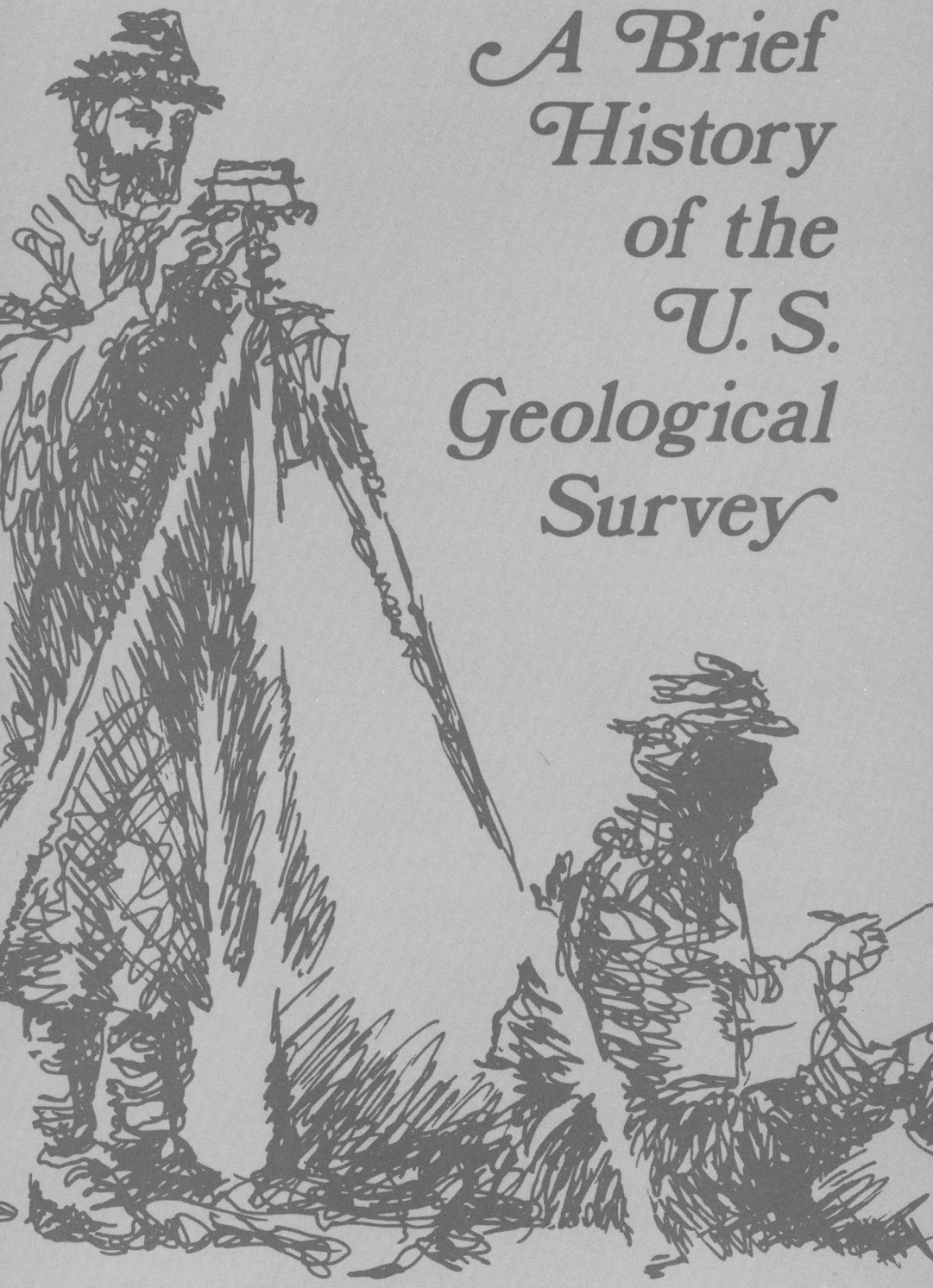
A Brief History of the U. S. Geological Survey



U. S. Department of the Interior/Geological Survey
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A Brief History of the U.S. Geological Survey

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 brings out well 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. Looking ahead, the sense of urgency in the Survey's mission deepens as 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.

V. E. McKelvey

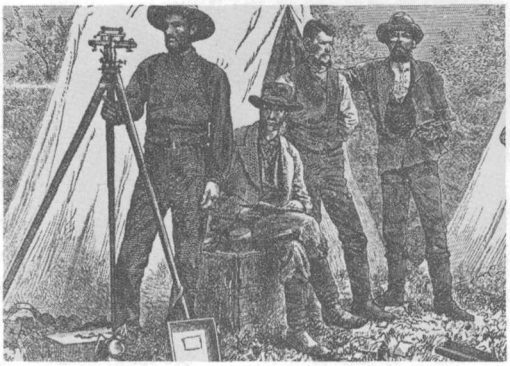
The United States Geological Survey was established on March 3, 1879, in the closing hours of the final session of the 45th Congress, when the bill appropriating money for sundry civil expenses of the Government during fiscal year 1880 was signed by President Rutherford B. Hayes. Included in the bill was provision for a new agency in the Interior Department, 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 exploring the West at the time—two under the Interior Department and one under the Army—and the General Land Office was conducting its land-parceling surveys. A fourth exploratory survey had recently completed fieldwork and was finishing its reports.

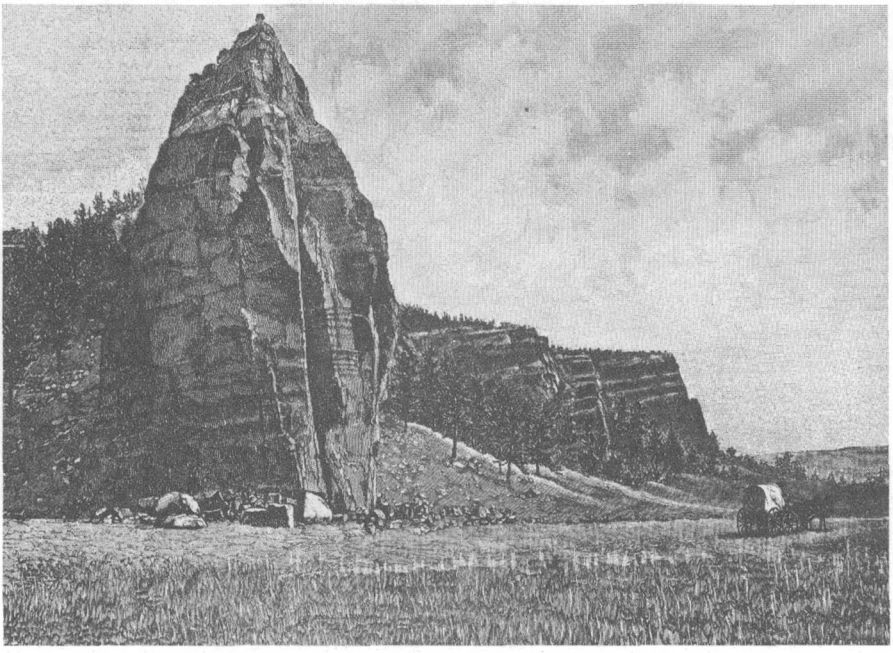
The establishment of a Federal geological survey was a natural step at that stage in the development of Government science. In its early years, the Federal Government made few scientific investigations, and, in fact, many considered Federal science, as well as Federal engagement in public works, to be unconstitutional. Exploration of the West had been a function of the Army for the first half of the 19th century, although occasionally civilian scientists accompanied the expeditions. Some of the States established geological surveys in the 1820's and 1830's to aid in the development of their natural resources. In the 1840's, as the need for geographic knowledge became more urgent for a growing nation, the Federal Government also became more deeply involved in scientific activities, and in the 1850's geologists took an active part in the great railroad surveys.

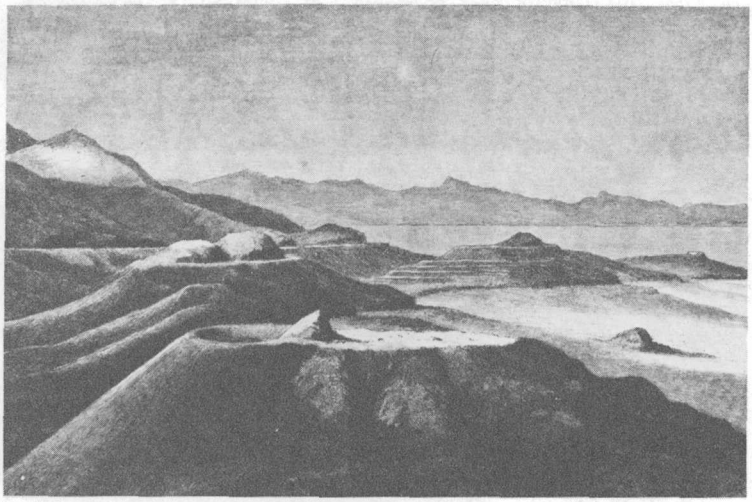
During this same period, growth in the industrial capacity of the Nation accelerated, especially after coal began to replace wood in the manufacture of iron. The United States had begun as a primarily agrarian nation, but in 1859, the value of the products of U. S. industry surpassed the value of agricultural products for the first time, and industry began to play the greater role in national development.

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, and was planned, organized, and directed by Clarence King, though administered by the Army



Western scenes from early Survey reports: Surveyors on an early Survey expedition (left), Land of the Standing Rocks (bottom), Cup-Butte (right).



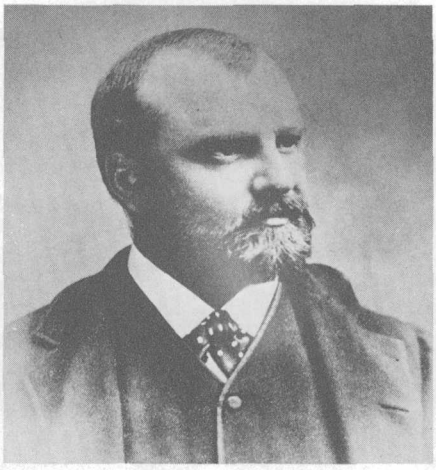


Engineers. A survey of the natural resources of the new State of Nebraska, authorized on the same day under the Land Office and with Dr. F. V. Hayden in charge, increased in scope and size until it became the Geological and Geographical Survey of the Territories under the Department of the Interior. 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 exploratory activities in 1869 with a reconnaissance survey and in 1871 initiated the Geographical Surveys West of the One Hundredth Meridian, both 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. However, the prosperous years 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.

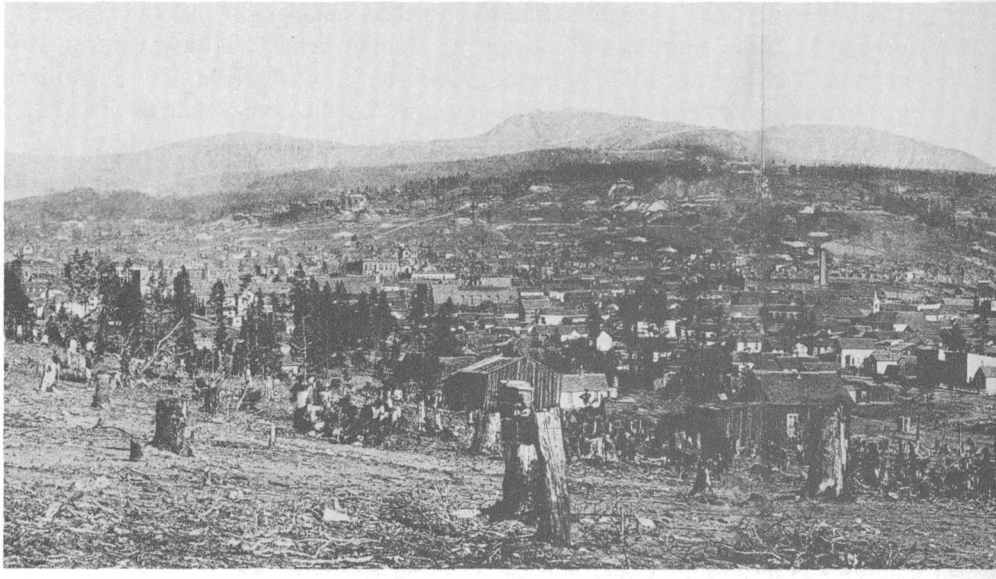
The Academy favored civilian science. To attain the desired accuracy and economy in surveys of mensuration, it recommended that the Coast and Geodetic Survey be transferred from the Treasury Department to Interior, renamed the Coast and Interior Survey, and be given responsibility for geodetic, topographic, 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 geologic 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 and was dropped, and at the last minute the transfer of the Coast Survey was also omitted and only the Geological Survey was established.

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



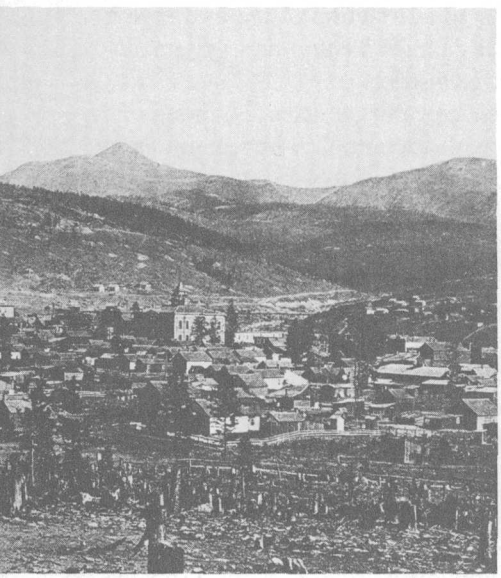
Clarence King was appointed by President Hayes as the first Director of the new Survey. He was only 37 at the time, a graduate of Yale's Sheffield Scientific School, one of the youngest members of the National Academy of Sciences, and a man of rare charm and outstanding literary ability as well as scientific achievement. His 40th Parallel survey had led the way in converting western exploration to an exact science; he was now 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, leaving much to the judgment of the Director, and some of King's decisions shaped the course of Survey work for many years. The Survey's classification of the public lands, he concluded, was not meant



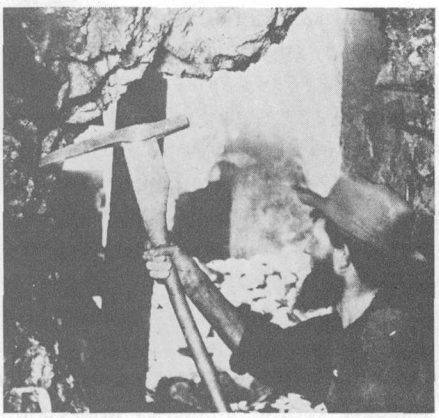
to supersede that of the General Land Office as a basis for granting title, but was rather to be a scientific classification to provide general information for all the people and a series of land maps. Information about the Nation's mineral wealth, mining and metallurgical techniques, and production statistics was meager, though the mineral industry was a primary industry on which others depended. Foreseeing the importance of scientific research in the continued industrial development of the Nation, he chose to emphasize mining geology, to devote but a small effort to general geology, and to confine paleontology and topographic work only to that necessary to support the geologic studies. The term "national domain" of the organic act was troublesome. It could mean the lands owned by the Nation (the public domain) or the lands within its outer boundaries. King believed it was essential for the Survey to be truly national in scope, but he chose the more conservative interpretation and confined operations to the public land States until Congress could clarify the matter.

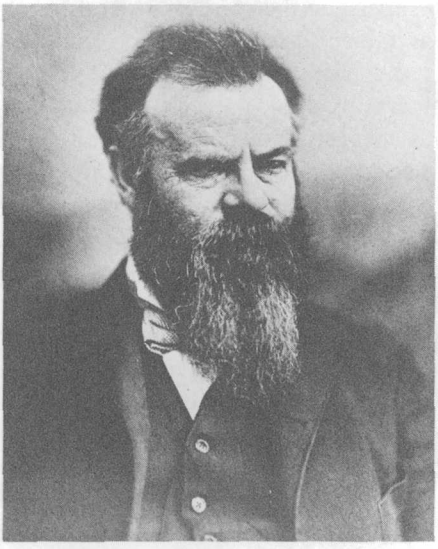
Comprehensive studies of the geology and technology of three great mining districts in Colorado and Nevada were begun. Mineral statistics were collected for the entire country, and studies were made of the iron and coal resources of the Nation through a cooperative arrangement with the 10th Census. An outstanding staff was recruited. The mining district investigations, aimed at developing principles of ore deposition, were the beginning of a new era in the use of geology in mining. The first report on the Leadville district became known as the "miners' Bible;" a later updated study was promptly dubbed the "Revised Version." The mineral statistics studies led to publication of annual volumes on " Mineral Resources of the United States," a series still being published, though since 1925 by the Bureau of Mines.



The Leadville, Colorado, mining district, subject of an early mineral statistics study (left).

Mining the lode, Virginia City, Nevada (below).





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

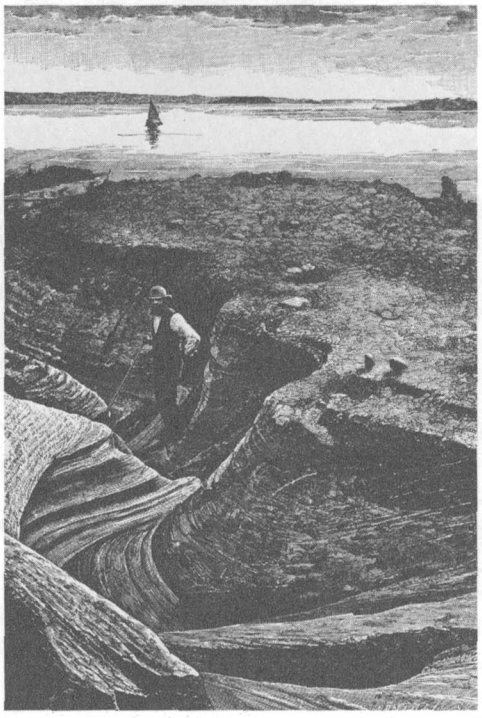
John Wesley Powell succeeded King as Director in March 1881. He was Director of the Bureau of American Ethnology but had also been serving as head of the Survey's General Geology Division. Powell was several years older than King and largely self-taught. After service in the Civil War, in which he lost his right forearm, he had been a college professor before beginning his western explorations. His scientific interests were wide ranging; in geology he had been primarily concerned with landforms and land use. In his "Report on the Land of the Arid Region of the United States," published in 1878, he had pointed out that very little of the remaining public land was suitable for conventional farming, and only a small fraction of the arid region was irrigable. He had then proposed radical changes in the land system, including organization of irrigation and pasturage districts.

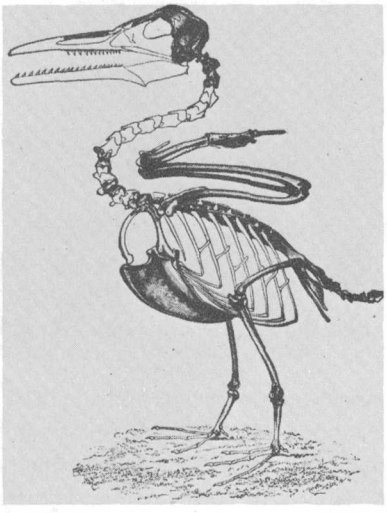
Powell called geology the most comprehensive of all sciences, though its most fundamental connection he held was with topography, and maintained that all wisely conducted geologic investigations ultimately resulted in practical benefit to the mineral industries. In his first full year as Director, independent topographic work was authorized, and new investigations were begun in general geology and paleontology. In 1882, the scope of the Survey's work became unquestionably national when the duty "to continue preparation of the geologic map of the United States" was added to those in the organic act of 1879 and the collection of mineral statistics (except those for gold and silver) was authorized. Topographic mapping to provide a base for the geologic map was begun immediately in the Eastern States, and all topographic work was placed under the supervision of a Chief Geographer.

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 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 that Government scientific work should be severely limited in scope. The Commission held hearings during two sessions of Congress, and in the end, recommended no changes in the existing bureaus. The majority of the Commission found the Geological Survey to be well administered and said there was no doubt of the wisdom of a geological survey of the whole country. The Commission did, however, restrict the amount that could be spent on publications.

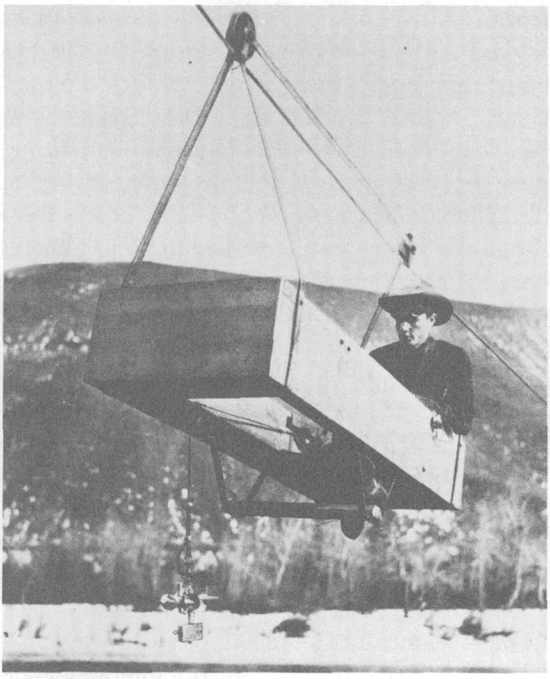
By the late 1880's, time had demonstrated the wisdom of some of Powell's conclusions in his arid lands reports. There had been an influx of people into the arid region in the early part of the decade, and would-be farmers came into competition with cattlemen for water and land. Severe winters and dry summers in the middle eighties made the problem acute. In October 1888, money was appropriated to the Survey to determine irrigable



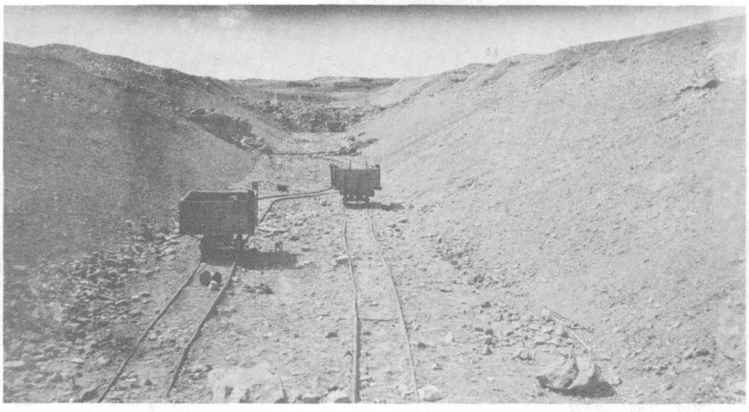


Geology is closely related to the other earth sciences. Powell authorized Survey investigations in topography and paleontology: Exploring glacial grooving, Kelley's Island, Lake Erie (left), Restoration of Icthyornis victor, a bird with teeth (above).

Device developed by Survey engineers for measuring streamflow during hydrographic surveys (right).



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



lands and reservoir and canal sites in the arid regions. 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. The Irrigation Survey began immediately after passage of the appropriation bill as an expansion of the regular topographic mapping program. Shortly thereafter, several promising young men, among them F. H. Newell, were recruited to learn stream gaging and inaugurate the hydrographic survey, and finally several well-known engineers were added to the staff. By the end of June 1889, about 150 reservoir sites and approximately 30 million acres of irrigable land had been selected.

Powell optimistically believed that his program could, with proper support, be completed in 6 or 7 years, but he was given less than 2. To prevent speculation, the Congressional authorization in 1888 had provided that all lands that might be irrigated by the reservoirs and canals to be located by the Survey should be withdrawn from entry. In May 1890, the Acting Attorney General ruled that all irrigable 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 that advocates of western development did not want at any cost. When the appropriation act for 1891 was passed, there were no funds for the Irrigation Survey, and the provision for withdrawal of public lands except for reservoir sites was repealed. In the following year, funds for topographic surveys were reduced, and in the summer of 1892, when the appropriation for fiscal year 1893 was passed, overall Survey funds were cut below the level for 1885, and work in geology, paleontology, chemistry, and physics had to be severely curtailed.

Major Powell resigned as Director in the spring of 1894 and was succeeded by Charles D. Walcott, who had joined the Survey in July 1879 as assistant geologist. He had risen through the ranks to become special assistant to the Director for geology, at the same time establishing a worldwide reputation as a paleontologist. Walcott also took a broad view of Survey functions—the Survey should be a scientific investigation agency that would aid in every possible way the development of industries affected by its findings and any practical objective that could be advanced by knowledge of the surface and interior of the Earth and its resources.

During the 13 years of Walcott's directorate, the Survey experienced an extraordinary growth. At the outset he announced several adjustments in the program: Topographic map quality would be improved, the topographic corps

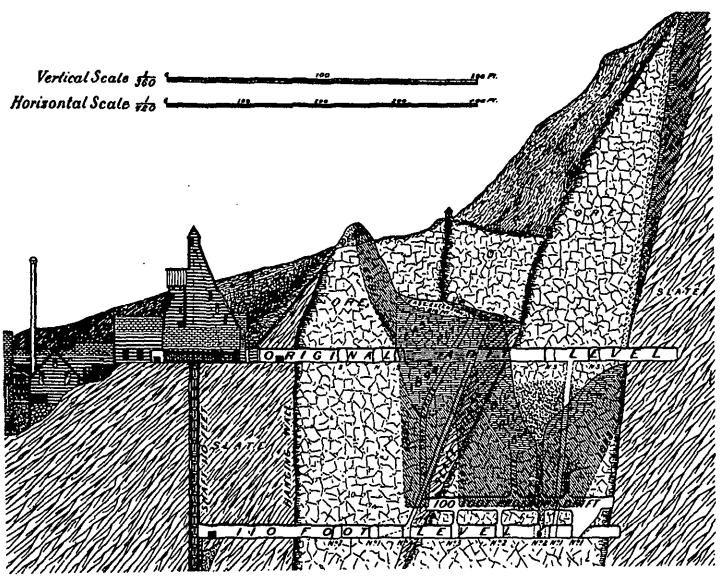
Charles D. Walcott, third Director of the U.S. Geological Survey.

placed under Civil Service, and mining geology would receive renewed emphasis. Other activities were soon undertaken or developed in response to changing national goals and national needs. From the close of the Civil War until the early 1890's, Americans had devoted their energies to the settlement of the West and the development of industry. But now the western frontier had disappeared; the Nation was looking elsewhere to satisfy the urge to expand, and there was rising opposition to the policies that had allowed the development of monopolies and waste of natural resources.

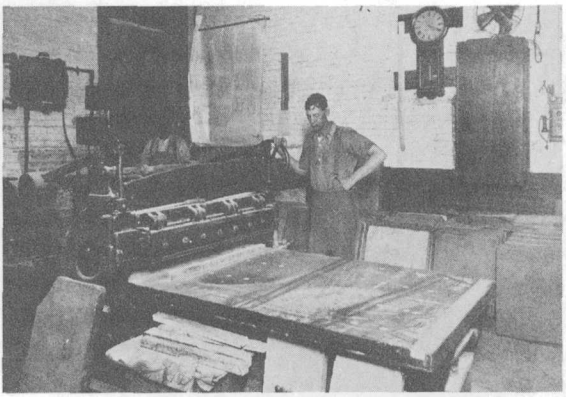
In 1894, a small appropriation was obtained for the specific purpose of "gauging streams and determining the water supply of the United States." Steamflow measurements had been continued in a modest way as part of the topographic program after the end of the Irrigation Survey; now water investigations became a regular part of the Survey program. Appropriations were increased regularly, and by 1900 some 40 Water-Supply Papers had been published, many of them on irrigation.

In 1895, Congress appropriated money for the Survey to investigate the coal and gold resources of Alaska. Though Alaska had been purchased in 1867, its resources were still almost unknown. After the gold strikes of the late 1890's, the appropriations were increased substantially, and the Survey extended its investigations to all mineral resources.

In 1897, the Forest Management Act placed management of the forest reserves in the Department of the Interior and stipulated that surveys of the "public lands that have been or may be designated forest reserves" were to be made under the supervision of the Director of the Geological Survey. Forest protection had been urged for many years by scientists and other conservation-minded citizens, and in 1891, Congress had provided for their reservation but not their management. Survey scientists were among those who had



Sketch of the Alaska-Treadwell Mine, 1895.



Lithographic stones were used to print early topographic maps.

strong interest in the subject, and the Director had in fact helped write the 1897 law. Although most of the reserves were wilderness areas, within the next 3 years the Survey mapped more than 32,000 square miles in and adjacent to the reserves.

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 insurrection and attached himself to the Bureau of Military Information, in what might be called an ancestral form of military geology.

In 1898, a Senate resolution 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.

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. In less than 22 years, the number of employees had grown from 38 to more than 400. More than 300 volumes of reports as well as several hundred articles in scientific journals and geologic folios had been published, and Survey scientists and engineers were engaged in mapping and in geologic, geographic, geodetic, paleontologic, hydrographic, chemical, and forest investigations in all parts of the United States.

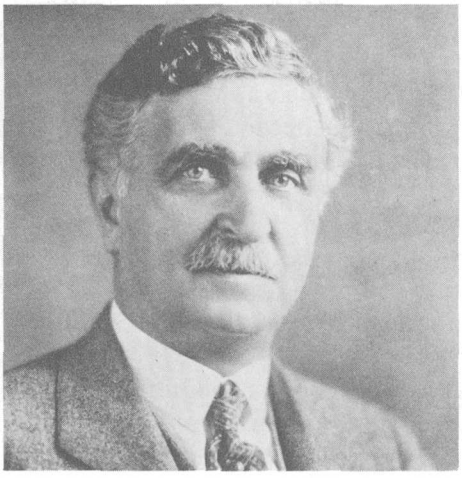
Coal deposits were tested and analyzed for fuel value and most economical use.

Theodore Roosevelt, who became President in 1901 after the assassination of President McKinley, was by inclination and training in full sympathy with the movement for scientific management of the Nation's resources. His first State of the Union message outlined a national forest and water policy that Gifford Pinchot, head of the Bureau of Forestry, and F. H. Newell, the Survey's Chief Hydrographer, had helped write. In June 1902, the Newlands Act was passed, establishing the Reclamation Service and inaugurating a Federal program for the reclamation of arid lands. 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.

The bituminous and other coal resources of the Nation became a matter of public interest after the prolonged anthracite coal strike of 1902 and its attendant hardships. In 1904, the Survey began analyzing and testing coals and lignites to determine their fuel value and the most economical method for their utilization. In the following year the program was expanded and additional field mapping of coal deposits in the Western States was undertaken. Investigations of structural materials were also begun; one of the first was a field study of the effects of the San Francisco earthquake of April 1906. Mineral resource investigations were intensified, and the collection of mineral statistics was more closely associated with field programs in economic geology. The value of that plan was to become particularly evident during World War I when the need for supplies of war materials became urgent.

To further the effects of science and conservation, President Roosevelt in 1903 appointed a committee to investigate the scientific work of the Government to increase its usefulness, efficiency, and economy. He also established a Public Lands Commission. Walcott was chairman of the committee on scientific work, and Newell one of the three Public Land Commissioners. The Walcott Committee favored organization of research around a problem rather than a discipline and recommended that all conservation agencies be placed in the Department of Agriculture. The Land Commission recommended that classification of the public lands be pushed and proposed several changes in the administration of grazing and forest lands. The only immediate result was the transfer of the management of the forest reserves from Interior to Agriculture in 1905. Before long, however, the Survey was deeply involved in a new form of land classification. The first Director's conclusion that the Survey's classification was for general information prevailed until 1906. Then, when evidence was uncovered, in part by Survey geologists, that much western coal land had been acquired fraudulently, some 66 million acres of potential coal-bearing lands were withdrawn from entry at the request of the President, until the Survey could determine their extent, location, and value.

The spring of 1907 brought several changes. Walcott became the Secretary of the Smithsonian Institution. In March the Reclamation Service became an independent bureau, and F. H. Newell its Director. On April 1, the fuel testing and structural materials investigations were combined as the Technologic Branch under Joseph A. Holmes. On May 1, George Otis Smith, who had joined the Survey after receiving his doctorate from Johns Hopkins University in 1896, succeeded Walcott as Director. Though barely 36, he had already established a reputation as a capable geologist and administrator. At the time of his appointment he was geologist-in-charge of the Section of Petrography; the year before he had been chairman of one of the subcom-



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

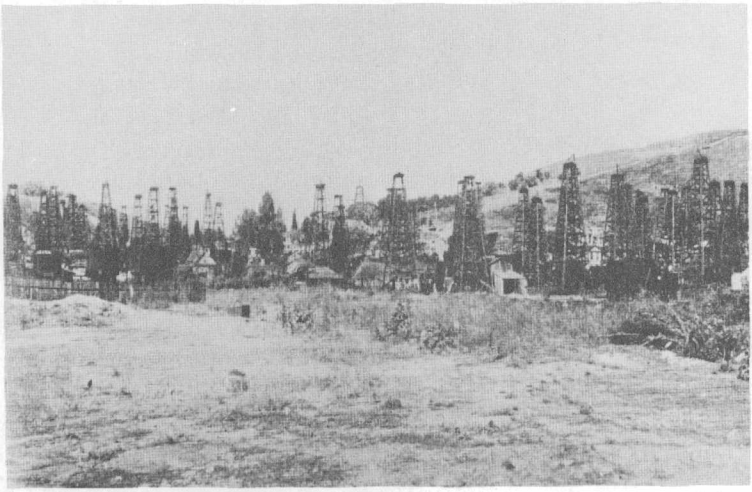
mittees of a presidential commission that sought to put the operation of Government agencies on a modern businesslike basis. In Director Smith's view, geologic research under Government auspices should be largely practical. He was particularly interested in a business policy for the public domain, and in the early years of his directorship the Survey became intimately involved in public land administration.

In the summer of 1907, geologists in the field 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. Lands were being obtained fraudulently and oil development hindered. On the recommendation of the Director, some potential oil-bearing lands in California were withdrawn from agricultural entry, pending classification, in August 1907. In February 1908, he 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. In September 1909, oil-bearing lands in California and Wyoming were withdrawn from all forms of entry, and in 1912, the first two naval petroleum reserves were established.

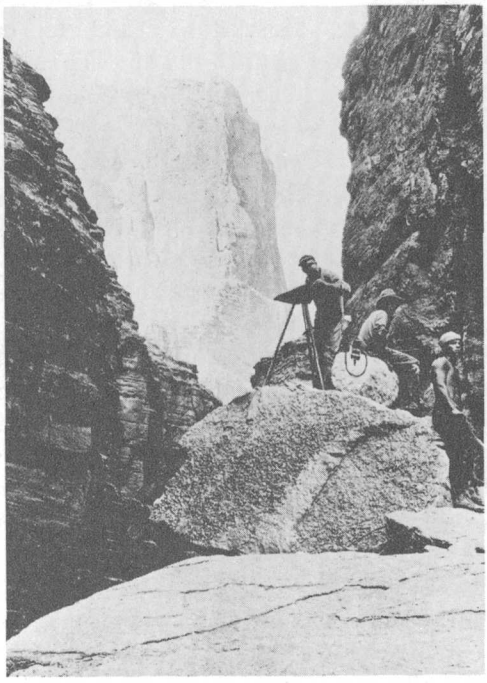
In 1908, President Roosevelt convened a Governors Conference on Conservation to dramatize the need for natural resource management. A National Conservation Congress was appointed, and Survey scientists prepared appraisals of the various mineral commodities and of water resources. At that time the Survey published its first Coal Map of the United States. 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, the phosphate lands were withdrawn.

The great increase in land classification work led to the establishment of a Land Classification Board in December 1908. Within a few months of its formation, the Survey was assigned responsibility for classification of lands under the Enlarged Homestead Act, and in that same spring waterpower sites on several western rivers were selected and withdrawn on the basis of Survey data in aid of the legislation to carry out the recommendations of the Inland Waterways Commission. The Commission, which had been appointed in 1907, proposed a multipurpose approach to river development(similar to the Tennessee Valley Authority of the 1930's)and also that a single agency be designated to coordinate water resource development and administration. Though the legislation did not pass, the sites remained withdrawn. In 1912, the Land Classification Board was raised to branch status, equal in rank with the Geologic, Topographic, and Water Resources Branches.

Meanwhile, in 1910, the Bureau of Mines had been established, and the Survey's Technologic Branch had been transferred to form the nucleus of the new agency, along with its Chief, Joseph A. Holmes, who became the bu-



Development about 1906 of the Eastern Oil Field in Los Angeles, California, as the Survey intensified the search for oil (above).



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

reau's first Director. The structural materials investigations were transferred at the same time to the Bureau of Standards to become part of that bureau's materials testing program.

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

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

geologists were assigned to search for commercial deposits of the "war minerals." Early in 1917, 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 control distribution of fuels necessary to the war effort, Survey scientists worked in close cooperation with it, and Survey engineers 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.

After the war, energy sources continued to be of paramount importance. 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. 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 responsibiilty for the necessary streamflow records and for examination of proposed projects on the public lands outside the National Forest. 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 Washington and Boston. Independent engineers made the study under the direction of the Survey and proposed a power grid that anticipated the present northeast power network. In 1922, after the great coal strike, 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.

In 1923, the Survey extended its intensive study of possible oil-bearing formations 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. In March 1924, after the Teapot Dome scandal, 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, the Federal Oil Conservation Board was established to reappraise Federal oil policies, and Director Smith was named Chairman of the Advisory Committee.

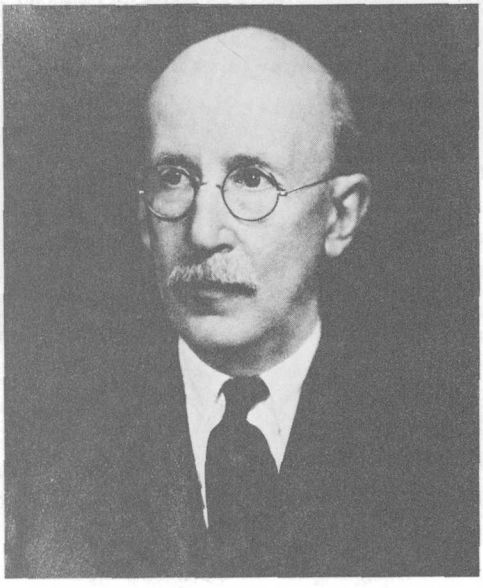
Much of the Survey's work was hampered by lack of funds. The Federal budget had been sharply reduced after the war, and the Survey appropriation was down to a prewar level. Fieldwork was curtailed or postponed, and many scientists and engineers left to seek more remunerative private employment. Nearly 60 percent of the country was still unmapped, and much that had been mapped was in need of resurvey; at the same time the demand for topographic maps to aid industrial and engineering projects, especially highway construction, was increasing. The Survey proposed a plan whereby the mapping of the country could be effectively and economically completed by 1932, but without funds was unable to inaugurate it. Even when the Temple Act in 1925 called for completion of a topographic map of the United States within 20 years, appropriations were not made to carry out the work. Many geologic investigations were made in cooperation with other Federal agencies, the States, and the National Research Council. Several West Indian republics also sought Survey assistance in topographic and geologic mapping,

and Survey scientists and engineers were given leave to supervise their mapping programs.

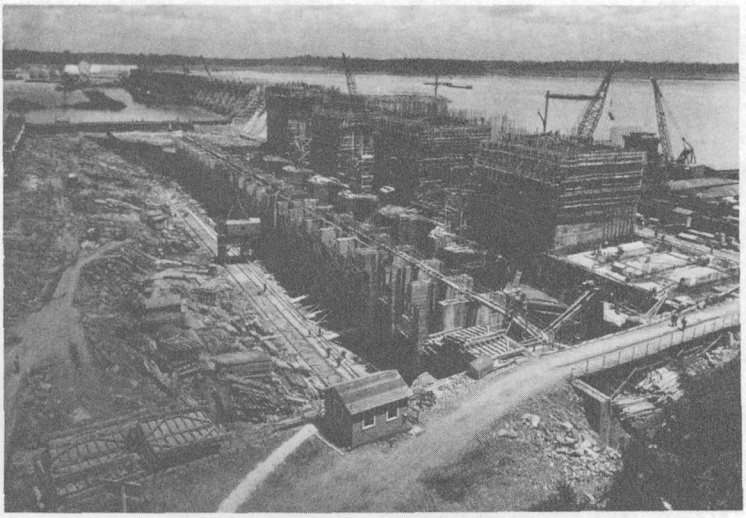
Meanwhile chemical and mineralogical studies of cuttings from oil wells in Texas had disclosed the presence of potash-bearing salts at relatively shallow depths. As the investigation continued, many thousands of cuttings were examined, and in 1926, money was appropriated for a 5-year program of core drilling as a cooperative effort of the Survey and the Bureau of Mines. Mineable deposits were discovered and commercial production began in New Mexico, the successful culmination of efforts beginning in 1911.

On July 1, 1926, the Survey's Division of Mineral Resources was transferred from Interior to the Department of Commerce along with the Bureau of Mines. Responsibility for supervising mining operations on the public lands, which the bureau had exercised under the Leasing Act of 1920, remained a function of the Department of the Interior and was assigned to the Geological Survey. The name of the Land Classification Branch was changed to the Conservation Branch, a name which more properly described its functions.

By the end of the decade Federal expenditures for science had been generally increased. The Survey's 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 now 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 prospect-



Walter Curran Mendenhall, fifth Director of the U.S. Geological Survey.

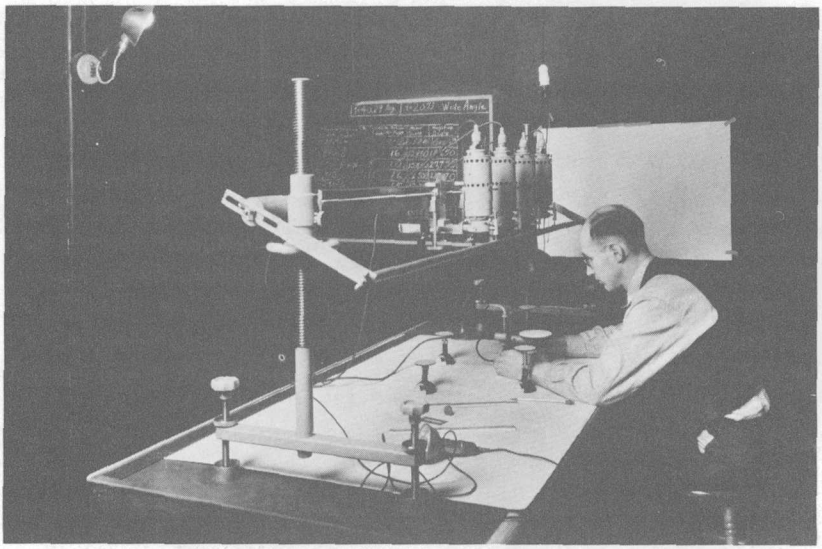


Construction of the TVA Wheeler Dam at a site in Muscle Shoals, Alabama, selected with the aid of Survey studies and aerial photography.

ing 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 Chairman of the newly reorganized Federal Power Commission; he was succeeded as Director by Walter Curran Mendenhall. Mendenhall, who had joined the Survey in 1894 fresh from Ohio Normal University, had had unusually broad experience in the Survey, serving in Alaska, in the Geologic and Water Resources Branches, and as Chairman of the Land Classification Board for 10 years before becoming Chief Geologist in 1922.

As Chief Geologist, Mendenhall had been pleading for increased funds for basic research, pointing out that, "There can be no applied science unless there is science to apply." For 1 year additional funds were appropriated for fundamental research, and then in 1932, the Federal budget was sharply cut as the effects of the Depression began to be felt. Fieldwork was suspended, some employees placed on administrative furlough, others separated from the service. Almost immediately after the inauguration of Franklin Delano Roosevelt in March 1933, however, conservation became part of the Government's program to combat the Depression, and the Survey's special skills and knowledge were in demand. The Tennessee Valley Authority, 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 experiment-



With the development of photogrammetry, topographic maps could be produced more quickly and easily.

ing since 1904, and ultimately led to a complete revolution in mapmaking procedures. The Public Works Administration, established in June, 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.

By 1938, the Survey's own appropriation had been restored to pre-Depression 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, and 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, air fields, 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."

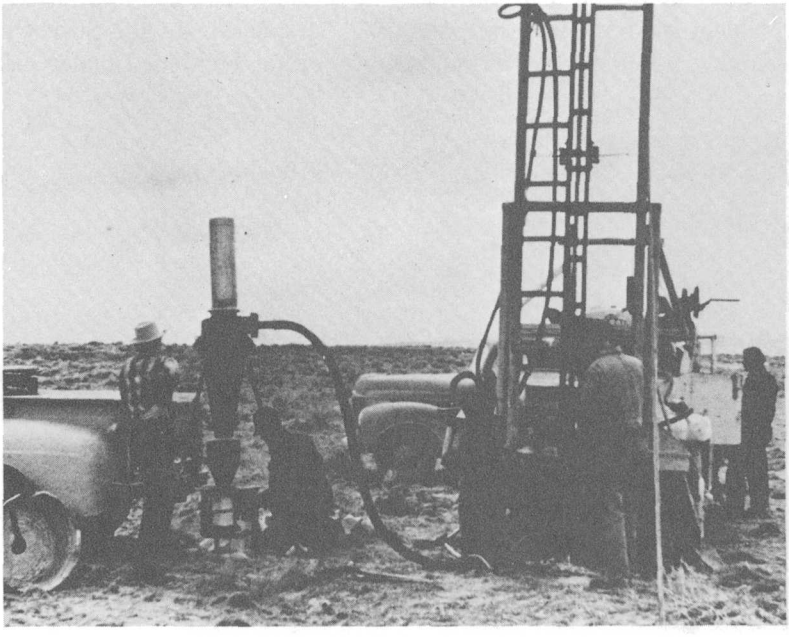
Director Mendenhall served for 2 years beyond normal retirement age and in May 1943 was succeeded by William Embry Wrather, then Associate Chief of the Metals and Minerals Division of the Board of Economic Warfare. For most of his professional life Wrather had been an independent consulting geologist, though he had had brief experience with the Survey while he was a student at the University of Chicago. Expansion of the Survey's activities, already begun under the spur of war needs, continued under his guidance.

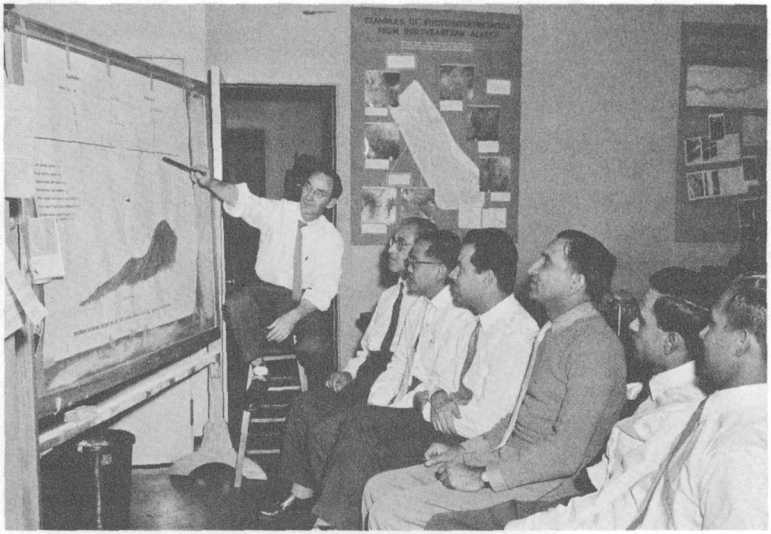
William Embry Wrather, sixth Director of the U.S. Geological Survey.

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 a long and ultimately successful program of exploration, mapping, and research for fissionable materials was begun in 1947 on behalf of the Atomic Energy Commission (AEC).

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

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





Foreign geologists participating in a Survey photogeology training program.

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.

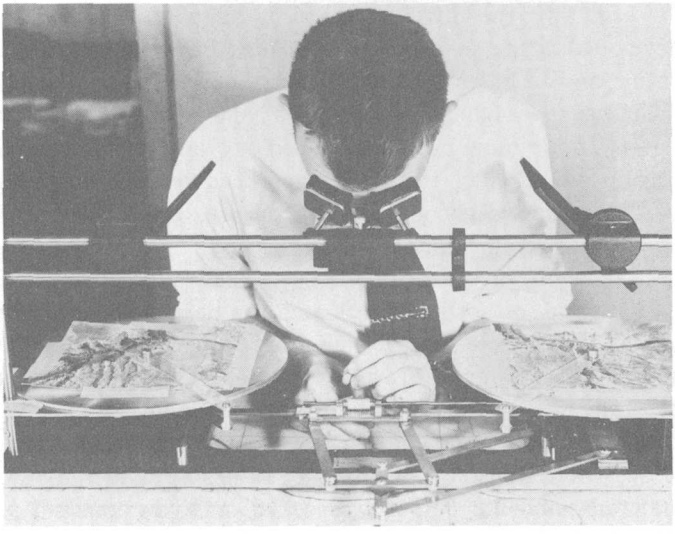
In 1949, the Government's program of assistance to economically underdeveloped areas in the Eastern Hemisphere was expanded to include scientific and technical assistance. Survey scientists and engineers were soon on their way to Afghanistan, India, Thailand, and the Philippine Islands. The in-service 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

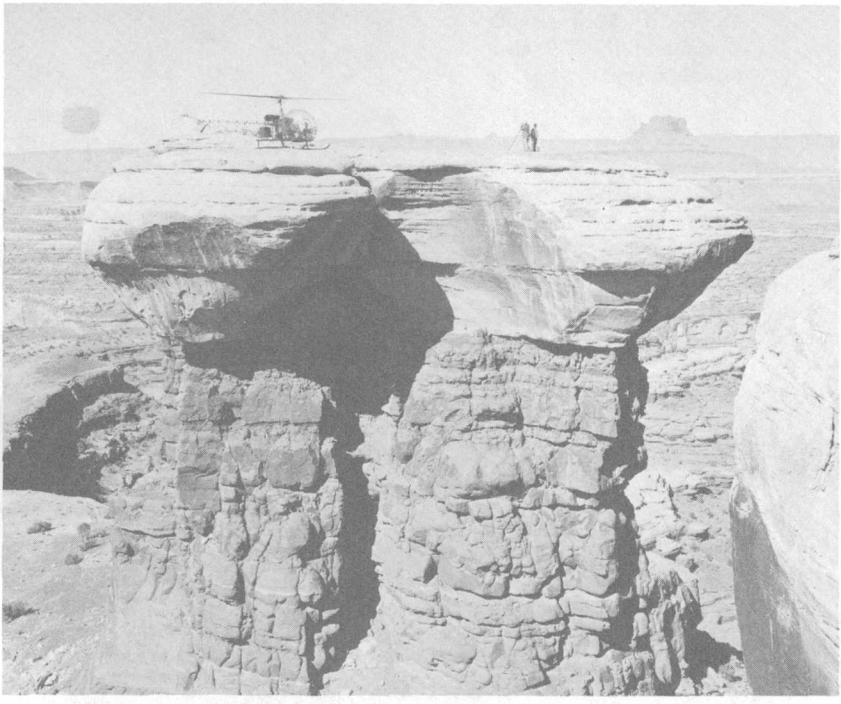
deficiencies of 23 minerals and to undertake special studies on behalf of the Petroleum Administration for Defense.

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 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 and of 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 made more precise, and the art of mapping geology by photogrammetric methods was developed. Helicopters transported men and equipment to mountaintops and other remote spots for survey control measurements, and two planes 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 responsibilty for supervision of lease operations on the Outer Continental Shelf.

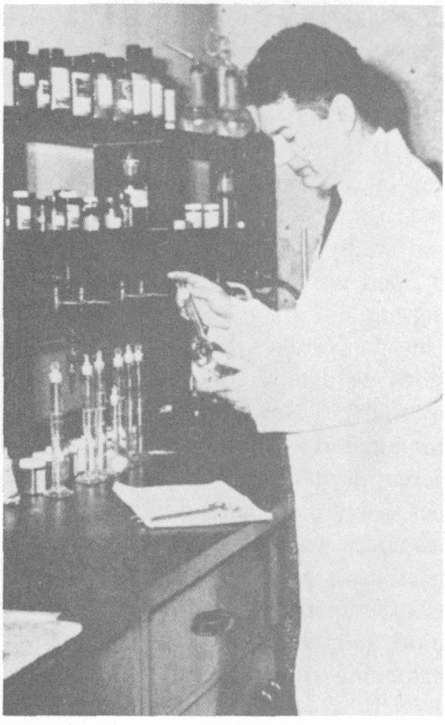
These many demands upon the Survey led to its steady growth. From a 1940 level of $5.5 million, total funds available for Survey expenditure increased to $48 million in fiscal years 1952-54. In its 75th year, the Survey had about 7,000 employees. Mapping and investigations were underway in all 48 States, Alaska, Hawaii, and Puerto Rico, and technical assistance programs were active in Latin America, the Near East, Asia, and Africa. Sixty-



Compiling a geologic map from information taken from aerial photographs.



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



Survey scientist analyzing samples of uranium and thorium. Some exceedingly sensitive tests will detect as little as one ten-billionth of a gram of uranium (left).

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

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

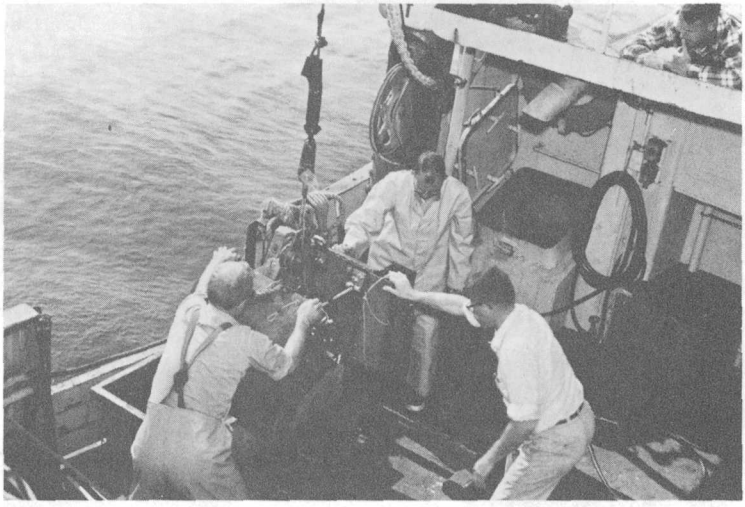
nine percent of the country had now been mapped topographically, but only 33 percent met modern standards. Data on streamflow were being obtained at some 6,400 gaging stations. Rent and royalty income from lands under Survey supervision had increased about 18-fold in 25 years to $73.5 million. In fiscal year 1955, 188 new book reports (as well as 30 chapters of a new edition of the Topographic Manual) and 2,115 new maps were published, and 3½ million maps and book reports were distributed.

In January 1956, Thomas B. Nolan, Assistant Director of the Survey since December 1944, became its seventh Director. Like the first Director, he was a Yale man, especially interested in research that would assist the development of mineral resources. He had joined the Survey in 1924 as a junior geologist. In 1933, he had received the Spendiaroff Prize, awarded to a particularly promising young geologist, and in 1954 the K. C. Li Medal and Prize for advancing the science of tungsten.

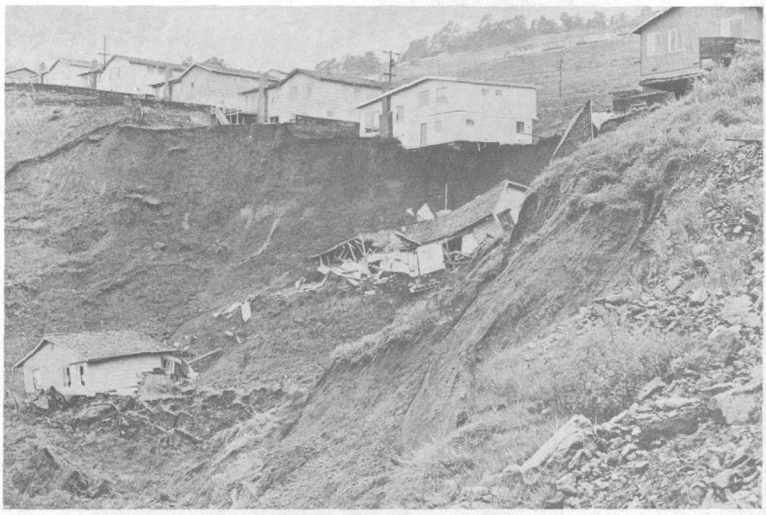
To the perennial problem of supplying the Nation's demand for mineral, fuel, and water resources, new dimensions were now added. Through improved methods of exploration, the ability to exploit lower grade sources, and the substitution of common for less common materials, science and technology were combining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

Astronaut in Survey training program for the geologic investigations of the Moon that are now history (left).

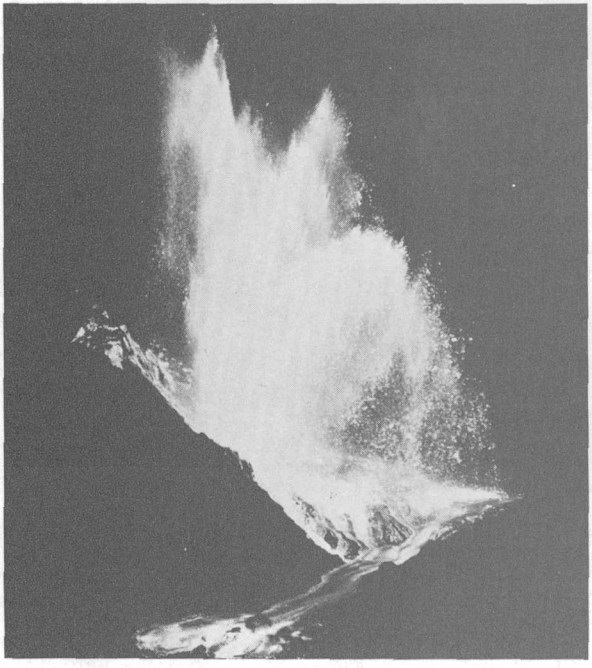
Studies of the sea floor aid in solving problems caused by rapid population growth (below).



Survey investigations also took on new dimensions. Evaluation of the effects of underground nuclear explosions at the AEC'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, 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 and also to aid in solving the problems caused by rapid population growth, urbanization, and industrial expansion in coastal



Urbanization increases vulnerability to damage from natural disasters, such as landslides. Survey research has led to better zoning regulations (above).



Research at the Survey's Hawaiian Volcano Observatory aids in the prediction of eruptions and investigates the formation of ore deposits (left).

areas. Research at the Survey's Hawaiian Volcano Observatory aided in the prediction of volcanic eruptions and provided new understanding of the formation of ore deposits. Research into the causes of landslides and other mass movements led to the development of better zoning regulations in some metropolitan areas. Studies in plant ecology and geomorphology aided in water conservation. Geochemical exploration techniques, developed to aid the search for mineral resources, were adapted to investigations of subtle differ-

After the Alaska earthquake of 1964, the Survey established a National Center for Earthquake Research to seek ways of minimizing property damage and loss of life by more accurate prediction.

ences in the natural distribution of chemical elements that might have a bearing on public health.

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. Survey geologists were also assigned to the Task Force of the Federal Reconstruction and Development Planning Commission and helped select sites for rebuilding the devastated area. 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 responded by establishing the National Center for Earthquake Research at its Menlo Park, California, headquarters.

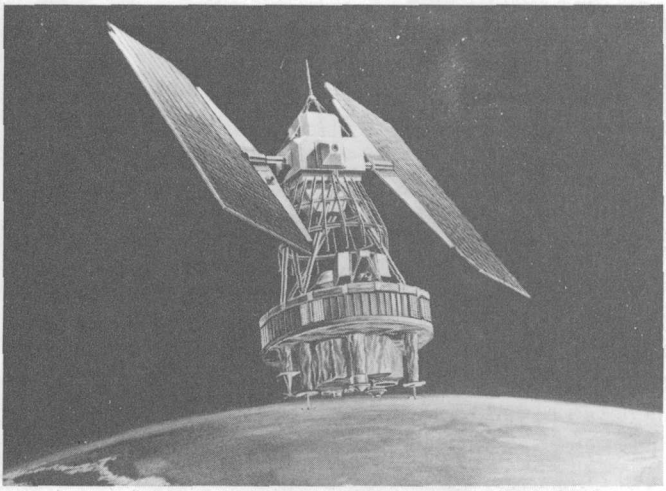
Water resources investigations were by now in progress in nearly every State, some concerned with the specific problems of a political subdivision, others with the hydrologic environment of a natural unit such as a river basin; some concerned with the use of water, others with contamination of water; and some with the movement of water, and others with its geochemistry. In 1964, by directive of the Bureau of the Budget, the Survey established an Office of Water Data Coordination to coordinate and plan all Federal activities in collecting water data.

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

In the fall of 1965, William T. Pecora became Director when Dr. Nolan returned to full-time research. Pecora had joined the Survey in 1939 after studies at Harvard and Princeton. He had had experience in fieldwork at home and abroad and in administration as Chairman of the Civil Service Board of Examiners for Geology, Chief of the Geochemistry and Petrology Branch, and Chief Geologist.

The rising standard of living with its insatiable demands for raw materials, coupled with concern for a deteriorating environment, led the Survey into new areas of research and service. In 1966, because of the short supply and widening gap between production and consumption of gold, silver, and some other metals, a heavy metals program was begun—a concentrated effort to find new sources. The mineral resource potential of several primitive areas was evaluated to aid in decisions on their incorporation into a wilderness system. Appraisals of world resources of oil, gas, natural-gas liquids, and oil shale were published as part of the ongoing study of energy resources. 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 were assigned to the Survey. The Survey had previously carried out a 2-year series of feasibility experiments for the project with NASA, other Government agencies, universities, and research institutions.

In 1967, responsibility for Government-wide coordination in national topographic mapping and related activities was assigned to the Geological Survey. By this time standard quadrangle map coverage was available for approximately 75 percent of the total area of the 50 States, Puerto Rico, the Virgin Islands, Guam, and American Samoa. A nationwide computer system



Satellites, such as NASA's Earth Resources Technology Satellite (ERTS-1), provide a wealth of information about the Earth through the Interior Department's Earth Resources Observation Systems (EROS) Program, administered by the Geological Survey (above).

More than 100 billion tons of coal are potentially recoverable by open-pit mining techniques, but plans must first be made to restore and use the land when strip-mining operations cease (right).

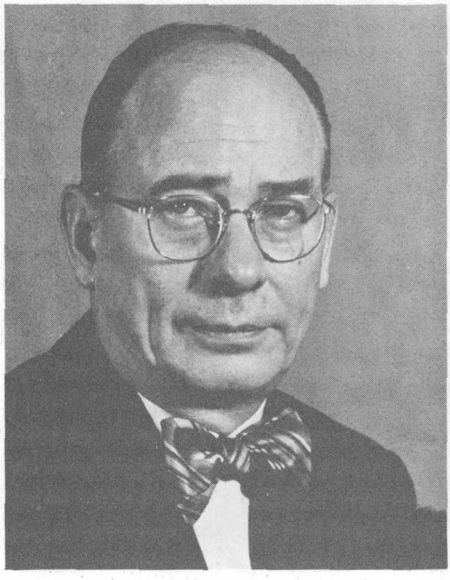
was established to provide computing services and related technical support to the scientific and administrative activities of the Survey and other bureaus and offices of the Department of the Interior.

In 1968, a giant oil field was found in Alaska's Arctic Slope, near where Survey reconnaissance studies in 1923 had indicated promising prospects. Transportation of that oil, by tanker or pipeline, posed many new problems. New studies of the Nation's coal resources indicated that more than 100 billion tons are potentially recoverable by open-pit mining techniques, but

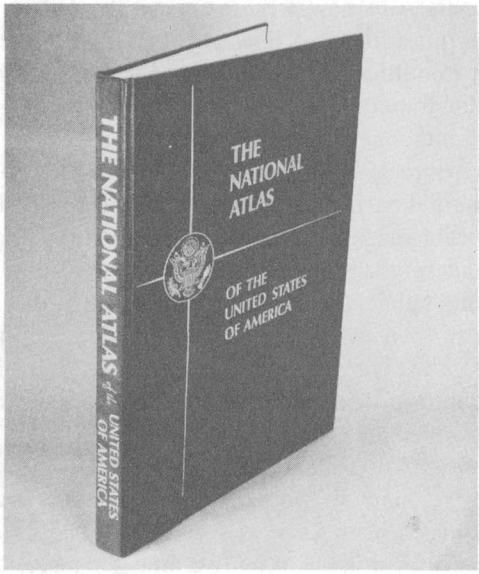
adequate plans must first be developed to restore and utilize the strip-mined lands once mining operations cease. Geothermal energy was of increasing interest, and the Survey classified about 1.8 million acres of land in the Western States as "being within known geothermal resources areas." The basic elements of the national water data network were developed. Topographic mapping of the major islands of the Trust Territory of the Pacific Islands was begun. A report summarizing the potential and known mineral resources of the sea beyond the Continental Shelf and the technology for their exploration and exploitation was presented to the United Nations and used to formulate policy on peaceful uses of the seabed and ocean floor beyond the limits of national jurisdiction.

In 1969, men trained by the Survey walked on the Moon,and a Survey geologist spent 60 days on the ocean bottom in an experiment designed to measure man's capacity for research on the sea floor over an extended period. Oil leaks from a well on a Federal Outer Continental Shelf lease in the Santa Barbara Channel blackened nearby beaches and threatened marine life. Studies by a task force of geologists and engineers led to new and more stringent operating regulations to prevent or control such incidents in the future.

In 1970, a pilot study of the application of geology, geophysics, hydrology, and topography in improving regional urban planning and decision making was begun in the San Francisco Bay region. The National Atlas—a reference tool comprising more than 700 physical, historical, economic, sociocultural, and administrative maps—was printed, culminating the combined efforts of more than 80 Federal agencies and a score of specialists and consultants over a period of several years.



V. E. McKelvey, ninth Director of the U.S. Geological Survey.



The National Atlas contains more than 700 maps depicting physical, historical, economic, socio-cultural, and administrative characteristics of the Nation.

In 1971, after Director Pecora became Under Secretary of the Interior, Vincent E. McKelvey, a career research scientist with the Survey since 1941, most recently its Chief Geologist, was appointed Director. McKelvey was internationally known for his studies of phosphates and uranium and 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, as well as 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 quality was being measured at more than 4,000 stations. Mineral production from land supervised by the Survey was valued at more than $3 billion, and annual royalties were approaching half a billion. More than 4,000 maps and 200 book reports were being published each year, as well as several hundred articles in technical journals. A Data Center was established at Sioux Falls, South Dakota to handle the anticipated demand for data from the first Earth Resources Satellite. And the Survey's hope, cherished since the 1880's, of a building all its own was about to become a reality.

There are new elements in the Survey's program in the mid-seventies—and old goals. The topographic mapping program still aims at providing nationwide map coverage at scales most useful to meet the needs of map

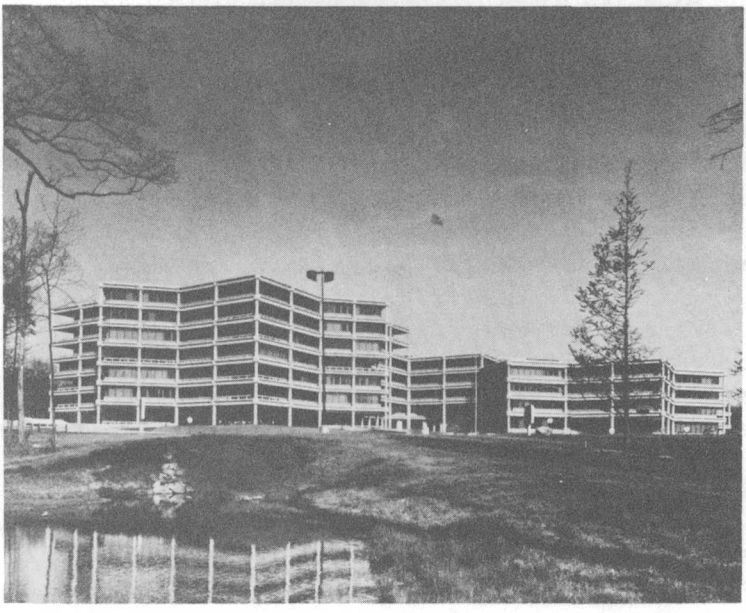
users. But now we have orthophotomaps as well as contour maps, the scale is more likely to be 1:24,000 than 1:250,000, and the maps are needed for a multitude of purposes as well as bases for geologic maps. Examinations of the mineral resources are still underway, but now we seek not seven but numerous metals, as well as construction materials and especially energy resources, offshore as well as onshore, and by satellite and submersible. Water studies, a far cry from the problem of irrigating the arid lands, now aim at problems such as waste disposal and siting of mines and plants as well as the quantity and quality of the water supply for communities. Classification of the public lands so that they might be reserved for their best use gave rise to a program of managing leased public lands which every year brings to the Treasury more than twice the Survey's annual appropriation. Now data are being sought nationwide on a systematic and comprehensive scale to plan better uses of all land—residential, industrial, and recreational as well as agricultural and mineral.

The few who began with the Survey in 1879 would undoubtedly be amazed at the size and complexity of today's operation and by the methods used by today's scientists and engineers. But just as surely they would approve. For the challenge then even as now was, in the words of the first Director, for the Nation "to utilize with the highest technical skill and with the utmost scientific economy, all elements of national wealth."

* * *

(from information provided by Mary C. Rabbitt)

John Wesley Powell Federal Building, National Center, Reston, Virginia.



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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.