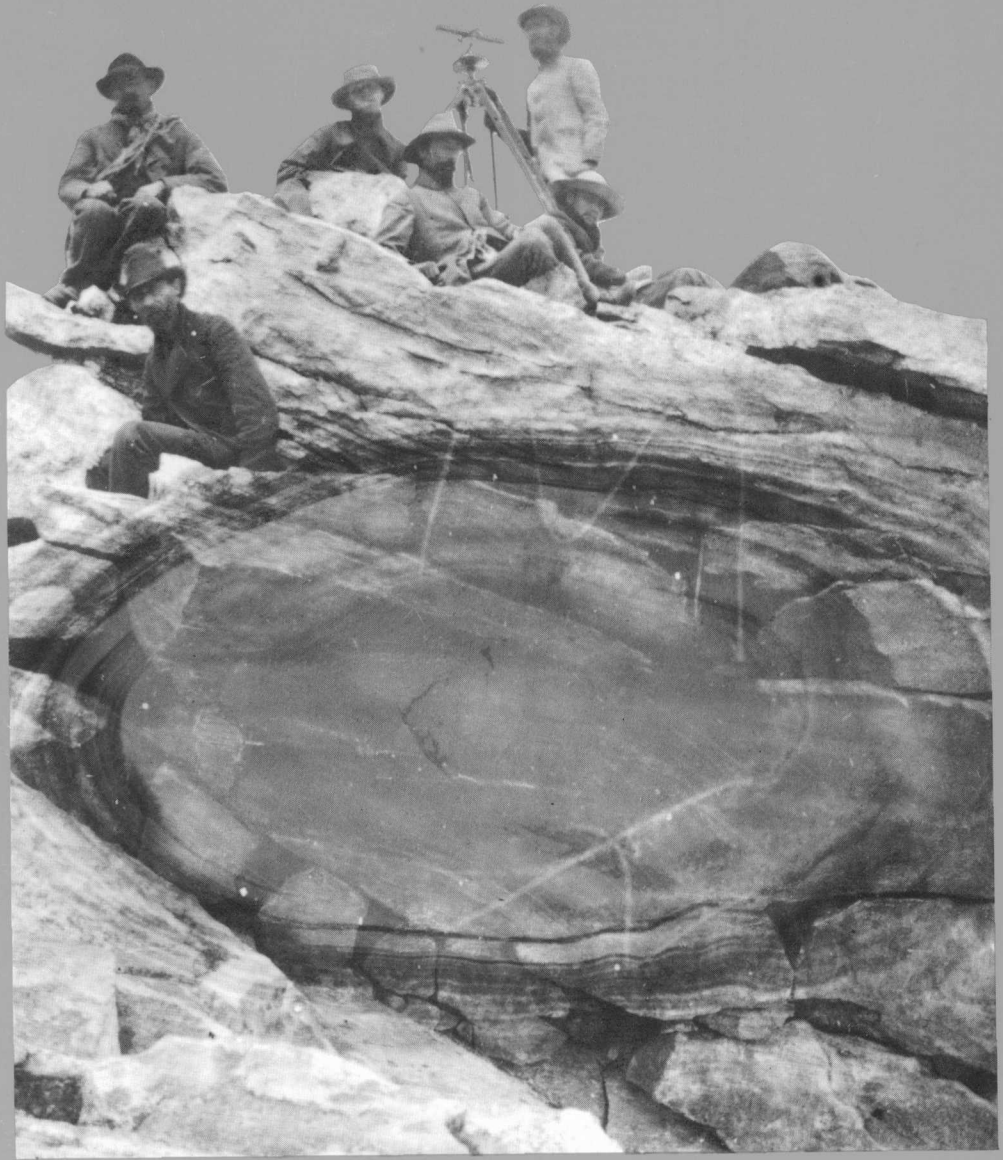
U.S. Department of the Interior/Geological Survey

A Brief History of the U.S. Geological Survey



An early headquarters of the U.S. Geological Survey.

A Brief History of the U.S. Geological Survey

by Mary C. Rabbitt

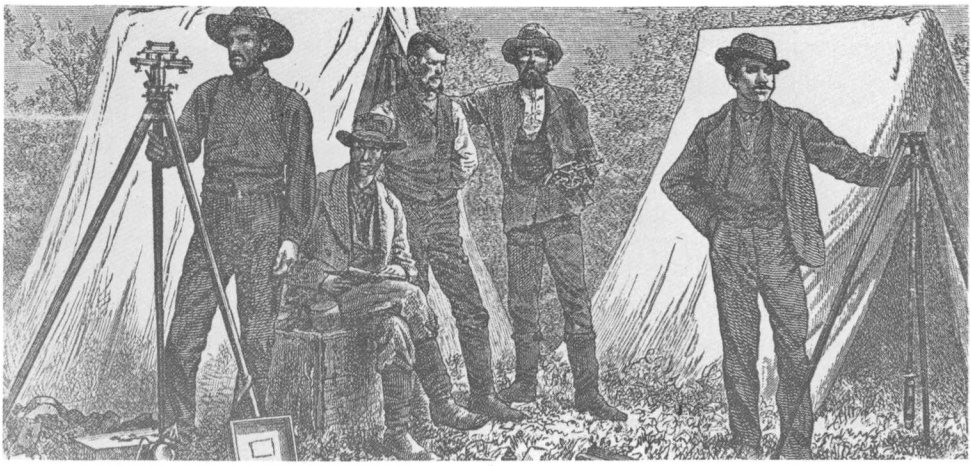
Foreword

Established by an Act of Congress in 1879 and charged with responsibility for "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain," the U.S. Department of the Interior's Geological Survey has been the Nation's principal source of information about its physical resources—the configuration and character of the land surface, the composition and structure of the underlying rocks, and the quality, extent, and distribution of water and mineral resources. Although primarily a research and fact-finding agency, it has responsibility also for the classification of Federal mineral lands and waterpower sites, and since 1926 it has been responsible for the supervision of oil and mining operations authorized under leases on Federal land.

From the outset, the Survey has been concerned with critical land and resource problems. Often referred to as the Mother of Bureaus, many of its activities led to the formation of new organizations where a management or developmental function evolved. These included the Reclamation Service (1902), the Bureau of Mines (1910), the Federal Power Commission (1920), and the Grazing Service (1934, since combined with other functions as the Bureau of Land Management). Mrs. Rabbitt's summary of the Survey's history in the following pages describes the development of these diverse activities and the Survey's past contributions to national needs related to land and resources.

A sense of urgency has characterized much of the Survey's work since its inception. As we look ahead, the sense of urgency in the Survey's mission deepens when we face the increasingly difficult tasks of meeting our requirements for energy, mineral, and water resources; improving the efficiency and safety of our use of the land; and maintaining environmental quality. Between now and the end of the century, we will need to build a "Second" America in the sense that we will produce, manufacture, and build as much as we have throughout the Nation's previous history—even if during that period it is possible to reduce the rate of economic and population growth. And because it is these elements that lead to environmental deterioration, the Nation may incur as much environmental damage as accompanied the building of the First America—unless appropriate actions are taken to avoid it. Sound information about the land and its resources is essential to success in meeting resource needs, using the land wisely, and preserving environmental quality, and we are keenly aware that our past has indeed been mere prologue to the accomplishment of more difficult tasks ahead.

H. William Menard, Director
U.S. Geological Survey,
1978-1981



The United States Geological Survey was established on March 3, 1879, in the closing hours of the final session of the 45th Congress, when the bill appropriating money for sundry civil expenses of the Government for the fiscal year beginning July 1, 1879, was signed by President Rutherford B. Hayes. Included in the bill was provision for a new agency in the Department of the Interior, charged with responsibility for "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain."

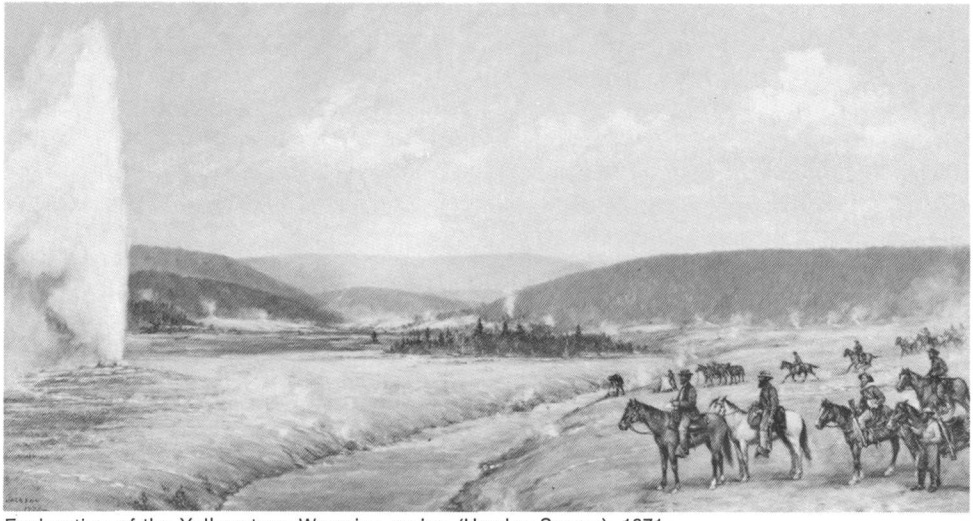
The legislation establishing the Survey stemmed from a report of the National Academy of Sciences, which had been asked by the Congress in 1878 to provide a plan for surveying and mapping the Territories of the United States that would secure the best possible results at the least possible cost. Three surveys were actively mapping the West at the time under the auspices of the Interior Department: the Geological and Geographical Survey of the Territories under F. V. Hayden, the Geographical and Geological Survey of the Rocky Mountain Region under John Wesley Powell, and the land-parceling surveys of the General Land Office. Under the Army Engineers, the Geographical Surveys West of the 100th Meridian were also systematically mapping the West. The Geological Exploration of the Fortieth Parallel, under the Army Engineers administratively but conducted by civilian scientists under the direction of Clarence King, had completed its fieldwork in 1872 and was then finishing up its reports.

The establishment of a Federal geological survey was a natural step at that stage in the development of Government science. In its early years, the Federal Government had made few scientific investigations. In fact, many considered Federal science, as well as Federal involvement in the construction of public works, to be unconstitutional. Exploration and related

scientific activities were undertaken in a limited way by the military services. Mapping of the public lands was from the first under the supervision of a civilian, the Geographer, but charting of the coast, first authorized under the Treasury Department and civilian control, was before long transferred to the Navy. Some of the States therefore established geological surveys in the 1820's and 1830's to aid in the development of their natural resources; at first the agricultural resources, and then the mineral resources.

As the Nation grew and the need for geographic knowledge became more urgent, the Federal Government also became more deeply involved in scientific activities. The Corps of Topographical Engineers was established in 1838 to map the West. Support for the Wilkes Exploring Expedition to the Pacific led to the establishment of the Naval Observatory. The Coast Survey regained its independence as a civilian agency. The General Land Office called on geologists to classify the mineral lands of the Upper Mississippi Valley and Michigan. In the 1850's scientists accompanied most of the Corps of Topographical Engineers' explorations in search of a transcontinental railroad route, adding to the knowledge of the West.

Ferdinand V. Hayden, U.S. geologist.

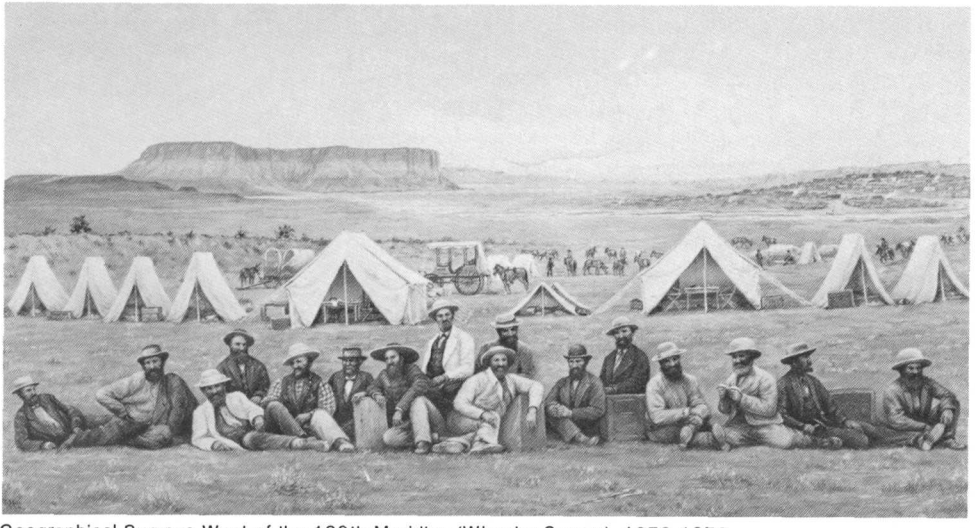


Exploration of the Yellowstone Wyoming region (Hayden Survey), 1871.

During this same period, growth in the industrial capacity of the Nation accelerated, especially after coal began to replace wood in the manufacture of iron. The United States had begun as a primarily agrarian nation, but in 1859, the value of the products of U.S. industry surpassed the value of agricultural products for the first time. Industry began to play a greater role in national development. State surveys established at this time reflected the growing sectionalism, those in the South tending to emphasize agricultural resources while those in the Northwest were more concerned with mineral resources.

After the Civil War, civilian scientists began to take a leading role in western exploration and to stress geology and the investigation of natural resources along with mapping. The Geological Exploration of the Fortieth Parallel, the first of the four great surveys that preceded the U.S. Geological Survey, was authorized by Congress on March 2, 1867. It was planned, organized, and directed by Clarence King, though administered by the Army Engineers. A survey of the natural resources of the new State of Nebraska, authorized on the same day under the Land Office and with Dr. F. V. Hayden in charge, increased in scope and size until it

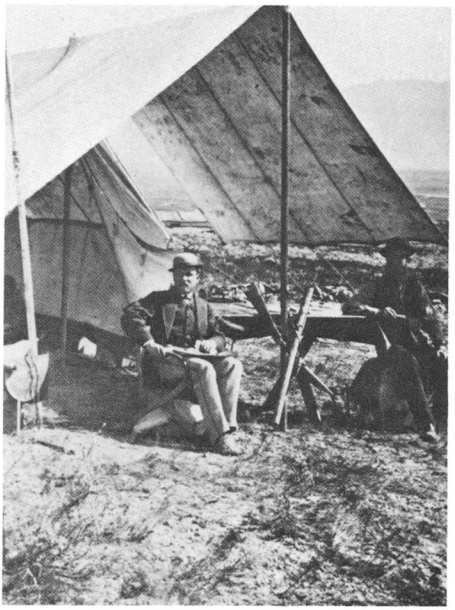
Lt. George M. Wheeler, U.S. Army Engineers.



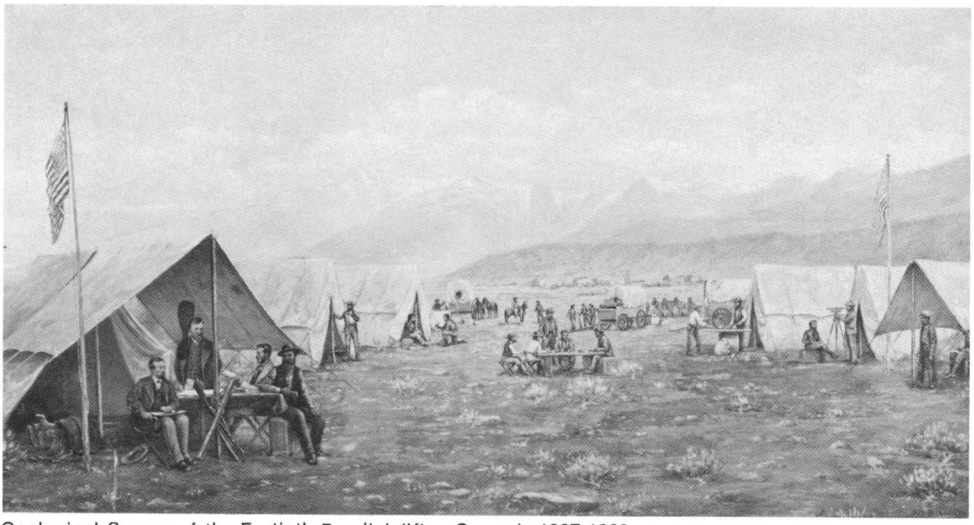
Geographical Surveys West of the 100th Meridian (Wheeler Survey), 1872-1879.

became the Geological and Geographical Survey of the Territories under the Department of the Interior. Yet a third survey, at first under the Smithsonian Institution and later under Interior, grew out of the daring exploration of the Colorado River by John Wesley Powell in 1869. The Army resumed its major exploratory activities with reconnaissance surveys in 1869 and 1871 and in 1872 initiated the Geographical Surveys West of the 100th Meridian, under Lt. George Wheeler.

During the prosperous years of the early 1870's, all Federal scientific activities expanded. Though conflicts of interest among some of the western surveys led to a thorough discussion of civilian versus military control of mapping by Congress in 1874, the question was left unresolved. The prosperous years, however, were followed by lean years after the financial crisis of 1873, and the need for economy led to another consideration of the problem and the referral to the National Academy of Sciences.

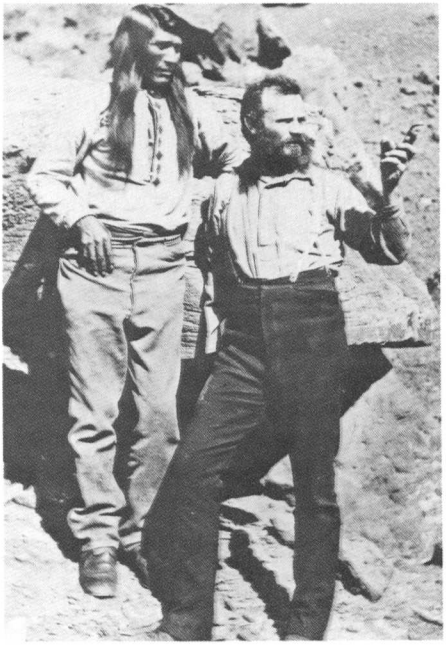


Clarence King (in center of photo) at campsite (King Survey), 1868.

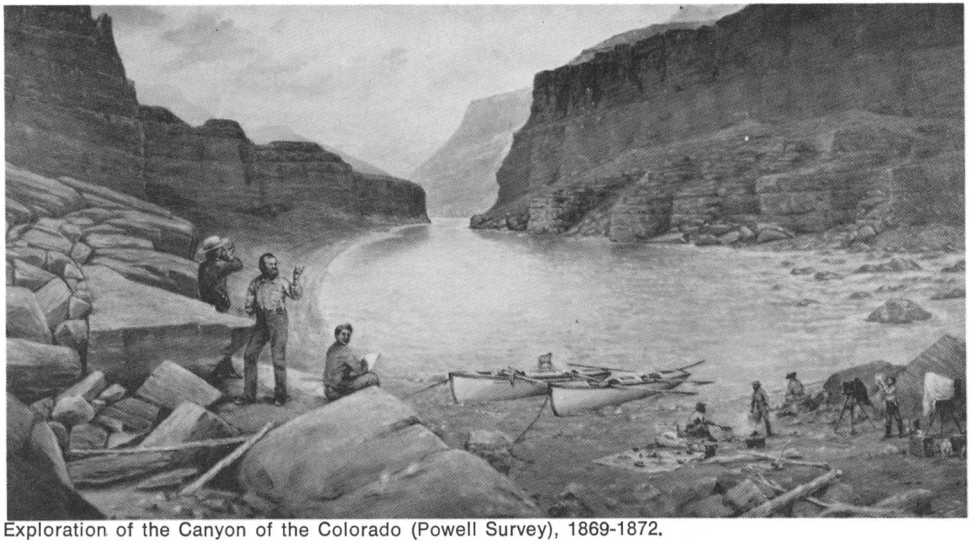


Geological Survey of the Fortieth Parallel (King Survey), 1867-1869.

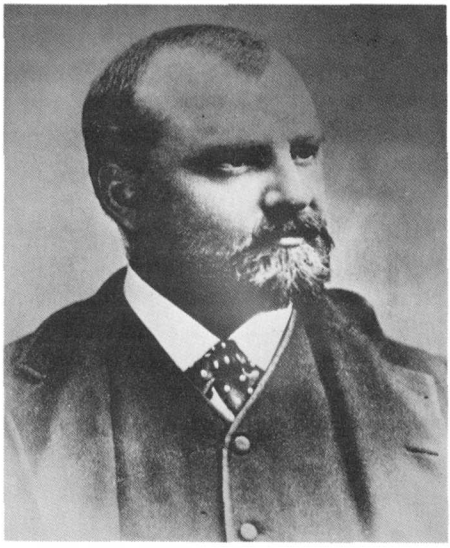
The Academy favored civilian science. To attain the desired accuracy and economy in surveys of mensuration, it recommended that the Coast and Geodetic Survey be transferred from the Treasury Department to Interior, renamed the Coast and Interior Survey, and be given responsibility for geodetic, topographic, and land-parceling surveys in addition to its former work. The Academy also recommended that an independent organization, to be called the U.S. Geological Survey, be established, also in the Interior Department, to study the geological structure and economic resources of the public domain. All the Academy recommendations were embodied in a bill introduced on February 10, 1879. The change in the land-parceling surveys aroused strong objections among Western Congressmen and was dropped, and at the last minute the transfer of the Coast Survey to the Interior Department was also dropped and only the Geological Survey was established.



Tau-gu, a chief of the Paiute Indian tribe, and Major Powell in southern Utah, 1872.



Exploration of the Canyon of the Colorado (Powell Survey), 1869-1872.



Clarence King, first Director of the U.S. Geological Survey, 1879-1881.

The King Years

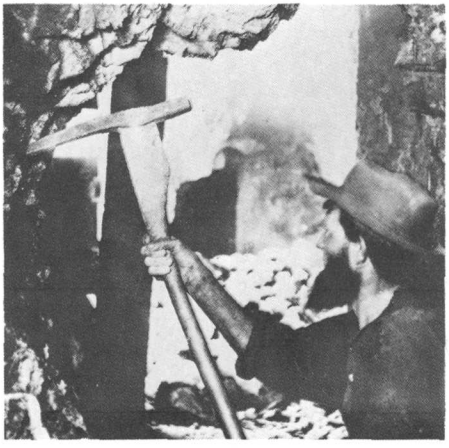
Clarence King was appointed the first Director of the new Survey by President Hayes. King's Fortieth Parallel Survey had led the way in converting western exploration to an exact science; he was then in a position to exert a unique influence on the organization of geological work for the Nation. The enabling legislation was brief and did not define in detail the duties of the new organization which left much to King's judgment. The Survey's classification of the public lands, he concluded, inasmuch as Congress had made no change in the General Land Office, was not meant to supersede the classification made by the Land Office as a basis for granting title. King therefore planned a series of land maps to provide information for agriculturists, miners, engineers, timbermen, and political economists.

Information about the Nation's mineral wealth, mining and metallurgical techniques, and production statistics was meager. But the year in which the Survey was estab-

The Leadville, Colorado, mining district, subject of an early mining geology study.

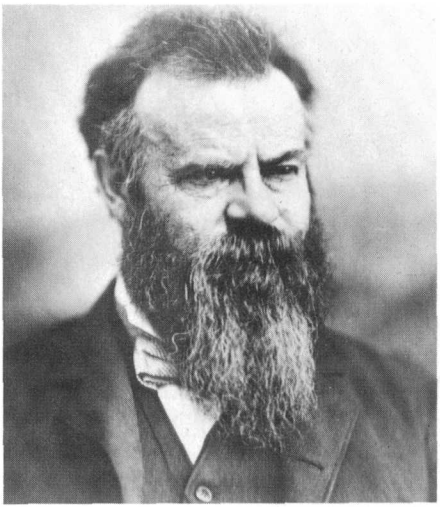
lished was one of great monetary uncertainty, when knowledge of precious metal resources was vital, and one in which the iron and steel industry faced problems in obtaining suitable raw materials. King therefore chose to emphasize mining geology, to devote but a small effort to general geology, and to confine paleontology and topographic mapping to what was necessary to support the geologic studies.

The term "national domain" of the organic act also proved troublesome. Although the framers of the law had meant it to include all lands within the national boundaries, a Department attorney ruled that it meant the lands to which the Government had not parted title. The literal interpretation of that ruling would preclude work in a mining district where most of the land had become private property. King asked Congress to clarify the meaning. The House promptly extended the field of the Survey to the entire Nation, but Congress adjourned before the Senate acted. For the first year, therefore, operations of the Survey were confined to the public-land States, but investigations in the eastern States were begun through a cooperative arrangement with the Tenth Census. In the West, comprehensive studies of the geology and technology of three great mining districts—Leadville in Colorado, and the Comstock and Eureka in Nevada—were begun. In the East, iron resources were systematically investigated. Mineral statistics were collected for the entire country. The results of these studies were published in three volumes of the Tenth Census reports, providing the first comprehensive study of the Nation's mineral resources and a compendium of mining law, and in monographs of the Geological Survey which inaugurated a new era in the use of geology in mining.



Mining the lode, Virginia City, Nevada.

When King accepted the directorship, he intended to serve for only a short time, until the Survey was well organized and functioning. Though an able administrator, he did not enjoy working in Washington. The failure to obtain congressional approval to extend the operations of the Survey into the eastern States, and the failure to gain increased appropriations undoubtedly strengthened his desire to leave. In March 1881 he submitted his resignation, and the newly inaugurated President James Garfield appointed John Wesley Powell as his successor.



John Wesley Powell, second Director of the U.S. Geological Survey, 1881-1894.

The Powell Years

Powell, at the time he was appointed Director, was in charge of ethnologic studies at the Smithsonian Institution but had also been serving informally as the head of the Survey's second, or General Geology, Division. His formal education had been sporadic and he was largely self taught. As a youth he had made natural history collections, and after service in the Civil War (in which he lost his right forearm) he had been a college professor and director of a small natural history museum in Illinois before beginning his western explorations. His scientific interests were wide ranging, but his background in natural history led him to collect and classify facts, as well as objects, as a method of investigation. In 1872, for example, he classified valleys to understand their origin; a decade later, he classified the publications of the American Institute of Mining Engineers to understand the nature of mining engineering.

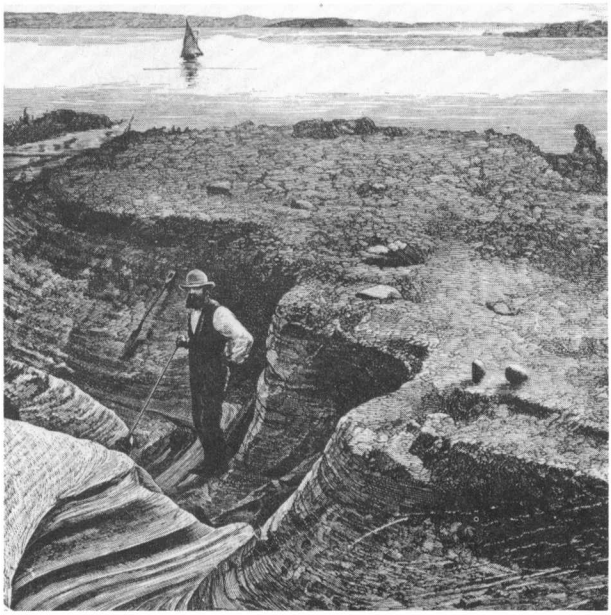
Coming from an agrarian background, Powell was primarily concerned with landforms and land use. In 1878, he wrote a "Report on the Lands of the Arid Region of the United States," in which he pointed out that very little of the remaining public land was suitable for conventional farming, and that only a small fraction of the arid lands was irrigable. He then proposed radical changes in the land system, including organization of irrigation and pasturage districts, which Westerners opposed as they did changes in the surveying practices of the General Land Office.

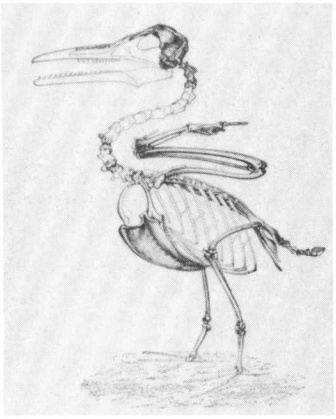
Powell called geology the most comprehensive of all sciences, although he held that its most fundamental connection was with topography. Immediately on becoming Director, he authorized topographic work independent of geologic studies. In 1882, authorization was given "to continue preparation of the geologic map of the United States." Topographic mapping to provide a base for the geologic map was begun immediately in eastern as well as western States, and all topographic work was placed under the supervision of a Chief Geographer. The geologic work was redirected toward preparation of the geologic map. Paleontologic and stratigraphic studies were begun, and mining geology languished for lack of

funds. Topographic mapping, however, became the largest part of the Survey program.

The rapid growth of all the scientific bureaus, including the Survey, brought about the appointment of a Joint Congressional Commission in 1884 to secure greater efficiency and economy among them. One of the principal reasons for the investigation was the potential or actual duplication of Coast Survey mapping by the expansion of the Geological Survey's topographic mapping program after 1882, although the functions of the Signal Service and Coast Survey—Hydrographic Office relations were also at issue. The National Academy of Sciences recommended that all the scientific work of the Government be encompassed in four bureaus, organized on the basis of scientific discipline, which preferably would form a Department of Science but which at least should be in one executive department. Others, the Secretary of the Navy for one, held that scientific work should be conducted in and directed by the department that needed scientific assistance, and still others held that Government scientific work should be severely limited in scope. The Commission held hearings during two sessions of Congress, and in the end presented a divided report. The majority recommended no changes in the organization of the existing bureaus but limited the amount that could be spent on publications. The next session of Congress demanded an itemized request for funds so it could control other expenditures.

A change in climate in 1886 provided Major Powell with an





Geology is closely related to the other earth sciences such as topography and paleontology: Exploring glacial grooving, Kelley's Island, Lake Erie (left); Restoration of *Icthyornis victor,* a bird with teeth (above).

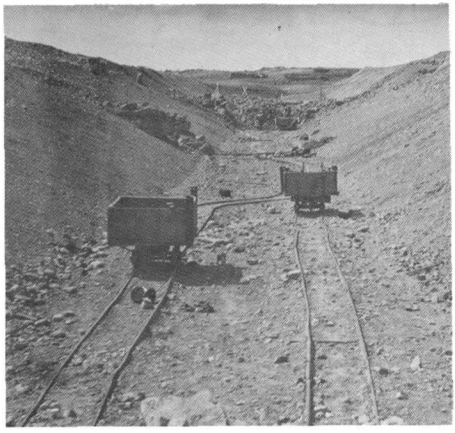
opportunity for the practical application of his knowledge of the arid regions. During the 1870's and early 1880's there had been a great influx of people into the Great Plains and would-be farmers came into competition with cattlemen for water and land. The drought of 1886 and the severe winter that followed were severe blows, and in 1888 Congress authorized a survey to determine the irrigable lands and reservoir and canal sites in the arid regions. To prevent speculation, Congress then stipulated that all lands that might be irrigated by the reservoirs and canals to be located by the survey be withdrawn from entry.

Given the opportunity he had long awaited, Major Powell planned first a topographic survey to plot catchment basins, then a hydrographic survey to measure streamflow, and finally an engineering survey to determine the feasibility of construction. Work began immediately after passage of the Appropriations Act in October 1888 as an expansion of the regular topographic mapping program.

In his arid lands report of 1878, Powell had defined the arid region as the region where rainfall was less than 20 inches a year. Most of the area west of the 100th meridian was in the arid region. Between the arid region of the West and the humid region of the East was a region which he called the subhumid region, where rainfall was 20 to 28 inches a year. Powell concentrated the Survey's work in the arid regions in Colorado and the States and Territories west of Colorado, and by the end of the first year's work he had selected approximately 30 million acres of irrigable land and 150 reservoir sites. Most of the farmers who were hurt by the change of weather, however, were in the States and Territories to the east, at the eastern edge of the arid region and in the subhumid region.

In May 1890, the Acting Attorney General ruled that all irrigable

Encampment near Embudo, New Mexico, where national stream-gaging network began, 1888.

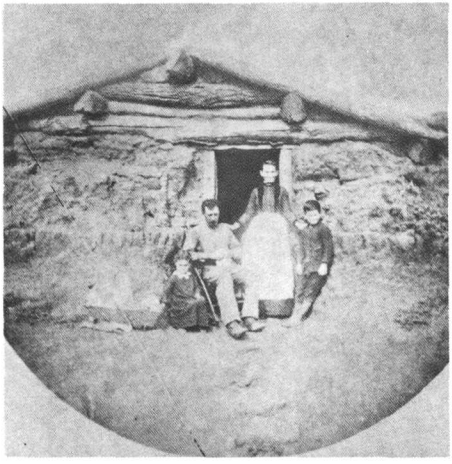


Excavation for a canal located by Survey investigations of arid regions.

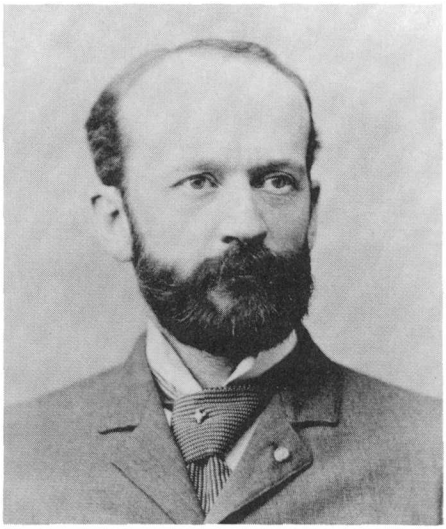
lands had been withdrawn from entry on October 2, 1888, and as no one knew which lands were irrigable until the Survey certified them, all claims filed after that date had to be invalidated. The public domain was in fact closed to entry, a situation which advocates of western development did not want at any cost. To complicate the situation, six new States had been admitted in 1889 and 1890, some wholly, some partly in the arid region, and their dowry lands, ceded by Congress to new States, were also withheld. In the summer of 1890 Congress repealed the provision for withdrawal of lands except those selected as reservoir sites and provided no further funds for the irrigation survey. For 1 year, however, it increased the funds for topographic mapping to provide the basic data.

In the late 1880's, the increasing agrarian unrest organized itself into powerful farmers' alliances which plunged vigorously into politics seeking alleviation of the farmers' problems, the trusts, and scarce credit. Congress in 1890 passed both an Antitrust Bill and a Silver Purchase Act. The monetary situation in 1890, however, was precarious. Production of gold had been declining for many years while the production of silver had steadily increased. Passage of the Silver Purchase Act did not provide the ample money supply the farmers demanded. A new downward spiral of commodity prices began in 1891, and for the first time in 20 years the Treasury announced an impending deficit. In a mood for economy, Congress in 1892 slashed appropriations for scientific agencies, especially those items which seemed to have little immediate practical purpose. The Geological Survey's appropriations for geologic surveys, paleontology, and chemistry and physics were drastically reduced, and only the appropriation for the report on mineral resources went unscathed.

Major Powell continued to occupy the position of Director until mid-1894 but his control of the Survey's geologic work came to an end in August 1892. Charles D. Walcott gradually took charge, first on an emergency basis, then with administrative responsibilities delegated by Powell. On July 1, 1893, he was appointed Geologist in charge of Geology and Paleontology by the Secretary, and a year later he became Director of the Survey when Major Powell submitted his resignation.



A typical Barber County, Kansas, homesite and family during the 1880's.



Charles D. Walcott, third Director of the U.S. Geological Survey, 1894-1907.

The Walcott Years

Walcott had joined the Survey in July 1879 as an assistant geologist and had won international recognition in following years for his work in what he chose to call paleontologic geology. Walcott revived the mission orientation of the Survey as outlined by King in 1879, but broadened the mission beyond that envisioned by King. The Survey would aid not just the mineral industry but all industries—in fact any practical objective that could be aided by a knowledge of geology. The Survey was not to be limited to practical geology; basic research would be undertaken whenever it was necessary in the solution of a geologic problem. During the 13 years of his directorate, the Survey experienced an extraordinary growth.

At the outset, Walcott announced two changes in the Survey program: topographic map quality would be improved, and mining geology investigations would be resumed. Within a few months, the topographic corps was placed under Civil Service. A practical demonstration was made of the advantages of combining topographic surveys and the subdivisional surveys of the General Land Office in Indian Territory. The value of topographic maps for practical purposes was greatly increased by the placement of permanent bench marks showing the exact location and elevation of fixed points.

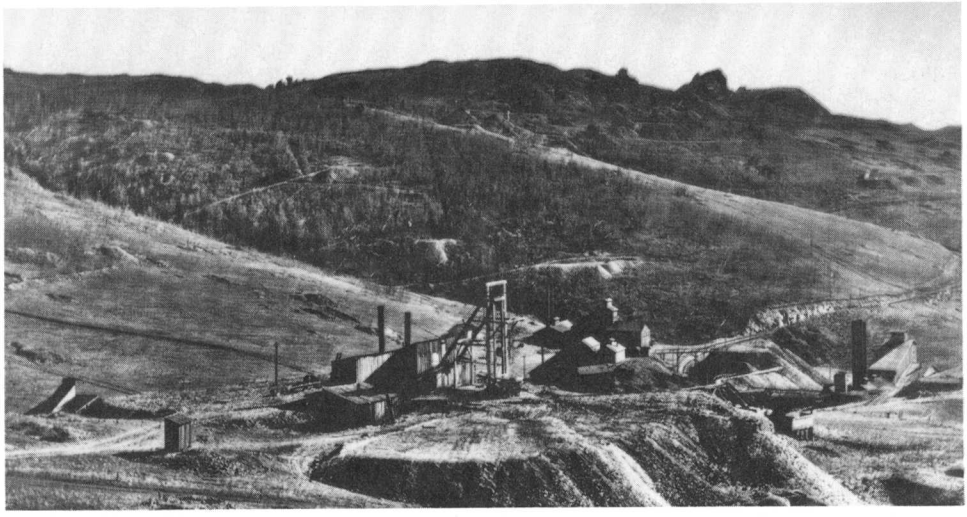
In 1897, the Forest Management Act placed management of the forest reserves in the Department of the Interior and required that surveys of the "public lands that have been or may be designated forest reserves" be made under the supervision of the Director of the Geological Survey. Although most of the reserves were wilderness areas, within the next 3 years

Using lithographic stones to print early topographic maps.

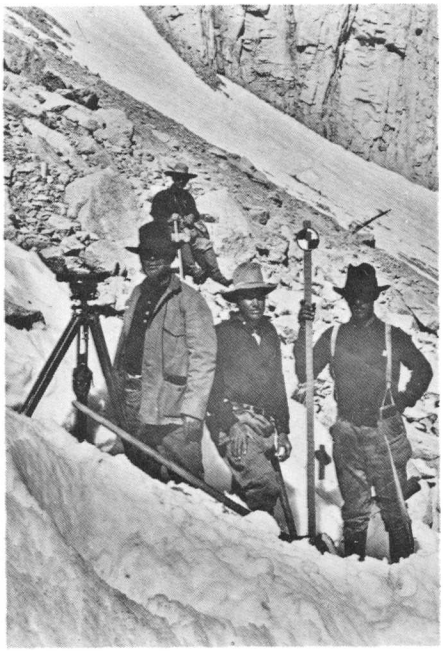
the Survey mapped more than 32,000 square miles in and adjacent to the reserves. At the same time, a steadily growing program of cooperation with the eastern States for topographic mapping on the larger scales needed for more urbanized areas was underway.

Mining geology studies were resumed and extended into the eastern States, and in view of the gold crisis, an intensive study of gold deposits, including exploration for new sources, was begun. The deposits at Cripple Creek, Colo., were studied in 1894, as were those at Mercur, Utah, which had become usable through development of the cyanidation process. Studies of gold deposits in Alaska began in 1895. By 1900, the value of gold produced annually in the United States had more than doubled what it was in 1890, and the United States adopted the gold standard as its monetary base. At the same time, mining district studies were underway in the iron districts of Michigan and Minnesota and the copper districts of Montana, Utah, and Arizona. As the Survey's work in economic geology won for it increasing recognition, the mining industry called for greater support, and parts of the mining industry urged that a Cabinet-level Department of Mines be established with the Survey as a nucleus.

A Senate resolution, in 1898, called for a Division of Mines and Mining in the Geological Survey to gather statistics on mineral resources and mineral production and to make investigations related to mines and mining. The resolution failed to pass. But when the Geologic Branch was reorganized after appropriations were increased in 1900, a Division of Mining and Mineral Resources was established to undertake studies in the distribution and production of economic minerals.



Cripple Creek mining district, Colorado, 1903.



Topographic leveling party on the slopes of Mount Whitney, California.

Cable-suspended stream-gaging car used in measuring stream velocity.

Geology was not restricted to mining geology. In 1897, a Survey geologist was detailed to the Nicaraguan Canal Commission to study the proposed canal route between the Atlantic and Pacific Oceans. The Commission made extensive use of his findings, marking perhaps the first time on this continent that geological evidence provided support for a great engineering project. Future activities in international geology were foreshadowed when Survey geologists were sent to investigate the mineral resources of Cuba and the Philippine Islands after the Spanish-American War. The geologist in the Philippines was unable to continue fieldwork because of the native insurrection, and attached himself to the Bureau of Military Information, in what might be called an ancestral form of military geology.

Nor was geology all practical. Fundamental studies were made in the genesis of ore deposits, in paleontology and stratigraphy, in glacial geology, and on the formation of rocks and minerals.

Geology was also involved in the study of water. In 1894, a small appropriation was obtained for the purpose of "gauging the streams and determining the water supply of the United States." Streamflow measurements had been continued in a modest way as part of the topographic mapping program after the end of the Irrigation Survey in 1890. With the new appropriation, work was expanded, and three kinds of investigations were gradually undertaken: stream studies,

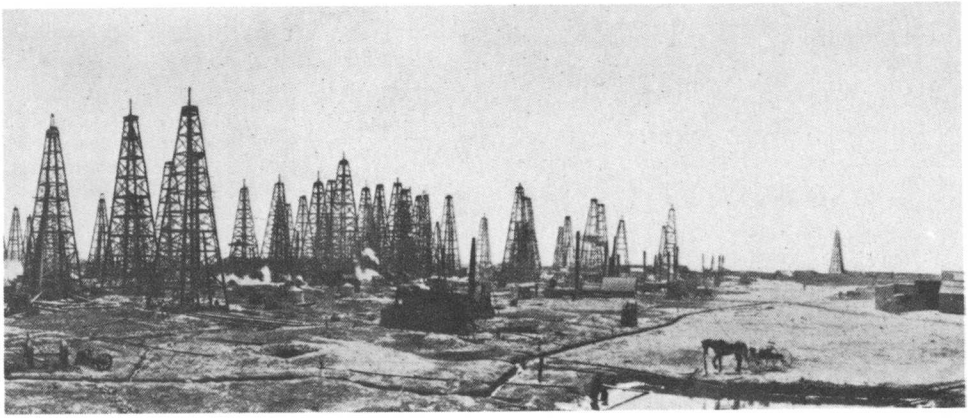
underground water studies, and water utilization studies. Appropriations were increased regularly, and a new series of publications was inaugurated to make available the ever-increasing volume of information.

The year 1901 was a turning point in both Survey history and national history. On March 3, 1901, exactly 22 years after passage of the Sundry Civil Expenses Bill that had established the Survey, another Sundry Civil Expenses Bill appropriated more than $1 million for the Survey's work, twice the amount available during Walcott's first year as Director, and 10 times the amount appropriated for the Survey's first year as a Federal agency. Survey scientists and engineers in 1901 were engaged in mapping and in geologic, geophysical, geochemical, geographic, paleontologic, geodetic, hydrographic, and forest investigations in all parts of the United States.

On January 10, 1901, a successful well was drilled at Spindletop, 20 miles southeast of Beaumont, Tex., inaugurating a new era in the oil industry. The discovery well was in new territory and required the construction of pipelines, refineries, and marketing organizations. In the summer of 1901, oil had become a major concern of geologists of the Survey.

President McKinley was assassinated in September 1901, and Theodore Roosevelt became President. By inclination and training, Roosevelt was in full sympathy with the movement for scientific management of the Nation's resources, and his first State of the Union message outlined a national forest and water policy that Gifford Pinchot, the Chief Forester of the Department of Agriculture, and F. H. Newell, the Chief Hydrographer of the Geological Survey, had helped write.

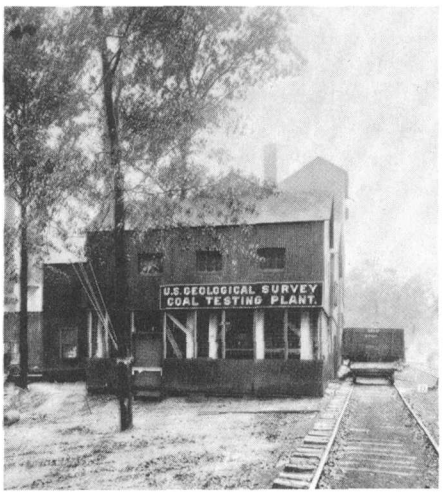
In June 1902, the Newlands Act established the Reclamation Service in the Department of the Interior and inaugurated a Federal



Oil field at Spindletop, near Beaumont, Texas.

program for the reclamation of the arid lands of the West. By order of the President, the Reclamation Service was made an adjunct of the Survey with Walcott as its Director and Newell as its Chief Engineer. The Hydrographic Branch was established in the Survey at the same time to continue the Survey's own water-resource investigations.

As Federal science became more and more involved with the economic life of the Nation, it had also become involved in the making of national policy. The bituminous and other coal resources of the Nation became a matter of public interest after the prolonged anthracite coal strike in 1902 with its attendant hardships. President Roosevelt appointed a commission to arbitrate the dispute, including among its members the Survey's coal statistician. The Commission in its report was critical of the monopoly exerted by the railroads, the wasteful methods of mining, and of mining safety practices.



Testing and analyzing coal deposits for fuel value and most economical use.

As Federal science tended more and more toward the practical, scientists sought private funds to support basic research. In 1902, the Carnegie Institution of Washington had been established with Walcott as its first Secretary. In 1903, President Roosevelt appointed a committee to investigate the scientific work of the Government to increase its usefulness, efficiency, and economy, with the Director of the Geological Survey as chairman. That committee concluded that in general the work of scientific research on the part of the Government should be limited primarily to utilitarian purposes and that research in pure science on broad and general grounds should be within the scope of private institutions. The committee favored organization of research around a problem rather than a discipline, and recommended the transfer of several bureaus, including the Geological Survey, to the Department of Agriculture. The recommended transfers would effectively concentrate the scientific bureaus in one department and thus achieve the recommendation of the National Academy of Sciences in 1884.

Only a few of the recommendations were carried out, for by this time attention was focused on public-land administration, especially the disposition of the forest lands. As the result of an investigation launched by the Secretary of

the interior, several persons had been indicted for fraudulent acquisition of land.

In October 1903, President Roosevelt appointed a Public Lands Commission composed of the Commissioner of the General Land Office, the Chief Hydrographer of the Geological Survey, and the Chief Forester, charging them to recommend changes needed to effect the largest practical disposition of the public lands to settlers and to secure in permanence the fullest and most effective use of the resources of the public lands. The Commission urged increased emphasis on the classification of public lands and proposed several changes in the administration of grazing and forest lands.

When the Public Lands Commission made its report, the Geological Survey had just been authorized to undertake a program of analyzing and testing coals and lignites to determine their fuel value and the most economical methods for their utilization as a demonstration at the Louisiana Purchase Exposition. The program almost immediately began to produce significant results, and in 1905 it was extended and became part of the regular Survey program. At the same time, a similar program for the testing of structural materials was begun. In the summer of 1905, a new program of mapping western coal deposits was started. Clearly, emphasis in the Survey's program in economic geology had now shifted to nonmetallic resources. Then in 1906, after evidence was uncovered that much coal land had been fraudulently acquired, some 66 million acres of potential coal-bearing lands were withdrawn from entry at the order of President Roosevelt until the Survey could determine their extent, location, and value. The duty of "classification of the public lands" of the organic act became a very different matter.

Forest in Skagit Valley, north of Hamilton, Skagit County, Washington.

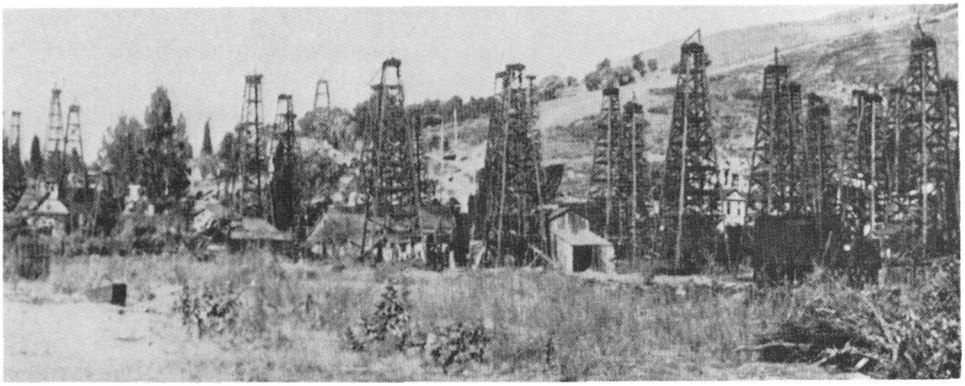
Walcott left the Survey in the spring of 1907 to become Secretary of the Smithsonian Institution. Before he left, the Reclamation Service became an independent agency, and F. H. Newell, who had been the Survey's Chief Hydrographer and also Chief Engineer of the Reclamation Service, became its Director. The fuel-testing and structural-materials-testing programs were combined as the Technologic Branch, under Joseph A. Holmes.

George Otis Smith, fourth Director of the U.S. Geological Survey, 1907-1931.

The Smith Years

Walcott was succeeded as Director of the Survey by George Otis Smith. Smith had joined the Survey after receiving his doctorate from Johns Hopkins University in 1896 and was barely 36 years old when he was appointed Director. He was then Geologist-in-charge of the Section of Petrography of the Geologic Branch but had come to the attention of Secretary of the Interior, James R. Garfield, when he had served as chairman of one of the subcommittees of a presidential commission that sought to put the operation of Government agencies on a modern business-like basis. Smith was particularly interested in a business policy for the public domain, and in the early years of his directorship the Survey became intimately involved in public-land administration.

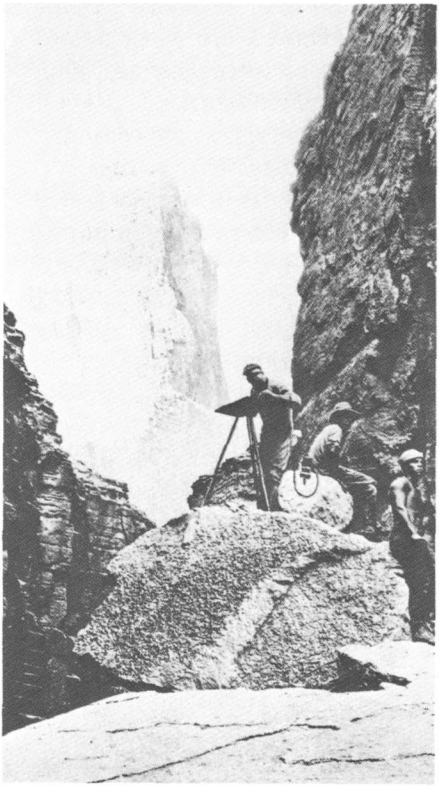
In the summer of 1907, a large proportion of the geologic force was engaged in classification of western coal lands. Geologists working in the California oil fields urged the Director to take action to safeguard oil development on the public lands. Oil-bearing land at that time could be obtained only under the Placer Law, which required that a discovery be made before the land could be acquired. But as drilling for oil cannot be a secret, lands were being obtained under other laws and oil development was thus hindered. On the



Development of the Eastern Oil Field in Los Angeles, California (ca. 1906).

recommendation of the Director, the Secretary of the Interior withdrew some potential oil-bearing lands from agricultural entry, pending classification, in August 1907. The classification program was thus extended from coal lands to oil lands.

In 1908, President Roosevelt convened a Governors Conference on Conservation to dramatize the need for natural-resource management. A National Conservation Congress was thereafter appointed, and Survey scientists prepared appraisals of the various mineral commodities and of water resources. In one report the Survey pointed out that although farming practices in the United States had not yet generally exhausted the land so that phosphate fertilizers were in demand, depletion of American phosphate deposits was being threatened by their export for use in Europe. In December 1908, newly discovered western phosphate lands were withdrawn from entry, and the Survey's classification program was extended to phosphate lands.



Surveying the western rivers for land classification and river development programs.

The great increase in land classification work led to the establishment of a Land Classification Board in December 1908. Within a few months of the Board's formation, the Survey was assigned responsibility for classification of lands under the Enlarged Homestead Act, and a program of hydrographic classification was added to that of mineral-land classification.

The Technologic Branch began investigations of accidents in coal mines, and after substantial appropriations were received from Congress to continue the work, a Mine Accidents Division was set up. While basic work was being recessed in parts of the Survey to undertake the work of public-land classification, the Technologic Branch was able to undertake some fundamental studies of the origin of coal and petroleum.

When William Howard Taft succeeded Roosevelt as President in March 1909, he appointed a new Secretary of the Interior who shared his strict views of the power of the executive. Secretary of the

Interior, Richard A. Ballinger, almost immediately questioned certain actions of the Reclamation Service which he thought had greatly exceeded its legal authority in committing itself to plans for work—the cost of which was greater than existing funds—and in withdrawing waterpower sites. The suspicions of the Chief Forester, Gifford Pinchot, who had been Roosevelt's chief advisor on conservation, were aroused, and the differences between the two men eventually led to a full-scale congressional investigation in the winter and spring of 1910.

Secretary Ballinger's reliance on the Geological Survey had meanwhile greatly increased its classification program. Evaluations of waterpower sites were added to the hydrographic classification program. In February 1908, the Director had recommended that filing for oil lands in California be suspended to ensure adequate supplies for the Navy, which was then converting from coal to oil. Secretary Garfield had not acted on the recommendation but, in September 1909, Secretary Ballinger withdrew all oil-bearing lands in California and Wyoming from all forms of entry, thus increasing the oil-land classification problem. The legality of the various withdrawals was questioned, but Congress resolved the issue by passage of the Pickett Act in 1910. The mineral resources of large segments of the public lands thereafter became unavailable. Coal lands could be sold after being classified and appraised by the Geological Survey, but no provision was made for sale of oil or phosphate lands.

The efforts of many years for establishment of a Bureau of Mines finally met with success in May 1910. The Survey's Technologic Branch was designated as the nucleus of the new agency in the original legislation, but a month later it was agreed to transfer the structural-materials testing to the National Bureau of Standards, and only the mine-accidents and fuel-testing investigations went to the Bureau of Mines. Joseph A. Holmes became Director of the new agency.

During the first decade of the 20th century, the Survey had given birth to two new Federal agencies and developed a new program of public-land classification. During that same period, geologists had been leaving the Survey for positions in the mineral industry. In 1911 the Chief Geologist resigned to become vice president of an oil company. There was an attempt to return to research. The Land Classification Board was raised to Branch status in 1912 to cut down the paperwork in the Geologic Branch.

After the outbreak of World War I in Europe, Survey activities shifted to investigations connected with military and industrial preparedness. Anticipating shortages of domestic petroleum supplies, the Survey sent every available oil geologist to search for areas favorable for the occurrence of oil. Other geologists were assigned to search for commercial deposits of the "war minerals." Early in 1917,

Oil seepage from a ridge above Cape Simpson, Alaska, indicates the presence of petroleum in the naval reserve.

a Division of Military Surveys was formed, and plans for topographic work were adjusted to conform with a program drawn up by the Army's General Staff.

When the United States entered the war, the Survey was almost wholly on a war basis. The majority of the technical personnel of the Topographic Branch were commissioned in the Army's Corps of Engineers, as were many scientists from the other branches. Deposits of war minerals were intensively sought at home, and in time the search was extended to Central and South America and the West Indies. The results were highly successful; except for nitrates and potash, adequate supplies of all essential materials were found before the war's end. The Survey also became the main source of information on mineral production, both domestic and foreign, and its data were used to solve a variety of industrial and transportation problems. When the Fuel Administration was established to stimulate production and to control distribution of fuels necessary to the war effort, Survey scientists worked in close cooperation with it. Survey engineers also undertook a nationwide survey to determine where waterpower could be substituted for steam-generated power or where coal could be saved by interconnecting electric plants or systems.

Among the postwar problems calling for immediate attention were the lack of maps and the insufficiency of energy resources. When war was declared, the Army had found itself without maps upon which to base its defense of the border areas. Industrial development, land reclamation, power-generation projects, and highway construction were also creating a demand for topographic data. Nearly 60 percent of the country was still totally unmapped, and much that had been mapped was in need of resurvey. The Engineers,

Architects, and Constructors Conference on National Public Works in 1919 urged the President and Congress to make provision for completing the topographic map of the United States in the shortest possible time compatible with requisite accuracy. The Survey proposed a plan whereby the mapping could be effectively and economically completed by 1932 but without funds was unable to inaugurate the plan. Meanwhile, several West Indian republics sought Survey assistance in both topographic and geologic mapping, and Survey scientists and engineers were given leave to supervise their mapping programs.

Exhaustion of domestic supplies of petroleum within a decade was forecast, and shortages did develop in 1919 and 1920. In February 1920, the Mineral Leasing Act was passed, and the oil and other mineral deposits in the public domain were opened up for development with the royalties and other income from the leased lands to be divided among the States and the Federal Government. Without the need for withdrawals and appraisal of coal lands for sale, the Survey's responsibility for classification of mineral lands was fundamentally changed.

Launching boats at the last camp, above Hance Trail, Grand Canyon National Park, Arizona.

In June 1920, the Federal Water Power Act established the Federal Power Commission, composed of the Secretaries of Agriculture, the Interior, and War, to issue licenses for development of waterpower on Federal lands. The Survey took responsibility for the necessary streamflow records and for examination of proposed projects on the public lands outside the National Forests. In 1921, a superpower survey was authorized to investigate if economy in fuel, labor, and material could be gained by a comprehensive system for generation and distribution of electric power in the region between Boston and Washington. Independent engineers made the study under the direction of the Survey and proposed a power grid that anticipated the present northeast power network.

After the great coal strike in 1922, the Coal Commission was established to study the problems of the industry and aid Congress on legislation that would ensure the Nation of an adequate supply of coal. Director Smith was made a member of the Commission, and the Survey's resource data provided the basis for much of the Commission's report.

The Survey, in 1923, extended its intensive study of possible oil-bearing areas to Naval Petroleum

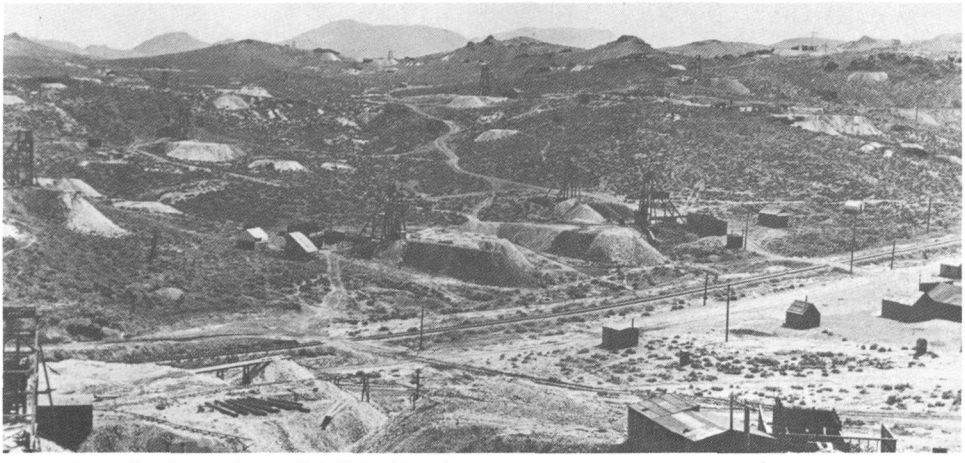
Reserve No. 4 on the Arctic coast of Alaska. Research was begun on the source materials and the formation of petroleum. Survey physicists and chemists joined the effort by developing improved recovery techniques and by laboratory and field tests of geophysical methods of exploration. By the mid-twenties, new discoveries in the midcontinent region, the gulf coast, and California resulted in an oil surplus. Overproduction and competition leading to reckless waste became a major public concern.

After the Teapot Dome scandal, in March 1924 President Coolidge appointed a three-man commission to study the efficient management of the naval petroleum reserves, and Director Smith became its chairman. In December of that year, a Cabinet-level Federal Oil Conservation Board was established to reappraise Federal oil policies, and Director Smith was named Chairman of the Advisory Committee. Then on July 1, 1925, the Survey took over responsibility for supervising mining operations on the public lands, following the transfer of the Bureau of Mines—which had been responsible for mining operations on public lands since passage of the Leasing Act of 1920—to the Department of Commerce.

The name of the Land Classification Branch was changed to the Conservation Branch as more properly descriptive of its functions:

> classification of lands according to their highest use; the protection of the public interest in undeveloped mineral, waterpower, and agricultural resources; and the promotion of economical and efficient development of mineral deposits on public and Indian lands.

The regulatory functions involved in the last-named were entirely new to the Survey, and required a large force of mining and petroleum engineers.



Mining rich gold-silver veins at Goldfield, Nevada (ca. 1905).

Both the topographic and water-resources programs by this time were heavily dependent on cooperative and transferred funds. Congress passed the Temple Bill in February 1925 calling for completion of a topographic map of the United States within 20 years. Congress authorized an appropriation of $950,000 for the first year, and also authorized cooperative arrangements with States and other civic subdivisions to expedite mapping. Congress, however, did not make the authorized appropriations, and soon made it evident that it expected the States to bear most of the cost. Under the circumstances, the topographic mapping program was controlled by the cooperators and could not be national. A similar situation existed in the Water-Resources Branch. Less than 30 percent of its total funds were directly appropriated, and the bulk of the work was stream gaging. At the same time, in some parts of the country, the demand for ground water for municipal supplies or irrigation had become so great that there was danger of overdevelopment. There was also a new urgency to the demands for quantitative information on the availability of and most efficient methods of utilizing ground water, but only a few investigations could be undertaken.

The Geologic Branch in the post-war years had experienced a second exodus of geologists to industry, particularly the oil industry, which paid salaries far greater than federal salaries. W. C. Mendenhall, who had become Chief Geologist in 1922, stressed the need for basic research, saying that "there can be no applied

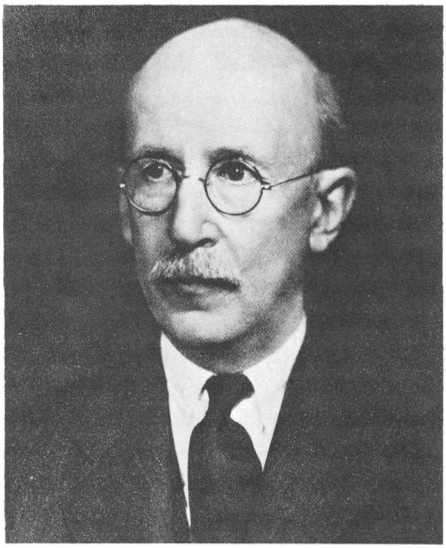
Analyzing materials in Hooe Building chemistry laboratory.

science without science to apply" and was able because of the attrition to strengthen the research not directly connected with economic geology. Thus, there came about a reversal of emphasis in the Geologic Branch. In 1925, its work was described as the establishment of principles, the discovery of new generalizations and laws, and geologic mapping; the preparation of economic reports again played a minor role.

As the Survey approached its 50th anniversary, the appropriations for topographic mapping and water-resources investigations were significantly increased to match contributions from the States, and for its 50th year the Survey had available total funds of $3.4 million. It had 998 permanent employees and was conducting mapping and investigations in 45 States, Alaska, Hawaii, and the District of Columbia. Nearly 44 percent of the continental United States exclusive of Alaska had been topographically mapped. Streamflow was being measured at 2,238 gaging stations. Income from mineral leases, licenses, and prospecting permits on the public lands under Survey supervision that year was $4.1 million. Sixty book reports and 76 new or revised maps were published, and just short of a million copies of publications were distributed. In noting the anniversary, the Director commented that the Survey had grown in stature, widened its field of endeavor, and increased its usefulness but had not grown old.

In December 1930, George Otis Smith was appointed to the newly reorganized Federal Power Commission, and was succeeded as Director by Chief Geologist Walter Curran Mendenhall.

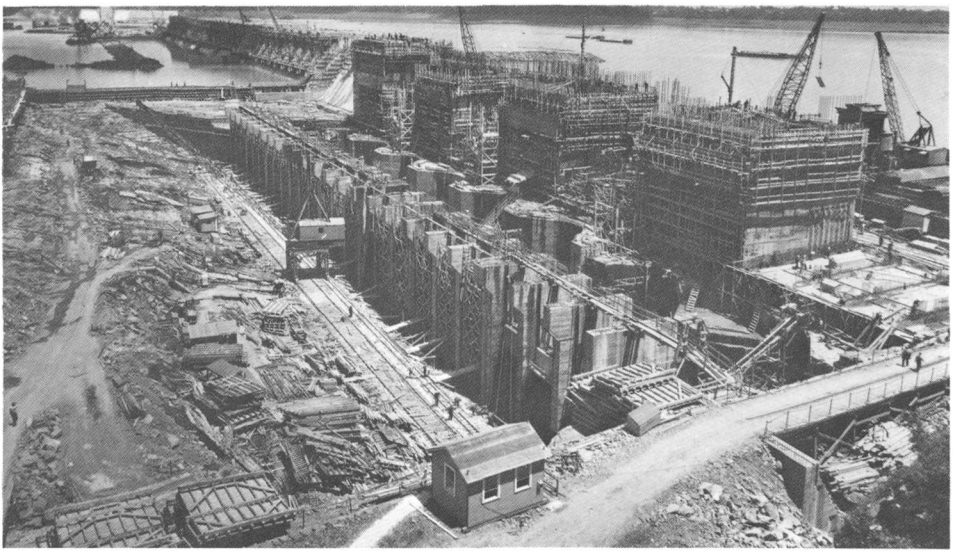
Personnel of the U.S. Geological Survey's Accounts Division.



Walter C. Mendenhall, fifth Director of the U.S. Geological Survey, 1931-1943.

The Mendenhall Years

Mendenhall had joined the Survey in 1894, fresh from Ohio Normal University. He had experience in the Alaska, in the Geologic, and in the Water Resources Branches, and on the Land Classification Board. For 10 years he had been Chief of the Land Classification Board and had been Chief Geologist for 8 years; thus half his Survey career had been in administrative work. Mendenhall became Director a year after the start of the Great Depression, and a year later, the Federal budget was sharply cut as the effects of the depression began to be felt. Fieldwork was suspended, some employees were placed on administrative furlough, and others were separated from the service. But adversity has its uses, as the Survey, established in one depression and renewed in another, had long since discovered. Almost immediately after the inauguration of Franklin Delano Roosevelt in March 1933, conservation became part of the Government's program to combat the



Constructing the TVA Wheeler Dam, Muscle Shoals, Alabama.

depression, and the Survey's special skills and knowledge were in demand.

The Tennessee Valley Authority (TVA), established in May 1933, turned to the Survey to meet its need for maps of the entire valley. The TVA assignment provided an opportunity for a full-scale test of the use of aerial photography for mapping, with which the Survey had been experimenting since 1904, and ultimately led to a complete revolution in mapmaking procedures. The Public Works Administration, established in June 1933, allocated funds for topographic mapping, mineral resource studies in eastern and southern States, land-classification studies, and much needed safety work on the public lands. Survey data were used in planning many of the Public Works projects concerned with water, and the Survey itself began extensive studies of the relation of rainfall to runoff and of the magnitude and frequency of floods.

The remaining public lands were by then valuable primarily for grazing. In June 1934, the Taylor Act was passed, providing for organization of the public grasslands into grazing districts under the control of the Secretary of the Interior. By the following March, the President withdrew all remaining public lands to determine the most useful purpose for which they might be used. The work of agricultural and grazing classification which the Survey had begun in 1909 was transferred to the new Grazing Service, now part of the Bureau of Land Management.

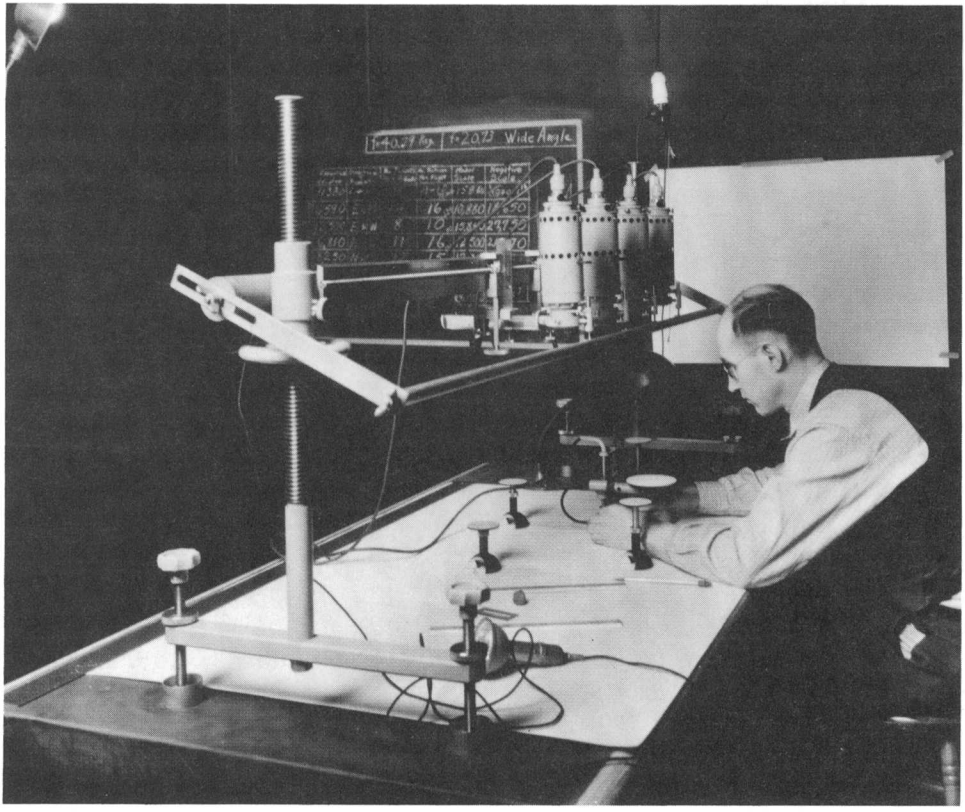
By 1938, the Survey's own appropriation had been restored to pre-Depresison level and, no longer dependent on uncertain emergency funds, the Survey planned to resume its long-term research and mapping projects. But the war clouds were already thickening over Europe and Asia. Strategic mineral investigations were begun in 1939. Topographic mapping of strategic areas in accordance with military priorities was begun in 1940. In 1940 also, the State Department allotted funds to the Survey to begin investigations in cooperation with other American republics to identify mineral deposits of potential importance in hemisphere trade.

For the next several years the Survey bent its entire energies to the war effort. Seven strategic metals were the first objects of search, but as the war continued practically all metals and minerals were in demand. Even rare elements, formerly only of scientific interest, were needed for secret war projects such as the atomic bomb. Geologists, geophysicists, chemists, physicists, petrologists, and paleontologists were all drawn into service, and the Survey reached out to universities and industry to recruit others. New methods were devised to aid in the search, among them a method of airborne magnetic surveying that the Survey developed in cooperation with the Navy.

Photogrammetric methods began to supplant field surveys as the

basic mapmaking procedure, and formidable strategic mapping assignments were completed in this way. The Army Air Force called for help in compiling maps of Alaska for military purposes, especially aerial navigation. To meet the need, the trimetrogon method was developed; it proved so useful that the project was extended, and maps were prepared for several million square miles in areas that had previously been inadequately mapped or not mapped at all. Information was needed on the quantity, quality, and availability of surface and ground water for cantonments, naval stations, military hospitals, training fields, airfields, manufacturing plants, and a host of other purposes. The Survey supplied the information in more than 15,000 special reports. The military needed geologic information on strategic foreign areas; a military geology unit set up to supply it became so valuable that it earned the name of the "Army's pet prophets."

Midway in World War II, Director Mendenhall, who had served 2 years beyond normal retirement age, was succeeded by William Embry Wrather.



Producing topographic maps quickly and easily with the development of photogrammetry.

William E. Wrather, sixth Director of the U.S. Geological Survey, 1943-1956.

The Wrather Years

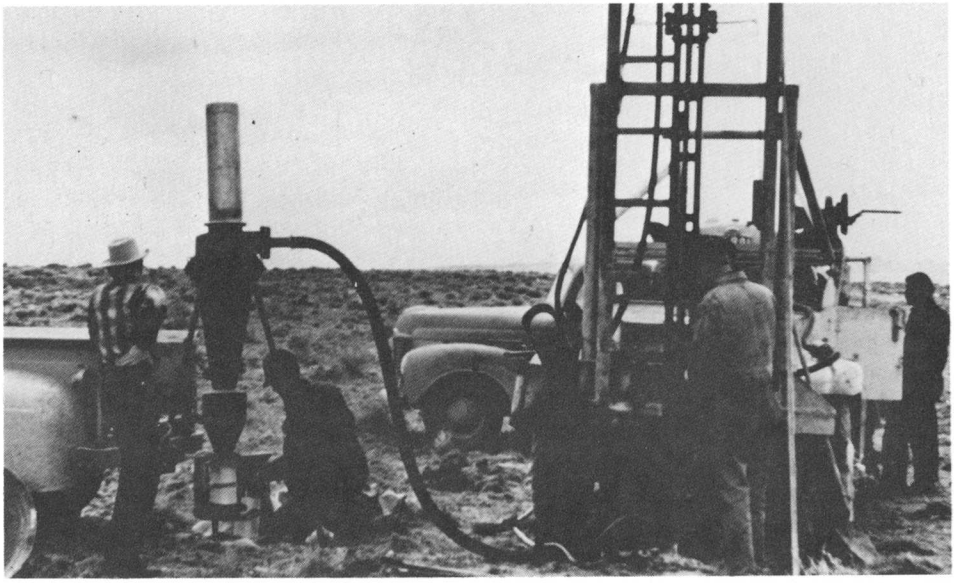
For most of his life Wrather had been an independent consulting petroleum geologist, but he was then Associate Chief of the Metals and Minerals Division of the Board of Economic Warfare. In December 1944, Thomas B. Nolan, who had played a leading role in the strategic minerals program, was appointed Assistant Director, the first to hold the office. Nolan, like the first Director, was a graduate of the Sheffield Scientific School at Yale, and like the first Director also, had a strong interest in research to aid the mineral industry. He had joined the Survey in 1924 after receiving his doctorate from Yale and his abilities had been quickly recognized. In 1933, the International Geological Congress had awarded him its Spendiaroff Prize as a particularly promising young geologist. The two men, in many ways, complemented each other and in the favorable light with which science was viewed in the postwar world, the growth of the Survey, begun under the spur of war needs, continued after 1945. Some of the postwar problems were reminiscent of those after World War I.

After the war, half the Nation, including a large part of the public lands, was still without topographic maps, and many of the maps that were available were inadequate to meet the needs of the postwar world. The Survey submitted a plan to provide adequate topographic maps for the entire Nation within 20 years, needing only funds to implement it. Geologic mapping was even more inadequate. Less than 10 percent of the country had been mapped geologically on scales suitable for an appraisal of natural resources and land potential to meet modern needs, and the rate of mapping possible with funds available was only one-sixth of that needed to complete the job by 1980. Base metal reserves had been greatly depleted during the war, so major projects had to be undertaken on copper, lead, zinc, iron, and the ferro-alloy metals. The limit of the Nation's capacity to produce efficiently from known oil fields had been reached, so regional studies were continued to aid the search for new supplies. The United States was accounted a have-not nation in radioactive raw materials, so investigations begun during the war for the Manhattan Project were expanded into a long and ultimately successful program

of exploration, mapping, and research for fissionable materials on behalf of the Atomic Energy Commission.

The success of the TVA program led to widespread interest in similar programs for other river basins, and development of the Missouri River basin by coordinated projects of the Bureau of Reclamation and the Corps of Engineers was begun after the war. The Survey was called on to conduct an extensive topographic mapping program on behalf of the Bureau of Reclamation, and Survey engineering geologists helped to determine the availability of construction materials, suitability for irrigation, susceptibility to landslides, and water-holding capacity of various sites. The demand for construction of large dams to impound water for irrigation, power development, and industrial use focused attention on such problems as the effect of water loss by evaporation and the limitation of the useful life of reservoirs by deposition of sediment. There had been a heavy drain on ground-water resources during the war and conditions were critical in many areas. Saltwater encroachment was a subject of special concern in some coastal areas. Systematic investigation of these and other problems was undertaken, and the monthly Water Resources Review was established in an attempt to meet the need for current information.

The Government's program of assistance to economically underdeveloped areas in the Eastern Hemisphere was expanded in 1949 to include scientific and technical assistance. Survey scientists and engineers were soon on their way

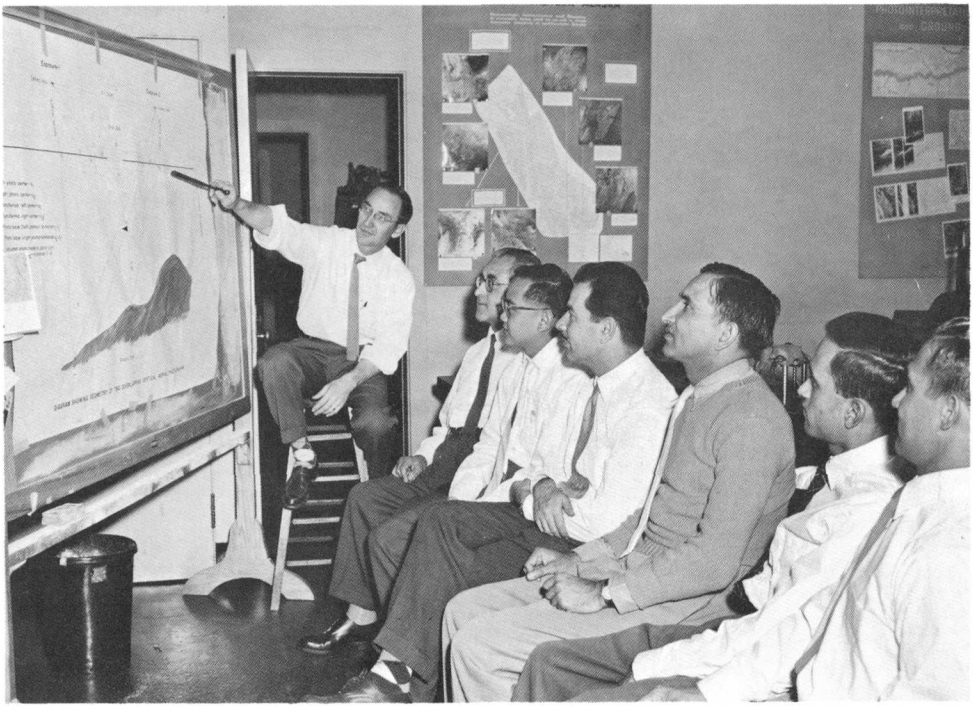


Drilling for core samples of mineral deposits, Grand County, Utah.

to Afghanistan, India, Thailand, and the Philippine Islands. The in-service training program in geology and the administration of research organizations, which the Survey had been giving to promising young scientists of Latin American countries, was also extended to scientists of the Eastern Hemisphere countries.

In 1950, the uneasy peace that followed World War II was shattered by the outbreak of hostilities in Korea. As defense became the underlying theme of national policy, Survey activities were again reoriented. The topographic mapping program was revised to meet defense needs. The military geology program was expanded, as was the search for radioactive raw materials. A program of urban geology, barely begun, was accelerated to aid in civil defense. The Defense Production Act of 1950 provided for stockpiling of critical materials, and the Survey was called on to recommend programs to reduce deficiencies of 23 minerals and to undertake special studies on behalf of the Petroleum Administration for Defense.

Defense needs in combination with the ever-rising standard of living were making heavy demands on the Nation's mineral, fuel, and water resources. The Survey's mapping and resources investigations placed increasing emphasis on the search for and evaluation of



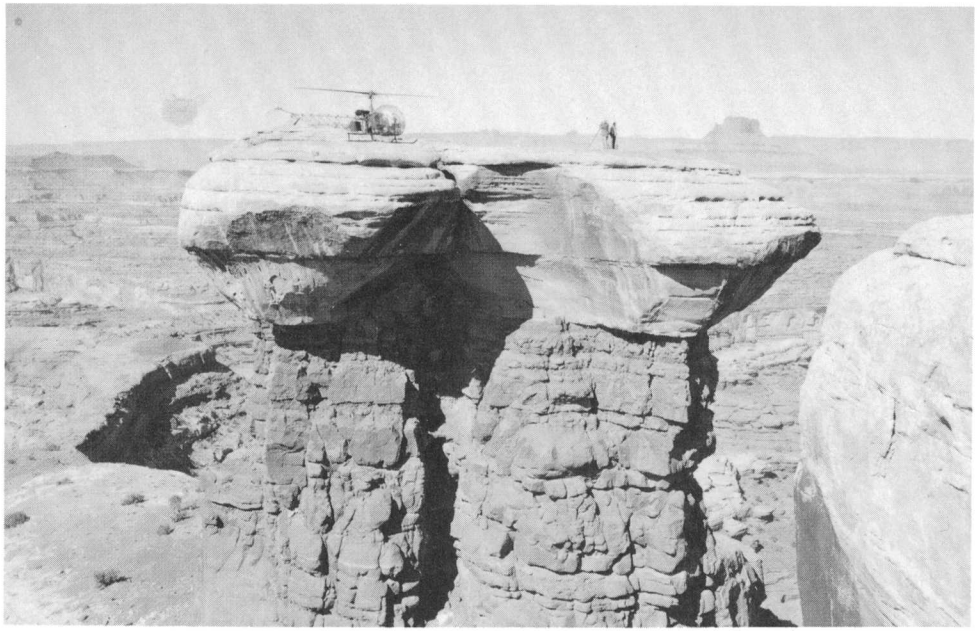
Foreign geologists participating in a Survey photogeology training program.

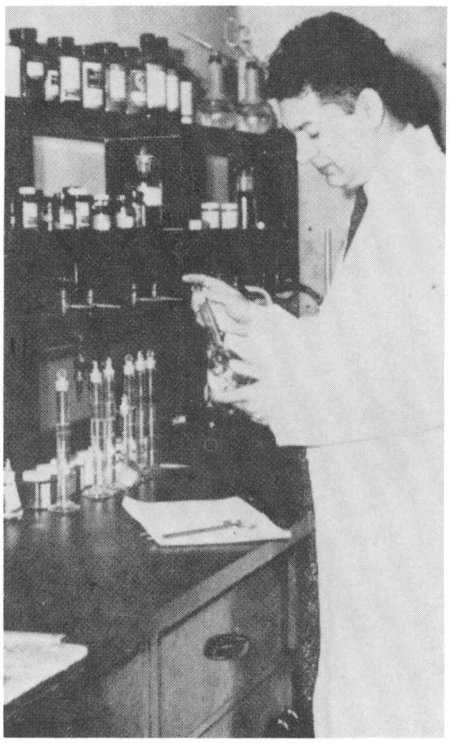
deposits, the wise use of water, and research aimed toward new and improved methods. The period was marked by: an increasingly sophisticated use of physics and chemistry in geologic investigations, by the development and use of a wide variety of new and highly sensitive instruments, by faster and more accurate analytical methods, and by the extension of investigations into new and unusual environments. Chemical methods were developed for field use, and laboratories became mobile. Photogrammetric techniques, procedures, and instruments were developed. Helicopters transported men and equipment to mountaintops and other remote spots for survey control measurements, and two airplanes were routinely occupied in airborne magnetic and radioactivity surveys. Survey engineers and scientists were at work in Asia, Africa, and both Americas, on the ice floes of the Arctic, and on the icy peaks of Antarctica. In 1953, the Survey was assigned responsibility for supervision of lease operations on the Outer Continental Shelf.

Compiling a geologic map from aerial photographs.

These many demands upon the Survey led to its steady growth. From a 1940 level of $5.5 million, total funds available for Survey expenditure increased to $48 million in fiscal years 1952 through 1954. In its 75th year, the Survey had about 7,000 employees. Mapping and investigations were underway in all 48 States, Alaska, Hawaii, and Puerto Rico, and technical assistance programs were active in Latin America, the Near East, Asia, and Africa. Sixty-nine percent of the country had now been mapped topographically, but only 33 percent met modern standards. Data on streamflow were being obtained at some 6,400 gaging stations, and the chemical quality of more than 85,000 samples of water was determined. Modern statistical methods were being applied to problems of field geology: an oil and gas laboratory was established to conduct research on the origin, migration, and accumulation of oil and gas; two volcanic eruptions were studied, and a major contribution was made in the development and successful testing of a shallow-reflection seismograph. Rent and royalty income from lands under Survey supervision had increased about 18-fold in 25 years to $73.5 million.

In January 1956, when Director Wrather retired because of illness and age, Assistant Director Thomas B. Nolan became the seventh Director of the Geological Survey.





Landing men and instruments on an otherwise inaccessible toadstool formation in the Orange Cliffs area, Utah (top).

Survey scientist analyzing samples of uranium and thorium (left).

Sampling snowpack as Survey activities expand to the Antarctic (bottom).

Thomas B. Nolan, seventh Director of the U.S. Geological Survey, 1956-1965.

The Nolan Years

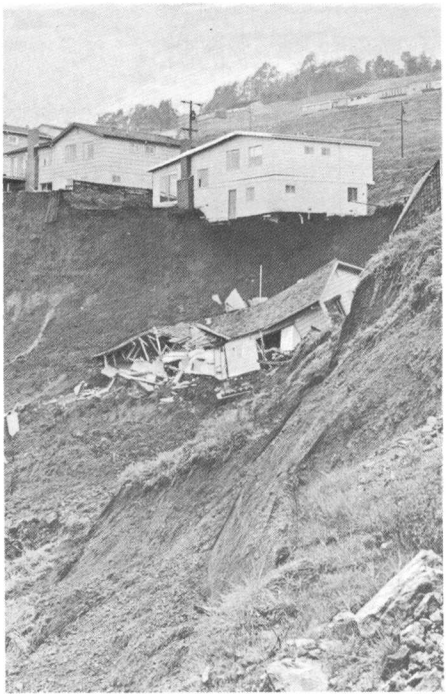
The Survey's commitment to research and the advancement of geology in the public service was intensified and broadened during Nolan's directorship.

Through improved methods of exploration, the ability to exploit lower-grade sources, and the substitution of common for less common materials, science and technology were combining to keep up with the increasing demands for raw materials—though scarcities still existed and new ones would develop. New dimensions, however, were being added to the problem of supplying the Nation's demand for mineral, fuel, and water resources. In some areas, overspecialized exploitation of mineral resources caused economic problems, and in other areas competition for resources, where development of one precluded use of others, created resource-management problems. At the same time, the increasing industrial development and urbanization of America were creating wastes, causing health hazards, and heightening vulnerability to damage by natural geologic processes.

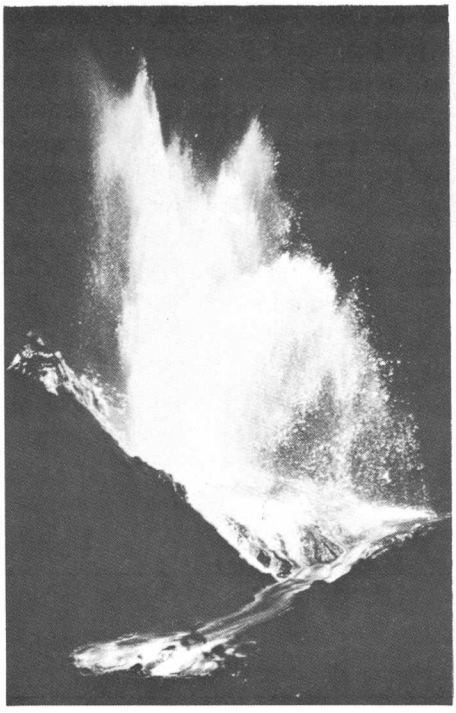
Survey investigations also took on new dimensions. Evaluation of the effects of underground nuclear explosions at the Atomic Energy Commission's Nevada Test Site, begun in 1956, was expanded to include study of the geologic conditions affecting the peaceful uses of atomic energy and the disposal of radioactive wastes. Research in support of space exploration began in 1959 with photogeologic mapping of the Moon. Four years later,

Astronaut in Survey training program for geologic investigations of the Moon.

in cooperation with the National Aeronautics and Space Administration, the Survey began to train astronauts in geology and to investigate and evaluate methods and equipment for geological and geophysical exploration of the Moon. A program of marine studies was begun in 1962 to identify and evaluate potential mineral resources on or beneath the sea floor; the program was also to aid in solving the problems caused by rapid population growth, urbanization, and industrial expansion in coastal areas. Geochemical exploration techniques, developed to aid the search for mineral resources, were adapted to investigations of subtle differences in the natural distribution of chemical elements that might have a bearing on public health. Study of geologic processes led to measures to protect the public from natural disasters. Research at the Hawaiian Volcano Observatory provided new understanding of the formation of ore deposits and also aided in the prediction of volcanic eruptions. Research into the causes of landslides and other mass movements led to the development of better zoning regulations in some metropolitan areas. Then in September 1962, Congress extended the authority of the Survey into areas outside the national domain.



Urbanization increases vulnerability to damage from natural disasters such as landslides.

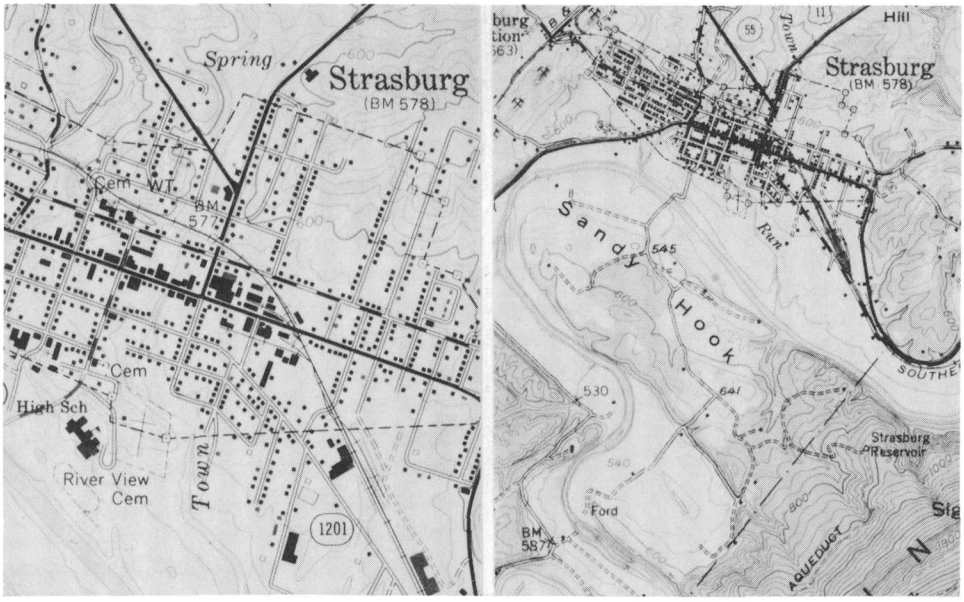


Research at the Survey's Hawaiian Volcano Observatory aids in the prediction of eruptions.

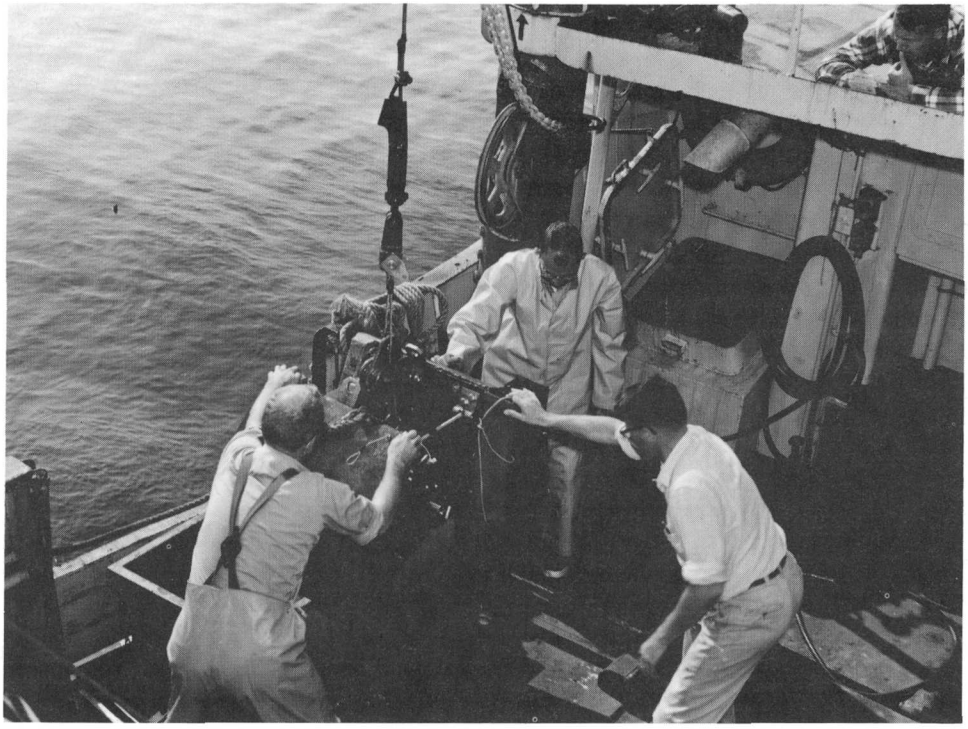
As it entered its 85th year, the Survey prepared a long-range plan for its programs. Research functions were obviously not susceptible to a definite schedule, but some phases of the work were planned for orderly progression toward completion. Standard 7½- and 15-minute quadrangle maps had been published for approximately 60 percent of the total area of the United States and advance prints were available for another 9 percent. The long-range plan called for an increase in production capacity to complete topographic maps of the United States and outlying areas in either 7½- or 15-minute series by fiscal year 1976 and the 7½-minute series for all areas of the United States except Alaska by fiscal year 1981. Research would be continued in mapping systems and cartography, and the applications of electronic data-processing systems investigated. The long-range plan called for an increase of approximately 50 percent in the collection of basic water data in the decade 1964-1973, and the recording and processing of water data by automation by 1968. The plans also called for the availability of generalized or detailed ground-water information for 75 percent of the country and reconnaissance information for the remainder by the end of 1974, and an increase in research to approximately 25 percent of the water-resources program. Research in economic geology, engineering geology, regional geology, and experimental geology would be doubled to meet the accelerating needs for resources and to provide the basic geologic data for urban expansion, engineering construction, and other purposes. The marine program would map and evaluate the composition, structure, and resources of the ocean floor, to study geologic and hydrologic processes that operate within the oceans, and thus to understand better the conditions under which ancient sediments and ore deposits were formed.

The 1960's were years of unrest in the United States, of a heightened social consciousness in nearly all segments of the population, and of protest marches and civil disorders. Concern for the environment, for the endangered species of life, and for the overuse of toxic and dangerous substances became widespread. Above all, people became more aware of their interdependence as well as independence, and of the need to work together. The Survey had long enjoyed cooperative relations with States and with other Federal agencies, but these were now recognized as essential. In the long-range plan for geologic mapping, for example, attainment of the goal was based on cooperative efforts of other geologists in both the public and private sectors.

One of the greatest earthquakes of all time struck south-central Alaska on March 27, 1964. Within a few hours the Survey began a scientific and engineering study that extended through several field seasons and provided perhaps the most complete documentation yet made of a natural disaster. In



Comparison of 7½-minute (left) and 15-minute (right) quadrangle maps of Strasburg, Virginia.



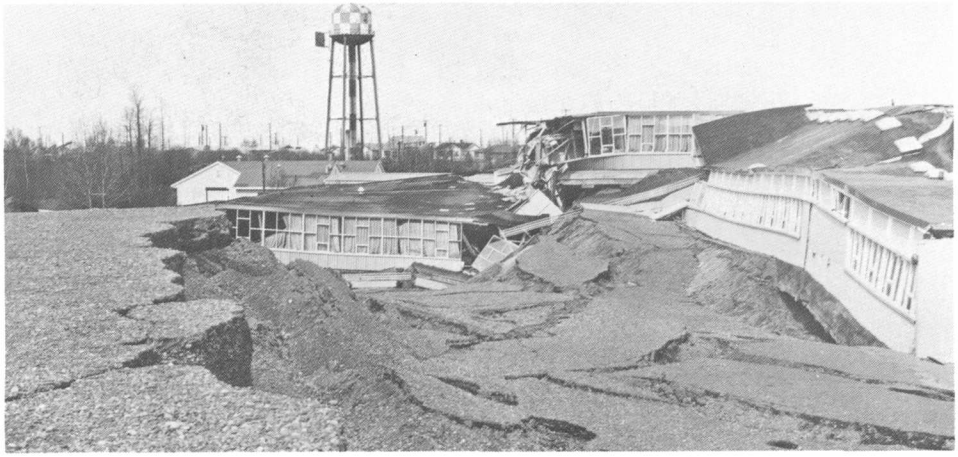
Marine geologists prepare sampling buckets to study the sea floor.

addition to the scientific investigations, Survey geologists were assigned to the Task Force of the Federal Reconstruction and Development Planning Commission and helped select sites for rebuilding the devastated area. Then when a presidential panel, appointed in the wake of this great earthquake, recommended a program of fundamental research with the aim of predicting earthquakes and minimizing damage, the Survey established a National Center for Earthquake Research at its Menlo Park, Calif., headquarters.

In 1964 also, an Office of Water-Data Coordination was established in response to a directive of the Bureau of the Budget establishing guidelines for coordinating Federal activities in collecting data and developing a national plan for acquisition of data. The objectives were to be sure that water information was available to those who require it for effective development and management of water resources, that the data are collected in a timely, effective, and economical fashion, and that information is readily accessible at a single focal point.

Three years later, in 1967, the responsibility for Government-wide coordination of federally funded domestic surveying and mapping activities was assigned to the Department of the Interior, and delegated to the Survey. The objective was to achieve a greater benefit to the Nation from a given mapping effort, to reduce or to eliminate duplication in the national mapping effort, and to increase the information resources of the Geological Survey so that its Map Information Office would become a more effective single source for mapping data.

In the meantime, in the fall of 1965, Dr. Nolan, after 21 years as Assistant Director, Acting Director, and Director, resigned to resume fulltime research and was succeeded by William T. Pecora.



Damage to Government Hill School following the Alaska Earthquake, 1964.

William T. Pecora, eighth Director of the U.S. Geological Survey, 1965-1971.

The Pecora Years

Pecora had joined the Survey in 1939 after studying at Princeton and Harvard. He also had experience in fieldwork at home and abroad and in administration as Chairman of the Civil Service Board of Examiners, Chief of the Geochemistry and Petrology Branch, and Chief Geologist. Pecora's administration was a blend of the old and the new. In April 1966, a heavy metals program was begun as a joint effort of the Survey and the Bureau of Mines to stimulate domestic production of a group of metals that were in short supply. About 90 percent of the program effort at the start was on gold because of its international monetary importance. Appraisals of world resources of oil, gas, natural-gas liquids, and oil shale were published as part of the ongoing study of energy resources. Appraisals of the iron-ore resources of the United States were prepared for inclusion in a United Nations survey of the world's iron-ore resources, and as copper consumption doubled, more information on copper deposits was sought. The Survey joined several public and private research institutions in a detailed seismic exploration of the Earth's upper mantle; evaluated the mineral resource potential of several primitive areas to aid in decision on their incorporation into a wilderness system; took on management and direction of an Interior Department program aimed at gathering facts about the Earth's resources from orbiting satellites carrying sophisticated remote-sensing instruments; and established a Computer Center Division. The Survey also introduced a new map product, the orthophotomap, which is a topographic map on

Producing an orthophotograph.

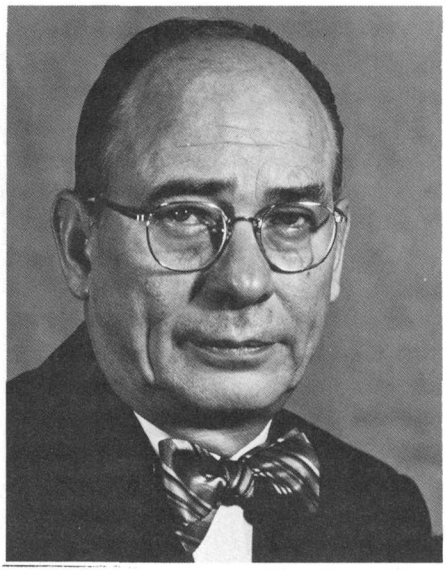
which natural and cultural features are portrayed by color-enhanced photographic images in true position with cartographic symbols added as needed for interpretation.

The last decade of the Survey's first century has been marked by an increase in multidisciplinary studies and the effort to make scientific information acquired through years of solid research available in a form to be most easily used in the solution of contemporary problems. For most of these problems there is no simple solution, and a careful weighing of positive and negative factors is required. One of the most difficult is that involved in the development of mineral resources needed to maintain the American standard of living where such development may affect the environment adversely—such as the offshore development of oil, transportation of oil from a giant field on Alaska's Arctic slope, and the open-pit mining of coal, all of which would alleviate a growing energy shortage but with the potential of damage to the environment. The necessity of evaluating the effect on the environment of contemplated actions calls for a multidisciplinary analysis to which the Geological Survey contributes its special insight based on long years of investigation.

Aerial view of communities constructed near San Andreas fault (center), California.

Land use in developing areas, particularly in areas of geologic hazards such as earthquakes, landslides, or floods, also involved several Survey disciplines. The Survey was already producing engineering geologic maps of the Denver-Boulder, Colo., area as part of a cooperative project with the Denver Regional Council of Governments. The maps could be interpreted and used directly for land-use planning by city and county officials, urban planners, subdivision developers, engineers, and builders lacking geologic training. In January 1970, the Survey began a 3-year pilot study of the physical environment and resources of the San Francisco Bay region in cooperation with the Department of Housing and Urban Development. The study emphasized the use of geology, geophysics, hydrology, and topography and their application to improved regional urban planning and decisionmaking.

In 1971, Pecora became Under Secretary of the Interior, and Vincent E. McKelvey, a career research scientist with the Survey since 1941, but most recently its Chief Geologist, was appointed Director.



Vincent E. McKelvey, ninth Director of the U.S. Geological Survey, 1971-1978.

The McKelvey Years

McKelvey, a native of Pennsylvania, was educated at Syracuse University and obtained his doctorate from the University of Wisconsin. He was internationally known for his studies of phosphates and uranium, long-range energy and mineral-resource needs, and his analyses and assessments of seabed resources, investigations particularly applicable to the problems of the seventies.

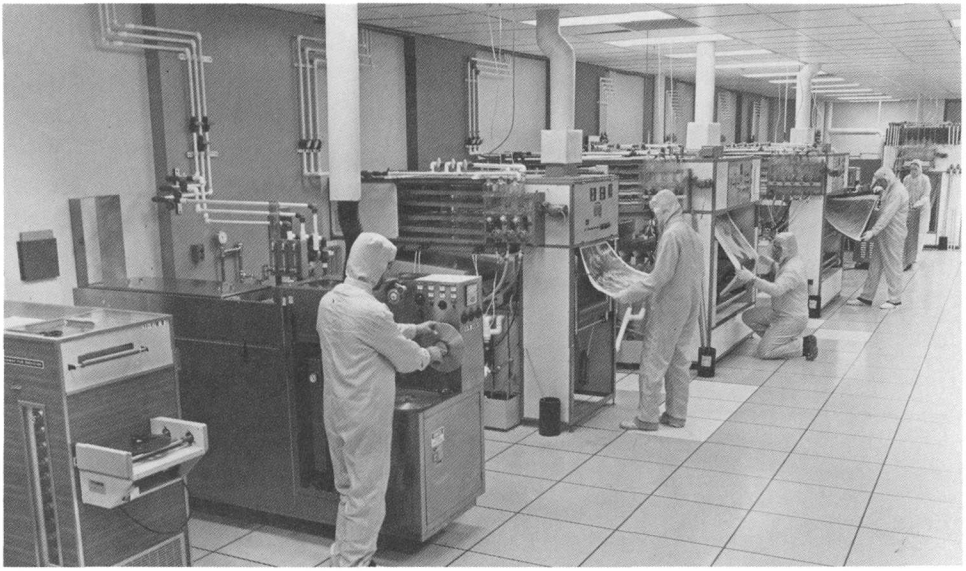
As he took office, the Survey was conducting investigations and mapping in all 50 States, in Antarctica and the Trust Territories, and carrying out technical assistance programs in countries from Argentina to Zambia. The Survey that year had an operating budget of $173 million and 9,200 employees. General-purpose topographic maps were available for 84 percent of the total area of the 50 States, Puerto Rico, the Virgin Islands, Guam, and American Samoa. Streamflow data were being collected at more than 11,000 gaging stations, and water

Survey Topographers at South Pole, Antarctica.

quality was being measured at 4,000 stations. Mineral production from lands supervised by the Survey was valued at more than $3 billion, and annual royalties were approaching $0.5 billion.

The diversity and complexity of Survey operations increased during McKelvey's directorship. The pilot study of the San Francisco Bay region was followed by several similar studies of urban areas. In 1973, a Land Resource Analysis program was begun in response to the need for earth-science data to assist land-use planning and resource management primarily of nonurban areas not yet critically affected by growth and development but which, according to existing trends, were in danger of being seriously impacted in the future. In 1975, the Land Information and Analysis Office was established to provide a focal point within the Survey for these multidisciplinary earth-resource and environmental studies. One of its main objectives was to bring about closer interaction between the scientists and engineers and the planners and decisionmakers so that maps and book reports would be prepared in a form more readily understandable to the user group. *Nature to be Commanded . . .*, a demonstration of the value of earth-science information in land and water management in a variety of urban settings, was published in 1978.

The launch of the first Earth Resources Technology Satellite (ERTS-1, now Landsat-1) in July 1972 ushered in a new era in the acquisition and management of data. A data center was established at Sioux Falls, S. Dak., to handle distribution of the satellite data and



Photographic processing laboratory at EROS Data Center, Sioux Falls, South Dakota.

Southern California as seen from 570 miles in space.

Completing photomosaic of South Polar region of Mars.

other remotely sensed data. Investigations were also begun of the applicability of the data to geologic, hydrologic, geographic, and cartographic studies. In 1976, the Survey published *ERTS-1, A New Window on our Planet,* which contains case histories on the use and application of satellite data to earth-resource mapping, monitoring, and inventory.

Planetary studies were extended. During 1971, plans to systematically map the geology of Mars were formalized with the National Aeronautics and Space Administration (NASA). A cooperative program was planned, involving both Geological Survey and university geologists, with the Survey responsible for overall program management. A shaded-relief map of Mars was published in 1973. In the summer of 1976, two Viking spacecraft landed on the surface of Mars at a site selected by scientists at the Survey's Flagstaff, Ariz., office. By that time the Survey had prepared more than 100 maps of Mars, Mercury, Venus, and the Moon in support of space exploration efforts.

The marine program assumed new significance, for many regions of the oceans were less well known than the planets. Subsea mineral deposits might be resources for the future, but an understanding of the behavior of marine geologic processes is also of importance if people are to live and build along coasts and out into the sea. Survey investigations included oil and gas resource appraisal, environmental

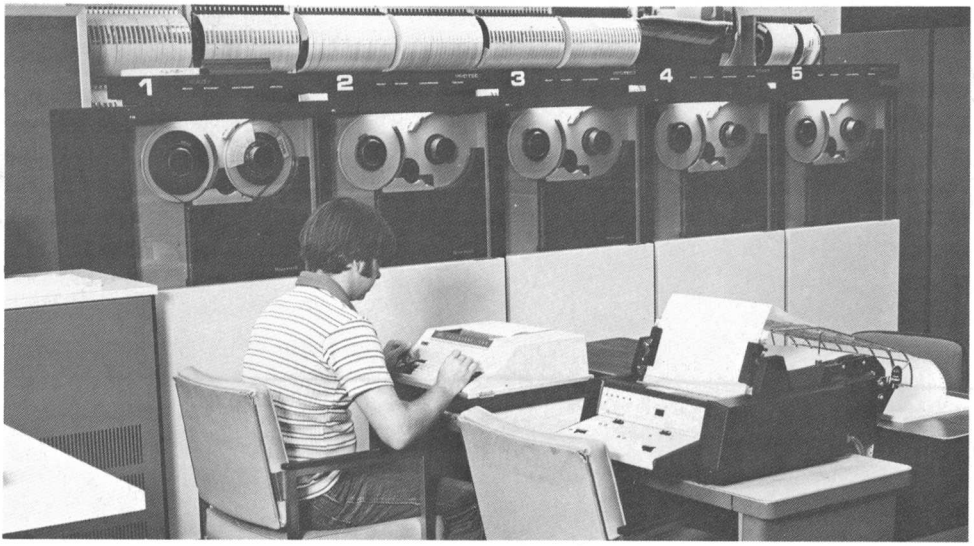
investigations assessing the potential impacts of geologic hazards on the development of offshore oil and gas resources, geochemical studies of deep-sea deposits and engineering studies of deep-sea sediments, and the development of deep-ocean remote-sensing instruments.

Major efforts were made to delineate the hazards associated with earthquakes, volcanic eruptions, landslides, mudflows, ground subsidence, and floods, and advances were made toward a capability of predicting some of these disasters.

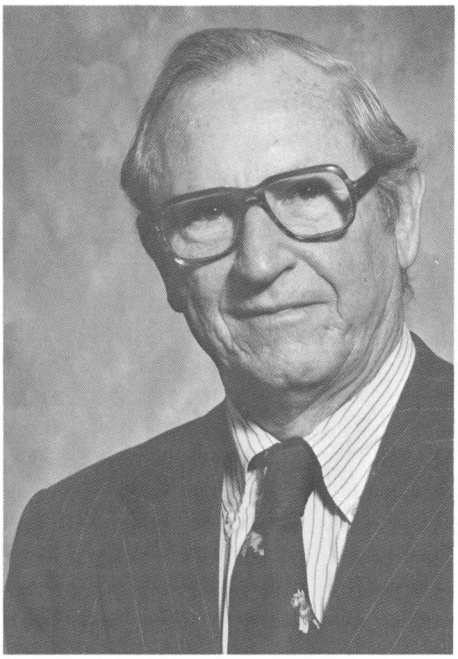
Computers were increasingly used to improve productivity in a variety of areas, for resource and scientific data, for advanced mapping techniques, for checking chemical analyses, for water-resource data, for enhancing the quality of satellite images, for lease-tract evaluation, and for royalty accounting.

In June 1977, under provisions of the Naval Petroleum Reserves Production Act of 1976, jurisdiction of the Petroleum Reserve in Alaska was transferred from the Department of the Navy to the Department of the Interior. Responsibility for administration of the continuing petroleum exploration program on the Reserve and operation of the South Barrow Gas Field was delegated to the Director of the Survey.

The basic responsibilities remain, of collecting, analyzing, and publishing detailed information about the Nation's energy, mineral, land, and water resources. For the fiscal year beginning in October 1978, the Survey's total appropriation was more than $640 million, and the Survey employed more than 13,000 scientists, engineers, technicians, and administrative support personnel to carry on its work.



At work in the Survey's Computer Center Division.

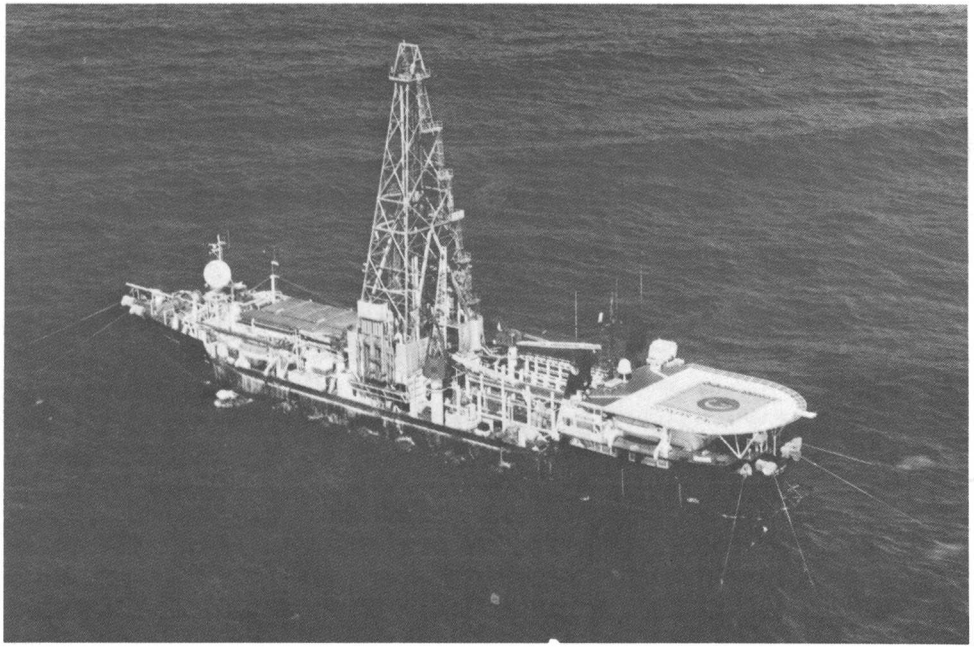


H. William Menard, tenth Director of the U.S. Geological Survey, 1978-1981.

Beginning the Menard Years

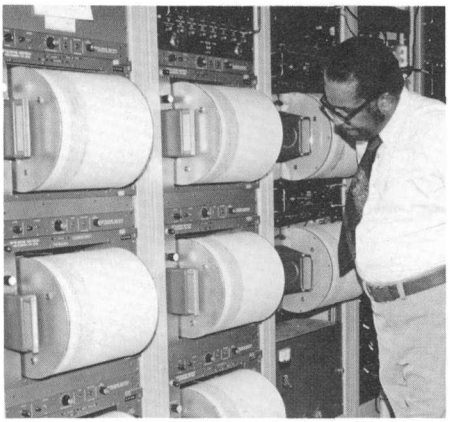
As the Survey approached its Centennial Year, its tenth Director, H. William Menard, installed in April 1978, said:

To make decisions for rational use of lands, to explore for and develop our resources wisely, to mitigate the effects of geologic hazards—these and other related problems are formidable challenges to all Americans. In particular, however, heavy burdens of responsibility will be placed on earth scientists, for sound knowledge about the Earth and natural processes are basic to the solution of these critical resource and environmental problems.

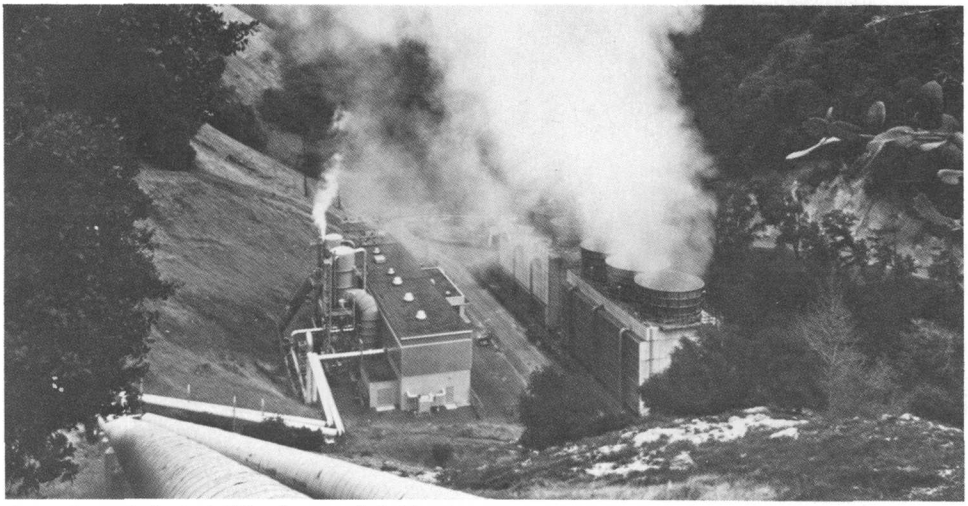


Initial operation of the drillship *Glomar Pacific* on the Atlantic Outer Continental Shelf.

The challenge is sobering indeed, but it is the same challenge as that described by the first Director, for the Nation "to utilize with the highest technical skill and with the utmost scientific economy, all elements of national wealth," a challenge now grown infinitely more complex by the growth of the Nation and the growth of knowledge during the intervening years.



A Survey geophysicist checks seismographs which record worldwide earthquakes at National Earthquake Information Service (NEIS), Golden, Colorado.



A geothermal plant at "The Geysers," California.

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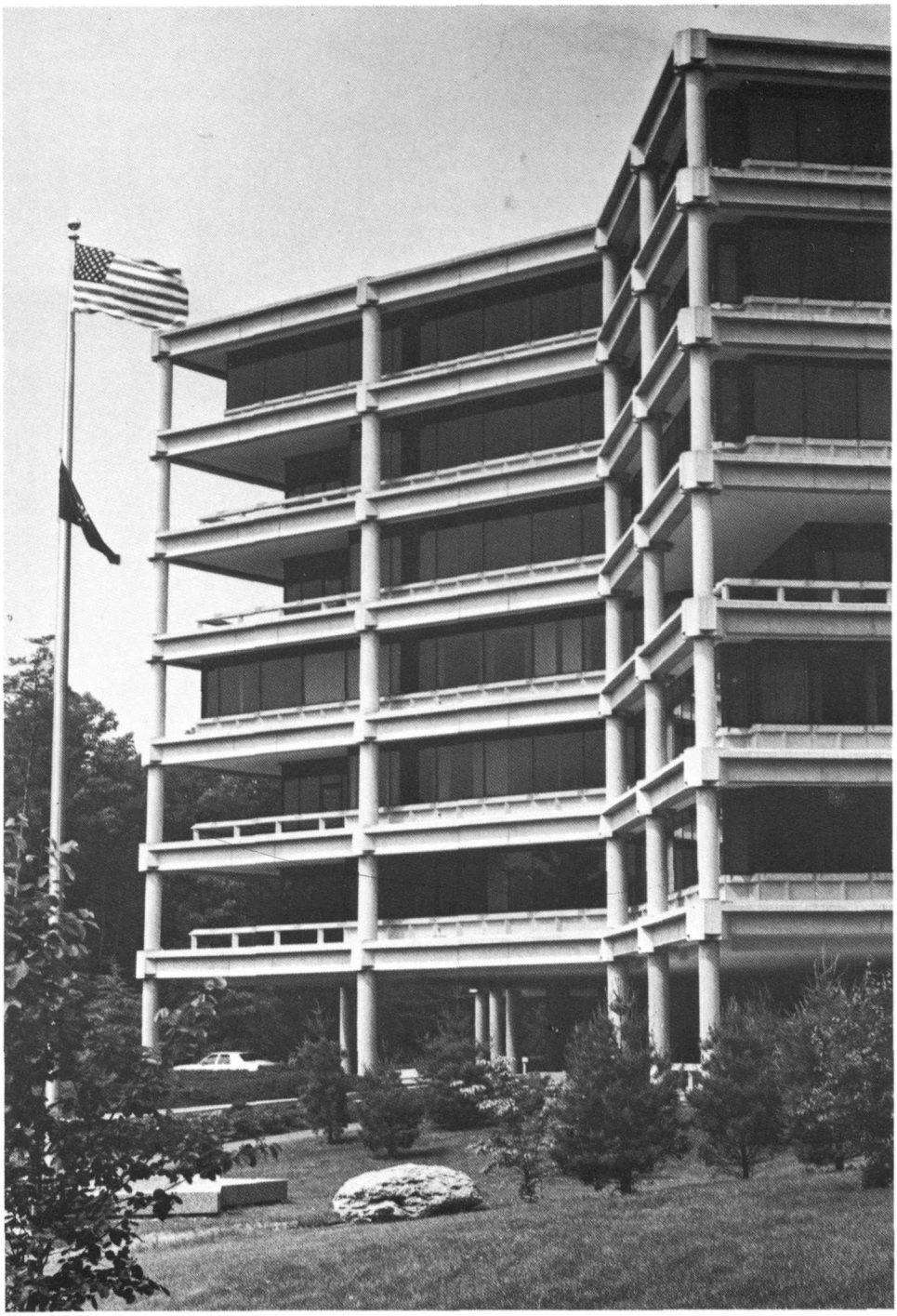

Today's headquarters of the U.S. Geological Survey.

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 respons bility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.