment, and the program got underway in April. In the beginning, operations were on a three-shift basis and the unit prepared maps of areas in Virginia, as part of a cooperative project with the State, as well as the TVA maps. The area covered by conventional field surveys in the fiscal year beginning July 1, 1936, declined to only 14,302 square miles in 36 States and Puerto Rico, but nearly 80 percent of it was mapped at 1:62,500 and larger scales.

Problems remained in the Conservation Branch. The classification of the public lands remained nearly at a standstill for lack of funds for field explorations. However, the increase in appropriations for mineral-lease supervision permitted reasonably prompt action to be taken on proposed plans for cooperative or unit development of oil fields and somewhat better supervision of production operations. At the end of the fiscal year, 1,343 plans had been received and only 42 awaited original technical consideration. The volume of work under field supervision continued to increase; during the year production increased between 5 and 10 percent and revenue to about $6.3 million.

The first session of the 75th Congress began on January 5, 1937, with the Democrats in virtually unassailable control; it ended on August 21 with little of the President's legislative program accomplished and the Democrats badly divided. In his annual message to Congress on January 6, President Roosevelt had asked for an addition to the Neutrality Act covering specific points raised by the "unfortunate civil strife in Spain" and immediate consideration of the extension of certain authorizations in power due to expire. Two days later he presented a budget for fiscal year 1938 balanced except for debt reduction and promised a completely balanced budget for 1939. Then, in the second inaugural address on January 20, he challenged Congress with the need to help the "one third of a nation ill-housed, ill-clad, and ill-nourished." Roosevelt also spoke of the necessity of bringing "legislative and judicial action into closer harmony," and on February 5 he submitted to Congress a plan for reorganizing the Federal judiciary, including the authorization for appointment of one additional Supreme Court Justice for each Justice who did not retire within 6 months of reaching 70. The bill to reform the judiciary aroused widespread and bitter opposition, tied up Congress for several months, and in the end the Senate on July 22 recommitted the bill to the Judiciary Committee where it died. In a 2-month period beginning in late March, however, the Supreme Court sustained several important New Deal measures, and on May 18 the retirement of Justice Van Devanter was announced, so even though he lost the battle, Roosevelt felt he had won the war. The court fight, however, produced a new coalition of Republicans and conservative Democrats that contrived to block other legislation "so as matters turned out in Congress and the party, it could better be said that he lost the battle, won the campaign, but lost the war."

Congress responded promptly to Roosevelt's request for neutrality legislation. On January 6, it passed a joint resolution forbidding the export of munitions to either side in Spain and in April passed the Neutrality Act of 1937, adding to previous requirements the so-called "cash-and-carry" clause that belligerents who purchased nonmilitary goods in the United States pay for them immediately and transport them in their own ships. During the spring, Congress also passed the Guffey-Vinson Bituminous Coal Act, reenacting all the chief provisions of the Guffey-Snyder Act of 1936 that the Supreme Court had outlawed in 1936, except the wages-and-hours clause. The Guffey-Vinson Act authorized a code of fair competition for the bituminous coal industry and placed the output of soft coal under Federal regulation.

Later in the session, however, Congress became more recalcitrant, and among the measures that made no progress was the President's plan to create regional conservation authorities. The National Resources Committee in December 1935 had pointed out that many problems were neither solely within a State or entirely national but regional in nature. It had followed that up in December 1936 with two reports, one on drainage-basin problems and their solution, the other on the future of the Great Plains, which the Committee defined as extending eastward from the eastern front of the Rocky Mountains to the line west of which major readjustments in land and water use appeared necessary to meet climatic conditions, very roughly the traditional one hundredth meridian. The drainage-basin report outlined a pattern of water development and control designed to solve the problems, including even specific construction projects, and in effect presented the framework of a national water plan. The Great Basin report was less specific but pointed out that nature had established a balance in the Great Plains area, which had been disturbed when settlers had moved in; now the intruders must either restore nature's balance or devise a new one. Both reports stressed the need for early completion of topographic mapping, hydrologic and other scientific surveys in the region. On June 3, 1937, the President sent a special message to Congress:



A determination of the origin of the oil- and gas-producing Bartlesville and Burbank sands of Kansas and Oklahoma was of commercial importance as well as scientific interest because the mapping of structure, which the petroleum industry had long used in its search for new sources, was not applicable to these sands, which characteristically occurred in belts of elongate bodies 50 to 150 feet thick, 1/2 to 2 miles wide, and 2 to 6 miles long. In a regional study, N. W. Bass and his coworkers used modern shoreline features as models, outlined contemporaneous deposits in the two States, and concluded that the shoestring sands were most probably deposited as systems of offshore bars on the oscillating western shore of the Cherokee sea. The trends of hypothetical offshore bars, patterned after modern coastal charts, are shown on a sketch map of parts of Osage and Kay Counties, Oklahoma. The solid black dots and areas indicate wells and fields where the Burbank is present, the plus signs wells in which it is absent. (From N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, 1937.)

Nature has given recurrent and poignant warnings through dust storms, floods, and droughts that we must act while there is yet time if we would preserve for ourselves and our posterity the natural sources of a virile national life.

He suggested that the time had come when we should allot a definite portion of each year's budget to "this work of husbandry," and proposed the establishment of seven regional authorities which would, at least in the early years, be chiefly concerned with the development of integrated plans to conserve and safeguard the prudent use of waters, water power, soils, forests, and other resources of the areas entrusted to their charge. Congressman Joseph Mansfield and Senator George Norris promptly filed identical bills to establish these regional bodies, which were then referred to the committees they chaired and locked up. Six weeks later, in a countermeasure that was passed with despatch, Senator James Pope of Idaho offered a bill that declared it the policy of Congress to assist in providing facilities for water storage and utilization in the arid and semiarid areas of the United States and authorized the Secretary of Agriculture to formulate and keep current a program of projects for construction and maintenance of such facilities. Just before adjourning, having made it very clear that another bureau would not be established or additional funds appropriated, Congress asked for a comprehensive plan for the development of Alaska and its resources.

Recommendations for expanded hydrologic and topographic mapping programs also fell afoul of the conservative mood and the need for economy. In September 1936, the National Resources Committee had released a report appraising existing hydrologic programs prepared by a specially appointed committee from the viewpoint of engineers who had to use the data. That committee found the programs adequate in some respects but seriously deficient in others, and stated that

> **In the light of past experience with crop losses, dam failures, flood damages, and similar losses to life, health, and property, due in part to inadequate data, we feel confident that there can be no thoroughly sound Nationwide development of water resources unless certain deficiencies are remedied.**

Among the deficiencies were the collection of data on stream flow, fluctuations of ground-water levels, and quality of water. The committee was critical of reliance on cooperative programs and considered it "absolutely essential" that a network of Federal stations for stream-flow measurements be established. More specifically, the committee recommended the establishment and maintenance of 500 base stations at Federal expense and the rehabilitation of 1,000 existing cooperative stations. In addition, it recommended the expansion of the observation-well program by an additional 4,000 base stations and 6,000 cooperative secondary wells, and an increase of 200 Federal quality-of-water stations and 400 secondary cooperative stations. The total cost for these stations was estimated as $2,306,250 for the first year and $1,132,500 for each succeeding year.

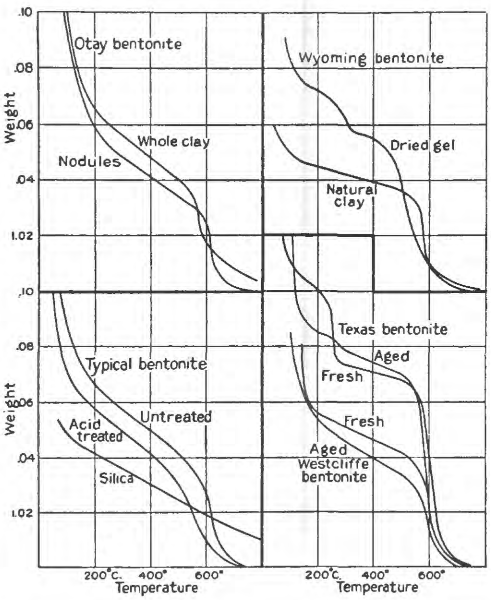
Secretary Ickes' program for expediting the topographic mapping of the United States, in response to Senator Carl Hayden's resolution of April 17, 1936, was sent to Congress on January 29, 1937. Ickes said that inasmuch as only 25 percent of continental United States exclusive of Alaska had been adequately mapped, that is, had maps less than 40 years old, and 46 percent was entirely unmapped, mapping 1.5 million square miles, including Puerto Rico and Alaska, in 20 years, at an average rate of 75-85 thousand square miles a year was a "reasonable program for present consideration." Such a program would cost $100 million, $20 million for triangulation and leveling, $80 million for mapping and reproduction. The Secretary recommended that the program be entirely Federal but agreed with Director Mendenhall that the States be permitted to contribute funds to expedite the program. Ickes further recommended that the Congress appropriate $4 million for topographic mapping by the Geological Survey in 1938 without restricting any funds to cooperative projects.

The President's budget did not reflect the recommendation of the National Resources Committee that the hydrologic program be expanded or Secretary Ickes' recommendation for expansion of the topographic mapping program. The Department had asked for an appropriation of only $874,000 for gaging streams, an increase of $82,683, and $1,000,000 for topographic mapping, an increase of $350,000, far cries from the $2 and $4 million proposed by the NRC and Secretary Ickes. For the Survey as a whole, the Departmental budget called for an increase of some $609,000 in its appropriation, including small increases for all line items except printing and binding. Among the increases was one of $25,000 for geologic surveys because "the need for a general inventory of strategic minerals is ever before us, and international conditions at present emphasize that need. We should like to make a modest beginning of a long-continuing inventory * * *." The Bureau of the Budget countenanced no such extravagance as proposed by the Department. It chopped $590,000 from the overall recommendation and recommended a total appropriation for the Survey for fiscal year 1938 of only $19,183 more than the appropriation for the year underway: $10,000 for engraving and printing maps, $8,683 for stream gaging, and $500 for preparation of illustrations.

The House committee did not delve deeply into the Survey's needs. It accepted most of the recommendations of the Bureau of the Budget but cut the appropriation for mineral leasing supervision by $40,000 on the ground that most of the work had been done on the unit-plan system, and reduced the limitations for attendance at scientific meetings and for personal services in the District of Columbia. The hearings were enlivened only by pleas from Congressman Ross Collins of Mississippi, Walter Reid, the mining engineer who had procured the donation of the Kunz collection to the Survey library, and Isaiah Bowman, president of John Hopkins University, for additional funds for that library, which was described as the "only one real central source of geologic information in the country," and, to the obvious surprise of committee members, as better than the Library of Congress. As a result, the limitation on funds to be used for purchase of books, which had been reduced to $2,000 in 1905, was restored to its old level of $6,000. Congressman James Scrugham had little to say during the Survey hearings. He had twice persuaded the House to approve funds for strategic minerals in the Naval Appropriations bill, only to have the Senate refuse. This year he waited for Secretary Ickes' appearance a week later and asked him for an investigation and recommendation as to the cost of a strategic-minerals program. This year, for the first time, the Senate had agreed to the appropriation of funds for strategic minerals in the Navy bill. The total appropriation for the Survey in the bill approved on August 9 was $2,927,000, and only the Water Resources Branch could look forward to more funds for the coming year.

It was late June, only a week before the start of the new fiscal year, when the Senate committee began its hearings on the Survey appropriation. By that time the cooperative offerings for water-resources investigations were only a few thousand dollars less than the appropriation voted by the House, so the Senate committee recommended an increase of $100,000, to $900,000, for water-resources investigations. The Senate also restored the cut in the appropriation for supervision of mineral leasing. Secretary Ickes had explained that field supervision was only a small part of the unit-plan operations; moreover, the number of properties under supervision had increased by 40 percent during the preceding 5 years but production had increased 80 percent and revenue 94 percent in the same period. No change was made in the funds for classification of the public lands but in a separate bill Congress authorized the extension for another 2 years of oil and gas prospecting permits outstanding on December 31 while awaiting completion of unit plans. The committee devoted some time to discussion of the topographic mapping program and Secretary Ickes' plan was made a part of the record but no change was made in the appropriation. There was no discussion of strategic minerals. While the Senate had the Interior bill under consideration, the Chinese and Japanese had gone to war without benefit of any formal declaration. On July 7, Japanese troops on night maneuvers near Peking clashed with the Chinese, the fighting spread rapidly, and soon a large-scale campaign was underway in northern China.

The increased appropriation for stream gaging, although less than desired, permitted the continued growth and diversification of the work of the Water Resources Branch. A net increase of 452 in the number of river-measurement stations in the year beginning July 1, 1937, brought the total up to 3,831. Investigations of notable floods were continued and reports prepared on those in eastern New Mexico in May and June 1937 and in northern California in December 1937. Ground-water investigations were made in 34 States, the District of Columbia, the Territory of Hawaii, and on the Island of Guam.



Although adsorbent or bleaching clays were used to purify oil, the bleaching-clay industry had long been a hit-or-miss proposition because little was known of the nature of the clays, their action on oils, or the location and extent of deposits until the Survey in the mid-1920's began a series of laboratory and field studies that eventually placed the industry on a rational basis. P. G. Nutting developed methods of testing the clays, tested thousands of samples, determined the nature of the bleaching action, and classified the materials possessing bleaching properties. The illustration shows thermal hydration curves for various clays and components of clays. In 1934 and 1935, several Survey geologists using PWA funds made field investigations of clays in the Southeastern States and Texas and discovered extensive and valuable beds of highly active bentonite in Florida. (From P. G. Nutting, 1943.)

The greatest change in the branch was the expansion of the Quality of Water Division, which for many years had been largely a service organization. The study of sediment and suspended matter in the Colorado River, begun in 1925, had been its first continuing independent investigation. A growing appreciation of the relation between the quality of water and its utility, especially for industrial purposes, had encouraged the publication of water analyses in the early 1930's, and the Rio Grande Joint Investigation brought further recognition in 1937. In the spring of 1937, the division was asked to participate, along with the Ground Water Division, in a cooperative investigation to determine the source of the salinity in the Pecos River. C. S. Howard organized the chemical work and a laboratory was established at Roswell, New Mexico, with W. F. White in immediate charge. Later, another chemist was sent to Texas to supervise analysis of water samples in connection with ground-water problems. In July 1937, cooperative agreements were made with the State of Connecticut for expansion of the study of the salinity of the Connecticut River begun as part of the ground-water investigations and with the State of Georgia for analyses of water samples taken at gaging stations maintained by the Surface Water Division. The latter agreement was expanded on December 1 into an intensive study of the salinity of the Savannah River so the new intake of river water for the Savannah municipal supply could be located at a point above any possible salt-water contamination.

The Ground Water Division was increasingly preoccupied with the need for legal control of ground water. The Washington State Department of Conservation and Development, anticipating the need for legislative action, entered into an agreement with the Survey for a statewide investigation, which began with the organization of a small observation-well program under the direction of A. M. Piper. In New Mexico, which had pioneered with the first ground-water control law, A. M. Morgan was sent to observe wells in the Roswell area where increased irrigation from shallow wells had made it necessary to determine the amount of available shallow ground water. At the spring meeting of the American Water Works Association in 1938, David Thompson and A. G. Fiedler, in a paper later awarded the Goodell Prize, said

> **where ground water is available for irrigation or for large communities or industries, there must be assurance that the consumption of water will not**

Although the United States was by far the world's largest consumer of platinum, until 1938, when a phenomenal increase in production in Alaska made the United States the world's fourth largest producer of platinum, it produced only a negligible part of its requirements. The great increase in Alaskan production, from 6,042 ounces in 1937 to an estimated 34,000 ounces in 1938, came almost entirely from placer deposits in southwestern Alaska, which had been discovered in 1926, after a dredge was installed in 1937. The photograph shows a dragline excavator on Platinum Creek. J. B. Mertie Jr., in his 1938 investigation, found the source of the platinum in the placers and related their occurrence to the geomorphic history of the region. (From J. B. Mertie, Jr., 1940.)

exceed the safe yield of the water-bearing formations; otherwise, failure will result. In order to limit the draft to safe yield, some kind of legal control of consumption is necessary.

Ground-water laws, however, had to be based on knowledge of the resources but that could be ascertained through scientific investigations. Thompson and Fiedler favored a law based on the doctrine of appropriation conferring the right of use rather than ownership, and the exercise of that right only as long as the use was for beneficial purposes and essentially continuous.

In some other areas where investigations were underway, ground water was used primarily for a single purpose but in others there were multiple and potentially conflicting uses. In Virginia, where D. J. Cederstrom began an investigation in the tidewater area south of the James River as the cooperative program with the State was resumed, industry was contemplating the use of ground water. In Texas, three separate areas were studied, and A. N. Sayre was concerned with the possibilities of obtaining ground water for municipal and industrial purposes in Angelina County in southeastern Texas, while S. F. Turner, in the Bryan area of east-central Texas, and Penn Livingston and R. R. Woolley in the Big Spring area of northwest Texas, were concerned only with municipal use. In the Oklahoma Panhandle, S. L. Schoff investigated the suitability and safe yield of ground water for irrigation; in Kansas, David Thompson and S. W. Lohman investigated the ground-water resources in the *Equus* beds north of Wichita where improper handling of brines in evaporation ponds had resulted in contamination of the shallow ground water that was the source of rural and potential urban water supplies; and in Nebraska, R. C. Cady and H. A Waite sought ground water for irrigation and municipal supplies. Near Tacoma, Washington, which was seeking an additional source for municipal supplies, A. M. Piper and G. A. LaRocque tried to determine the safe yield and chemical quality of the ground water.

The Topographic Branch began preparing for an expanded national mapping program that it felt would sooner or later be authorized. The status of mapping in the United States was reviewed, maps of 79,668 square miles, based on reconnaissance surveys made before 1896, were found inadequate by modern standards, and the areas reclassified as "unmapped," increasing the unmapped area of the Nation to 55.0 percent. Conventional field methods were used to map 13,538 square miles in 35 States and Puerto Rico, more than 90 percent at scales of 1:62,500 or larger. An additional 1,169 square miles were mapped at a scale of 1:24,000 by photogrammetric methods. Work was resumed on the United States portion of the 1:1 million map of the world, the general adjustment of horizontal and vertical control to agree with the standard datums in the United States was continued, eight bulletins reporting the results of control surveys were published, maps of five States in the sectional map of the United States were also published, and progress was made on office work on river surveys.

The Geologic Branch program in 1937 remained at about the same level as the preceding year and included many ongoing projects and a few new endeavors. Physiographic and geologic studies were continued in many parts of the country and a new study of the physical geography of Florida was begun. Metals investigations in Nevada were resumed, after the lapse of a few years, and continued in other Western States, the Tri-State lead and zinc districts, and in the Southeastern States. A new element was added to the Idaho cooperative project when S. R. Capps began a study of alluvial deposits and physiographic history in the central part of the State. A new venture in cooperative work was begun when E. B. Eckel, who had completed the La Plata project in Colorado, was assigned to assist the Corps of Engineers by reporting on the geology and advising on the choice of site of the Savage River dam and reservoir in northwestern Maryland.

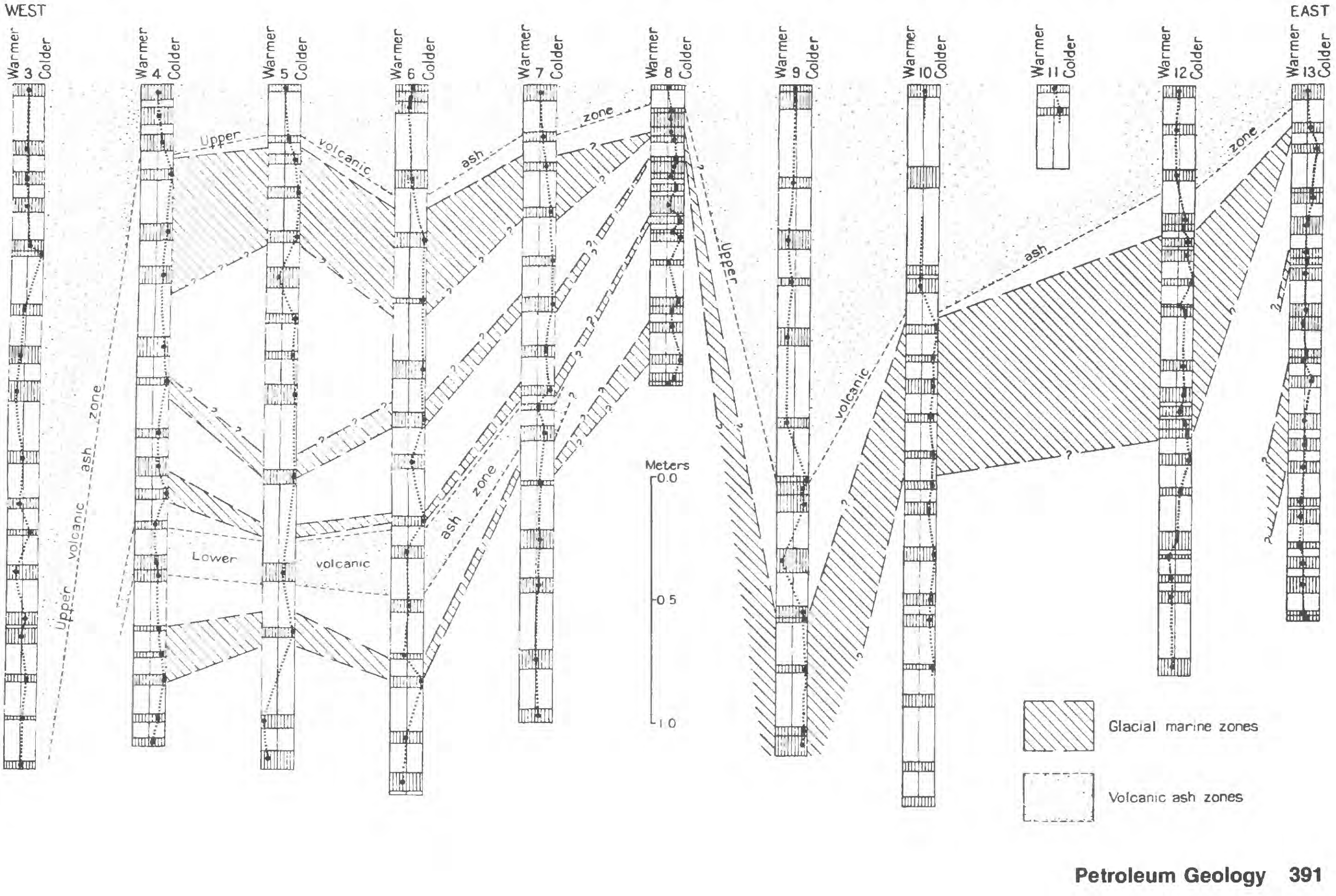
Somewhat more emphasis than before was given to fuel-related, especially petroleum-related, investigations. Proven petroleum reserves of the Nation were about 13 billion barrels, according to the latest estimate from the American Petroleum Institute, but there was some pessimism about the future. An analysis by W. E. Pratt, vice president of Humble Oil, showed that the discovery rate of new fields, after reaching a peak between 1925 and 1930, had declined sharply and was then inadequate to increase or even maintain the known reserves. In his presidential address to the American Association of Petroleum Geologists in 1936, however, A. I. Levorsen had pointed out that petroleum geology to that time had been directed toward a search for structural traps. There was a limit to the number of anticlines that might be found but stratigraphic traps, a term he coined, had accounted for one-fourth to one-third of past production, and future exploration might well be based on stratigraphic methods. Levorsen concluded that

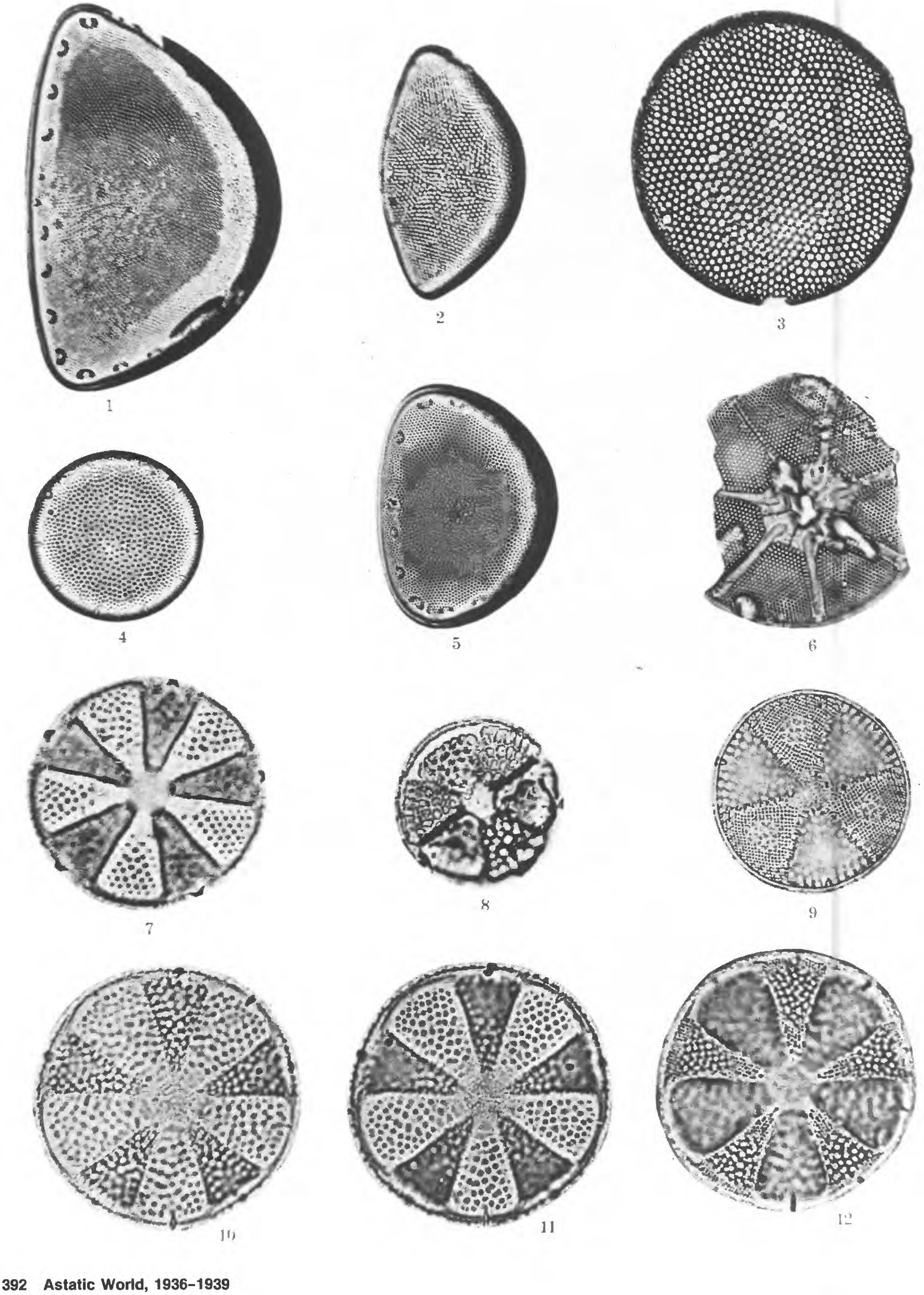
> **Our future is limited only by our ability to reason geologically and the foundation for such reasoning is a real knowledge of geology, more geology, and then still more geology.**

A somewhat similar note was struck by I. M. Goubkin at the International Geological Congress in Moscow in the summer of 1937:

> **I am sure that none of the great geologists of the world gathered here will assert that we have reached our "ceiling" in our knowledge in the domain of petroleum geology. The science of oil as an independent branch of economic geology is, as a matter of fact, just beginning to develop, and our knowledge of the conditions of the origin and accumulation of oil in the earth's crust will grow together with the future development of this branch of science. We therefore presume that all talk of exhaustion of the world oil reserves in the near future is of no practical significance, and in all probabilities will have no real meaning still for a long time to come. By this time**

Scientists studying 11 North Atlantic deep-sea cores obtained between Newfoundland and Ireland by C. S. Piggot of the Geophysical Laboratory in the spring of 1936 recognized six zones of distinctive lithologic character: two in which silicic volcanic ash was common and four interpreted as glacial marine deposits formed when drift ice from continental glaciers transported quantities of rock debris far out into the ocean basin. Between the glacial marine zones the sediments consist chiefly of foraminiferal ooze or marl, much like that being formed today in the same area. The illustration also shows past fluctuations in the temperature of the surface water at the site of each core. The shaded blocks represent samples taken for the study of organisms, the center line of each column represents the present surface-water temperature, the large dot in each shaded block indicates qualitatively the deviation from the present temperature, and the dotted line connecting these points the trend of the temperature change from one sample to the next. (From W. H. Bradley and others, 1942.)

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By the mid-1930's, micropaleontology, which developed as a specialized branch of the science in the 20th century, was beginning to expand from morphology to paleoecologic and other studies in line with the main trends of macropaleontology. In the study of the North Atlantic cores, foraminifers, which had been most useful in stratigraphic correlation elsewhere, could not be used for detailed correlation from one core to another because of differences related to their ecology and geographic distribution although the foraminiferal facies characteristic of cold and warm climates correlated with the alternation of glacial-marine and warm-water sediments indicated by the lithology. Diatoms, such as those shown in the illustration, also exhibited warm-water and cold-water alternations but at different positions in the cores than those inferred from lithology and foraminiferal facies. Possible explanations for the differences were sought in the longer settling time of the diatoms and the action of cold and warm currents. (From W. H. Bradley and others, 1942.)

the progress of science will provide with extensive possibilities of utilizing other kinds of natural resources as a source of energy, and develop new kinds of synthetic products which will fully substitute.

The Survey's fuels investigations included both field and laboratory investigations. The field studies were primarily stratigraphic, as they had been for many years. In the 1937 field season, R. B. Stewart continued to map Reef Ridge in the Coalinga district in California and concluded that the oil seeps that had interested geologists for many years might be due to local accumulations in lenticular bodies that had since been exposed by erosion but that such stratigraphic traps, if preserved under Reef Ridge, would be difficult to find. Systematic mapping was continued in Utah, Wyoming, and Montana; in the Gulf Coast, W. H. Monroe resumed work in the Jackson area of Mississippi where the State had just completed a deep test well. In the Midcontinent region, N. W. Bass continued his investigation of subsurface rocks of Mississippian age in Kansas and T. A. Hendricks his mapping near the Ouachita Mountains of Oklahoma. Parker Trask and P. G. Nutting continued their studies of sediments, Trask searching for criteria for recognizing source beds of petroleum while Nutting summarized 8 years of work on the bleaching clays, used in processing oil, fats, waxes, and much sulfur, that had put the industry on a firm basis.

Hendricks also served as the Survey representative on the Committee on Coal Classification of the American Society for Testing Materials, which completed its 10-year study by publishing standard classifications of coal by rank and grade. The classification by rank was based on the degree of metamorphism and the designations of individual coals differed in only a few borderline cases from the designations by the fuel-ratio system that the Survey had developed from Persifor Frazer's system of 1879; such differences as existed were the result of refinements. The classification of coals by grade was based on four characteristics of coals of primary importance in its utilization: calorific value, ash, sulfur content, and ash-softening temperature.

The Alaskan Geology Branch made no field investigations related to petroleum although the Branch Chief P. S. Smith was on record that the latent oil resources of Alaska might be of importance to the world's future economics. Two of the principal projects were concerned with strategic metals. J. B. Mertie, Jr., and Gerald FitzGerald teamed up to complete the study of the platinum deposits in the vicinity of Goodnews Bay, near the mouth of the Kuskokwim River in southwestern Alaska, which were then the principal source of platinum metals in the United States, and John C. Reed began surveys on Admiralty Island in southeastern Alaska to obtain information about possible nickel deposits as well as the gold lodes that had long yielded a small but constant output. F. H. Moffit returned to one of the least known parts of the Alaska Range, near the head of Copper River, to determine the general features of the geology and whether geologic conditions were favorable for the occurrence of gold and other mineral deposits similar to those known on the outskirts of the area. R. H. Sargent, after 28 seasons in Alaska, transferred to the Topographic Branch where he succeeded W. M. Beaman as Chief of Inspection and Editing.

The Conservation Branch, faced with a formidable volume of work and unable to persuade Congress of the need for additional funds, assigned several field engineers to Washington and was thus able to effect a considerable reduction in the number of pending cases and to place the work of reviewing unit plans on a current basis by the end of the year. Although there was some consequent loss to field supervisory activities, mineral production from the public and Indian lands continued to increase and the revenue therefrom increased by more than 50 percent over the preceding year to a record $9.75 million. The Science Advisory Board as far back as 1933 had recommended the transfer of the field supervision of mineral leasing on the public domain to the Bureau of

Mines, but in August 1937 the Select Committee of Congress to Investigate the Executive Agencies decided that the recommendation had "theoretical merit" but was "not advisable as a practical administrative measure." The Geological Survey classified the mineral lands and must be consulted in connection with mineral leasing so transferring the work of field supervision would just add another bureau and multiply the paperwork. Furthermore, the committee concluded, "it is admitted that the Geological Survey has conducted this branch of its work with judgment and efficiency, so that no tangible benefit would result from the transfer."

In late summer the Japanese-Chinese conflict broke out in the Shanghai area and the Japanese naval blockade of South China was extended. President Roosevelt declined to invoke the Neutrality Act on the ground that it would have worked to China's disadvantage, but on September 14 he forbade the transportation of munitions to either nation on U. S. Government vessels and warned private shippers that they acted at their own risk. The bombing of Chinese cities by the Japanese outraged world opinion, and in October both the League of Nations and President Roosevelt condemned the Japanese action. Roosevelt's speech, in which he urged an international quarantine of aggressors as the only means of preserving peace, aroused considerable criticism in the United States, which remained dominantly isolationist in sentiment.

By October 1937, the economy was creating problems at home. Late in the summer, the stock market began to decline and then, as wave after wave of selling tumbled prices to new lows, it began to seem like 1929 all over again. Congress was called into special session on November 15, but instead of presenting a new economic program, the President called for action on four bills that had not been passed in the session that adjourned in August, including administrative reorganization and regional planning. The session was disorganized, and none of the bills was passed. The Western States were opposed to regional planning, and Congressman Edward Taylor, who conceded many of the main purposes of the proposal were "laudable," said that "insofar as they apply to the waters of the streams throughout the entire arid region of the West they are in bold violation of, and absolutely destructive of, the vested property rights and the established system of development of any western resources by irrigation and reclamation of our public and private lands. They utterly ignore the doctrine of priority of water rights by appropriation, which is the foundation of all the agricultural development throughout the arid West." Thus it was that "the entire delegation in Congress from 13 of the Western States are unalterably opposed to the measure in its present form." On the day before the session ended, Senator Hayden proposed a substitute measure that would eliminate the possibility of another Federal agency while providing for more coordination among existing agencies by setting up a National Resources Board that would formulate plans but have no control over construction.

Before the special session adjourned, foreign affairs were back in the headlines. On December 12, Japanese bombers attacked American and British ships near Nanking, China, and sank the U.S.S. *Panay*. Secretary of the Navy Claude Swanson wanted war immediately. Secretary Ickes noted in his diary that "Certainly war with Japan is inevitable sooner or later, and if we have to fight her, isn't this the best possible time." Instead of war, however, the United States on December 14 formally demanded apologies, reparations, and assurances against further incidents, and the Japanese responded the same day. On December 14, also, Congressman Louis Ludlow of Indiana reintroduced his resolution, which several times had failed to pass, calling for an amendment to the Constitution to require a national referendum on a declaration of war. A national poll in 1937 indicated that nearly three-fourths of those polled favored such a referendum, and passage of the Ludlow resolution in the new session seemed assured until President Roosevelt sent Congress a message pointing out

In 1939, F. E. Matthes reported that in all probability many of the small cirque glaciers in Western United States were "the modern successors rather than the lingering remnants of the glaciers of the ice age." In the Sierra Nevada, he had noted morainal embankments at the ends of glaciers still loosely piled together in slopes that had not yet everywhere assumed the angle of rest, some with bodies of glacier ice still buried beneath them. The morainal embankment at the front of the east lobe of the Lyell Glacier is shown in a photograph by W. T. Lee. Moreover, the extreme sensitivity of glaciers in and near Yosemite National Park to departures from average precipitation and temperature conditions indicated that they would be destroyed in about a century by only a moderate sustained deficiency of snow coupled with somewhat higher summer temperatures. Matthes suggested that these glaciers did not exist during the middle third of the post-glacial interval, which was warmer and drier than the present. (From F. E. Matthes, 1939.)

that such an amendment "would cripple any President in his conduct of our foreign relations, and it would encourage other nations to believe that they could violate American rights with impunity."

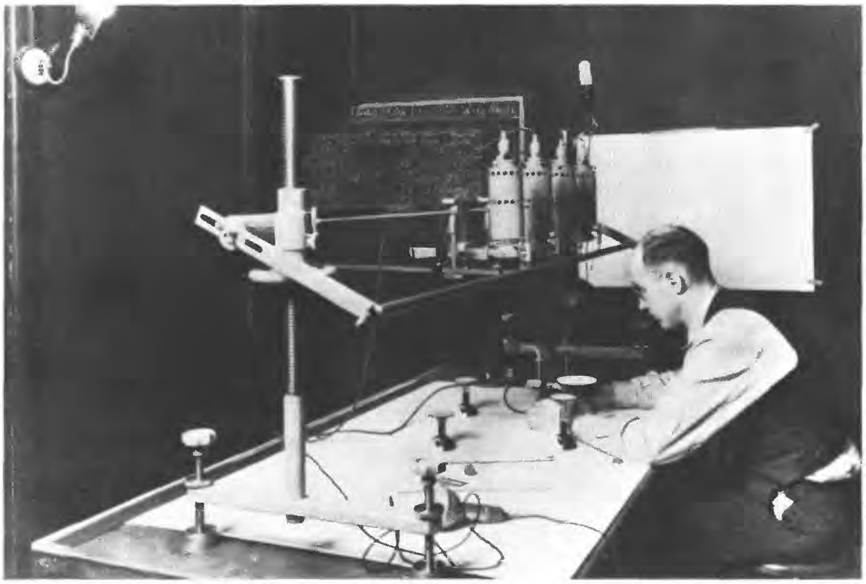
Roosevelt's annual message to Congress in January 1938 was for the most part concerned with domestic issues after a brief reference to the unsettled world conditions and the need for a strong defense. The President again called for a balanced budget although not at the expense of the welfare of individual Americans, some 8 to 11 million of them unemployed. A special meassage on January 28 recommended increased expenditures for defense, including antiaircraft materiel, defense industry tools, and an increase in the authorized naval construction program. The Naval Expansion Act was passed on May 17 but otherwise Congress was more preoccupied with domestic affairs and the economy. In April, the President sent to Congress a series of recommendations for combatting the business recession, including a $3 billion spending program; he followed it 2 weeks later with recommendations for curbing monopolies and the growing concentration of economic power. Congress responded to both proposals within a few weeks but in reverse order, setting up a Temporary National Economic Committee, a joint legislative-executive body to conduct a full-scale investigation of the economy on June 16, and appropriating the $3 billion on June 21. Other New Deal legislation passed during the session included the Agricultural Adjustment Act of 1938, a modified form of the 1933 act, and the Fair Labor Standards Act, which established a minimum wage of 40 cents an hour and a maximum work week of 40 hours, to be put into effect within 8 years for wages and 3 years for hours.

The National Resources Committee's report on Alaska and its resources, in response to the resolution of August 21, 1937, was sent to Congress on January 20, 1938. Although the Senators and Representatives who sponsored the resolution had declared their belief that Government agencies had all the needed information locked up in their files, the committee reported that information about the Territory was "wholly insufficient for any adequate program" and recommended that "surveying, mapping, land classification, mineral exploration, and other scientific investigations already in progress should be carried forward at a faster pace than at present." The committee also suggested that the administration of conservation policy—though not the policy itself—be reexamined, and that suitable steps be taken, by modification of the mining laws if necessary, "to insure that the Government may retain such control over mineralized areas about to be opened up as is in the interest of orderly and efficient development." The committee also noted that aviation would play a large part in any program for the development of the resources of Alaska, and that aeronautical maps should be made available. The Coast and Geodetic Survey had had such a program under consideration for some time but funds had not been made available to undertake it.

During 1937, the National Resources Committee had also prepared a series of regional plans, revised and extended its report on drainage-basin problems, and issued two reports in an effort to read the future. "Our Cities—Their Role in the National Economy" recognized the problems attendant upon the increasing urbanization and the need to consider social and economic plans to deal with them. "Technological Trends and National Policy," prepared under the sponsorship of the Science Committee, was written because

> **Anticipation of the future is the key to adequate planning for the best use of our natural resources.**

It was the first major attempt to assess how new inventions might affect living and working conditions in America in the next 10 to 25 years. The report noted that science and technology had brought about great advances in American life in the 20th century but pointed out that invention, which was commonly the intermediate step between scientific research and technological application, was "a great disturber," but also "The greatest general cause of change in our modern civilization." Inventions affected all social institutions from the family



In 1936, the Survey set up an office in Chattanooga, Tennessee, to prepare topographic maps of the entire Tennessee River Valley by photogrammetric methods, beginning a revolutionary swing away from field methods as the basic mapmaking procedure. The photograph shows the Survey's original multiplex equipment in the Chattanooga office in 1937. This equipment, manufactured by Zeiss Aerotopograph Company, was later modified by the Survey in cooperation with Bausch and Lomb to provide greater accuracy along with economy and speed, but was superseded after World War II by the development of a succession of more refined instruments. (Courtesy of Morris M. Thompson.)

to the State, and as their adoption was often resisted, sometimes for social, sometimes for economic reasons, the time from the first development to full use, which averaged 30 years, was often a period of social and economic maladjustment. The five men who analyzed the outlook for the future in the mineral industries, F. G. Tryon, G. S. Rice, and Oliver Bowles of the Bureau of Mines, Professor T. T. Read of Columbia University, and K. C. Heald of the Gulf Oil Company, concluded that the short-term prospect was favorable but the long-term prospect was one of growing difficulties. In the next 10 years, they believed mineral technology would overcome the increasing handicaps of nature, leaner ores, greater depths, and exhaustion, and perhaps even effect greater savings in labor and in concentrating mineral production in a smaller number of larger and more efficient plants. Thus "aside from the hazard of war, technology and its allies, exploration and transport, should be able to supply all the fuel and earth materials that the world can consume at prices not greatly different from those to which we became accustomed during the 1920's." Over a longer time, however, technology would have a harder time to overcome the handicaps of nature, and more of the world's mineral industry would have to pass into the stage where technological gains could no longer offset them.

Two speeches, one by Congressman Scrugham and the other by John W. Finch, Director of the Bureau of Mines, were placed in the *Congressional Record* shortly thereafter to illustrate the necessity of special consideration of the strategic minerals. At the time, the War Department had classified strategic materials as those essential to the national defense for the supply of which in war dependence must be placed, in whole or in large part, on sources outside the continental United States and for which strict conservation and control measures would be necessary. A second class of "critical materials" was described as those for which the procurement problems in war, while difficult, were less serious than those of strategic materials, due to greater resources or to a lesser degree of essentiality, and for which conservation and distribution control measures would probably be necessary. There were 9 minerals on the list of strategic materials: aluminum, antimony, chromium, manganese, mica, nickel, mercury, tin, and tungsten, and 25 minerals on the list of critical materials, including iron, copper, lead, zinc, and petroleum. Finch proposed an appropriation of $500,000 a year for the Bureau of Mines and the Survey to make a comprehensive study of ways and means of adapting the Nation's domestic reserves of strategic minerals to a permanent solution of the deficiency-mineral problem.

The Science Committee followed up its report on technological trends with one on research in the Federal Government. The committee first addressed itself to the perennial question of what scientific research should be done by the Government, and concluded that there were certain fields, such as those involved in national defense or in setting standards, in which the Federal Government was obliged to carry on research, others (among them, geology) in which the Federal Government was better equipped to carry on research, and still other fields in which programs were so extensive that the Federal Government was better able to coordinate them. It found, however, that procedures with respect to authorizing and financing research tended to limit rather than promote intelligent consideration of the Government's scientific program. Research workers found it difficult to make clear to the Bureau of the Budget and the Congress the desirability of new research enterprises, and as it was easier to get support for established lines of work, new research was postponed or begun under a subterfuge. Agencies presented their budget requests inadequately, were timid in their statements, and failed to make clear that research is essential to the public welfare. Appropriating authorities, on the other hand, frequently acted as if research workers were making requests for purely personal or selfish reasons.

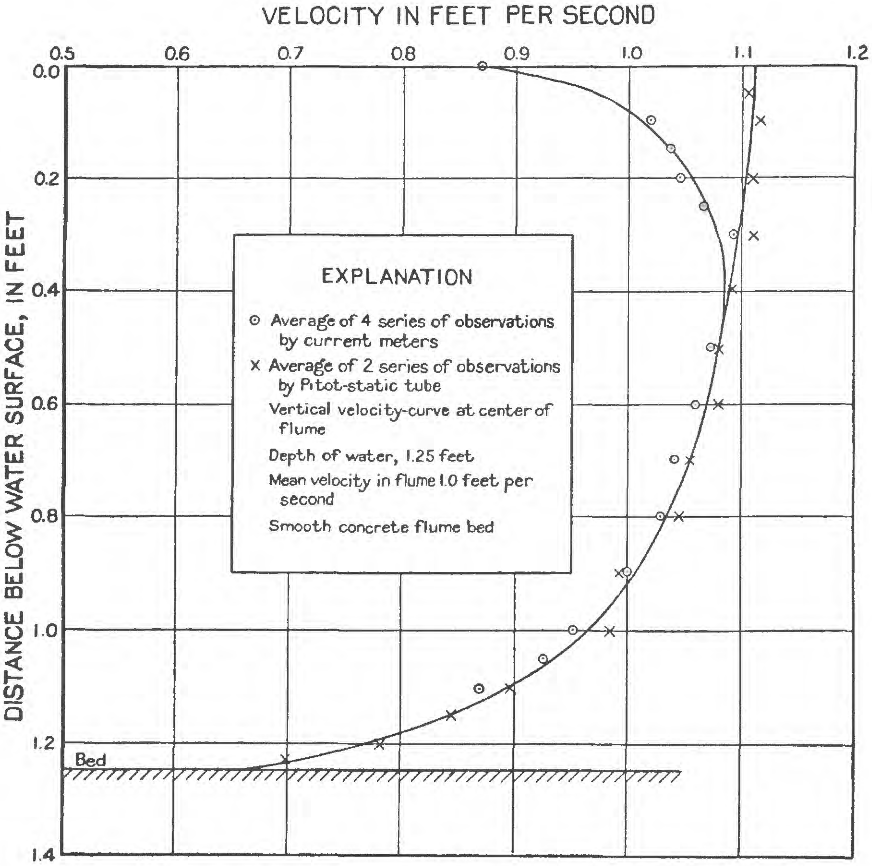
A case in point was the Geological Survey budget for the year beginning July 1, 1938. The Survey had convinced the Bureau of the Budget that it needed an increase of $251,880: $150,000 for water-resources investigations, $75,000 for topographic surveys, $15,000 for classification of the public lands, and the remainder for administrative salaries, preparation of illustrations, and supervision of mineral leasing. The approved increases, however, bore little resemblance to the real needs, and none had been granted for research. Congress, for the most part, either accepted the recommendations of the Bureau of the Budget or sliced small amounts from them.

The National Resources Committee had recommended establishment of a network of Federal stations for hydrologic measurements at an initial cost of $2.3 million and an annual cost thereafter of $1.1 million. The Bureau of the Budget recommended an appropriation of $1,050,000 for water-resources investigations but restricted $850,000 to matching cooperative offerings. By the time the appropriations hearings were held, some months before the new fiscal year would get underway, cooperative offerings of almost $883,000 were already in prospect. The House voted to cut the appropriation to $1,000,000, in effect cutting the small amount available for purely Federal work. The Senate restored the cut and the final bill provided $1,050,000.

The Ickes plan for topographic mapping called for Federal appropriations of $100 million at the rate of $5 million a year to accelerate the mapping of the United States. The Bureau of the Budget recommended an appropriation of $725,000 and Congress accepted the recommendation.

In 1936, the National Resources Committee sponsored a joint investigation of the water resources of the Rio Grande Basin by the Geological Survey, the Bureau of Agricultural Engineering, the Bureau of Reclamation, and the Bureau of Plant Industry to determine the available water supply, water uses and requirements, and the possibilities of additional supplies. Above Fort Quitman, Texas, where the investigation was concentrated, nearly all the water of the river, 99 percent of which came from Colorado and New Mexico in about equal amounts, was being consumed by irrigation in Colorado, New Mexico, and Texas, and there had been a long-standing controversy among the three States over the depletion of the water in the upper part of the basin. This investigation was the first time that States and the Federal Government joined together to find a satisfactory basis for allocation of the waters of a river by assembling the factual data needed to make the allocation. The aerial photograph shows irrigated farms in the Middle Rio Grande Conservancy District in New Mexico. (From National Resources Committee, 1938.)

The Survey had long used the 0.2- and 0.8-depth or the 0.6-depth methods for measurements of river discharge, but they were not always practicable in very shallow water. There the current meter was placed at mid-depth, a point at which the actual velocity is not the mean for the vertical and where the registration of the current meter may be affected by its proximity to the water surface or to the stream bed. To determine coefficients to be applied to measurements made under such adverse conditions, Survey hydraulic engineer C. H. Pierce investigated the performance of current meters in very shallow water experimentally at the National Hydraulic Laboratory at the National Bureau of Standards. The underregistration of current meters near the water suface is shown on the graph. (From C. H. Pierce, 1941.)



The Survey in its justification for the appropriation for geologic surveys, stressed the need for mineral inventories and intensive study of strategic and deficient minerals.

> **It 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.**

The Bureau of the Budget recommended no increase in the appropriation for geologic surveys and Congress accepted the recommendation.

The National Resources Committee recommended an acceleration of Alaskan studies and mapping. The Survey in its justification stated "More than half the Territory still remains entirely unsurveyed, and even in those areas that have been surveyed on exploratory or reconnaissance standards, there are many places that should be examined more thoroughly if adequate assistance and encouragement are to be given to the finding and development of the mineral deposits that are believed to lie undeveloped in the region." The Bureau of the Budget recommended an appropriation of only $60,000, Congress fretted about the amount of money that was being spent in Washington to support field work in Alaska, and accepted the recommendation.

The Senate Appropriations Committee, to the obvious dismay of its chairman, Senator Hayden, spent most of one morning worrying about the authorization to spend $6,000 for books for the Survey library. Where were the books bought, were they checked to be sure that they weren't foreign propaganda, even "how many people have you got down there engaged in reading books." The authorization to spend $6,000, however, was allowed to stand.

While the appropriations bill was making its way through Congress, Germany submitted an ultimatum to Austria, the German army invaded Austria on March 12, and on March 14, Hitler took formal possession. England and France protested but were too deeply involved in internal problems to take action, Italy accepted the occupation without protest, and no international crisis ensued. The acquisition of Austria, however, left Czechoslovakia like a wedge in the heart of the new Germany. Although the German Government assured the Czech Government of its desire to improve relations between the two countries, Hitler had promised protection to German minorities in other countries, and there were more than three million Germans in the frontier regions of Czechoslovakia.

In the final version of the appropriation bill, which was approved on May 9, 1938, a total of $3,164,680 was appropriated for the Survey, $14,200 less than the amount recommended by the Bureau of the Budget but $23,000 more than the appropriation for fiscal year 1931. With great optimism, Director Mendenhall said that "it was gratifying that for the fiscal year 1938–39 the direct appropriation was restored to its earlier level, although its distribution among the several activities of the bureau was somewhat changed. With this encouragement, which it is hoped foreshadows more adequate and less fluctuating support, projects could be planned and undertaken with more confidence and could be pursued in a more orderly and effective way."

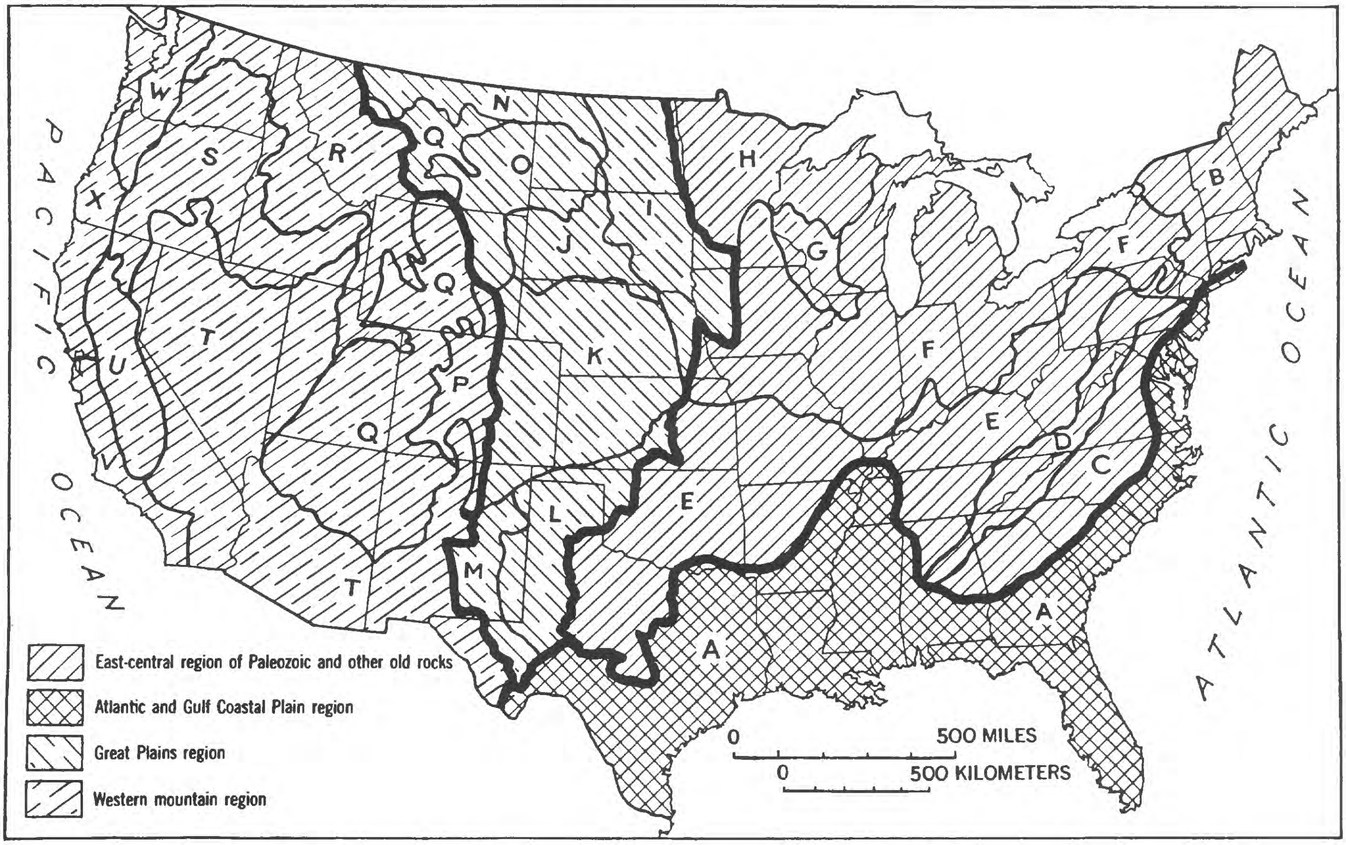
The Water Resources Branch was the chief beneficiary of the redistribution of funds among Survey activities, its appropriation for the year beginning July 1, 1938, more than double its appropriation for the year beginning July 1, 1930. Cooperative and transfer funds had also increased and the total funds for water-resources investigations were approximately equal to the Federal appropriation for the entire Survey. The change in the branch as the result of the increased funds was far more than an increase in size; traditional data-gathering activities had been strengthened, but the data were also being gathered in new ways and analyzed to new purposes, and the whole research spectrum had broadened.

During the fiscal year, there was a net gain of 334 gaging stations in the Division of Surface Water, so the total at the year's end was 4,165, or 1,502 more than on July 1, 1931. Nearly 3,000 of them were equipped with water-stage recorders. Flood investigations reached a new level of sophistication. Data were gathered on floods in Texas in January, June, and July 1938 and the hurricane floods in New England in September 1938, but several special investigations were also undertaken. Among the latter were studies of potential floods in the well-populated and industrialized Willamette Basin of Oregon where the Army Engineers had several multipurpose projects under consideration, of the effect of climate and topography on flood runoff in two basins in Washington west of the Cascade Mountains, of the erosion of stream channels by successive cloud-burst floods in Colorado and Utah and the relation of the transportation and deposition of flood debris to flood discharge. Under the auspices of the Works Progress Administration, data were compiled under Survey supervision on selected topographic features of drainage basins in Northeastern United States as a basis for quantitative studies of differences in flood behavior. The Quality of Water Division added to its activities studies of silt movement in streams in the Boise River Basin in Idaho and the St. Francis River Basin in Missouri for the Flood Control Coordinating Committee of the Department of Agriculture, and aided the Public Health Service in its investigation to determine if natural conditions were responsible for the high death rate from tuberculosis in Giles County, Tennessee.

Ground-water investigations were either systematic areal surveys or more intensive special investigations leading to the determination of hydrologic principles. O. E. Meinzer had divided the United States into four ground-water provinces: an East-Central old-rock region, which included about one-third of the Nation's area and two-thirds of its population; the Atlantic and Gulf

Coastal Plain region; the plains east of the Rocky Mountains; and the Western Mountain region, which also included about one-third the area and was chiefly arid. New or continuing investigations were underway in all four regions, in 37 of the 48 States, Hawaii, and the Virgin Islands, and periodic measurements of water levels or artesian pressure were being made in 5,000 wells. In the East-Central region, new investigations were begun in Massachusetts, by M. L. Brashears, in Indiana, by C. L. McGuinness, and in Ohio, by David Thompson and F. H. Klaer, Jr. In the Atlantic and Gulf Coastal Plain region, V. T. Stringfield supervised several projects: a statewide observation-well program in Mississippi by G. F. Brown, and special studies of areas in Georgia, Florida, and Louisiana by M. A. Warren, H. H. Cooper, Jr., and J. C. Maher where industrial use of ground water had caused a serious decline of water levels. In the plains east of the Rocky Mountains, T. W. Robinson and the Iowa State Geologist, H. G. Hershey, began an investigation to correlate pumpage of ground water, fluctuations in water levels, and the geologic source of water supplies. Robinson confirmed the semidiurnal fluctuations observed in two wells during the Pecos River investigation and correlated them with the transit of the Moon, and thus concluded they were earth tides. R. C. Cady and O. J. Scherer extended the Nebraska investigation to Box Butte County; S. W. Lohman supervised investigations in Kansas, including the search for a new source for the Wichita municipal supply and a supply for and economic feasibility of irrigation from deep wells in Ford County; and in Oklahoma, S. L. Schoff extended the Panhandle investigation to Cimarron County. In the Western Mountain region, H. E. Thomas began special investigations in three Utah valleys where ground-water conditions had become critical, Penn Livingston began a cooperative project in Nevada to determine if the decline in artesian head in wells near Las Vegas was due to leakage, and observation-well programs were begun in Oregon and the Spokane Valley of Washington under the supervision of A. M. Piper.

In a summary report on ground-water conditions, resources, and utilization published in 1939, O. E. Meinzer noted that more than half the 123 million people living in the United States according to the 1930 census were wholly or chiefly dependent on ground water for their water supply, and that ground water was also extensively used for irrigation. Survey investigations since 1903 provided data that enabled Meinzer to divide the United States into four major ground-water regions and to subdivide each region into one or more provinces, as shown in the illustration, with respect to the availability of ground water and the formations from which it was obtained. (From O. E. Meinzer, 1939.)

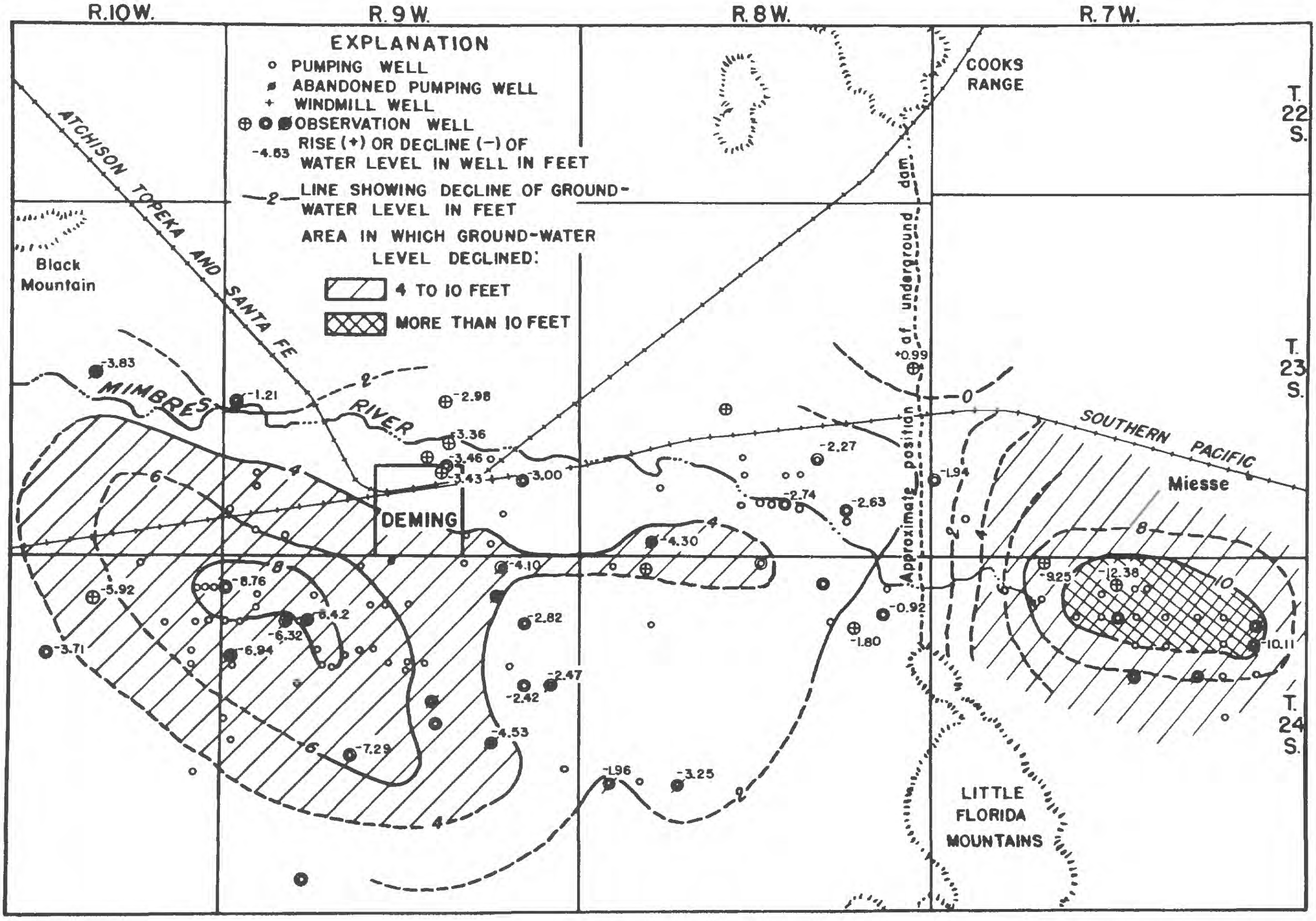


The Federal appropriation for topographic surveys for the year beginning July 1, 1938, was slightly less than the appropriation for fiscal year 1931, but the Topographic Branch had total funds of $2.5 million, two-thirds as much again as it had in 1931. Some 70 percent of the funds came from 16 States, the Tennessee Valley Authority, the War Department, and the emergency public works funds. Despite the high proportion of outside funds, an effort was made to adhere to the national mapping plan, and mapping was done in 45 States and Puerto Rico. Of the 27,735 square miles covered by new topographic surveys, resurveys, and revisions, all but 1,377 were mapped at field scales of 1:48,000 or larger for publication at standard scales. Photogrammetric methods continued to gain favor, and maps of 2,091 square miles were made during the year, 1,974 in the Chattanooga office and an additional 117 in the Washington office.

Total funds for the Conservation Branch were also approximately the same as for fiscal year 1931, but the distribution among branch activities was very different. Funds for classification of the public lands were only 56 percent of what they had been while those for supervision of mineral leasing were 125 percent of the 1931 funds. Yet most of the work of mineral classification consisted in determining areas subject to inclusion in plans for unit or cooperative development, consideration of oil and gas leases to be exchanged for outstanding oil and gas permits, preparation of reports on initial applications for oil and gas leases as well as classifying lands embraced in applications for surface rights under the nonmineral public-land laws, all work which required a knowledge of the geology. The number of properties under supervision was declining, and consequently there was also a slight decline in revenue.

Total available funds for the Geologic Branch in the year beginning July 1, 1938, were about 12 percent more than in fiscal year 1931, although funds appropriated directly to the Survey for geologic investigations were slightly less, in large part because of an allotment from the Public Works Administration for strategic-mineral studies and for classification of mineral lands, an allotment large enough to finance 21 of the 73 field parties that worked in 30 States. The work of the year included continuing, revived, and new projects that covered a broad spectrum of research, much of it long-range, some of it new and urgent. There was, however, an air of something new even in the long-term projects. In several areas, field geologists were using aerial photographs as base maps or as aids in tracing certain features. In the laboratories, Survey chemists and mineralogists devoted much time to the study of new minerals, and W. E. Schaller was awarded the second Roebling Medal of the Mineralogical Society of America "in recognition of his outstanding contributions to chemical mineralogy, to crystallography, to the paragenesis of the pegmatite minerals, and to systematic and descriptive mineralogy." W. H. Bradley, M. N. Bramlette and others who had been studying the North Atlantic deep-sea cores reported that the bottom sediments and their animal and plant life gave evidence of striking climatic changes during and since the latest glacial stage.

Some Geologic Branch projects that had roots deep in the past. W. C. Alden, who had joined the Survey in 1896, completed field work for his last major report, on the physiography and glacial geology of western Montana and adjacent areas. H. E. Gregory began systematic mapping of the Paunsaugunt region of southeastern Utah, where both the Powell and Wheeler surveys had mapped in the 1870's but at scales too small or without the detail needed in 1938. In the East, Florence Bascom, Charles Butts, and George Stose, whose first Survey reports had been published near the turn of the century, were still unravelling the intricacies of Appalachian geology. The Survey made a major contribution to the science in publishing a new lexicon of geologic names, two volumes containing 2,396 pages, which *Economic Geology* called "indispensable."



In 1935, the Geological Survey began a program of systematic observation of water levels in wells as they registered changes in natural ground-water reservoirs and provided a yearly inventory of the water supplies of the areas covered by the program. In the part of the Mimbres Valley of New Mexico shown on the map, the observations showed that water levels declined in a 7-year period from less than 1 foot to slightly more than 12 feet. An underground barrier between the Little Florida Mountains and Cooks Range apparently retarded eastward percolation of the ground water and thus water levels in wells northwest of the Little Florida Mountains declined less than those in wells farther to the west, and the largest decline was east of the barrier. (From U.S. Geological Survey Water-Supply Paper 845.)

The Fuels Section continued its methodical studies of stratigraphy and structure in California, the Colorado Plateau, the northern Rockies, and the Midcontinent region. One major new project was begun, an investigation of the surface and subsurface stratigraphy, structure, and lithology of the Santa Maria Basin in Santa Barbara County, California, and the bearing of the geology on the discovery and development of oil and gas in that area. Several members of the section were also called on to prepare chapters on coal, petroleum, and natural-gas reserves for a report on energy resources by the National Resources Committee.

The Metals Section continued its studies of mining districts in several Western States, the Tri-State region, and the Southern Appalachians. In Colorado, Q. D. Singewald mapped in the Beaver-Tarryall area in Park County, of renewed interest because of the increase in gold production from the Alma district just to the west. W. S. Burbank completed a manuscript on the structural control of ore deposition in the Uncompahgre district of Ouray County with suggestions for prospecting. In Idaho, work was completed in the Silver Belt of the Coeur d'Alene district and in the Boise Basin project; S. R. Capps continued his study of placer deposits in the Secesh Basin in Idaho County. James Gilluly continued work in Cochise County, Arizona before leaving the Survey to teach at the University of California in Los Angeles, and T. B. Nolan resumed mapping in the Eureka district of Nevada.

In the spring of 1938, as the political situation in Europe became critical, S. G. Lasky and R. J. Roberts began a field study of the manganese deposits in the foothills of the Artillery Mountains in western Arizona. The deposits had been known for several years but were low-grade, and beneficiation by known methods appeared hopeless until the Bureau of Mines in 1936 reported a laboratory method for recovering manganese by leaching and electrolysis. Interest in the deposits was then renewed for they were within the zone of efficient transmission of electric power from Boulder Dam. During the summer of 1938, several more strategic-mineral investigations were begun. E. F. Burchard investigated the manganese deposits in Perry and Lewis Counties, Tennessee, in cooperation with the State, and Josiah Bridge made a study of the Mascot-Jefferson zinc district. C. P. Ross investigated the quicksilver deposits in the Mayacmas and Sulphur Bank districts in California, and G. A. Rynearson and C. T. Smith the chromite deposits in Siskiyou County.

The Geologic Branch laboratories, too, became increasingly involved in economic studies. Chemists devoted considerable time to analyses to determine the economic possibilities in different areas in the United States, mainly on the public lands, that contained such raw materials as phosphates, potash, manganese, and iron. More definite evidence was obtained of the existence at depth in Grand County, Utah, of a considerable bed of carnallite, a mineral well known in foreign potash fields but previously unknown in large quantities in this country. Clay studies were centered on the location and development of American clays equivalent to the special-purpose clays imported from Japan, Germany, and England.

Only the Alaskan Geology Branch had a serious shortage in funds in 1938–39 in comparison with fiscal year 1931. Its appropriation was only 80 percent of the 1931 appropriation and there was no large transfer of funds from the Railroad as there had been in 1931. Only two combined geologic-topographic parties took the field, F. H. Moffit and T. W. Ranta in the northern part of the Copper River Valley and John C. Reed and J. Mark Holmes on Chichagof Island in southeastern Alaska, where Reed sought detailed information on the geology of the gold lode mines that had long been productive in order to delimit the more favorable areas for prospecting. J. B. Mertie, Jr., unaccompanied by a topographer, investigated the old consolidated gravel deposits of Tertiary age in the Yukon Valley west of the international boundary that appeared to have been the source of much of the placer gold being mined in adjacent areas. Under the direction of Gerald FitzGerald, who succeeded R. H. Sargent in charge of Alaskan topographic surveys, the use of photogrammetric methods in mapping was extended, and aerial photographs were made of the Tanana Valley east of Fairbanks and of certain tracts on Admiralty Island in southeastern Alaska that could not be readily covered by ground methods.

By the beginning of September 1938, the Czech-German crisis had reached the critical stage. On September 12, Hitler demanded that the Sudeten Germans be given the right of self-determination. While the east coast of the United States was being battered by a hurricane, the European crisis reached its climax. French, Italian, and British ministers conferred with Hitler in Munich, and on September 29, a pact was signed calling for the cession to Germany of the Sudeten territory.

American opinion about the Munich pact was divided. A Gallup poll indicated that most Americans approved, but many worried about the future. Secretary Ickes wrote in his diary that the pact was probably not too great a price to pay if it insured permanent peace, but he doubted very much that it would, "Hitler being the maniac that he is." President Roosevelt, who had appealed to Hitler and Mussolini for the conference rather than war, did not comment publicly on the settlement although Ickes urged him to tell the country of the gravity of the situation because he knew isolationist sentiment was still strong and he thought people simply would not believe him. Moreover, Roosevelt was concerned about the upcoming elections. He had taken an active part in the campaign to effect the nomination of party liberals and lessen his dependence on conservative Democrats. His intervention, however, was far less successful that he had hoped. For the first time since 1928 the Republicans gained seats in the Congress, 81 in the House and 8 in the Senate.

American opinion began to consolidate in opposition to Germany shortly after the 1938 elections. The day after the election, November 9, has gone down in history as the Kristallnacht, named for the broken glass of shop windows as Hitler inaugurated his campaign to rid the world of the Jewish people, and German Jews were murdered, their synagogues burned, and $23 million worth of damage done. The American Ambassador was promptly ordered home from Berlin, and when the Conference of American States met in Lima in December, the American delegation made strenuous efforts to line up the Latin American nations against interference by European dictators. In his annual message to Congress in January 1939, President Roosevelt for the first time since taking office in 1933 proposed no new domestic reforms but stressed instead the danger to democracy and international peace by the forces of oppression. The budget message proposed a total of $9 billion, including $1.3 billion for national defense, for fiscal year 1940, and a second budget message a few days later asked for additional appropriations of $525 million for an emergency program for national defense, including the facilitating of material procurement.

In the light of the growing threat to world peace, C. K. Leith tried, but without success, to persuade the American Institute of Mining and Metallurgical Engineers and the Mining and Metallurgical Society to revive the committees on industrial preparedness that had been established after the World War. In December 1938, however, the Mining and Metallurgical Society held a symposium on strategic minerals at its annual meeting and passed a resolution recommending to the administration and the Congress the accumulation of emergency stocks of specific strategic minerals for war preparedness. In the meantime, Leith had taken his case directly to the military. The Mineral Advisory Committee of the War Department was revitalized and placed under the Army and Navy Munitions Board, and in late December Leith was appointed chairman of the committee and given responsibility for preparation of studies on strategic minerals and metals and for recommendations, where domestic supplies were inadequate, as to the quantities of stocks of materials that the Government should purchase. Seventeen minerals were chosen as essential and subcommittees of industry and Government representatives set up to study them. D. F. Hewett of the Survey was a member of the committee on manganese.

On January 12, 1939, Senator Elbert Thomas, acting for the Committee on Military Affairs, filed the first of several bills to provide for the acquisition of stocks of strategic and critical materials. The Senate Committee began hearings immediately and on February 28 reported out an amended version of the Thomas bill and recommended it be passed. The preamble stated "that the natural resources of the United States in certain strategic and critical materials being deficient or insufficiently developed to supply the industrial, military, and naval needs of the country for common defense, it is the policy of Congress and the purpose and intent of this act to provide for the acquisition of stocks of these materials and to encourage the development of mines and deposits of these materials within the United States, and thereby decrease and prevent wherever possible a dangerous and costly dependence of the United States upon foreign nations for supplies of these materials in times of national emergency." Section 7 of the bill "authorized and directed" the Secretary of the Interior, through the Director of the Bureau of Mines and the Director of the Geological Survey, "to make scientific, technologic, and economic investigations concerning the extent and mode of occurrence, the development, mining, preparation, treatment, and utilization of ores and other mineral

Deposition of sediment in irrigation canals and in parts of the Boise River channel, as above the Diversion Dam shown in the photograph, had increased maintenance costs in many canals since the mid-1920's. During an 18-month period in which Survey scientists measured the daily discharge and sediment loads in the drainage basin, they found that the sediment consisted largely of coarse material at stations above the active placer mines near Idaho City but entirely of fine material below the mines. They concluded that most of the coarse material passing the stations above Idaho City was deposited behind tailings from dredging operations in the placer mining area but that in earlier years when the spring runoff was greater a large amount of coarse material had been carried downstream, discharged into the Boise River, and deposited in the river channel or in the larger irrigation canals. Much of the fine material was carried through the canals and eventually deposited in diversion ditches or on farm land. (From S. K. Love and P. C. Benedict, 1948.)

substances found in the United States or its Territories or insular possessions which are essential to the common defense or the industrial needs of the United States, and quantities or grades of which are inadequate from known domestic sources of supply, to devise new methods for the treatment and utilization of lower-grade reserves, and to develop substitutes for such essential ores and mineral products." Section 7 also authorized the exploration and development of deposits of such minerals on public lands and privately owned lands, with the consent of the owner, and the appropriation of $500,000 for each of the fiscal years 1940 through 1943, $350,000 for the Bureau of Mines and $150,000 for the Geological Survey.

Before the Thomas bill was reported out, President Roosevelt sent to Congress a report on energy resources that contained one of the strongest endorsements of Federal research yet made. A subcommittee of the National Resources Committee, chaired by Ralph J. Watkins, Director of the Bureau of Business Research and Professor of Statistics, University of Pittsburgh, and including in its membership Director Mendenhall of the Geological Survey, A. C. Fieldner of the Bureau of Mines, Fred Tryon of the Bituminous Coal Commission, and Joel D. Wolfsohn of the General Land Office, was responsible for the report and several members of the Survey contributed to it. The report pointed out the obvious fact that energy resources are at the foundation of an industrial civilization and that, except for water power, they are exhaustible and water power at best can supply only a fraction of energy requirements. Coal reserves of the United States were ample—estimated as 3,000 billion tons, in comparison with an annual production in 1937 of about 1/2 billion tons—but proven reserves of petroleum and natural gas were meager—15 billion barrels of petroleum compared to the 1937 consumption of 1 1/4 billion barrels, and 6 to 100 trillion cubic feet of natural gas in comparison to a 1937 consumption of 2 1/2 trillion. In the interest of safeguarding the Nation's patrimony in energy resources, the committee recommended a national policy of conservation and prudent utilization, to be achieved by promotion of greater efficiency in the production of mineral fuels from the standpoint of recovery, promotion of greater economy in the use of fuels, and placing a larger share of the energy burden on lower-grade fuels and water power. The Federal Government, it said, must take responsibility for these actions as the only agency that represented all national interests and that could also cope with interstate problems. The report concluded:

National policies must be formulated, and those policies are only as sound as the foundation of fact and deduction upon which they rest and then only to the extent that this foundation is utilized. Most well conceived Governmental action, if traced back to its source, will be found to spring from the work of one or many research workers, distributed among the Government offices and laboratories. They must supply the answers which are the tools and the material used in the formulation of sound policies. To be prepared to supply the answers to the complex questions that will be asked during the next year or the next decade, research workers must be continually engaged in advancing the frontiers of knowledge. This is research. It is essential through the Government and nowhere more so than in those agencies on whose work a program of conservation of energy resources must be based.

The Energy Resources Committee had considered coal, oil, gas, and water power as energy sources but while their report was in preparation fundamental research in Europe altered the long-term outlook. Nuclear physics had advanced dramatically in the early 1930's. Enrico Fermi's experiments in Rome with neutron bombardment had produced puzzling results with uranium, but late in 1938 Lisa Meitner recognized the phenomenon as nuclear fission and calculated the large amount of energy released. Fermi had just arrived in the United States, after receiving the Nobel Prize for Physics, when he received word of the discovery and recognized the possibility of a sustained chain reaction. Fermi and Leo Szilard, who had come to the United States from Hungary in 1937, began the experiments that led to atomic energy.

Meanwhile, the regular appropriations bills had begun their tortuous path through Congressional committees that were intent on cutting expenses and balancing the budget. Secretary Ickes challenged the House Appropriations Committee with the statement that "the people are demanding more and more services every year from the Federal Government, and Congress is granting more and more services. And you cannot give services unless you pay for them." For the Geological Survey, the Interior appropriations bill included a modest increase of $151,320, including $50,000 to match increased contributions from the States for water-resources investigations and $18,000 for more adequate operation of Federal stream-gaging stations; $50,000 to purchase new equipment and increase the capacity for printing maps; $15,000 for supervision of mineral-leasing operations; $9,000 for five new positions in Texts, the

In March 1936, extraordinary floods in the Northeastern and Middle Atlantic States caused the loss of 150–200 lives and hundreds of millions of dollars of property damage and completely disrupted transportation. The photograph shows the airport at Washington, D.C., covered by flood waters of the Potomac River. The magnitude of the problem of flood control, particularly in urbanized areas, and the necessity of adequate basic information for planning purposes was impressed on people as never before. In June 1936, Congress passed a Flood Control Act under which the Federal Government for the first time assumed responsibility for flood control throughout the country. (From N. C. Grover, 1937.)

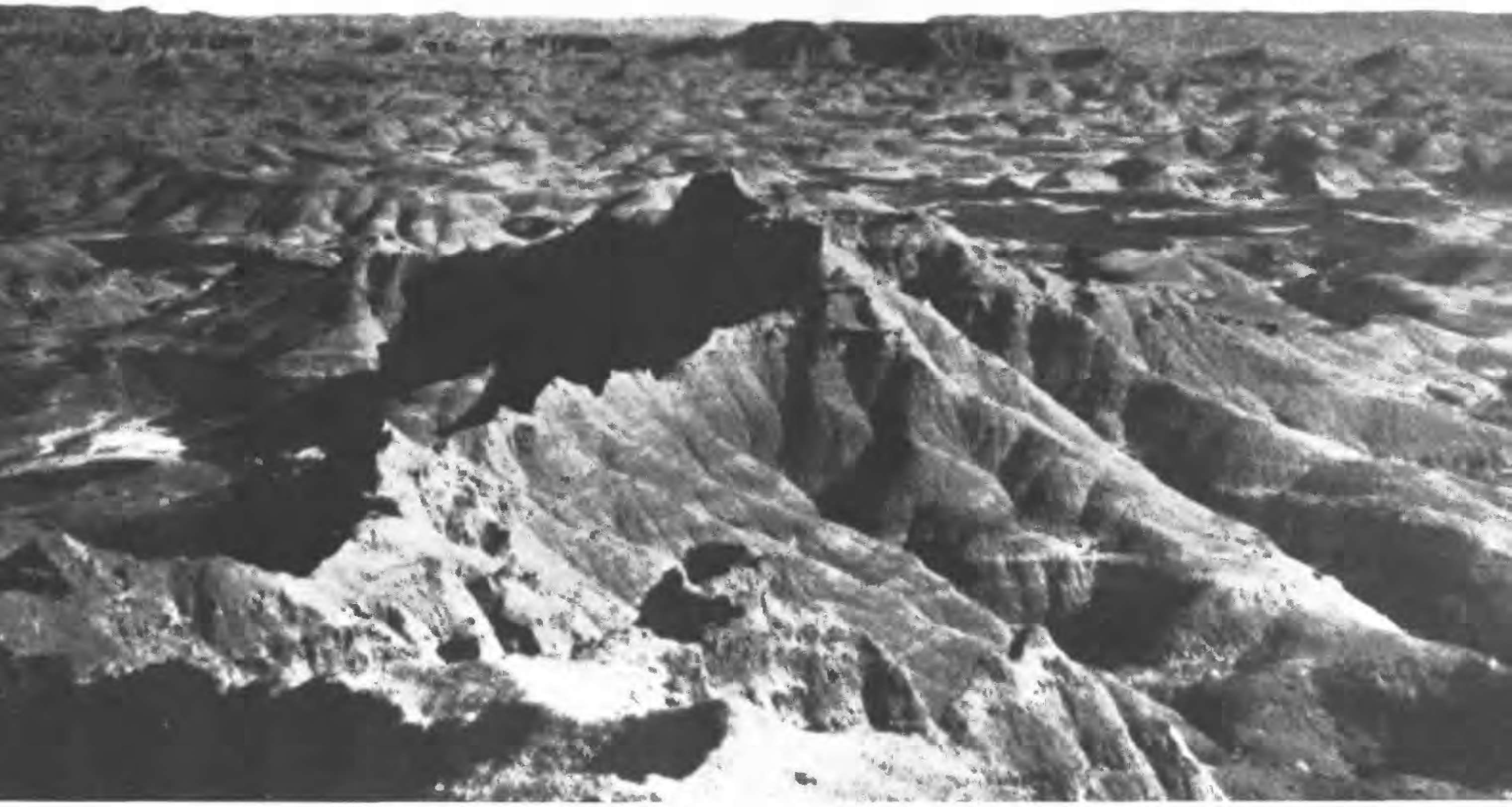
Library, and Accounts, and $5,000 for printing and binding because the Comptroller General had ruled that forms could not be reproduced by mimeograph but had to be printed at the Government Printing Office. For topographic and geologic surveys, the Bureau of the Budget recommended the same appropriations as those for fiscal year 1939.

The Chairman of the Committee on Surveys and Maps of the American Engineering Council, John S. Dodds, wrote to President Roosevelt protesting the inadequacy of the appropriation for topographic surveys. Roosevelt's secretary had replied that $115,000 had been included in the War Department budget for mapping strategically important areas but no large additional amounts had been asked for the Geological Survey and the Coast and Geodetic Survey "because of the possibility of giving subsequent consideration of an expansion of the mapping program in its relation to national defense needs." In late January 1939, Director Mendenhall told the House Appropriations Committee that the War Department was pressing the Geological Survey to increase the rate of mapping, that it wanted the Survey to spend $8 million and more in the next year or two to make maps in national defense areas. Although Mendenhall pointed out that the Survey could not do that much mapping under existing financial conditions, the House committee approved the recommendation of the Bureau of the Budget.

The next move was made by Senator Hayden by a resolution, passed on February 27, requesting the Secretaries of War, Commerce, and Interior "to confer and jointly to submit to the Senate as soon as practicable a report outlining the necessity for additional surveys and mapping in the United States, and to advise the Senate as to what would be proper expenditure for that purpose." The three Secretaries replied on March 23 that "Basic three-dimensional contour maps, made by modern methods in accordance with accurate engineering standards, are recognized as fundamental both to national defense and to the planning of internal improvements." They proposed an immediate acceleration of the mapping program, beginning with a 3-year expansion from $5 million to at least $7 million and its continuation thereafter at that level. At least half the mapping should be done in strategic areas in accordance with priorities determined by the Secretary of War. The basic control work should be done by the Coast and Geodetic Survey, for which it should receive $1 million a year, the topographic mapping by the Geological Survey, which would receive the rest of the funds.

The Survey had again stressed the need for strategic-mineral studies in its justification for geologic surveys in fiscal year 1940, stating its intention "to give as much attention as possible to strategic and critical minerals without too serious an interruption to the regular program." The House committee decided the Survey could do that without an increase in appropriation. In fact, the House Committee made only one change in the recommendations of the Bureau of the Budget, eliminating the increase of $15,000 for supervision of mineral-leasing operations. The Senate passed the Interior appropriations bill on April 17 without any change in Survey appropriations, and the bill was approved on May 10.

The Senate had already passed the strategic materials bill which authorized the appropriation of $500,000 for strategic-mineral studies when it took up the Interior appropriations bill. The Departments of State, War, Navy, Commerce, and the Interior had all recommended favorable consideration, and the Treasury Department had stated there was no objection to consideration of the bill on the ground that it was not part of the President's budget program, for the bill did not provide funds in the ordinary sense but simply authorized appropriations. The House passed an amended version of the bill on April 25, the conference committee took the month of May to iron out the differences,



On January 25, 1939, part of the Badlands of South Dakota was set aside as a national monument because of its scenic and scientific interest. John Evans, who, in 1849, had been the first geologist to visit the area, reported it to be "one of the most extraordinary and picturesque sights that can be found in the whole Missouri country," and that although in the summer "the scorching rays of the sun are reflected from the white or ash-colored walls, unmitigated by a breath of air, or the shelter of a solitary shrub," the "drooping spirits of the scorched geologist" did not flag for the "fossil treasures" well repaid him. Collectors visited the area regularly thereafter, and spectacular collections of vertebrate fossils were made by F. V. Hayden, O. C. Marsh, W. B. Scott, J. B. Hatcher, and H. F. Osborn. Evans' sketch of the Badlands, published in 1852, is on page 88 of Volume 1. This photograph, by N. H. Darton, is from the files of the U.S. Geological Survey.

and the bill was finally passed and approved on June 7. Once the bill was signed the process of obtaining funds through an appropriations act could begin.

In the few months since Congress had convened, the political situation in Europe had grown increasingly ominous. On March 15, 1939, while the House was considering the Interior appropriations bill, Germany occupied the rest of Czechoslovakia and demanded the surrender of Memelland from Lithuania. On March 23, when Secretaries Ickes, Dern, and Roper urged an immediate expansion of topographic mapping, Germany annexed Memel and demanded passage through the Polish corridor. On March 31, as the Senate passed the strategic materials bill, England and France, reacting to Hitler's demands on Poland, pledged help to the Polish people. Only a few days earlier, on March 28, Madrid had fallen to Franco's forces and the Spanish Civil War had come to an end. By the time the Senate passed the Interior appropriations bill on April 17, Spain had joined Germany, Italy, and Japan in the anti-Communist pact and Italy had invaded Albania. In May, while the House and Senate ironed out their differences on the strategic materials bill, Great Britain and Turkey signed a mutual assistance agreement in case of aggression or war in the Mediterranean area, Esthonia and Latvia concluded a mutual nonaggression pact with Germany, which Finland, Norway, and Sweden declined to join, and Germany and Italy signed a political and military alliance.

The situation in the Pacific also became more critical. In May, serious fighting broke out on the Mongolian frontier between Russia and Japan. Then on June 14, the Japanese blockaded the British concessions at Tientsin and warned Great Britain that it must cooperate with Japan in establishing the new order in the Far East, thus straining relations between the two countries almost to the breaking point.

The summer of 1939 slipped by. The King and Queen of England came for a visit in June. The World's Fair attracted large crowds in New York City and the Golden Gate Exposition on Treasure Island in San Francisco Bay drew others to the west coast. Transatlantic planes began carrying passengers to Europe. Geological Survey parties took to the field endeavoring to carry on as normal a program as possible while plans were made to inaugurate strategic-minerals and mapping programs if or when funds became available. On July 1, there was a major reorganization of the Federal Government in accordance with the provisions of the Administrative Reorganization Act, which Congress had passed on April 3. Three new agencies were established: the Federal Loan Agency, the Federal Security Agency, and the Federal Works Agency; major independent offices were consolidated, abolished, or placed in one of the new agencies or under an existing agency in the Executive Branch; some bureaus within the Executive departments were transferred to other departments. Under these provisions, the National Resources Committee became part of the Federal Works Agency, the Bureau of Fisheries was transferred from the Department of Commerce to the Department of the Interior and the Bureau of Biological Survey from the Department of Agriculture to the Department of the Interior. Secretary Ickes, however, did not get his dearest wish, the Forest Service.

Congress refused to appropriate all the funds requested for emergency relief because of the increased unemployment after the 1937 recession and brought on a nationwide strike of WPA workers; it passed the Hatch Act prohibiting active participation of Federal employees below the policymaking level in political campaigns. The Senate ratified the treaty with Panama, which had been pending since 1936. The Third Deficiency Appropriations bill, which provided $150,000 for strategic-minerals investigations by the Geological Survey, was passed on August 5. Off and on during the summer Congress debated the wisdom of new neutrality legislation or a repeal of the arms embargo but on August 5 it adjourned without taking any action. Senator Borah insisted that his sources of information were better than those of the State Department—there would be no war in Europe that year.

Only 16 days after Congress adjourned, the world was startled by the reversal in relations between Germany and Russia as they announced they had signed a trade agreement and were about to sign a nonagression pact. The pact was signed in Moscow on August 23, and France and Great Britain began to mobilize. On September 1, as the United States prepared to enjoy the long Labor Day weekend, Hitler's armies moved into Poland, and on September 3, after Hitler had rejected Anglo-French demands that the troops be withdrawn, Great Britain and France announced that a state of war existed with Germany.

In the United States there was a sense of déjà vu, of 1914 all over again. Most Americans were surprised by the outbreak of war in Europe but determined that this time we would remain out of the conflict. The United States officially proclaimed its neutrality on September 5 and under the terms of the Neutrality Act of 1937 prohibited the export of arms and munitions to the belligerent nations. Franklin Roosevelt, however, unlike Woodrow Wilson in 1914, did not ask Americans to remain neutral in thought but more in the mood of Woodrow Wilson in 1917, declared that "when peace has been broken anywhere, the peace of all countries everywhere is in danger."

For the Geological Survey, the sense of déjà vu must have included an element of resignation. At the end of its first 25 years the Geological Survey had been a highly successful research organization, but it had been transformed into an institution for applied science by the stress on conservation and the public lands under George Otis Smith, beginning in 1907. The basic research function, although subdued, continued to survive and was again becoming a recognizable part of the program when World War I, the energy crisis that followed it, and the years of emphasis on private enterprise intervened. Basic research was reinstated and a more balanced program developed under Mendenhall, first in the Geologic Branch and then in the rest of the Survey, until in 1939, despite the difficult years of the depression, the Geological Survey was once more a mature and successful research organization. After more than two decades of almost unchanged Federal appropriations and then several years of uncertain and fluctuating appropriations, Federal support for the Survey's work reached new high in 1939, and it had a staff of competent, even outstanding, scientists and engineers. A natural supposition was that with the coming of war, the Survey might once more be diverted into another period of applied science.

The Federal Government of 1939, however, played a very different and far greater role in national life than did that of 1904. Beginning with the Theodore Roosevelt administration, slowed by World War I and the years of Republican ascendancy, and reinvigorated by Franklin Roosevelt, the idea of strong Presidential leadership had been established and the growth of Federal power promoted. Under the second Roosevelt, too, economic and social planning by the Federal Government had become an established fact, and scientific research was accepted as a necessary Government function. The conservation efforts of the second Roosevelt had surpassed those of the first and done so much for the physical rehabilitation of the country and the husbanding of its resources that conservation was widely supported. Thus, as the Survey entered its 61st year, it was ready to begin a period not of decline but of extraordinary growth.

Notes and Bibliography

The chapter notes identify the sources of directly quoted material and a few indirect statements, and give the reference to the U.S. Statutes at Large for most applicable laws discussed in the text. These have been keyed to the relevant page and either to the first few words of the quotation or to a significant phrase. The bibliography, despite its length, is not all inclusive. Complete citations have been given for most published material used as background and for sources of quotations of illustrations. Citations are arranged alphabetically by author and include for congressional documents the serial number of the volume in which the document appears. Annual reports of the Director of the U.S. Geological Survey and the Secretary of the Interior are with few exceptions cited only in the notes.

To aid the reader in finding pertinent references in the bibliography or in seeking additional material on a particular topic, a simple index has been prepared, with references identified by author and date. Biographical material in the Dictionary of American Biography (DAB) and the Dictionary of Scientific Biography (DSB) have been included, with the pertinent volume number, in the index although the citations were not listed in the bibliography itself. Additional biographical material was also obtained from the National Cyclopedia of American Biography, Who Was Who in America, Who Was Who in American Politics by Dan and Inez Morris, or the Biographical Directory of the American Congress, 1774–1961.

Notes

Title.

"for the common defence and general welfare": Article I, Section 8 of the Constitution provides that "The Congress shall have Power to lay and collect Taxes, Duties, Imposts and Excises, to pay the Debts and provide for the common Defence and general Welfare of the United States." This section is the authorization for appropriation and expenditure of public funds for scientific research.

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83. "If this erosive action * * *": R. B. Dole and Herman Stabler, 1909, p. 83.
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391. "Our future is limited * * *": A. I. Levorsen, 1936, p. 530.
"I am sure * * *": I. M. Goubkin, 1939, p. 178.

394. "theoretical merit"; "not advisable * * *"; and "it is admitted * * *": U.S. Congress, 75th, 1st session, Senate Report 1275, p. 394.
"laudable" and "insofar as they apply * * *": Congressman Edward Taylor, *in* Congressional Record, 75th Congress, 2d session, Appendix, p. 597.
"the entire delegation in Congress * * *": Ibid.
"Certainly war with Japan * * *": Harold L. Ickes, 1953, v. 2, p. 274.

395. "would cripple any President * * *": Franklin D. Roosevelt, *in* Congressional Record, 75th Congress, 3d session, p. 277.
"modern successors rather than * * *": F. E. Matthes, 1939, p. 20.

396. "wholly insufficient * * *"; "surveying, mapping, land classification * * *"; and "to insure that the Government * * *": U.S. National Resources Committee, 1938, p. 30.
"Anticipation of the future * * *" and "a great disturber": U.S. National Resources Committee, 1937b, Foreword, p. viii.

397. "aside from the hazard of war * * *": Ibid., p. 176.
The speeches by Congressman Scrugham and Director Finch are *in* Congressional Record, 75th Congress, 3d session, Appendix, p. 1419–1420 and 1827–1830.

399. "It is futile to wait * * *": Hearing before subcommittee of House Appropriations Committee, 75th Congress, 3d session, on appropriations for the Interior Department, p. 390.
"More than half the Territory * * *": Ibid., p. 392.
"how many people * * *": Senator Kenneth McKellar, *in* Hearing before subcommittee of Senate Appropriations Committee, 75th Congress, 3d session, on appropriations for the Interior Department, p. 63.

400. "it was gratifying * * *": W. C. Mendenhall, *in* Annual Report of the Secretary of the Interior for the fiscal year ended June 30, 1939, p. 139.

402. "in recognition of his outstanding contributions * * *": E. S. Larsen, Jr., *in* American Mineralogist, v. 24, 1939, p. 53.
"indispensable": Economic Geology, v. 34, 1939, p. 122.

404. "Hitler being the maniac * * *": Harold L. Ickes, 1953, v. 2, p. 480.

405. "that the natural resources of the United States * * *": Preamble to Senate bill 572, to acquire stocks of strategic and critical

materials, p. 1.

"authorized and directed" and "to make scientific, technologic, and economic investigations * * *": Ibid., Section 7.

407. "National policies must be formulated * * *": National Resources Committee, 1939, p. 15.

"the people are demanding * * *": Secretary Ickes, *in* Hearing before subcommittee of House Appropriations Committee, 76th Congress, 1st session, on Interior Department appropriations bill, p. 17.

408. "because of the possibility * * *": Letter of Marvin McIntyre to John S. Dodds, *in* Hearing before subcommittee of House Appropriations Committee, 76th Congress, 1st session, on Interior Department appropriations bill, p. 459.

"to confer and jointly to submit * * *": U.S. Congress, 76th, 1st session, Senate Resolution 87, February 27, 1939.

"Basic three-dimensional contour maps * * *": U.S. Congress, 76th, 1st session, Senate Document 54, p. 1.

"to give as much attention as possible * * *": Ibid., p. 476.

409. "one of the most extraordinary * * *"; "the scorching rays * * *"; "drooping spirits * * *"; and "fossil treasures": John Evans, *in* David Dale Owen, Report of a geological survey of Wisconsin, Iowa, and Minnesota and incidentally of a portion of Nebraska Territory, Philadelphia 1852, p. 196 and 197.

410. "when peace has been broken * * *": Franklin D. Roosevelt, Radio address to the Nation, September 3, 1939, *in* Congressional Record, 76th Congress, 2d session, Appendix, p. 40.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.