UNITED STATES DEPARTMENT OF THE INTERIOR

ANNUAL REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE SECRETARY OF THE INTERIOR
FOR FISCAL YEAR ENDED JUNE 30, 1930

UNITED STATES DEPARTMENT OF THE INTERIOR

FIFTY-FIRST ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

1930

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Directors of the Geological Survey

CLARENCE KING, 1879–1881
JOHN WESLEY POWELL, 1881–1894
CHARLES DOOLITTLE WALCOTT, 1894–1907
GEORGE OTIS SMITH, 1907–

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ANNUAL REPORT

OF THE

DIRECTOR OF THE GEOLOGICAL SURVEY

DEPARTMENT OF THE INTERIOR,
GEOLOGICAL SURVEY,
October 15, 1930.

SIR: The appropriations made directly for the work of the Geological Survey for the fiscal year 1930 included 13 items, amounting to $2,182,671. In addition $150,000 was appropriated for printing and binding for the Geological Survey, and an allotment of $12,960 for miscellaneous supplies was made from appropriations for the Interior Department.

A detailed statement of the amounts appropriated and expended is given at the end of the report. The balance on July 31 was $8,149.

The total amount of funds made available for disbursement by the Geological Survey, together with State funds directly disbursed for work administered by the Federal officials, was $4,212,294.

A LOOK AHEAD

The work of scientific investigation is a continuing work, and its field always expands, never contracts. So in beginning a second half century of service to the Nation the United States Geological Survey looks out over wider opportunities. Its fifty-first year has been the largest and broadest year of its history in expenditures and in activities. More than $4,000,000 was expended in highly specialized service, yielding results much varied in type but alike in contributing to the industrial development of the country and widening man's understanding of his environment.

Only an observer with shortened and narrowed vision can forecast the termination or even any curtailment of such activities as those of the Geological Survey. Like the Department of the Interior as a whole, the Geological Survey has been most intimately connected with western development, and that development is to-day far from completed. It is true that the strictly exploratory work of the Geological Survey is now in large measure confined to Alaska, but the more intensive phases of agricultural, industrial, and mining development have barely been begun in much of the western territory. Indeed, with less than half of the area of the United States covered by accurate topographic maps and with an endless variety of geologic problems awaiting attention, the exploration

of the Nation's resources can hardly be regarded as completed, and their full utilization is plainly a matter of the somewhat distant future. In a year when its engineers are blazing trails in the forests of the extreme northeast and northwest corners of the country, he is a rash prophet who sees a speedy completion of the investigations of the Geological Survey—he fails to realize that our country is still young.

Some measure of the increasing activity of the Geological Survey is afforded in the statistical record of its fifty-first year. As compared with the preceding year, the fiscal year 1930 shows increases of nearly 10 per cent in total expenditures, nearly 20 per cent in new maps issued, and nearly 30 per cent in number of book publications. The personnel, of which more than 80 per cent is professional in type, was larger than even in the years when the Bureau of Mines was a branch of the organization. Indeed, the appropriations this year exceeded by 50 per cent those for 1910, the last year before the Bureau of Mines was separated from the Geological Survey, and the total expenditures in 1930, including cooperative funds, were more than double those in 1910. This 20-year period since the separation of these two services specially directed to the promotion of the mining industry has been one of notable growth for both; yet because of the postwar economies their growth has not approached that of the industry they serve.

Fifty years ago Director King in writing on this same subject—the future of the Geological Survey—pointed out that we were then only "at the very threshold of the industrial life of the Republic"; and he outlined the need of facts as to the primary or raw-material industries. His forecast of the future growth of the mineral industry and of the scale on which the Geological Survey should carry on its fact-finding investigations has proved surprisingly far short of the facts, both estimates being less than a quarter of what we now know to be the truth. Plainly, even that far-seeing scientist failed to grasp completely the problem of the material development of our country. And so to-day the vanishing point of our look ahead also may fall far short of true perspective.

The discovery of geology by industry in recent years has placed the small corps of Government scientists under new and larger obligations. The army of geologists and engineers in commercial work necessarily look to the Federal service for the collection of geologic facts and the working out of new generalizations and principles. Practical men realize that pure research of to-day is applied science of to-morrow, and they ask their Government to furnish the fundamentals.

High-pressure industrial development throughout the country has involved an increasing demand for raw materials, with a corresponding larger need of basic engineering information. It is significant that the demand for intensive study of ore possibilities is most active to-day in the same mining States, Colorado and Nevada, where the first mining work of the Geological Survey was done, the production of the epoch-making monographs on Leadville, Eureka, and the Comstock, which had as their purpose to meet the anxious desires "of miners as well as of students of geology and economy." The Geological Survey's special duty to help keep up the flow of

raw materials to industry is greater, not less, than it was 50 years ago.

Another phase of Governmental activity hardly foreseen in the beginning of the Geological Survey's existence is the degree to which the public domain is administered on a scientific basis. In the 20 years beginning in 1907 approximately a million dollars was spent for geologic work in areas in which the Federal Government owns coal lands. Upon this investment of appraising its property the Government is now collecting between $400,000 and $500,000 a year in royalties from coal mined from Government leases. The Government oil and gas leases have been still more productive, although the chief contribution of this service to the public interest has been the conservation of the natural resources belonging to the people. Even more important, however, than the enforcement of the best economic practices by the Federal engineers is their contribution to the conservation of life and health, both the zinc and the coal mines under Federal supervision showing better accident records than other mines in the same States. Larger attention to the Government's real-estate business in classifying the unused public lands and in supervising mining leases would pay good dividends.

The investigations of water resources, which at first sought simply the answer to the agricultural problem presented by the wide expanses of arid land in the West, now serve many purposes. Power development on a scale not approached elsewhere in the world has furnished added incentive to accurate stream measurement, and the quality as well as the quantity of water available for industrial and municipal use is now found an absolutely necessary subject of study in all parts of the United States. As the Secretary of the Interior has said, "In controlled water lies the future of our country." The exceptional drought of the present year has demonstrated to the public at large how essential an adequate supply of water is to modern life in all its phases. This field of investigation is expanding.

A similar evolution has taken place in topographic mapping. The work that produced the small-scale reconnaissance type of map has given place to more and more detailed surveying, with a product that can be used in planning engineering projects. New standards and new methods are constantly improving these maps, which as yet cover less than half the area of the United States. There is urgent need of completing these maps for use by this generation, but even were that end attained, the expansion of industrial projects and the advance of urban developments would necessitate a continuing program of revision and resurvey to make these "mother maps" of full and permanent utility.

The present accumulation of unanswered requests for needed work, the embarrassing abundance of untouched problems, and the broad expanse of unoccupied fields afford little basis indeed for any feeling that the activity of the Geological Survey will soon reach any state of diminishing returns. Rather, the prospect of investigations that promise large returns of public benefit becomes more inviting as the work expands. Not less attractive, too, is the field of scientific inquiry that yields products needed for educational and cultural use. Popular interest in science makes a legitimate demand upon the Federal scientific bureaus.

In short, the Geological Survey is a fact-finding agency, collecting and presenting the information regarding the country's natural resources necessary for the formulation of a national plan. The demand for such facts will continue as long as our people continue to carry on commerce and industry by a more intensive conquest of nature.

That " we are but started as a Nation " was the text of Secretary Wilbur's message at the formal opening of the project of harnessing the Colorado River. And every citizen of vision realizes that the future of this continent-wide country, blessed though it is with most of the natural advantages, must be built on more substantial foundations than those laid in the days of pioneer settlement and exploitation. Our wealth of resources must be more wisely used in the light of better science and better engineering. The prospects for winning a prosperity more generally distributed and more firmly established furnish the incentive for applying science to national welfare.

The one hundredth report of the Director of the United States Geological Survey may be expected to be simply a report of progress.

PUBLICATIONS OF THE YEAR

The following publications were issued during the fiscal year 1930:

ANNUAL REPORT

Fiftieth Annual Report of the Director of the Geological Survey.

MONOGRAPH

55. Titanotheres of ancient Wyoming, Dakota, and Nebraska, by H. F. Osborn.

PROFESSIONAL PAPERS

154. Shorter contributions to general geology, 1928.
154–A. Moraines and shore lines of the Lake Superior Basin, by Frank Leverett.
155. The flora of the Denver and associated formations of Colorado, by F. H. Knowlton.
156. Revision of the lower Eocene Wilcox flora of the Southeastern States, with descriptions of new species, chiefly from Tennessee and Kentucky, by E. W. Berry.
158. Shorter contributions to general geology, 1929.
158–B. The contact of the Fox Hills and Lance formations, by C. E. Dobbin and J. B. Reeside, jr.
158–C. The Helderberg group of parts of West Virginia and Virginia, by F. M. Swartz.
158–D. Petrography of the Pioche district, Lincoln County, Nev., by J. L. Gillson.
158–E. The varves and climate of the Green River epoch, by W. H. Bradley.
158–F. Contact metamorphism of the rocks in the Pend Oreille district, northern Idaho, by J. L. Gillson.
158–G. Early Pleistocene glaciation in Idaho, by C. P. Ross.
158–H. The flora of the Frontier formation, by E. W. Berry.
158–I. Borate minerals from the Kramer district, Mohave Desert, Calif., by W. T. Schaller.
165–A. Lithologic studies of fine-grained Upper Cretaceous sedimentary rocks of the Black Hills region, by W. W. Rubey.
165–B. A flora of Green River age in the Wind River Basin of Wyoming, by E. W. Berry.

BULLETINS

797. Mineral resources of Alaska, report on progress of investigations in 1926, by P. S. Smith and others.
799. Geology of the McCalls Ferry-Quarryville district, Pa., by E. B. Knopf and A. I. Jonas.
800. Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin.
806. Contributions to economic geology (short papers and preliminary reports), 1928, Part II, Mineral fuels.
808. Geology of the De Queen and Caddo Gap quadrangles, Ark., by H. D. Miser and A. H. Purdue.
809. Formulas and tables for the construction of polyconic projections, compiled by C. H. Birdseye.
810. Mineral resources of Alaska, report on progress of investigations in 1927, by P. S. Smith and others.
810–B. The Chandalar-Sheenjek district, Alaska, by J. B. Mertie, jr.
810–C. The Mount Spurr region, Alaska, by S. R. Capps.
811. Contributions to economic geology (short papers and preliminary reports), 1929, Part I, Metals and nonmetals except fuels.
811–A. The New World or Cooke City mining district, Park County, Mont., by T. S. Lovering.
811–B. Recent mining developments in the Creede district, Colo., by E. S. Larsen.
811–C. Indiana oolitic limestone, relation of its natural features to its commercial grading, by G. F. Loughlin.
811–D. The Rawlins, Shirley, and Seminoe iron-ore deposits, Carbon County, Wyo., by T. S. Lovering.
811–E. Tertiary volcanic tuffs and sandstones used as building stones in the upper Salmon River Valley, Idaho, by C. H. Behre, jr.
812–A. The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont., by C. E. Dobbin.
812–B. The Kevin-Sunburst oil field and other possibilities of oil and gas in the Sweetgrass arch, Mont., by A. J. Collier.
812–C. Geology and coal resources of the Meeker quadrangle, Moffat and Rio Blanco Counties, Colo., by E. T. Hancock and J. B. Eby.
812–D. Geology and oil resources along the southern border of San Joaquin Valley, Calif., by H. W. Hoots.
813–A. Mineral industry of Alaska in 1928 and administrative report, by P. S. Smith (with selected list of Geological Survey publications on Alaska).
813–B. The Chakachamna-Stony region, Alaska, by S. R. Capps.
813–C. Mining in the Fortymile district, Alaska, by J. B. Mertie, jr.
816. Geology of the Eagle-Circle district, Alaska, by J. B. Mertie, jr.
822–B. The Granby anticline, Grand County, Colorado, by T. S. Lovering.

WATER-SUPPLY PAPERS

578. The Mohave Desert region, Calif., a geographic, geologic, and hydrologic reconnaissance, by D. G. Thompson.
597. Contributions to the hydrology of the United States, 1928.
598. Geology and ground-water resources of North Dakota, by H. E. Simpson, with a discussion of the chemical character of the water, by H. B. Riffenburg.
599. Ground water in Yellowstone and Treasure Counties, Mont., by G. M. Hall and C. S. Howard.
600. Geology and ground-water resources of central and southern Rosebud County, Mont., by B. C. Renick, with chemical analyses of the waters by H. B. Riffenburg.
601. Surface water supply of the United States, 1925, Part I, North Atlantic slope drainage basins.
602. Surface water supply of the United States, 1925, Part II, South Atlantic slope and eastern Gulf of Mexico basins.
603. Surface water supply of the United States, 1925, Part III, Ohio River Basin.
604. Surface water supply of the United States, 1925, Part IV, St. Lawrence River Basin.

605. Surface water supply of the United States, 1925, Part V, Hudson Bay and upper Mississippi River basins.
606. Surface water supply of the United States, 1925, Part VI, Missouri River Basin.
607. Surface water supply of the United States, 1925, Part VII, Lower Mississippi River Basin.
608. Surface water supply of the United States, 1925, Part VIII, Western Gulf of Mexico basins.
609. Surface water supply of the United States, 1925, Part IX, Colorado River Basin.
610. Surface water supply of the United States, 1925, Part X, The Great Basin.
613. Surface water supply of the United States, 1925, Part XII, North Pacific slope drainage basins: B, Snake River Basin.
614. Surface water supply of the United States, 1925, Part XII, North Pacific slope drainage basins: C, Pacific slope drainage basins in Oregon and lower Columbia River Basin.
615. Surface water supply of Hawaii, July 1, 1924, to June 30, 1925.
616. Geology and water resources of the Kau district, Hawaii (including parts of Kilauea and Mauna Loa Volcanoes), by H. T. Stearns and W. O. Clark, with a chapter on ground water in the Hawaiian Islands, by O. E. Meinzer.
617. Upper Colorado River and its utilization, by Robert Follansbee.
618. The Green River and its utilization, by Ralf R. Woolley.
619. Geology and water resources of the Mokelumne area, Calif., by H. T. Stearns, T. W. Robinson, and G. H. Taylor.
621. Surface water supply of the United States, 1926, Part I, North Atlantic slope drainage basins.
624. Surface water supply of the United States, 1926, Part IV, St. Lawrence River Basin.
625. Surface water supply of the United States, 1926, Part V, Hudson Bay and upper Mississippi River Basins.
626. Surface water supply of the United States, 1926, Part VI, Missouri River Basin.
627. Surface water supply of the United States, 1926, Part VII, Lower Mississippi River Basin.
629. Surface water supply of the United States, 1926, Part IX, Colorado River Basin.
632. Surface water supply of the United States, 1926, Part XII, North Pacific slope drainage basins: A, Pacific slope basins in Washington and upper Columbia River Basin.
636–B. Suspended matter in the Colorado River in 1925–1928, by C. S. Howard.
636–C. The New England flood of November, 1927, by H. B. Kinnison.
636–D. Surface water supply of the San Joaquin River Basin, Calif., 1895–1927, by H. D. McGlashan.
636–E. Surface water supply of Pacific slope basins in southern California, 1894–1927, by H. D. McGlashan.
636–F. Water-power resources of the Umpqua River and its tributaries, Oreg., by B. E. Jones and H. T. Stearns.
637–A. Surface water supply of minor San Francisco Bay, northern Pacific, and Great Basins in California, 1895–1927, by H. D. McGlashan.

GEOLOGIC FOLIO

225. Fairfield-Gettysburg, Pa., by G. W. Stose and F. Bascom.

TOPOGRAPHIC AND OTHER MAPS

[The figures in parentheses indicate limiting parallels and meridians of the areas covered]

Alabama:
Barton (34° 30′–34° 45′; 87° 45′–88°).
Alaska:
Valdez and vicinity (60° 55′–61° 15′; 146° 10′–146° 55′).
Arizona:
Aztec (32° 45′–33°; 113° 15′–113° 30′).
Bridge Canyon (35° 37′ 30″–35° 52′ 30″; 113° 30′–113° 45′).
Yucca (34° 45′–35°; 114°–114° 15′).

Arkansas-Louisiana:
El Dorado (33°–33° 15′; 92° 30′–92° 45′).
California:
Allensworth (35° 45′–35° 52′ 30″; 119° 22′ 30″–119° 30′).
Alpaugh (35° 52′ 30″–36°; 119° 22′ 30″–119° 30′).
Delano (35° 45′–35° 52′ 30″; 119° 7′ 30″–119° 15′).
Ducor (35° 52′ 30″–36°; 119°–119° 7′ 30″).
Famoso (35° 30′–35° 37′ 30″; 119° 7′ 30″–119° 15′).
Hacienda Ranch (35° 45′–35° 52′ 30″; 119° 30′–119° 37′ 30″).
Inglewood (33° 54′–34°; 118° 18′–118° 24′).
Pixley (35° 52′ 30″–36°; 119° 15′–119° 22′ 30″).
Porterville (36°–36° 7′ 30″; 119°–119° 7′ 30″).
Quincy School (35° 45′–35° 52′ 30″; 118° 52′ 30″–119°).
Richgrove (35° 45′–35° 52′ 30″; 119°–119° 7′ 30″).
Sausalito School (35° 52′ 30″–36°; 119° 7′ 30″–119° 15′).
State, scale 1 inch=8 miles.
Stone (35° 45′–35° 52′ 30″; 119° 15′–119° 22′ 30″).
Stratford (36° 7′ 30″–36° 15′; 119° 45′–119° 52′ 30″).
West Alpaugh (35° 52′ 30″–36°; 119° 30′–119° 37′ 30″).
Colorado (see also Great Plains):
Grand Valley (39° 15′–39° 30′; 108°–108° 15′).
Northwestern Colorado (land classification; 39°–41°; 106° to Utah line).
Roan Creek (39° 15′–39° 30′; 108° 15′–108° 30′).
Great Plains:
Land classification of central Great Plains, sheets 4 and 5 (eastern Colorado).
Land classification of northern Great Plains (Montana, North Dakota, South Dakota, Wyoming). 8 sheets.
Hawaii:
Mauna Kea (19° 45′–20°; 155° 15′–155° 30′).
Idaho:
Casto (44° 30′–44° 45′; 114° 30′–115°).
Illinois (see also Kentucky-Illinois):
Blue Island (41° 37′ 30″–41° 45′; 87° 37′ 30″–87° 45′).
Brisbane (41° 22′ 30″–41° 30′; 87° 52′ 30″–88°).
Englewood (41° 45′–41° 52′ 30″; 87° 37′ 30″–87° 45′).
Frankfort (41° 22′ 30″–41° 30′; 87° 45′–87° 52′ 30″).
Harvey (41° 30′–41° 37′ 30″; 87° 37′ 30″–87° 45′).
Mokena (41° 30′–41° 37′ 30″; 87° 52′ 30″–88°).
Mount Sterling (39° 45′–40°; 90° 45′–91°).
Park Ridge (42°–42° 7′ 30″; 87° 45′–87° 52′ 30″).
Springfield (39° 45′–40°; 89° 30′–89° 45′).
Illinois-Indiana:
Calumet City (41° 30′–41° 37′ 30″; 87° 30′–87° 37′ 30″).
Calumet Lake (41° 37′ 30″–41° 45′; 87° 30′–87° 37′ 30″).
Dyer (41° 22′ 30″–41° 30′; 87° 30′–87° 37′ 30″).
Indiana (see Illinois-Indiana; Michigan-Indiana).
Kentucky. (See also Tennessee-Kentucky):
Lexington (38°–38° 15′; 84° 15′–84° 30′).
Taylorsville (38°–38° 15′; 85° 15′–85° 30′).
Kentucky-Illinois:
Paducah (37°–37° 15′; 88° 30′–88° 45′).
Kentucky-Ohio:
Greenup (38° 30′–38° 45′; 82° 45′–83°).
Kentucky-Tennessee-Virginia:
Middlesboro (36° 30′–36° 45′; 83° 30′–83° 45′).
Maine:
Katahdin (45° 45′–46°; 68° 45′–69°).
Michigan:
Corunna (42° 45′–43°; 84°–84° 15′).
Mount Clemens (42° 30′–42° 45′; 82° 45′–83°).
Michigan-Indiana:
Three Oaks (41° 45′–42°; 86° 30′–86° 50′).
Minnesota. (See Wisconsin-Minnesota.)
Montana. (See Great Plains.)

or informal talks at scientific, technical, and other meetings and contributed articles to the press, in order to give wider circulation to some of the salient results of the Geological Survey's work that are of general public interest. A list of these addresses and articles is given below.

ADDRESSES

The California situation, National Petroleum Association, Atlantic City, September 19.
American coal industry, American Institute of Mining and Metallurgical Engineers, San Francisco, Calif., October 7.
Development of the American coal industry, 1913–1928, prepared in collaboration with F. G. Tryon, World Engineering Congress, Tokyo, Japan, October 29.
International fellowship of engineers, World Engineering Congress, Tokyo, Japan, October 31.
Address, Washington Society of Engineers, Washington, D. C., February 5.
Discussion of unit operation, American Institute of Mining and Metallurgical Engineers, New York City, February 18.
Address, Women's Auxiliary, American Institute of Mining and Metallurgical Engineers, Washington, D. C., March 1.
Address, York Engineering Society, York, Pa., March 7.
The engineer as an economist, Engineers Club, Philadelphia, Pa., March 18.
Address, Washington Society of Military Engineers, Washington, D. C., March 19.
The university and natural resources, University of Arizona, Tucson, Ariz., April 24.
Petroleum resources of the United States, National Industrial Conference Board, New York City, May 15.
Address, Butte section, American Institute of Mining and Metallurgical Engineers, Butte, Mont., June 5.
The engineer's larger opportunity, Montana School of Mines, Butte, Mont., June 6.
Better citizens for Montana (not presented in person), University of Montana, Missoula, Mont., June 9.
Address, Lions Club, Washington, D. C., June 25.

ARTICLES

Agree on two domes, North Dome in doubt, California Oil World, July 18.
Letter to the editor, Coalinga Daily Record, August 9.
How does America stand in natural resources? Forbes, September 15.
California cooperation, California Oil World, December 26.
Practical conservation, United States Daily, February 5.
Gas conservation sorely needed in California, Oil and Gas Journal, February 20.
Natural resources, 1929, American Journal of Sociology, May.
Another year of cooperative effort, Oil Bulletin, June.

The branch chiefs also represented the Geological Survey at technical and other meetings, and some of them made addresses, a few of which are listed below:

Geology and the State, by W. C. Mendenhall, twenty-fifth anniversary of Illinois Geological Survey, Urbana, Ill., April 30.
Mountain building in Alaska, by P. S. Smith.
The geologic heritage of Alaska, by P. S. Smith,
The necessity of preserving level bench marks, by J. G. Staack, County Surveyors' Institute, Columbus, Ohio, February 6.

The most notable publication of the year was Monograph 55, Titanotheres of Ancient Wyoming, Dakota, and Nebraska, by Henry Fairfield Osborn, a monumental work in two volumes comprising 953 pages, 237 plates, and 797 text figures. This work is the culmi-

nation of investigations begun about 50 years ago, soon after the Geological Survey was organized. The study was undertaken by the distinguished paleontologist Othniel C. Marsh and after his death, in 1900, was assigned to Professor Osborn. The task has been long and difficult, but the results have transformed our knowledge of the early Tertiary geology of the Rocky Mountain basin region, and the history of the titanothere family in its evolution from small, weak forms to giant "thunder beasts" has afforded a unique opportunity to acquire new information as to the actual modes of evolution and to revise our theories as to the causes of evolution and of extinction.

A brief statement of the scope and extent of the Geological Survey's activities follows:

GEOLOGIC WORK

About 125 geologists and associated chemists and physicists were engaged in the study of problems connected with the rock crust of the earth and its resources available for the citizens of the United States. Mineral fuels, fertilizers, and structural materials were the subjects of the principal investigations, for the continued production of these raw materials is essential to present-day civilization.

Geologic work was done in 30 States and Hawaii, and, as in the past, there was active cooperation with State surveys, as well as with other Government agencies and nongovernmental scientific associations.

EXPLORATIONS IN ALASKA

In Alaska the Geological Survey performs pioneer service under frontier conditions. In the field season of 1929 a geologic reconnaissance was made near the headwaters of the Copper River, combined geologic and topographic reconnaissance surveys were conducted in the Lake Clark-Mulchatna region, and geologic work of a reconnaissance nature was continued in the Yukon-Tanana region, these three projects including about 3,600 square miles. The Navy Department again cooperated in aerial photographic work in southeastern Alaska, adding about 12,000 square miles to the 10,000 square miles photographed from the air in 1926. The resulting prints are now available for compiling drainage maps which can be utilized as bases for future topographic mapping.

Investigation of mineral resources and the collection of mining statistics were continued in connection with the field work of geologists and were combined with the supervision of operations under coal and oil leases on Government lands by the small staff at the two local offices maintained by the Geological Survey.

At the end of the fiscal year work on seven field projects had been started, including reconnaissance topographic mapping in the Ketchikan district, geologic and mining studies in the Taku Valley near Juneau, geologic investigations in the vicinity of the Alaska Railroad, geologic reconnaissance mapping of part of the Chulitna Valley and adjacent parts of Broad Pass, exploratory and reconnaissance topographic surveys in the Nushagak and adjacent areas of southwestern Alaska, geologic reconnaissance of the region lying north of the Yukon and adjacent to the international boundary, and a study of the general mining developments and conditions, with visits to such of the camps as time and other conditions permit.

TOPOGRAPHIC MAPPING

The topographic maps prepared as an essential base for detailed geologic mapping have proved to have hundreds of other uses, and the general realization of their value is shown in the increasing funds made available by States and other Federal units for cooperation in this work. The State cooperative funds during the year amounted to $441,851.91 and were furnished by 25 States, 3 counties, and Hawaii. The area mapped during the year amounted to 22,397 square miles, and the total area now mapped is 1,344,158 square miles. Nine

States, the District of Columbia, and Hawaii are completely mapped, and the percentages in the other States range from 8 in Florida to 90.8 in New Hampshire. Of the continental United States, exclusive of Alaska, 44.2 per cent has been mapped. River surveys amounting to 131 linear miles were also made. Some of the work in Washington and Hawaii was done by aerial photography. Surveys of the boundaries of the proposed Great Smoky Mountains and Shenandoah National Parks were continued. The other Government units for which surveys were made included the Forest Service, Bureau of Yards and Docks, Corps of Engineers, Navy Department, War Department, State Department, Biological Survey, and National Park Service.

INVESTIGATIONS OF WATER RESOURCES

The work on water resources consists primarily of research and investigation—the collection of facts in regard to the quantity, quality, availability, and utilization of water. The growing realization of the necessity of reliable data as a basis for water development of any kind is reflected in the persistent and increasing demand for such facts. The work is done largely in cooperation with other Government organizations, with State, county, and municipal agencies, and with permittees and licensees of the Federal Power Commission. The amount expended by State, county, and municipal agencies for such work during the year, in part directly and in part through the Geological Survey, was $397,971.25. This sum covered work in 34 States and Hawaii. Including the cooperative work, the study of surface waters, which consists primarily of the measurement of the flow of streams, was carried on in 47 States and Hawaii, in which at the end of the year 2,426 gaging stations were being maintained. The work on ground-water resources has been planned to meet the more and more exacting public demand for precise information with increasing need for the water. Investigations relating to ground water and power or reservoir sites were made in 26 States and Hawaii. Research into the principles of hydrology has been continued in order to provide a more secure basis for ground-water investigations. Cooperation was continued with well drillers' associations with a view to developing higher standards and better results in water-well drilling. The work on quality of water involved the examination of 1,180 samples of water. The investigations of power resources included the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants and reports on the origin of the coal used in such plants and the developed water power of the United States.

WORK IN CLASSIFYING AND LEASING PUBLIC LANDS

The classification of public lands with respect to their mineral, water power, and agricultural value and the technical supervision of mineral and power development on such lands and of mineral development on Indian lands were continued in 20 States and Alaska. The number of cases involving land classification acted on during the year was 17,379, and the results accomplished include net decreases of 58,126 acres in the area of outstanding coal withdrawals, of 1,881 acres in outstanding petroleum withdrawals, and of 280 acres in outstanding phosphate reserves. At the end of the year the total area classified as mineral in character amounted to 36,433,446 acres in 14 States and Alaska and the outstanding mineral withdrawals to 46,579,306 acres in 14 States. Definition of the "known geologic structure" of producing oil and gas fields was continued, and at the end of the year the net area so defined was 725,419 acres in seven States. Investigations to obtain information for classifying public land with respect to its value for the development of water power were made in one State. There was a net increase of 108,295 acres in the area included in power reserves, making a total of 6,587,865 acres in 20 States and Alaska, on which about 15,000,000 continuous horsepower can be developed. The net decrease in enlarged-homestead designations was 7,583,110 acres, making a total outstanding of 317,719,176 acres in 14 States, and the net increase in stock-raising homestead designations was 1,279,429 acres, making a total outstanding of 121,545,990 acres in 19 States. There was a net increase of 11,392 acres in public water reserves, and the total outstanding is now 429,823 acres in 12 States. The supervisory work on public lands subject to the mineral leasing laws was increased by the issuance of 120 leases, 320 permits, and 15 licenses, covering 559,987 acres, and decreased

by 10,184 cancellations and expirations of leases, permits, and licenses. The production of petroleum on such lands during the year was 27,419,509 barrels, of natural gas 39,124,116,000 cubic feet, and of gasoline 101,470,301 gallons, on which the royalty, rentals, and bonuses amounted to $4,148,608. The production of coal on such lands was 3,033,076 tons, of phosphate rock 22,101 tons, and of sodium salts 29,322 tons, on which the royalty, rentals, and bonuses amounted to $512,376. Supervision over oil and gas operations on naval petroleum reserves was continued, and the total production was 6,978,922 barrels of petroleum, 6,817,458,000 cubic feet of natural gas, and 25,567,986 gallons of gasoline, on which the royalty value was $1,612,167. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in eight States.

PUBLICATIONS

The increase in book publications of the year over other years was notable both in number and in pages, consisting of a gain of 29 per cent in number and 70 per cent in pages. Corresponding increases were shown in the manuscript edited and prepared for printing, the proofs read and indexes made, and the illustrations prepared. There were also increases of 18 per cent in maps published and of 174 per cent in maps edited and transmitted for engraving. The publications of the year consisted of 77 books and pamphlets of the regular series, 91 new or revised maps, 145 reprinted maps, and numerous circulars, lists of publications, etc. The total number of pages in the new book publications was 12,577. In addition to the publications in the regular series, 45 brief reports were issued in mimeographed form as memoranda for the press. The publications distributed numbered 833,343, of which 4,197 folios and 691,610 maps were sold for $46,480.18.

GEOLOGIC BRANCH

W. C. MENDENHALL, Chief Geologist

ORGANIZATION AND PERSONNEL

The administration of the geologic branch continued during the year to be conducted through 10 sections, as follows:

Paleontology and stratigraphy, T. W. Stanton, geologist, in charge.
Geology of metalliferous deposits, G. F. Loughlin, geologist, in charge.
Geology of areal and nonmetalliferous deposits, G. R. Mansfield, geologist, in charge.
Geology of iron and steel metals, E. F. Burchard, geologist, in charge.
Glacial geology, W. C. Alden, geologist, in charge.
Coastal Plain investigations, L. W. Stephenson, geologist, in charge.
Geology of fuels, H. D. Miser, geologist, in charge.
Volcanology, T. A. Jaggar, jr., volcanologist, in charge.
Petrology, C. S. Ross, geologist, in charge.
Chemistry and physics, George Steiger, chemist, in charge.

Claude E. Siebenthal, who had been ill for some months, was retired because of disability early in the fiscal year. Mr. Siebenthal died in Florida March 1, 1930. On June 20, 1930, R. C. Wells succeeded George Steiger as chief chemist, in charge of the section of chemistry and physics.

The professional force at the end of the year included 116 geologists of various grades, many of whom are not employed continuously, 7 chemists, and 2 physicists. During the year there were 14 appointments (1 associate geologist, 3 assistant geologists, and 10 junior geologists), 1 retirement, 2 transfers to other bureaus, and 2 resignations (1 geologist and 1 chemist). The subprofessional force comprises 5 draftsmen (1 temporary), 9 preparators of fossils (1 temporary), and 1 chief scientific aid, the changes being 1 addition from the clerical force, 2 appointments (preparators of fossils),

and 2 resignations (temporary draftsman and laboratory mechanic). In the clerical force there were 4 accessions and 4 separations, leaving a total of 27 clerks of various grades, 3 of whom are temporary.

ALLOTMENTS AND EXPENDITURES

The funds available for the work of the geologic branch for the fiscal year were as follows:

Geologic surveys	$350,000
Classification of lands	17,500
Volcanologic surveys	21,000
Investigating potash deposits	12,500
Repayments from other Federal departments	6,413
Repayments from State, city, and other cooperating organizations	28,692
	436,105

The expenditures from these funds may be classified approximately as follows:

Geologic investigations (economic and scientific, including volcanologic)	$329,233
Supervision, administration, services of clerical, technical, and skilled-labor forces, etc	105,489
Unexpended balances	1,383
	436,105

STATE COOPERATION

The first Director of the United States Geological Survey, in a communication to the State geologist of one of the Mid-Western States in 1880, said:

> The director desires to announce to you that he urges the inauguration and continuance of State surveys and wishes to cooperate with them to the mutual advantage of both.

Since that utterance of 50 years ago cooperation with State surveys has been an important element in the activities of the Federal Survey.

Cooperation between organizations engaged in work with similar objectives needs no advocacy. The State surveys are engaged in applying geology to the service of their respective States. The Federal Survey is engaged in rendering a similar service to the United States as a whole. Staffs, equipment, and available funds differ as between different State organizations and between these and the Federal organization. Each at any particular time may be relatively strong in certain particulars and relatively weak in others, for staffs are not permanent nor of uniform quality, and there are variations in the ability and the desire of legislatures to support the work. Obviously team work will be productive of more results, of higher quality, than isolated effort which disregards what others are doing in similar and perhaps adjacent fields.

The active State Geologists' Association provides a medium for the exchange of ideas and experiences between the representatives of the State organizations and thus fosters the efficiency of each. The Federal Survey, working sympathetically with the association, participates in and contributes to the exchange of ideas. It maintains direct cooperation with many of the State organizations—chiefly,

to be sure, in topographic mapping and work on water resources, partly because the States are usually not equipped for work of this sort, but also because by cooperating on the cost-sharing basis the needed base maps and stream-flow records become available to the States at a great saving in cost. Geologic cooperation is also maintained, though on a less extensive scale. Because the State surveys have their own geologic staffs, large or small, they have less need for geologic aid than for aid in other branches of the work. But as the Federal Survey geologic staff sometimes includes specialists in fields not represented on the staff of a State, it may be advantageous to the State to procure the services of these specialists through cooperation rather than to attempt development of such specialists on their own staffs—a process that may take several years. Again, many State geologic problems are also interstate, for State boundaries do not follow geologic boundaries. Many of these problems can be effectively attacked by cooperation between the geologic staffs of adjoining States. Others have phases that can not be solved without bringing together the evidence from broad areas overruning several State boundaries. In such problems the Federal Geological Survey may serve as a general integrating medium and thus render material aid to each State affected. Yet too often, by reason of an inadequate staff, it has not been possible for the Federal Survey to extend this appropriate and highly desirable type of cooperation to the States.

In some States there is either no official geologic survey or else an organization with only a small staff. Such States materially augment the work which they can do alone or which the Federal Survey could do alone by inviting the national organization to undertake economic or other surveys on a cost-sharing basis. The Federal Government and the State each contributes to the cost of the work, which is done under Federal auspices and by the Federal Survey staff, the resulting reports being printed either by the State or by the Government, as may be mutually agreed upon.

Many State geologists, past and present, have also at some time been members of the United States Geological Survey staff. This background of common experience does much to facilitate cooperation, to establish common standards, and to render the work, both State and national, of the greatest scientific and economic value.

WORK ON POTASH

On June 30, 1930, the Geological Survey completed its share of the fourth year of the potash investigations under the act approved June 25, 1926 (44 Stat. 768) as amended March 3, 1927 (44 Stat. 1388). This act authorized a 5-year program of cooperative core drilling, in which the Geological Survey was to select drilling sites, make chemical and mineralogical tests of the material obtained by drilling, and announce the results, and the Bureau of Mines was to execute contracts and to conduct drilling operations.

The selection of drilling sites has involved, in addition to the study and testing of Government cores, the collection and examination of thousands of samples of cuttings from oil wells in the Permian basin of Texas and New Mexico. (See report of the chemical laboratory, p. 26.) The examination of these cuttings has hitherto consisted principally of preliminary qualitative

chemical examinations, followed by quantitative determinations of potash in the more promising samples. This method, which provided satisfactory clues for the location of polyhalite beds, was found not to apply so well to the location of possible sources of the more soluble and more desirable potash minerals, such as sylvite, langbeinite, and carnallite. During this year, therefore, special attention has been paid to petrographic study of well cuttings to detect the presence of such minerals. This work, which also has involved thousands of determinations, has proved moderately effective and has been an influential factor in the location of all five drilling sites selected and recommended to the Bureau of Mines this year. Three of these sites were in New Mexico and two in Texas. Of the 21 sites thus far selected for drilling under the 5-year program 10 have been in New Mexico and 11 in Texas.

Cores were received from five Government tests, Nos. 12 to 16, and analytical and mineralogical work was completed on three of these; work on the last two was finished a few days after the end of the fiscal year.

Private core drilling was less active during the year, only two cores having been transmitted from permittees in New Mexico. This apparent slackening in private activity was due, however, to the change from core drilling to shaft sinking by the United States Potash Co. in New Mexico, the company that has done most of the core drilling. The activities of this company, which it is hoped may lead to early potash production in the New Mexico field, are attributable to the interest aroused by the Geological Survey's early announcements of potash discoveries in the Permian basin and more specifically to the subsequent discovery of grains of sylvite in cuttings from the McNutt No. 1 well in Eddy County, N. Mex., announced by the Geological Survey in April, 1926.

Press announcements of findings in four of the Government wells (Nos. 11–14) have been issued during the year. These indicate the discovery of beds of polyhalite of minable thickness and depth in wells 12 to 14 and of two areas (wells 12 and 13) in which sylvite, carnallite, or langbeinite is present, though probably not in sufficient quantity for commercial development.

A paper on the mineralogy of the drill cores from the potash field of New Mexico and Texas, by W. T. Schaller and E. P. Henderson, was submitted for publication. A paper on potash in the United States by G. R. Mansfield, was published in the Journal of Chemical Education.

WORK IN GEOLOGY BY STATES

ALABAMA

Studies of the iron ores of the State were continued by E. F. Burchard in cooperation with the Geological Survey of Alabama, and progress was made on the preparation of a cooperative report on the red ores of the northeastern part of the State. A short paper by Julia Gardner on a new Eocene *Leda* from Black Bluff was published in the Journal of the Washington Academy of Sciences.

ARIZONA

Reconnaissance stratigraphic examinations were made by H. D. Miser, J. B. Reeside, jr., and C. H. Dane in the Colorado Plateau region of northeastern Arizona, to collect data on early Mesozoic formations for the purpose of correlat-

ing some of these formations with those of the plateau region in adjoining States. A report on the investigations is in preparation. A report on iron ore on Canyon Creek, in the Fort Apache Indian Reservation, was prepared for the Indian Service by E. F. Burchard, who has also submitted a report on the same subject for publication in Contributions to economic geology. A report on the geology of the Camelsback dam site, Graham County, was made by Philip King for the Bureau of Reclamation. The chapter on the geology of Arizona to be embodied in the North American volume of Geologie der Erde, was completed by N. H. Darton.

ARKANSAS

A report on the geology and lead and zinc deposits of northern Arkansas, by E. T. McKnight, prepared under cooperative agreement with the Arkansas Geological Survey, is practically completed. Final completion awaits a brief visit to the region to settle some problems of stratigraphy and correlation. Progress was made by G. H. Girty in his study of the Morrow fauna of Arkansas and Oklahoma. A paper on deep wells that have reached basement rocks in the Coastal Plain in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas was prepared by H. D. Miser and E. H. Sellards, for publication by the American Association of Petroleum Geologists.

Publication: Bulletin 808. (See p. 5.)

CALIFORNIA

Additional field work near Barnwell, Searchlight, Nipton, and Kelso was done by D. F. Hewett in connection with his study of the geology and ore deposits of the Ivanpah quadrangle. Some progress was made on the report by Adolph Knopf on the copper deposits of Plumas County. A paper by Professor Knopf on certain of the problems involved has been published in Economic Geology. F. E. Matthes resumed work on his report on the geomorphology of the upper San Joaquin Basin. Field and office studies of the San Andreas rift were continued by L. F. Noble, partly in cooperation with the Metropolitan Water District of Southern California. A brief report was prepared for the district to aid it in determining the geologically most favorable places to cross the San Andreas fault zone with proposed aqueducts from the Colorado River.

Work at the Lassen Volcano Observatory, at Mineral, in charge of R. H. Finch, consisted of continuous operation of seismographs at Mineral and Viola, observations of temperatures of the hot springs, measurements of movements in the land-slip areas, and studies of certain of the flows in Lassen Volcanic National Park.

Manuscripts for reports on the geology and oil resources of the Elk Hills, by W. P. Woodring, P. V. Roundy, and H. L. Farnsworth, and on the geology of the eastern part of the Santa Monica Mountains and adjacent areas, Los Angeles County, by H. W. Hoots, were transmitted for publication; also a paper on names and definitions of the geologic units of California, by M. Grace Wilmarth. The Devil's Postpile and its strange setting are described by F. E. Matthes in an article for the Bulletin of the Sierra Club of California and some peculiar fossil forms from California and Mexico by W. C. Mansfield in the Proceedings of the United States National Museum. W. P. Woodring submitted the following short papers for publication in scientific journals:

Tertiary deposits bordering the Simi Valley [abstract]. Proceedings of Cordilleran section of Geological Society of America.

Upper Eocene orbitoidal Foraminifera from the Santa Ynez Range [abstract]. Proceedings of Cordilleran section of Geological Society of America.

Pliocene deposits north of Simi Valley.

Distribution and age of the marine Tertiary deposits of the Colorado Desert.

Publications: Professional Paper 158–I, Bulletin 812–D. (See pp. 4, 5.)

COLORADO

Cooperative work with the Geological Survey Board and the Metal Mining Board of the State of Colorado continued on an expanding scale under the general supervision of B. S. Butler. Mr. Butler and Q. D. Singewald continued the study of the Alma district, to be completed in 1931. With J. W. Vanderwilt Mr. Butler completed a study of the Climax district, which contains the largest molybdenum mine in the world. A preliminary report on the

Climax district was transmitted in July, 1930, for publication by the Colorado Scientific Society. W. S. Burbank continued work in the Ouray-Telluride area of the San Juan region. Some of his preliminary results have just been published by the Colorado Scientific Society in a paper entitled "Revision of the geologic structure and stratigraphy in the Ouray district of Colorado and its bearing on ore deposition." E. B. Eckel was appointed junior geologist to assist Mr. Burbank. T. S. Lovering completed his work on the Montezuma quadrangle and transmitted his final reports on that quadrangle and on the Breckenridge district. His paper on the geologic history of the Front Range, a by-product of the three years of work, has been published by the Colorado Scientific Society, and a preliminary paper on the mineral belt of the Front Range is in press with the same society. Mr. Lovering began a study of the Nederland tungsten district and examined several dam and reservoir sites in cooperation with the Denver Water Commission and the Bureau of Reclamation. E. N. Goddard, appointed junior geologist in June, is assisting Mr. Lovering in a study of the Jamestown district.

C. H. Behre continued work in the Iowa Gulch district and vicinity, south of Leadville, and the more significant results were published in the Proceedings of the Colorado Scientific Society in a paper entitled "Revision of structure and stratigraphy in the Mosquito Range and the Leadville district, Colorado," which is essentially a supplement to Professional Paper 148, on the geology and ore deposits of the Leadville district, and answers some of the questions raised in that report. Mr. Behre also spent a short time in the Sugar Loaf and St. Kevin districts, west of Leadville, to plan for a more thorough study later. Reconnaissance stratigraphic studies were made by H. D. Miser, J. B. Reeside, jr., and C. H. Dane in Sinbad Valley, Gateway, Paradox Valley, Gypsum Valley, Placerville, Ouray, and Durango, and by Mr. Dane in western Mesa and Montrose Counties in connection with studies on the stratigraphy and correlation of the Jurassic sandstones and associated formations of the Colorado Plateaus. A report on this subject including the plateau region of southwestern Colorado is in preparation. Mr. Reeside prepared a paper on the Cretaceous faunas in the section on Vermilion Creek, Moffat County, for publication in the Journal of the Washington Academy of Sciences. Edwin Kirk studied Devonian, Cambrian, and Ordovician sections near Ouray, Leadville, Aspen, Gilman, Glenwood Springs, and Colorado Springs. He continued the preparation of a paper on the Devonian stratigraphy of Colorado and nearly completed for outside publication his paper on the Harding sandstone of Colorado.

The coal resources, structure, and stratigraphy of the eastern Yampa coal field form the subject of a report in preparation by M. R. Campbell. Township descriptions of this field were completed by Mr. Campbell for the conservation branch. A comprehensive report on the geology of the entire San Juan region is being completed by E. S. Larsen, who contributed a short paper on the volcanic history of the San Juan Mountains for publication by the International Geodetic and Geophysical Union.

Publications: Professional Paper 155; Bulletins 811–B, 812–C, 822–B. (See pp. 4, 5.)

CONNECTICUT

See Mrs. E. B. Knopf's work in New York.

FLORIDA

W. C. Mansfield completed a paper on pelecypods of the Choctawhatchee marl of northwestern Florida prepared in cooperation with the Florida Geological Survey. Part VI of The molluscan fauna of the Alum Bluff group of Florida, the first of the gastropod papers, was completed by Julia Gardner.

GEORGIA

Field work in the Coastal Plain of Georgia, primarily for the preparation of a geologic map of the State, was begun by C. W. Cooke, in cooperation with the State geological survey.

HAWAII

In the Hawaiian Islands the work on volcanologic research in charge of T. A. Jaggar, jr., consisted of observations of Halemaumau, including mapping of changes in the pit, measurement from time to time of rim fissures, and measure-

ment of temperature stations at borings and at other points on the Kilauea floor; observations of Mauna Loa seismometrically and visually; operation of two 2-component seismographs and a newly set up vertical-component seismograph at the Kilauea station, a Japanese seismograph at the Uwekahuna Museum on the west cliff of Kilauea Crater, and 2-component seismographs under the direction of the observatory at Hilo and at Kealakekua, maintained by the Hawaiian Volcano Research Association; measurements of seismograms from Hawaii, Kodiak, and Dutch Harbor; publication weekly of the Volcano Letter; preparation of the Monthly Bulletin; designing, building, and repairing instruments and making tests with oscillating table; recording tide data from the Hilo gage; directing the work of the Hawaiian Volcano Research Association, including direction of research associates and travel to Honolulu meetings; maintaining time service by wireless at Kilauea and at Kealakekua.

In order that geologic surveys of the islands may be carried forward, Howard Powers, an assistant geologist, was appointed as assistant at the station. Mr. Powers made a reconnaissance of the island of Hawaii and began geologic mapping in Kona. He has also instituted systematic petrography as a part of the routine.

IDAHO

Field studies of the physiography and glacial geology of Fremont and Bonner Counties were continued by W. C. Alden, who also made progress on his report on the physiography of northern Idaho, eastern Washington, and western Montana. Partly in cooperation with the State, C. P. Ross made a reconnaissance of several small mining districts in south-central Idaho, and some of his results have been transmitted as short reports, part of which, on the geology and ore deposits of the Seafoam, Alder Creek, Little Smoky, and Willow Creek mining districts, have been published as mimeographed pamphlets by the Idaho Bureau of Mines and Geology. Another paper submitted for publication in Economic Geology is Classification of the lode deposits of south-central Idaho. A graphic history of metal mining in Idaho, by Mr. Ross, will be published by the Geological Survey in its Contributions to economic geology. Work in the Bayhorse quadrangle was continued by T. H. Hite, of the State Bureau, under Mr. Ross's direction. Cumulative results of Mr. Ross's work in Idaho are clarifying the hitherto obscure geologic features of one of the least-known regions in the Western States. Papers by G. R. Mansfield and C. P. Ross on old erosion surfaces in Idaho, discussions of a paper by A. L. Anderson on Cretaceous and Tertiary planation in northern Idaho, were submitted for publication in the Journal of Geology. Collections of Paleozoic and Tertiary invertebrates and Tertiary plants were identified by the paleontologists.

Publications: Professional Papers 158–F, 158–G; Bulletin 811–E. (See pp. 4, 5.)

ILLINOIS

W. W. Rubey completed field work and has made progress on the manuscript of a report on the Hardin and Brussels quadrangles, a cooperative project with the Illinois Geological Survey. The structural history of the Cap au Gres faulted flexure was described by Mr. Rubey in a paper for publication in the Bulletin of the Geological Society of America. David White continued his field and office studies in the cooperative project on the Pottsville flora of Illinois. He presented a paper on climatic implications of the Pennsylvanian flora for the quarter-centennial volume of the Illinois Geological Survey.

INDIANA

New species of Carboniferous invertebrates were described by G. H. Girty.

Publication: Bulletin 811–C. (See p. 5.)

IOWA

An article on the pre-Illinoian Pleistocene geology of Iowa, by W. C. Alden, was prepared for publication in the Journal of Geology.

KANSAS

A cooperative field conference on work on the Cretaceous of Kansas was held at Beloit, by J. B. Reeside, jr., with K. K. Landes and R. C. Moore, of the Kansas Geological Survey.

KENTUCKY

Drillings from a deep well in west-central Kentucky were studied by E. O. Ulrich. Collections of lower and middle Eocene plants were studied by E. W. Berry.

Publication: Professional Paper 156. (See p. 4.)

LOUISIANA

Studies of the petrography of the gypsum anhydrite cap rock of the salt dome at Sulphur were continued by Marcus I. Goldman. A revised map of the oil and gas fields of the State of Louisiana has been published. Cretaceous invertebrates from deep wells were identified by T. W. Stanton for several oil companies.

MARYLAND

Reports relating to investigations by L. M. Prindle of dam sites in the Potomac River system in Maryland were transmitted to the Corps of Engineers of the Army. Detailed reports on Baltimore and Frederick Counties are being prepared by A. I. Jonas for the Maryland Geological Survey, in informal cooperation with the United States Geological Survey. G. W. Stose did a little additional field work in connection with structural studies in Frederick and Washington Counties, the results of which will probably be incorporated in reports on the Hagerstown and Williamsport quadrangles.

MASSACHUSETTS

Further progress was made in the preparation of a report on the Taconic area, including the Berlin and Greylock quadrangles, by L. M. Prindle. (See also Mrs. E. B. Knopf's work in New York.)

MICHIGAN

Publication: Professional Paper 154–A. (See p. 4.) (The area described embraces the northern peninsula of Michigan.)

MINNESOTA

Publication: Professional Paper 154–A. (See p. 4.) (Describes that portion of northeastern Minnesota that was covered by a readvance of the Superior lode of the Labrador ice sheet late in the Wisconsin stage of glaciation.)

MISSISSIPPI

Well cuttings from the Bourland well, at Amory, were studied by Charles Butts and P. V. Roundy.

MISSOURI

E. O. Ulrich attended field conferences of the Missouri Geological Survey staff at several localities in the State in an effort to establish the sequence of the Eminence, Proctor, and Van Buren formations. New species of Carboniferous invertebrates were described by G. H. Girty. Carboniferous invertebrates were studied by P. V. Roundy.

MONTANA

Studies of the coal beds, structure, and stratigraphy of portions of Custer and Rosebud Counties were begun during the summer of 1929 and continued during May and June, 1930, by W. G. Pierce and party. A report on the geology and coal resources of the area is in preparation. A. J. Collier and party continued field mapping of the areal and structural geology and coal beds of McCone and Dawson Counties during the summer of 1929, and F. S. Parker began an extension of this investigation to cover portions of Richland and Dawson Counties in June, 1930. A report on the geology of the Little Rocky Mountains and the surrounding plains is in preparation by Mr. Collier. W. T. Thom, jr., continued field work in the Crow Indian Reservation, contributory to a report he has in hand on the geology and ground-water resources of Big Horn County and the Crow Reservation. A report on the Ashland coal field, Rosebud, Powder River, and Custer Counties, by N. W. Bass, has been submitted for publication by the Geological Survey.

A field study of the paleobotany of the Fort Union formation in eastern Montana was made by R. W. Brown. Cretaceous invertebrates were reported on by T. W. Stanton, and a report on Devonian invertebrates was made by Edwin Kirk for the Montana School of Mines. Further field work was done by W. C. Alden in parts of Sanders, Lake, Ravalli, and Beaverhead Counties, to gather additional data for his report on the glacial geology and physiography of portions of western Montana, northern Idaho, and eastern Washington. The study of the geology and mineral resources of the Libby quadrangle was continued by Russell Gibson. This work, begun as a Federal project in 1929, was continued in June, 1930, in cooperation with Lincoln County. The final report on the investigations of the greater Helena mining region by J. T. Pardee and F. C. Schrader is nearing completion. Mr. Pardee is also preparing a paper on late Tertiary faults in southwestern Montana.

Publications: Bulletins 811–A, 812–B. (See p. 5.)

NEBRASKA

Publication: Monograph 55. (See p. 4.)

NEVADA

Cooperation with the Nevada Bureau of Mines was established shortly before the beginning of the fiscal year, and under these auspices H. G. Ferguson resumed the study of mining districts in the Tonopah and Hawthorne quadrangles and the Tybo district, and T. B. Nolan began a resurvey of the Tonopah district. Developments at Tonopah have so greatly increased facilities for underground study since publication of the Geological Survey's report on the district in 1905 that much new light has been thrown on the complicated geologic problems. Mr. Nolan's preliminary report embodying these results was completed in June, 1930, for publication by the State Bureau of Mines. Further field studies were made by D. F. Hewett in portions of the Ivanpah quadrangle, and office work on his report on the geology and ore deposits of the quadrangle has progressed. Mr. Hewett also has in hand a report on examinations of manganese deposits in the vicinity of Las Vegas during 1929. The report by F. C. Schrader on the geology and ore deposits of the Carson Sink is nearing completion.

The report by Adolph Knopf and L. G. Westgate on the geology and ore deposits of the Pioche region was transmitted for publication as a professional paper. Edwin Kirk made a contribution to the Paleozoic stratigraphy of the region for incorporation in this report. Faulted fans west of the Sheep Range, southern Nevada, were described by C. R. Longwell in an article for the American Journal of Science.

Publication: Professional Paper 158–D. (See p. 4.)

NEW MEXICO

Field mapping of the coals of the Mesaverde formation of the southwestern edge of the San Juan Basin, in McKinley County, was continued by a party under the direction of J. D. Sears, and later by T. A. Hendricks, in 1929. Work to continue this mapping eastward and northward was resumed by Mr. Sears in 1930. Mr. Hendricks completed a manuscript on some details of sedimentation of the Mesaverde formation on the south side of the San Juan Basin for use as thesis material. A copy of this manuscript is in the open files of the geologic branch.

A reconnaissance survey of the Mesozoic stratigraphy in northwestern New Mexico was made by J. B. Reeside, jr., who also studied Cretaceous invertebrates from the Gallup region and the San Juan Basin. R. W. Brown reported on collections of fossil plants from the Mesaverde formation of the Gallup-San Juan Basin. G. H. Girty reported on various collections of Carboniferous invertebrates and described the new species in them. A paper on the correlation of the Jurassic sandstones of the Colorado Plateau region, including northwestern New Mexico, is in preparation by A. A. Baker, J. B. Reeside, jr., and C. H. Dane.

Informal cooperation with the New Mexico Bureau of Mines and Mineral Resources included continuation and extension of the work in the Magdalena mining district, begun some years ago by G. F. Loughlin. Field work in the district was completed, and substantial progress was made on the report.

A. C. Spencer continued preparation of his report on the geology and mineral resources of the Santa Rita district. The chapter on the geology of New Mexico for the volume on North America in Geologie der Erde has been completed by N. H. Darton. H. D. Miser and A. C. Spencer went to Carlsbad to serve on a board of review to consider a report by Kirk Bryan on the proposed enlargement of the Avalon Reservoir.

The work on potash is described on pages 14–15.

NEW YORK

Mrs. E. B. Knopf continued detailed geologic mapping and petrographic studies of metamorphism of crystalline schists in the Clove and Millbrook quadrangles. She submitted a paper entitled "Retrogressive metamorphism and phyllonitization" to the American Journal of Science, setting forth some of the results of her studies. W. B. Lang visited the mine of the Sterling Salt Co. at Cuylerville and examined a core at the University of Rochester to determine whether it contained potash. Further field work in the Taconic region, which includes the Berlin and Hoosick quadrangles, in New York, was done by L. M. Prindle, who also continued office work on his report covering the whole Taconic region.

OHIO

Progress was made on studies of Devono-Carboniferous faunas of Ohio by G. H. Girty.

OKLAHOMA

The fauna of the Sycamore limestone is described in a paper which G. H. Girty is preparing in collaboration with Mr. Cooper, of the Oklahoma Geological Survey. Mr. Girty is also preparing papers on the Morrow and the Moorefield faunas. P. V. Roundy is preparing a paper on the ostracodes and conodonts of the Sycamore limestone, and Edwin Kirk studied crinoids from this same formation. E. O. Ulrich studied the Tyner and Burgen formations in central and eastern Oklahoma, studied and reported on fossil invertebrates from the Simpson formation, and made a field study of that formation in the Arbuckle and Washita Mountains in cooperation with members of the Oklahoma Geological Survey. The sale of Osage leases at Pawhuska was attended by Mr. Roundy to advise the Indian Service concerning the adequacy of bids. A paper on deep wells that have reached basement rocks in the Coastal Plain in southeastern Oklahoma and adjoining areas was prepared by H. D. Miser and E. H. Sellards for the American Association of Petroleum Geologists.

OREGON

Work in cooperation with the Oregon State Mining Board, begun in June, 1929, continued throughout the year, with greatly increased scope in June, 1930. J. T. Pardee made preliminary examinations of several mining districts in western Oregon, and his report on the status of the industry has been released in mimeographed form. In June three parties under his direction were making detailed studies—A. F. Buddington and Eugene Callaghan in the Bohemia gold district, F. G. Wells and A. C. Waters in the Black Butte quicksilver district, and P. J. Shenon with assistants in the Takilma copper district. Mr. Pardee has continued examination of mineral deposits in outlying districts and has cooperated with the State Highway Department in a study of road materials.

In eastern Oregon D. F. Hewett examined accessible mines in the Sumpter quadrangle, to supplement data collected in 1914, and his paper on the present economic outlook of ore deposits in the quadrangle was completed soon after the end of the fiscal year. James Gilluly made a detailed study of the copper deposits that were the scene of considerable recent activity near Keating, in the Baker quadrangle, and less detailed studies of other districts in the quadrangle. His preliminary report on the deposits near Keating has been released in mimeographed form, and his final report is practically complete. In June Mr. Gilluly resumed work in the region with J. C. Reed, junior geologist.

Messrs. Pardee and Gilluly also examined several dam sites along the Columbia River for the War Department.

PENNSYLVANIA

In cooperation with the Pennsylvania Geological Survey investigations were continued by G. W. Stose on the Martinsburg shale, Delaware Water Gap quadrangle, and on the geology and mineral resources of the Hanover, York, Middletown, and Lancaster quadrangles, the reports on which will be published by the State organization. The manuscript for the geologic map of Pennsylvania to be published by the State Survey has been completed. Detailed reports on the geology and economic resources of the following quadrangles are in course of preparation for publication by the Federal Survey: Honeybrook and Phoenixville, by G. W. Stose; Butler and Zelienople, by G. B. Richardson; Tyrone, by Charles Butts. A paper on the unconformity at the base of the Medina sandstone in southeastern Pennsylvania was prepared by Mr. Stose for the Geological Society of America, and one on the gravel and peneplains of Pennsylvania for the Geological Society of Washington.

Devonian and Carboniferous invertebrates of the Bradford quadrangle were reported on by Mr. Butts. Paleozoic invertebrate collections obtained in eastern Pennsylvania by Mr. Stose were identified by E. O. Ulrich.

Publications: Bulletin 799, Folio 225. (See pp. 5, 6.)

SOUTH CAROLINA

A comprehensive report on the geology of the Coastal Plain of South Carolina is in preparation by C. W. Cooke.

SOUTH DAKOTA

D. F. Hewett examined manganese deposits at Chamberlain and prepared a brief report thereon entitled "Manganese-iron carbonate nodules in the Pierre shale near Chamberlain, S. Dak."

Publication: Monograph 55. (See p. 4.)

TENNESSEE

The Cretaceous and Tertiary formations of western Tennessee were examined in the field by L. W. Stephenson in informal cooperation with the Tennessee Geological Survey, in connection with a report on the Foraminifera to be prepared by I. G. Reimann for the State Geological Survey.

Publication: Professional Paper 156. (See p. 4.)

TEXAS

Field studies in Uvalde, Zavala, and Dimmit Counties, in cooperation with the water-resources branch in tracing the source of the water supply for the Winter Garden area, were made by L. W. Stephenson and Julia Gardner. Mr. Stephenson continued preparation of his monograph on the fossils of the Navarro formation of Texas. This work, which will require some additional field studies, is being done in cooperation with the Texas Bureau of Economic Geology, and the report will be issued as a publication of that bureau. Papers by Mr. Stephenson entitled "Unconformities in the Upper Cretaceous series of Texas" and "Two new mollusks of the genera *Ostrea* and *Exogyra* from the Austin chalk of Texas" were published in outside journals. Miss Gardner continued field work on the Eocene of southwestern Texas, which was supplemented by field work in Denmark and England and study of collections in museums of England, France, and Germany, for the purpose of establishing the Eocene age of the Midway formation.

Field and office work on the revised geologic map of the State was continued by N. H. Darton, who examined previously unmapped areas in the western and central parts of the State. He has prepared topographic base maps for many of the quadrangles in southwestern Texas. The geologic map of the Coastal Plain of Texas to be included in the new map of the State will incorporate, in addition to results of field investigations by Mr. Stephenson and Miss Gardner, data obtained from oil companies and other sources. Field studies of the geology of the Marathon Basin were continued by Philip King. This work is also partially contributory to the revised geologic map of the State.

A revised map of the oil and gas fields of Texas is in preparation. A paper by H. D. Miser and E. H. Sellards on deep wells that have reached basement rocks in the Coastal Plain of northeastern Texas was prepared for publication by the American Association of Petroleum Geologists.

Work on potash is described on pages 14–15.

UTAH

Detailed structural and stratigraphic studies in the Green River Desert and adjoining portions of the San Rafael Swell not previously mapped were begun in June, by A. A. Baker. A geologic report with special reference to stratigraphy and structure of the Monument Valley-Navajo Mountain district of the southern San Juan area is in preparation by Mr. Baker, who also completed his report on the geology and oil possibilities of the southeastern part of the Moab district, Grand and San Juan Counties. C. H. Dane carried on plane-table mapping and structural and stratigraphic studies in Grand County, a continuation of work begun in 1929. His report on the geology and oil possibilities of the Salt Valley area, Grand County, is being prepared.

The Book Cliffs coal field has been studied by D. J. Fisher, who has completed and transmitted a report on the general geology of the Book Cliffs southeast of Sunnyside and an economic contribution on the Book Cliffs coal field. Studies of the coals, stratigraphy, and structure of portions of the Wasatch Plateau are being continued by E. M. Spieker. The work is done primarily for the purpose of classifying the public lands as to coal resources, but reports descriptive of the scientific and economic results will also be prepared. A paper on the structure of the Manti-Salina area was submitted by Mr. Spieker for publication in the Bulletin of the Geological Society of America. A report on the correlation of the Jurassic sandstones and associated formations of the Colorado Plateaus, including southeastern Utah, is in preparation by A. A. Baker, J. B. Reeside, jr., and C. H. Dane. Early Paleozoic sections near Salt Lake City and Brigham City were studied by Edwin Kirk. T. B. Nolan continued office work on his report on the geology and mineral resources of the Gold Hill quadrangle. A paper on Paleozoic formations in this quadrangle was submitted for publication in the Journal of the Washington Academy of Sciences.

Publication: Professional Paper 158–E. (See p. 4.)

VERMONT

L. M. Prindle made a geologic reconnaissance trip through the Green Mountain Purchase area for the Forest Service in connection with a proposed national forest in this area. He also studied a part of the Taconic area, which includes the Bennington quadrangle, in southwestern Vermont. Mrs. E. B. Knopf made a short trip to northern Vermont and an adjoining section of Canada to study some of the schists and fault phenomena in the Green Mountains and their possible relations to similar phenomena in the Clove and Millbrook quadrangles, New York.

VIRGINIA

Charles Butts continued his field and office work in the Appalachian Valley, in cooperation with the Geological Survey of Virginia. The results of the investigations will be used in the revision of the geologic map of the State. The field work, a northward extension of that done during previous years, included portions of Craig, Roanoke, Montgomery, Botetourt, Alleghany, Rockbridge, and Augusta Counties. Special problems in stratigraphy and paleontology of this region were studied by E. O. Ulrich in company with Mr. Butts. The gravel deposits of Virginia were studied by M. R. Campbell in cooperation with the Virginia Geological Survey. L. M. Prindle examined the geology of certain dam and reservoir sites in the Valley of Virginia, for the Corps of Engineers.

A paper on silicified bog-iron deposits and associated silicified rocks at the contact between the Cambrian and Ozarkian (basal Ordovician), in Virginia, by M. I. Goldman, was published in Germany in a Festschrift in honor of Prof. Johannes Walther on the occasion of his seventieth birthday.

Publication: Professional Paper 158–C. (See p. 4.)

WASHINGTON

Field studies of the physiography and glacial geology of Chelan, Douglas, Grant, Lincoln, Okanogan, Ferry, Stevens, and Spokane Counties were continued by W. C. Alden, who also made progress on his report on the physiography of northern Idaho, eastern Washington, and western Montana. A paper on Columbia River terraces by Mr. Alden was delivered before the Geological Society of Washington. J. T. Pardee examined deposits of manganese on the Dosewallips River at Lake Crescent.

WEST VIRGINIA

Reports relating to investigations by L. M. Prindle of dam sites in the Potomac River system in West Virginia were transmitted to the Corps of Engineers.

T. A. Hendricks sampled coals from the Pocahontas coal fields for the use of the Bureau of Mines in a series of tests on the friability of coal.

Publication: Professional Paper 158–C. (See p. 4.)

WISCONSIN

W. C. Alden engaged in a field conference and the examination of glacial deposits in the northwestern counties of Wisconsin with E. F. Bean, State geologist.

Publication: Professional Paper 154–A. (Describes parts of northern Wisconsin that were covered by a readvance of the Superior lode of the Labrador ice sheet late in the Wisconsin state of glaciation.)

WYOMING

The origin and geologic history of the Tertiary rocks of the Green River Basin are being studied by W. H. Bradley, whose report on past investigations is well under way. Mr. Bradley made reports on the Alcova and Seminoe dam sites for the Bureau of Reclamation. J. B. Reeside, jr., and A. A. Weymouth completed a paper on mollusks from the Aspen shale (Cretaceous) of southwestern Wyoming, for publication in the Proceedings of the United States National Museum. A revised map of the oil and gas fields of Wyoming has been completed. The chapters on the Big Horn and Owl Creek Mountains, Wyoming and Montana, for incorporation in the volume on North America in Geologie der Erde, were completed by N. H. Darton.

Publications: Monograph 55; Professional Papers 158–E, 158–H, 165–A, 165–B; Bulletin 811–D. (See pp. 4, 5.)

MISSISSIPPI VALLEY

A detailed study of the geomorphology of the head of the Mississippi embayment was begun by F. E. Matthes as a part of a general study of the development of the lower Mississippi River. An understanding of the changes in the course of the river during its development and of the reasons for its present relations to the valley and to such physical features as Crowleys Ridge can hardly fail to be of importance in the consideration of any broad plan for river rectification or control.

BRAZIL

David White studied Mesozoic and Tertiary plants from the Geological Survey of Brazil.

VENEZUELA

A paper on the Pao deposits of iron ore in the State of Bolivar, Venezuela, was presented by E. F. Burchard at the meeting of the American Institute of Mining and Metallurgical Engineers in New York in February and was published by that organization as Technical Publication 295.

GENERAL INVESTIGATIONS

Investigations covering broad fields of geologic research or areas not confined to individual States are in progress by many of the geologists, and reports are in preparation on the following subjects:

Geology of the Rocky Mountains and northern plateau region, for Geologie der Erde, by J. B. Reeside, jr.; geology of the east-central United States, for Geologie der Erde, by Charles Butts; geology of the Great Basin, by D. F. Hewett; igneous rocks of the Great Basin, by James Gilluly; copper deposits of the southern Appalachian region, by C. S. Ross and M. N. Short; origin of chromite, by C. S. Ross; antimony deposits of the world, by F. C. Schrader; new estimates of the coal reserves of the United States, by M. R. Campbell; intercyclic interpolation of plates in Crinoidea, by Edwin Kirk; genus *Marginifera*, by G. H. Girty; genus *Productus*, by G. H. Girty; early Paleozoic cephalopods, by E. O. Ulrich and A. F. Foerste. Other investigations in progress are studies of stratigraphy and paleontology of the Appalachian Valley and of the Upper Cambrian trilobites of the family Telephidae, by E. O. Ulrich; Foraminifera of the Coastal Plain, by J. A. Cushman; micro-fossils, by P. V. Roundy; Cretaceous formations of the Western Interior province, by J. B. Reeside, jr.; and paragenesis of ore minerals, by M. N. Short.

Cooperative investigations with other organizations included work of David White and others in connection with committees of the National Research Council and the National Academy of Sciences.

The following papers giving the results of some of these studies were completed during the year and submitted for publication as professional papers or bulletins of the United States Geological Survey or through unofficial channels.

The kaolin minerals, by C. S. Ross and Paul F. Kerr. Shorter Contributions to General Geology. Abstract in Journal of the American Ceramic Society.

The Upper Cretaceous ammonite genus *Barroisiceras* in the United States, by J. B. Reeside, jr. Shorter Contributions to General Geology.

Microscopic determination of ore minerals, by M. N. Short. Bulletin of the United States Geological Survey.

Map of oil and gas fields of the United States.

Violarite and other rare nickel minerals, by M. N. Short and E. V. Shannon. American Mineralogist.

Occurrence and relations of alabandite, by D. F. Hewett and Olaf N. Rove. Economic Geology.

New Carboniferous invertebrates, II, by G. H. Girty. Journal of the Washington Academy of Sciences.

Dickite, a kaolin mineral, by C. S. Ross and Paul F. Kerr. American Mineralogist.

Correlation of Pleistocene coastal terraces, by C. Wythe Cooke. Journal of Geology.

Trophocrinus, a new Carboniferous crinoid genus, by Edwin Kirk.

The behavior of certain mud-crack casts during compaction, by W. H. Bradley. American Journal of Science.

Pleistocene seashores, by C. Wythe Cooke. Journal of the Washington Academy of Sciences.

Chromium, by W. D. Johnston, jr. Mineral Industry.

The incipient stages of rock metamorphism as recorded in coal, by M. R. Campbell. Economic Geology.

Stratigraphic names, by T. W. Stanton. Bulletin of the American Association of Petroleum Geologists.

Natural groups of coal and allied fuels, by M. R. Campbell. American Institute of Mining and Metallurgical Engineers.

A Cretaceous pelecypod with color markings, by J. B. Reeside, jr. Journal of the Washington Academy of Sciences.

Note on temperature gradients in the Permian Basin, by W. B. Lang. Journal of the Washington Academy of Sciences.

Outline of a suggested classification of coals, by David White. American Institute of Mining and Metallurgical Engineers.

Summary of nitrate deposits in the United States, by G. R. Mansfield, for presentation at meeting of Society of Economic Geologists.

WORK IN CHEMISTRY AND PHYSICS

E. P. Henderson resigned during the year to become assistant curator of the National Museum. His work was carried on temporarily by J. C. Reed and F. S. Parker, geologists, but they were later assigned to field work. At the end of the year R. C. Wells was designated chief chemist, thus relieving George Steiger, who will devote his time to research work.

The work in chemistry and physics includes tests necessary to the determination of rocks, ores, and minerals collected or received by the Geological Survey, qualitative and quantitative chemical analyses of specimens and samples collected by geologists, and researches relating to the problems in geology on which the Geological Survey is engaged.

During the year 363 samples were analyzed to furnish information in connection with studies being made by members of the Geological Survey and 2,900 specimens were identified for other persons. In addition 6,500 samples of cores and cuttings from 112 wells in Texas and New Mexico were analyzed or otherwise tested in connection with the exploration for potash. Petrographic examinations of the cores were made by W. T. Schaller, E. P. Henderson, J. J. Fahey, and F. C. Calkins, and chemical determinations principally by Mr. Fahey and E. T. Erickson. R. K. Bailey, stationed at Roswell, N. Mex., prepared logs of the well cores, made preliminary tests, and selected material for shipment to Washington for analysis.

J. G. Fairchild, who made most of the quantitative analyses of rocks during the year, also studied the reducing power of pyrite as measured by the nitrogen oxides evolved when it is heated with nitric acid. The diffusion of mixtures of gases through very small passages in rocks was studied by R. C. Wells for the purpose of explaining the origin of different natural gases. He also determined the solubility of some rare-earth nitrates in ether at ordinary temperatures.

Six days of field work was spent by W. T. Schaller in examining the soda pegmatites of the Maryland-Pennsylvania State line and a deposit of beryl in Maine. He also read several manuscripts critically, analyzed psittacinite from Arizona, studied the natural ammonium borates, among which a new species was identified, and prepared manuscript for a series of mineralogical notes covering the following subjects: Ptilolite from Utah; the mordenite-ptilolite group; clinoptilolite, a new species; hydrozincite from Nevada; tephroite from New Jersey; ludlamite from New Mexico; the ludwigite group; argentojarosite and associated secondary minerals from Utah.

Most of the time of George Steiger was devoted to administrative work. In collaboration with C. S. Ross he continued his studies of the function of water in the highly hydrated clay minerals. He also studied the chemical composition of the insoluble residue, other

than carbonate, in Indiana limestone and prepared a bibliography of chemical investigations relating to sedimentation for the National Research Council committee on that subject.

The science of radioactivity has in recent years contributed to geologic knowledge in several fundamental ways. It has offered geologists a new source of heat in the earth and a means of determining the age of certain minerals. Each of these subjects received attention from Geological Survey scientists the past year. C. E. Van Orstrand measured the temperature gradient in certain bore holes, and Mr. Wells analyzed some samarskites and uraninites for lead, uranium, and thorium, thus enabling the age of these minerals to be calculated. In addition, in conjunction with a determination of the atomic weight of the lead made by Prof. G. P. Baxter, of Harvard University, the results afford a means of determining the rate of disintegration of thorium during a very long period of time. These investigations have been urged and supported by Dr. A. C. Lane, chairman of the National Research Council committee on the determination of geologic time.

The investigations relative to potash, to which a large part of the time of the chemists was given, have consisted almost entirely in determining the percentage of potassium present and in identifying the minerals. Little has been done in explaining the conditions of formation of the minerals, but in a broad way it is clear that many chloride and sulphate minerals of potassium, resembling those of the German salt deposits, are present over an extensive area in New Mexico and western Texas. The progress of the year extends and confirms the findings recorded in last year's report.

In addition to attending to the usual administrative duties of the physical laboratory, Mr. Van Orstrand supervised investigations on geothermal gradients that are being conducted in Texas, Oklahoma, and California by the American Petroleum Institute, and in December, at the request of officials of that institute, he assumed the directorship of its project No. 26, an investigation that is being conducted in the physical laboratory of the Geological Survey by F. C. Weaver on a thermal conductivity method of gas analysis. Temperature tests were made in deep wells at Roswell, N. Mex.; Long Beach, Calif.; Thermopolis, Wyo.; Garnet, Kans.; and Florence, Kans. Considerable time was given to theoretical investigations on the flow and transfer of heat in the crust of the earth.

Laboratory methods and apparatus for finding the densities, porosities, and permeabilities of oil sands were further developed by P. G. Nutting and used in determining the properties of a great many oil sands from different localities. The results of some of these analyses have led to improvements in oil recovery in some fields. The study of adsorbing surfaces on silica and different silicates was continued, in particular their preparation and behavior toward water, petroleum, tar, and other substances. Many filtering clays were examined and tested. Further studies were made of the retention of moisture by clays under different conditions of humidity and temperature.

The following papers were completed during the year:

Fairchild, J. G., The volumetric determination of fluorine by the use of ferric chloride: Washington Acad. Sci. Jour., vol. 20, Apr. 19, 1930.

Nutting, P. G., The laws of distribution of particles in suspension: Science, new ser., vol. 70, p. 409, Oct. 25, 1929.

——— The stratified settling of fine sediments: Washington Acad. Sci. Jour., vol. 19, pp. 402–406, 1929.

——— Some physical problems in oil recovery: Oil and Gas Jour., Nov. 21, 1929, p. 44.

——— Adsorption and emulsion formation: Science, new ser., vol. 71, pp. 36–37, Jan. 10, 1930.

——— Vapor pressure and heat of vaporization: Ind. and Eng. Chemistry (in press).

——— The physical analysis of oil sands: Am. Assoc. Petroleum Geologists Bull. (in press).

Schaller, W. T., Crystal cavities in the New Jersey zeolite region (to appear as a bulletin of the Geological Survey).

——— and Henderson, E. P., Mineralogy of the drill cores from the New Mexico-Texas field (to appear as a bulletin of the Geological Survey).

Steiger, George, Investigations of chemistry that have a bearing on problems of sedimentation (to appear in annual report of committee on sedimentation, National Research Council).

Van Orstrand, C. E., Description of apparatus for the measurement of temperatures on deep wells; also some suggestions in regard to the operation of the apparatus, and methods of reduction and variation of the observations (to be published by the American Petroleum Institute).

Wells, R. C., Origin of helium-rich natural gas: Washington Acad. Sci. Jour., vol. 19, Sept. 19, 1929.

——— and Hess, F. L., Samarskite from Petaca, N. Mex.: Washington Acad. Sci. Jour., vol. 19, January, 1930.

——— The solubility of some rare-earth nitrates in ether: Washington Acad. Sci. Jour., vol. 20, Apr. 19, 1930.

——— Uraninite from Placer de Guadalupe, Chihuahua (to be published in American Mineralogist).

ALASKAN BRANCH

PHILIP S. SMITH, Chief Alaskan Geologist

ORGANIZATION AND PERSONNEL

The Alaskan branch consists of the chief Alaskan geologist, 3 geologists, 1 mining engineer, 1 coal-mining assistant, 2 topographic engineers, 1 draftsman, 4 clerks, and 1 minor apprentice lithographer. John B. Torbert, who had for many years done the greater part of the expert map drafting for the branch, died during the year.

SCOPE OF THE WORK

The task of obtaining information regarding the mineral resources of Alaska and assisting the industry in every practicable way has for many years devolved upon the Alaskan branch. In the third of a century that this work has been in progress the Geological Survey has published several hundred reports on various phases of the mineral industry of Alaska, and these have been accompanied by several hundred maps of different parts of the Territory. Practically every known mineral-producing camp has been visited by the geologists, engineers, and topographers of the Geological Survey, and reports regarding these camps have been issued. There still remain, however, extensive tracts of Alaska that have not yet been surveyed, though some of them are believed to hold promise

of containing mineral deposits that may be of value. In fact, although more than 40 per cent of the Territory has been surveyed, at least on exploratory standards, there is probably an area of more than 200,000 square miles that is regarded as of potential mineral value which should be studied as soon as funds and personnel can be assigned to the work. This is a conservative estimate and would exclude more than 100,000 square miles of country, such as the Yukon Delta and Yukon Flats, where, though there may be deposits of value, the services that can be rendered by geologists in a preliminary search would not be great enough to warrant much work until studies in other more promising areas have been completed.

Furthermore, it should be evident that the exploratory and reconnaissance standards that have been adopted for practically all the work so far accomplished in Alaska are adequate to give only general information, so that detailed investigations, such as are essential to the solution of most mining problems, are required for higher standards of work. The task of making a thorough inventory of the mineral resources of Alaska is a large one, on which only a start has yet been made.

FUNDS

The funds used by the Geological Survey in its Alaska work are provided in two items in the general act making appropriations for the Interior Department. One of these is "for continuation of the investigation of the mineral resources of Alaska." In the act for the fiscal year 1930 the amount appropriated was $67,500. In the similar act for 1931 the amount appropriated was $75,000. Each of these appropriations was made available immediately on the passage of the act in which it was contained. The other item is an allotment made from the appropriation "for the enforcement of the provisions of the acts of October 30, 1914, October 2, 1917, February 25, 1920, and March 4, 1921, and other acts relating to the mining and recovery of minerals on Indian and public lands and naval petroleum reserves." Allotments under this item are available only during the fiscal year specified. In each of the fiscal years 1929 and 1930 an allotment of $10,000 was made for work of this kind in Alaska. The two types of work indicated will be described for convenience as the work on mineral resources and the leasing work.

WORK ON MINERAL RESOURCES

PRINCIPAL RESULTS OF THE YEAR

The principal products of the Alaska work of the Geological Survey are reports and maps based on original surveys or investigations. During the year 21 such official reports have been issued or have been completed by their authors and approved for publication, as follows:

The Chandalar-Sheenjek district, by J. B. Mertie, jr. (Bulletin 810–B).
The Mount Spurr region, by S. R. Capps (Bulletin 810–C).
The mineral industry of Alaska in 1928, by Philip S. Smith (Bulletin 813–A).
Administrative report, fiscal year 1929, by Philip S. Smith (Bulletin 813–A).
The Chakachamna-Stony region, by S. R. Capps (Bulletin 813–B).
Mining in the Fortymile district, by J. B. Mertie, jr. (Bulletin 813–C).

Notes on the geology of upper Nizina River, by F. H. Moffit (Bulletin 813–D).
Mineral resources of Alaska: Report on progress of investigations in 1926, by Philip S. Smith and others (Bulletin 797).
Mineral resources of Alaska: Report on progress of investigations in 1927, by Philip S. Smith and others (Bulletin 810).
Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin (Bulletin 800).
Geology of the Eagle-Circle district, Alaska, by J. B. Mertie, jr. (Bulletin 816).
Geography and geology of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr. (Bulletin 815).
Mineral industry of Alaska in 1929, by Philip S. Smith (Bulletin 824–A).
Administrative report, fiscal year 1930, by Philip S. Smith (Bulletin 824–A).
Phototopographic work in southeastern Alaska in 1929, by R. H. Sargent.
The occurrence of gypsum at Iyoukeen Cove, Chichagof Island, by B. D. Stewart.
The Slana district, upper Copper River region, by F. H. Moffit.
The Lake Clark-Mulchatna region, by S. R. Capps.
Recent mining developments in the vicinity of Circle, by J. B. Mertie, jr.
The Upper Cretaceous floras of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds, by G. C. Martin (Professional Paper 159).
Glaciation in Alaska, by S. R. Capps.

Six short papers on the mineral production of Alaska and various phases of the work of the Alaskan branch were published as press bulletins.

Practically all the completed reports are accompanied by maps, the bases of which have been made principally from surveys conducted by the topographers of the Alaskan branch. The following maps have been published during the year:

Topographic map of Valdez and vicinity, by J. W. Bagley, C. E. Giffin, and R. H. Sargent; scale, 1:62,500. Published for sale.
Topographic map of Revillagigedo Island, by R. H. Sargent; scale 1:250,000. Compiled principally from aerial photographs taken by the Alaska Aerial Survey Expedition of the Navy Department, 1926. Issued in a preliminary photolithographic edition.
Map of Alaska; scale, 1:5,000,000. Containing index of Alaska maps and list of Alaska publications.
Topographic map of Goodnews Bay district, by R. H. Sargent and W. S. Post; scale, 1:250,000. Issued in a preliminary photolithographic edition.

Progress was also made in the preparation of a map of the Mount Spurr region and a map of the Lake Clark-Mulchatna region, scale 1:250,000, compiled from surveys in recent years in the Skwentna, Mount Spurr, Chakachamna-Stony, and Lake Clark-Mulchatna districts. Considerable work has also been done in compiling the results of recent surveys on a topographic map of the Yukon-Tanana region, scale 1:500,000, which has been in progress for several years, and in the revision of the map of Alaska on a scale of 1:2,500,000, with a view to the publication of a new edition for sale. The small general map of Alaska on a scale of about 80 miles to the inch is kept currently revised and reissued as frequently as required.

Besides the official reports, several articles were prepared by the scientific and technical members of the Alaskan branch for publication in outside journals, and 26 public lectures were given regarding the general work of the branch or some of its special features. Most of these were prepared unofficially but represent by-products of the regular work and serve to reach special audiences not readily reached by the official publications. Among the published articles may be mentioned the following:

Mountain building in Alaska, by J. B. Mertie, jr.; delivered before the Geological Society of Washington.

Alaska gold resources, by Philip S. Smith; published in Economic Geology.

Scientific work of the United States Geological Survey in Alaska in 1929, by Philip S. Smith; published in Journal of the Washington Academy of Science.

A new species of Tertiary cycads, by Arthur Hollick; for publication in Memoirs of the New York Botanical Garden.

Molybdenite deposit at Shakan, Alaska, by A. F. Buddington; for publication in Economic Geology.

Aerial photographing in southeastern Alaska, by R. H. Sargent; delivered at meeting of Association of American Geographers.

A study of the results of ice flow as shown in oblique and vertical photographs taken of glaciers in Alaska by R. H. Sargent; delivered at meeting of Association of American Geographers.

Photographing Alaska from the air, by R. H. Sargent; published in Military Engineer.

Glaciation in Alaska, by S. R. Capps; presidential address delivered before Geological Society of Washington.

Albert Perry Brigham, geologist, by Philip S. Smith; published in Annals of Association of American Geographers.

PROJECTS IN PROGRESS DURING THE SEASON OF 1929

The work done by the Geological Survey in connection with the study of Alaska is so diverse that it can not be reduced to common terms capable of unified tabulation or coordinated description. It embraces areal surveys that are readily definable in terms of square miles mapped, examinations in mining camps that cover only small tracts and yet require the outlay of much time and effort, and laboratory researches or office studies that exceed the scope of the original field investigations. The most comprehensive idea of the work of the Alaskan branch in 1929 may therefore be gained from descriptions of the projects undertaken.

In addition to the routine duties of supplying information to hundreds of inquiries received from the public and from other branches of the Government, the work of the branch consisted of seven principal projects, as set forth below.

Topographic supervision of aerial photographic work in southeastern Alaska was a continuation of a project started in 1926, when the Navy Department, at the request of the Geological Survey, photographed from the air about 10,000 square miles of southeastern Alaska, so that the resulting pictures might be used for preparing maps of the region. This work was so successful and of such inestimable value, not only to the Geological Survey but also to other Government bureaus, notably the Forest Service, that in the winter of 1928–29 the Geological Survey joined with the Forest Service in requesting the Navy Department to send another expedition to continue the work in tracts that had not been photographed. The Navy Department, recognizing the need of these bureaus and the excellent training that the work afforded for its own members, assigned the necessary personnel and equipment, under command of Lieut. Commander A. W. Radford. This unit photographed about 12,000 square miles of difficult country with speed, precision, and high technical competence, and the resulting films were turned over to the Geological Survey for cartographic use. In the course of this work many services were rendered to other Government bureaus concerned with Alaskan development. The successful accomplishment of this difficult piece of work without accident demonstrates the great value of the airplane as a means of transportation in a country that is almost untraversable by any other means and shows the economy that can be effected in many phases of the Geological Survey's work by this modern method of attack. In order that the naval officers might have knowledge of the requirements, a skilled topographic engineer of the Alaskan branch, R. H. Sargent, was attached to the expedition and served throughout its field work.

The turning over of the developed films ended the Navy Department's share of the work, but many steps must be taken before the data thus obtained are worked up into maps. As both the Geological Survey and the Forest Service required a print of each picture it was necessary to make nearly 50,000 separate prints—a task that occupied three men for about six months. This was a surprisingly good record, for two-thirds of the films required special manipulation to take out certain inclinations caused by the particular type of camera used, and all the work had to be done with close mathematical adjustments as well as photographic skill. This phase of the work was completed near the end of the fiscal year. The next step will be the mounting of these prints, most of which are assembled in groups of three on specially prepared cards. The prints must be accurately trimmed and mounted so that certain identifying marks on them will be brought into exact accord with other marks printed on the cards. This is a precise, time-consuming job that is estimated will take the equivalent of one man's time for a full year. From these mounted prints must then be taken the desired cartographic data, which will be compiled on a working sheet and supplemented by names and data from other sources to form a drainage map. This map will then be sent into the field to serve a topographer as a base on which to determine the altitude of all the natural features and represent them by means of contours. It is estimated that it will take more than 20 years before the area photographed in the two Navy Department expeditions will be worked up to this final stage if the current rate of progress is maintained. Obviously the rate should be much accelerated, but greater speed is impossible without additional funds.

A geologic reconnaissance of parts of the area lying near the headwaters of the Copper River and extending over into the drainage basin of the Tok River and its tributaries, north of the Alaska Range, was carried on by F. H. Moffit. This region was mapped topographically in 1902 on the exploratory standards of that day, and some geologic exploration was carried on at the same time. The geologic results were never published in full, however, and the great amount of geologic information that has been collected from near-by regions since that work was done raised many questions that could be answered only by a thorough field review and extension of the earlier observations. The region is one of direct and indirect importance in the search for workable mineral deposits in Alaska. It is of direct importance because it lies adjacent to areas that have long been known to be mineralized and to afford evidence of the presence of gold and lead and some indications of the presence of copper. Indirectly the area is of great geologic significance because it lies athwart the Alaska Range, and consequently the correct interpretation of its geologic history will throw light on the general history of the mountain building and related processes that were doubtless more or less closely connected with the mineralization of parts of Alaska. The tracing of the geologic sequence of events from the Copper River region on the south side of the mountains to the Tanana and Yukon Valleys on the north will greatly strengthen and supplement the information obtained from either district alone.

Combined geologic and topographic reconnaissance surveys in the Lake Clark-Mulchatna region were conducted by S. R. Capps, geologist, and Gerald FitzGerald, topographer. This party mapped more than 1,300 square miles of hitherto unsurveyed country and completed the work of blocking out the major features of an immense tract of the Alaska Range. The geologic results obtained show that this part of the range consists primarily of a great granitic intrusive mass which is flanked on the west by sediments and extrusive igneous rocks. Little prospecting has been done in the region, though placer gold has been recognized in some of the stream valleys and the presence of the great intrusive mass cutting a variety of other rocks offers some hope that lodes of value may be found in the vicinity of the contacts.

Geologic reconnaissance work was continued in the Yukon-Tanana region as part of the general project of coordinating the many observations that have been made in that region in the last 30 years and studying with more care certain tracts that had been passed by in the earlier surveys or given only cursory examination. The particular part of this large tract that was examined for this purpose in 1929 lies north of Fairbanks and west of Circle. This work was done by J. B. Mertie, jr., who revised or completed the mapping of the geology of about 1,500 square miles of country and visited almost all the producing placer camps in the Circle district. This season's work completes the field work on the major project of revising the geology of the tract lying between the Yukon and Tanana Rivers, but the office studies and preparation of a report and the maps to accompany it will require much additional time

and effort. The results of this critical study should be of much significance in explaining the general geologic history of the region and the conditions under which the mineralization was effected.

The collection of information regarding the output of minerals from Alaska was carried on as usual. The annual production reports are compiled on the basis of the calendar year, but the work of canvassing the producers and assembling the data is practically continuous.

The Geological Survey maintains in Alaska two district offices, one at Juneau and one at Anchorage. The main duties of the personnel attached to these offices relate to mineral leasing, but a part of their service relates to general investigations of mineral resources. Approximately two-fifths of the time of B. D. Stewart, who is in direct charge of the local offices, is allotted to general investigations of mineral resources, including visits to different parts of the Territory as conditions warrant. Mr. Stewart's long familiarity with mining matters throughout the Territory and his availability for consultation at Juneau have made his advice much sought by many of the Federal and Territorial agencies in Alaska, as well as by individual operators and prospectors. The Alaska offices also act as distributing points for publications of the Geological Survey and assist in furnishing the main office at Washington with information on many phases of the mineral industry of the Territory.

The customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active mining camps or those that have not been recently visited by members of the Geological Survey, was made by Philip S. Smith, chief Alaskan geologist. Earlier in the year Mr. Smith had attended the Fourth Pacific Science Congress in Java as one of the official delegates of the United States.

A field project in Alaska that does not fall within the jurisdiction of this branch was carried on by the volcanologic section of the geologic branch. Austin E. Jones, the representative of this section, reports that during July and August he installed specially designed and constructed seismographs at Dutch Harbor and Kodiak. The records obtained will be not only used to disclose the earth movements at those places but studied in connection with general volcanologic investigations relating to the whole northern Pacific Ocean Basin that are also being carried on simultaneously at stations in Hawaii and California.

In all the office work on the technical reports resulting from the field work the members of the Alaskan branch have received much assistance and valuable advice from their associates in other branches of the Geological Survey. T. W. Stanton, G. H. Girty, J. B. Reeside, jr., Edwin Kirk, David White, and E. W. Berry, paleontologists, have examined and reported on the fossils collected. The map editors have been especially helpful in critically scrutinizing the Alaska maps that were in course of preparation to see that they conform so far as practicable to the best Geological Survey standards.

The areas reported in the following table are based on the field season and not on the fiscal year. For this reason no account is taken of the work that was started during the field season of 1930 but remained uncompleted at the end of the fiscal year.

Areas surveyed by Geological Survey in Alaska, 1898–1929, in square miles

Field season	Geologic surveys			Topographic surveys		
	Exploratory (scale 1:500,000 or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)	Exploratory (scale 1:500,000 or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)
1898–1928	75,150	[a]174,305	4,277	55,630	208,530	4,066
1929		3,675			1,375	
	75,150	176,330	4,277	55,630	209,905	4,066
Percentage surveyed of total area of Alaska	43.6			46.0		

[a] Includes 1,650 square miles revised extensively in 1929, included also under 1929, and therefore counted only once in the total.

In this table only the net areas surveyed are listed in the appropriate column, though of course most of the areas that have been surveyed geologically have also been surveyed topographically. It is by no means unusual that areas surveyed hastily at first are later resurveyed with more precision on the same or a larger scale, and if the areas thus revised were not excluded from the totals the same areas would be counted twice.

The scale most commonly adopted for Alaska surveys, either geologic or topographic, is the reconnaissance scale (1:250,000), about 4 miles to the inch, with a contour interval of 200 feet. This scale is adequate for most general purposes, and the maps can be made expeditiously and cheaply. Obviously, however, so small a scale can not effectively show detailed features of topography or geology, and yet many of these are of prime importance in their relations to the mineral resources of the region. There is a constant demand for more detailed work, and this demand will become more and more insistent as the Territory develops. The present rate at which the work is being carried on is entirely inadequate to meet even the most general needs, and the requisite detailed mapping of the most promising tracts must be postponed far into the future or must supplant the equally pressing reconnaissance work unless more funds are available with which to speed up the work.

PROJECTS FOR THE SEASON OF 1930

Nine projects have been approved for the season of 1930. These projects had been under way for only a short time at the end of the fiscal year, and no specific details are available regarding the work accomplished. Seven of these projects which involve field work are reconnaissance topographic mapping in the Ketchikan district, geologic and mining studies in the Taku Valley near Juneau, geologic investigations in the vicinity of the Alaska Railroad, geologic reconnaissance mapping of part of the Chulitna Valley and adjacent parts of Broad Pass, exploratory and reconnaissance topographic surveys in the Nushagak and adjacent areas of southwestern Alaska, geologic reconnaissance of the region lying north of the Yukon and adjacent to the international boundary, and a study of the general mining developments and conditions, with visits to such of the camps as time and other conditions permit. The two projects that do not directly involve field work are the annual canvass of the mineral production from Alaska in 1930 and the preparation of the aerial photographs resulting from the Navy Department expedition in southeastern Alaska in 1929.

The topographic work in the Ketchikan district is needed by the Geological Survey in its studies of mineral resources and by the Forest Service and others who are concerned with the development of the power and pulpwood resources of the region. The party is in charge of R. H. Sargent, topographic engineer, and the work should be much facilitated by the fact that a drainage map of the entire area had been compiled from the aerial photographs taken by the Navy Department in 1926.

Late in 1928 and early in the spring of 1929 finds of sulphide ore in the Taku region, mostly within British Columbia, were reported and created considerable interest in the region, not only locally but sufficient to induce many outsiders to visit the field. In 1929 certain members of the Geological Survey viewed part of this region from the Navy airplanes, and it became apparent that there was a strip about 10 to 15 miles wide adjacent to the boundary but within the United States that might be worth prospecting. In order to obtain more adequate information regarding this area B. D. Stewart was assigned to carry on investigations there during the season of 1930.

The work in the vicinity of the Alaska Railroad was undertaken primarily in response to repeated requests from Col. O. F. Ohlson, as head of the railroad, that the Geological Survey assist by giving information as to ore deposits that might contribute to the tonnage carried by the railroad and by considering

some of the technical problems relating to mining that arise in connection with the operation of the railroad. As a result F. H. Moffit, who for more than 25 years has been engaged in the Alaska work, was assigned to the project. The precise service that can be rendered will have to be determined in the course of the work, but much of the time of the party will doubtless be devoted to the field examination of areas known to be more or less mineralized. The problem of assisting the mining industry of the Territory to take full advantage of the transportation facilities afforded by the railroad falls closely within the scope of the investigations that the Geological Survey has been carrying on for nearly a third of a century.

Related to the general problem of determining the mineral resources of the country near the Alaska Railroad are the investigations in the region adjacent to the head of Chulitna River, near Broad Pass, on the south flank of the Alaska Range. This work involves the geologic reconnaissance of a tract of nearly 1,000 square miles that had been surveyed topographically in earlier years but had not been examined geologically. S. R. Capps will be in charge of this survey. Close cooperation will be maintained between the Moffit and Capps parties, so that if time is available they may supplement the work of each other and examine additional mining camps adjacent to the railroad, knowledge of whose general conditions will have a bearing on the general problems of the region.

In southwestern Alaska, north of Bristol Bay, remote from ordinary lines of travel, is one of the largest unsurveyed tracts in Alaska, about which almost nothing is known. Near-by regions that have been examined by Geological Survey parties are mineral bearing, and there is strong reason for believing that the mineralization may extend into this region also. An expedition to determine these conditions, as well as the major features of the topography and other geographic facts, was assigned to Gerald FitzGerald, who reached the region by airplane from Anchorage. The principal purpose of the survey will be to serve as a guide in formulating more comprehensive plans for the geologic and topographic reconnaissance of the whole tract between Bristol Bay and the Kuskokwim, if the results obtained indicate the desirability of such a project.

The large tract of country lying north of the Yukon River, adjacent to the international boundary and south of the Porcupine River, is another of the great areas of Alaska about which almost nothing is known and in which practically no surveys have been made. A preliminary reconnaissance geologic survey in the southern part of this area is in charge of J. B. Mertie, jr. Some lines of evidence suggest that conditions favorable for local mineralization may be found in the region; but even if the search should not disclose mineral deposits of value, the area is likely to be of great geologic significance because observations made near its borders indicate that it is likely to contain one of the most complete Paleozoic sections to be found anywhere in Alaska and one that has undergone relatively little metamorphism. The general information that such a section is able to shed on the whole Paleozoic geology of Alaska can hardly be overestimated.

The general survey of Alaska mining conditions by the chief Alaskan geologist and the collection of statistics regarding the mineral output of Alaska will follow the same lines as heretofore.

If time and funds are available, a start will be made on the compilation, from the aerial photographs, of drainage maps of additional areas in southeastern Alaska. The Geological Survey has already received letters stating that the small drainage map of parts of the Ketchikan-Hyder region alone has saved thousands of dollars to persons developing the timber and power resources of that region. There is an equally urgent demand that a start on a similar mapping program be made in the vicinity of Juneau and on Admiralty Island, for which pictures are also available.

EXPENDITURES

The funds appropriated for the work of the Geological Survey on Alaska's mineral resources are generally made available immediately on the passage of the act, so that during a large part of any field season two appropriations are running concurrently. The following

statement shows the principal objects for which the funds appropriated during the fiscal year 1930 were expended:

Expenditures from funds appropriated for investigation of mineral resources of Alaska for the fiscal year 1930

Projects for the season of 1929	$13,016
Projects for the season of 1930	12,700
Administrative salaries, July 1, 1929, to June 30, 1930	3,410
All other technical and professional salaries, July 1, 1929, to June 30, 1930	29,168
All other clerical and drafting salaries, July 1, 1929, to June 30, 1930	7,894
Office maintenance and expenses	1,312
	67,500

Of the $25,716 allotted to field projects for the two seasons about 65 per cent was allotted to geologic or related general work and 35 per cent to topographic work.

The item for administrative salaries includes only those salaries that are directly related to general administration and does not include charges for administration such as each party chief is called on to perform with regard to the party in his charge. The low cost of administration is due principally to the fact that the administrative officers are engaged also in technical projects, which therefore bear their proportional charge of their salaries.

LEASING WORK

Part of the activities of the Alaskan branch are related to the proper conduct of mining work on the public mineral lands that have been or may be leased to private individuals or corporations under certain laws. Funds for this work throughout the United States are provided in a general item contained in the Interior Department appropriation act. The amount that was allotted to Alaska for the fiscal year 1930 was $10,000.

In order that the policies and practices that have been developed by the leasing unit of the conservation branch of the Geological Survey for handling the much larger volume of similar work in the States should be maintained in Alaska and at the same time the specialized knowledge of Alaska affairs possessed by the Alaskan branch should be utilized, the general conduct of the leasing work in Alaska is in a measure shared between the two branches, the office work in Washington being done principally by the conservation branch and the field work by the Alaskan branch. B. D. Stewart, supervising engineer, who has headquarters at Juneau, is in immediate charge of the field work, assisted by J. J. Corey, coal mining engineer, at Anchorage. The use of the same personnel and facilities for both the leasing work and the work on mineral resources avoids duplication of activities, lowers costs, and focuses the technical facilities on the main problem, which is the development of the Territory's mineral resources. At present about three-fifths of Mr. Stewart's time, all of Mr. Corey's time, and two-thirds of the time of a clerk in the Anchorage office are considered to be devoted to the leasing work. In the fiscal year 1930 the allotment for field expenses was approximately $1,500, an amount that is inordinately low and that

proved adequate only because the Alaska Railroad has extended to the limit its services in facilitating the movement of the engineers.

The primary purpose of the leasing work is to supervise the operations under the coal and oil leases or permits that have been granted by the Government and to advise and consult with the proper authorities, both Federal officers and private applicants, regarding lands that may be under consideration for lease or permit. Practically all the coal mining and much of the oil prospecting in Alaska is done on public lands by private individuals or companies under leases or permits issued by the Secretary of the Interior. The interest of the Government in these lands requires not only that these grants shall be a source of revenue to the Nation but that proper methods of extracting the minerals shall be employed, thus preventing waste or damage to the property, and that the lives, health, and welfare of those engaged in the work shall be properly safeguarded. Practically all the producing coal mines that have been opened in the Territory are in the region adjacent to the Alaska Railroad. The Government has therefore an especial interest in their successful operation. For this reason the Federal engineers have given intensive study to the problems confronting these mines and have been especially active in supervising their operations, not only to see that the terms of the leases are observed but also to be of as much assistance as possible to the small operators who are opening them, by giving them competent technical advice and aiding them in making their ventures successful. This service is appreciated by the operators, and the relations between them and the engineers are extremely cordial and friendly, with no hint of the antagonism that sometimes exists between inspector and inspected.

TOPOGRAPHIC BRANCH

J. G. STAACK, Chief Topographic Engineer

ORGANIZATION AND PERSONNEL

Changes in the administrative personnel of the topographic branch were necessitated by the resignation of Col. C. H. Birdseye, who had been chief topographic engineer since October 1, 1919, and under whose leadership the technical work had made notable advances. At the end of the year the organization of the topographic branch was as follows:

Atlantic division, Albert Pike, division engineer, in charge.
Central division, H. H. Hodgeson, division engineer, in charge.
Pacific division, T. G. Gerdine, division engineer, in charge.
Section of inspection and editing, W. M. Beaman, topographic engineer, in charge.
Section of computing, G. W. Hawkins, geodetic engineer, acting in charge.
Section of photographic mapping, J. H. Wheat, topographic engineer, in charge.
Section of cartography, A. F. Hassan, cartographic engineer, in charge.
Map information office, J. H. Wheat, topographic engineer, in charge.

Including the above-named engineers, the technical force comprises 169 topographic, geodetic, or cartographic engineers of various grades and 71 engineering field aides and draftsmen of various grades—a total of 240—a corps of trained topographic engineers larger than that of any other similar organization in the world. The clerical force comprises 16 clerks.

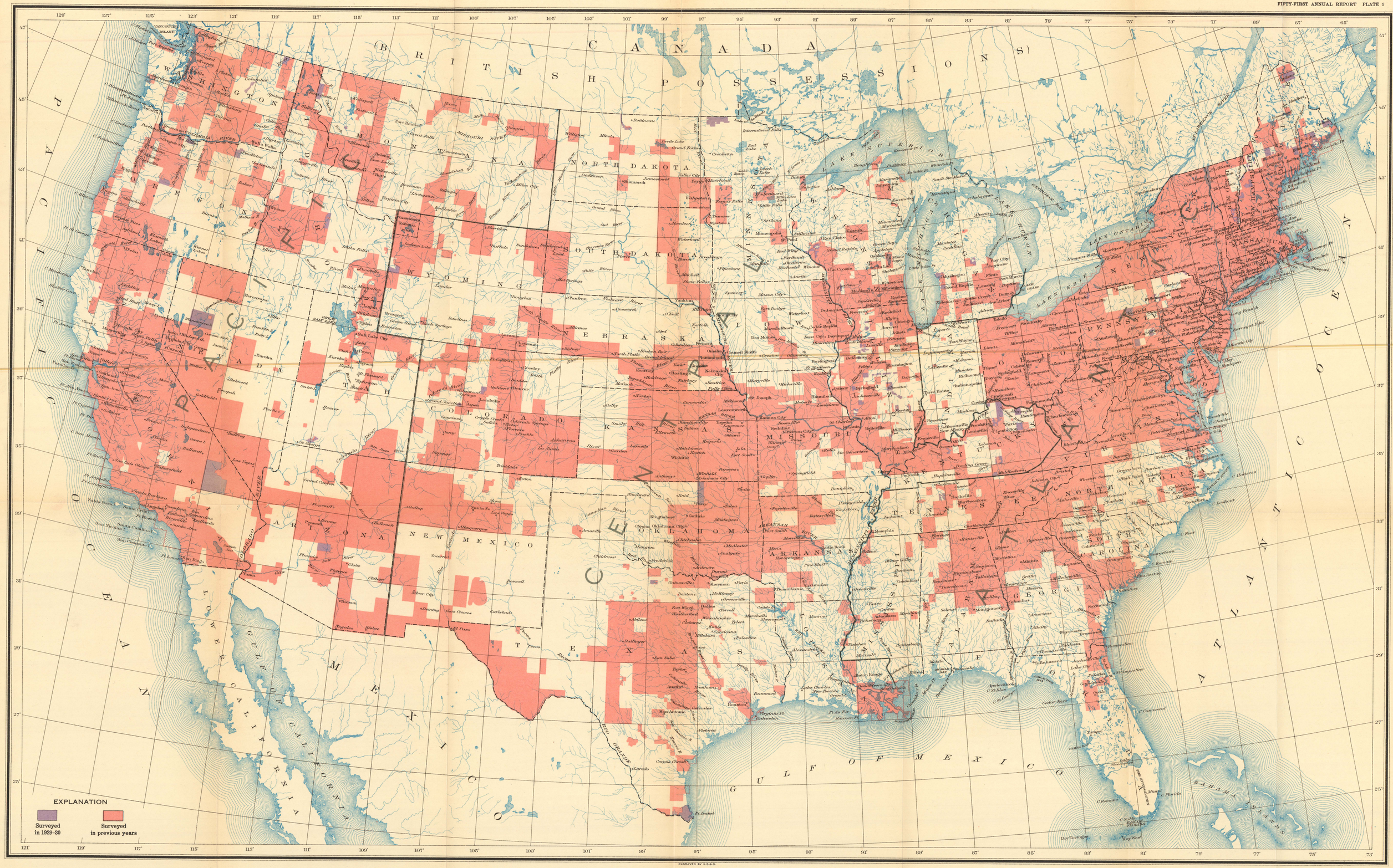
EXPENDITURES

An analysis of the expenditures for topographic mapping in the table which follows will show that the Geological Survey supplements to a large extent its own appropriations with State and other Federal funds for similar purposes, under a policy of cooperation which standardizes the topographic work and reduces its cost. Thus the total expenditures for topographic mapping were $1,286,589.85.

Appropriations and expenditures for topographic surveys for the fiscal year ended June 30, 1930

State or project	Appropriation for topographic surveys	Transfers and repayments for work performed for other Federal units	Total Federal funds	State cooperative funds	Total funds
Topographic surveys, 1930	$635,000.00	$127,368.76	$672,368.76	$441,851.91	$1,204,220.67
Great Smoky National Park, 1929-30	57,945.84		57,945.84		57,945.84
Shenandoah National Park, 1929-30	33,924.78		33,924.78		33,924.78
Total funds available	726,870.62	127,368.76	854,239.38	441,851.91	1,296,091.29
Expenditures:					
Alabama	8,072.75		8,072.75	10,000.00	18,072.75
Arizona	7,775.25		7,775.25		7,775.25
Arkansas	863.03	28.33	891.36		891.36
California	53,702.44	1,216.09	54,918.53	54,705.46	109,623.99
Colorado	13,732.50		13,732.50	5,000.00	18,732.50
District of Columbia		1,916.81	1,916.81		1,916.81
Georgia		21,082.49	21,082.49		21,082.49
Hawaii	12,539.92	997.48	13,537.40	21,309.34	34,846.74
Idaho	12,639.70	197.24	12,836.94	1,000.00	13,836.94
Illinois	75,002.74		75,002.74	56,884.80	131,887.54
Iowa	2,021.89		2,021.89	1,453.06	3,474.95
Kentucky	62,234.72		62,234.72	48,779.13	111,013.85
Maine	47,033.97	8,163.36	55,197.33	44,453.39	99,650.72
Michigan	34,636.86		34,636.86	23,945.48	58,582.34
Minnesota	2,077.34	25,810.17	27,887.51	3,086.98	30,974.49
Missouri	4,502.41		4,502.41	3,600.00	8,102.41
Montana	11,085.07		11,085.07		11,085.07
Nevada	5,287.89		5,287.89	1,910.88	7,198.77
New Hampshire	15,273.73		15,273.73	15,772.63	31,046.36
New Mexico	702.72		702.72		702.72
New York	3,513.92		3,513.92	8,653.98	12,167.90
North Carolina	28,672.48		28,672.48		28,672.48
North Dakota	2,783.75		2,783.75	1,914.40	4,698.15
Oklahoma	17,734.88		17,734.88	13,387.36	31,122.24
Oregon	14,457.54	9,072.67	23,530.21	4,287.58	27,817.79
Pennsylvania	23,558.89		23,558.89	24,997.50	48,556.39
South Carolina		21,894.44	21,894.44		21,894.44
Tennessee	41,195.04	1,266.25	42,461.29	13,999.23	56,460.52
Texas	48,077.14		48,077.14	37,148.37	85,225.51
Utah	11,928.89		11,928.89		11,928.89
Vermont	9,119.23		9,119.23	4,957.26	14,076.49
Virginia	65,185.00		65,185.00	22,425.99	87,610.99
Washington	11,486.24	30,134.85	41,621.09	1,284.91	42,906.00
West Virginia	3,264.93		3,264.93	2,500.00	5,764.93
Wisconsin	21,620.75	310.34	21,931.09	14,394.18	36,325.27
Wyoming	6,339.33		6,339.33		6,339.33
Miscellaneous repay		5,278.24	5,278.24		5,278.24
Computing	[a] 3,088.11		3,088.11		3,088.11
Contingent	550.54		550.54		550.54
Field distribution offices	600.00		600.00		600.00
Instruments (field)	[a] 3,138.55		3,138.55		3,138.55
Stationery (field)	[1] 183.04		183.04		183.04
Inspection and editing	[a] 6,691.85		6,691.85		6,691.85
Map information	3,551.50		3,551.50		3,551.50
One-millionth maps	8,196.74		8,196.74		8,196.74
Office of the chief topographic engineer	[a b] 8,170.87		8,170.87		8,170.87
Photographic mapping	[a] 4,902.92		4,902.92		4,902.92
Books for library	172.12		172.12		172.12
Total expenditures	[c] 717,369.18	127,368.76	844,737.94	441,851.91	1,286,589.85
Unexpended balance	[d] 9,501.44		9,501.44		9,501.44
Grand total	726,870.62	127,368.76	854,239.38	441,851.91	1,296,091.29

[a] Represents noncooperative portion of total cost; balance included in charges for State cooperation.
[b] Includes office salaries.
[c] $502,761.66 expended on State cooperation.
[d] Includes $7,020.10 Great Smoky National Park funds available during the fiscal year 1931.



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AREAS COVERED BY TOPOGRAPHIC SURVEYS MADE BY UNITED STATES GEOLOGICAL SURVEY PRIOR TO JULY 1, 1930

AND TERRITORY COVERED BY DIVISIONS OF TOPOGRAPHIC BRANCH

Scale 1/7000000

300 250 200 150 100 50 0 50 100 200 300 STAT. MILES

GENERAL OFFICE WORK

Incidental to the field work there is necessary office work, which consists in the inking and inspection and editing of the topographic field sheets prior to their submission for reproduction, in the computation and adjustment of the results of control field work, and in the preparation of partial culture and drainage bases from aerial photographs. During the year base maps of South Carolina, Texas, and Colorado were revised, republication of State maps being a valuable service to the users of maps who desire the State units. Stereoscopic mapping of the upper Columbia River, Washington, from aerial photographs was begun. Cooperation with the Air Corps, United States Army, was continued whereby aerial photographs were furnished for use in topographic mapping. In addition to this cooperative aerial photography, contracts were awarded to commercial firms for aerial photographic work, and the increased use of this valued adjunct to topographic mapping necessitates much skilled office work. (See also p. 81, Inspection and editing of topographic maps.)

SUMMARY OF RESULTS

The condition of topographic surveys to June 30, 1930, is shown on Plate 1. The status of topographic surveys is set forth in the following table, which shows a notable increase in the area covered by new surveys and resurveys, as compared with the preceding year. California, Illinois, Kentucky, Maine, and Texas are the States in which the largest amount of work was done, owing to their large cooperative appropriations. The Territory of Hawaii has taken its place with the few States completely mapped; and it may be further noted that the country as a whole is now 44.2 per cent mapped, the year's increment amounting to six-tenths of 1 per cent. The resurveys in large part covered areas previously surveyed on a smaller scale.

New topographic surveys of the United States, July 1, 1929, to June 30, 1930, and total area surveyed in each State

State	Publication contour interval (feet)	Mapped in fiscal year (square miles) for publication on scale of 1 to—							Total area mapped in fiscal year (square miles)			Total area mapped to June 30, 1930 (square miles)	Percentage of total area of State mapped to June 30, 1930	River surveys, scale 1 : 31,680 (linear miles)	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied
		12,000	20,000	24,000	31,680	62,500	125,000	250,000	Revision	Resurvey	New survey						
Alabama	20					126				126		21,491	41.3			110	
Arizona	5, 20, 100						618			120	498	58,896	51.7	[a] 53			
Arkansas												21,730	40.7				
California	5, 20, 25, 100			467	376		10	2,944	71	772	2,954	128,875	81.4		1,123		113
Colorado	25. 50	15		7		282			4	22	278	55,825	53.7		67		9
Connecticut												4,965	100.0				
Delaware												2,370	100.0				
District of Columbia	1	[b]								[b]		70	100.0		1	2	
Florida												4,716	8.0				
Georgia	5, 20			133						133		24,835	41.9		601		
Idaho	100						287				287	31,033	37.0		124		5
Illinois	5, 10, 20	[c] 1		[d] 161		1,839				461	1,483	33,183	58.6		1,050	973	
Indiana												3,668	10.1				
Iowa												13,167	23.5		75	158	
Kansas												64,159	78.1				
Kentucky	20					1,384					1,384	26,620	65.6		692	986	
Louisiana												8,823	18.2				
Maine	20					1,408					1,408	15,814	47.9		711	458	33
Maryland												12,327	100.0				
Massachusetts												8,266	100.0				
Michigan	5, 10					379					379	13,863	23.9		510	579	
Minnesota	2				561	98					659	8,013	9.5		293	237	
Mississippi												3,985	8.5				
Missouri	20					196				196		43,083	62.1				
Montana	5, 20, 100			30			381				411	42,302	28.8	[a] 10			
Nebraska												27,117	35.0				
Nevada	100							1,824			1,824	46,466	42.0		35		16
New Hampshire	20					464					464	8,485	90.8		138	22	11
New Jersey												8,224	100.0				
New Mexico	5, 25			23					23			41,915	34.2		33		
New York	20					196				196		49,204	100.0				
North Carolina	20				134					134		19,040	36.3		180	16	
North Dakota	10			72							72	13,148	18.6				
Ohio												41,040	100.0				
Oklahoma	20					719					719	41,927	59.8		38	334	
Oregon	2, 5, 10, 25, 50, 100			48			789			30	807	32,569	33.7	18	255	60	4
Pennsylvania	20					1,100				230	870	36,633	81.2		431	392	
Rhode Island												1,248	100.0				

South Carolina	5, 20			145						145		13,737	44.3		245	135	
South Dakota												19,243	24.8				
Tennessee	5, 20	[a] 1			104	416				345	176	23,556	56.1		405	457	
Texas	1, 2, 5, 10, 25	6		42	685	144			25	43	809	88,176	33.2		667	256	
Utah	50				69						69	19,172	22.6				19
Vermont	20					280					280	7,775	81.3				
Virginia	20				253	394				647		37,749	88.6		792	951	
Washington	2, 5, 10, 20, 25, 100			15	92		190			15	282	35,656	51.6	18	593	424	6
West Virginia	50					1,121			1,121			24,170	100.0				
Wisconsin	20					599				224	375	18,724	33.4		109	190	
Wyoming	5, 20, 100						296				296	30,670	31.3	32			
Total continental United States (exclusive of Alaska)		23		1,143	2,274	11,145	2,571	4,768	1,244	3,839	16,784	1,337,723	44.2	131	9,168	6,740	216
Hawaii	2, 10, 20	(f)	[g] 96			530			390	(6)	140	6,435	100.0		2	4	5

[a] Surveyed on scale of 1 : 48,000.
[b] 18 acres mapped on scale of 1 : 2,400.
[c] Mapped on scale of 1 : 4,800.
[d] Includes advance sheet edition for 57 square miles for final publication on a scale of 1 : 62,500.
[e] Mapped on scale of 1 : 2,400.
[f] 112 acres mapped on scale of 1 : 4,800.
[g] Advance sheet editions in 10-foot contours; final publication in 50-foot contours and on a scale of 1 : 62,500.

FIELD SURVEYS

Alabama.—The State geologist of Alabama cooperating, the survey of the Cottondale quadrangle was continued and that of the Blocton quadrangle was begun.

Arizona.—The survey of the Turret Peak quadrangle and of the north half of the Cave Creek quadrangle was completed for the Forest Service.

California.—In cooperation with the State engineer of California the survey of the Mouth of Kern, Rockpile School, Adobe Station, Millux, Conner, Bear Mountain, Waits, Edison, Bena, and West Elk Hills quadrangles and the revision of the Rosedale quadrangle were completed and the survey of the Pentland Junction quadrangle was begun. In cooperation with the county surveyor of Los Angeles County, the survey of the Sylmar, Dume Point, Roosevelt School, Humphreys, Lancaster, Oban, Lang, Saugus, No. 7, No. 5, and Flat quadrangles was completed, that of the Del Valle quadrangle was continued, and that of the Llano, Lovejoy Springs, Casa Desierto, Wilsona, and Ravenna quadrangles was begun. In preparation for geologic mapping, the survey of the Crucero quadrangle was completed. At the request of the Forest Service, the survey of the Hoaglin quadrangle was begun.

Colorado.—The survey of the Telluride mining district and of Abrams Mountain and vicinity was continued, that of Galena Mountain and vicinity was completed, that of Snowmass Mountain No. 4 quadrangle was begun, and that of part of the Montezuma quadrangle was revised. This work was done in cooperation with the Colorado Metal Mining Fund. In cooperation with the Colorado Geological Survey Board the survey of the Sugar Loaf-St. Kevin area was completed and that of the Kokomo area, Rico district, and Nederland area was begun. For the Forest Service, the survey of the Dillon quadrangle was completed.

District of Columbia.—The survey of the naval hospital grounds was completed for the Navy Department, maintenance, Bureau of Yards and Docks.

Georgia-South Carolina.—The survey of the upper Savannah River Basin, covering the Broad and Seneca Rivers with tributaries, the Tugaloo River, and parts of the drainage areas of the Little River, Ga., and the Little River and Stevens Creek, S. C., was completed in cooperation with the United States Army district engineer, Savannah.

Hawaii.—In cooperation with the commissioner of public lands of the Territory of Hawaii and the War Department the survey of the Wahiawa, Laie, Kaena, Kaawa, Kaipapau, Kahana, and Haleiwa quadrangles, a revision of part of the Kaneohe quadrangle by aerial photography, and a revision of parts of the Waipio, Hamakua, Kilauea, Hilo, Mauna Loa, Kohala, and Waikii quadrangles were completed. A survey of a part of the Wainanae quadrangle, on the island of Oahu, was completed for the Navy Department.

Idaho.—The survey of the Bayhorse quadrangle was completed in preparation for geologic mapping.

Illinois.—The survey of the Annawan, Hettick, Arenzville, Decatur, Manito, Cahokia, and Geneva quadrangles, Money Creek Reservoir, highway projects Nos. 129 (Effingham quadrangle), 130 (Rose Hill quadrangle), 87 (Woosung quadrangle), 15 (Mount Vernon, Richview, Ina, and Duquoin quadrangles), 132 (Prairie Home, Lovington, Mattoon, and Arcola quadrangles), 92 (Walnut and Amboy quadrangles), and 77 (Forreston quadrangle), and Decatur and vicinity was completed, that of the Jerseyville quadrangle was continued, and that of the Maroa, Niantic, Sycamore, Monks Mound, French Village, Granite City, Dunlap, Lacon, and Metamora quadrangles and highway projects Nos. 119 (Delavan, Minier, McLean, Le Roy, Arrowsmith, and Gibson City quadrangles), 91 (Maquon and Galva quadrangles), and 93 (Toulon and Camp Grove quadrangles) was begun. All this work was done in cooperation with the Department of Registration and Education of Illinois, Geological Survey.

Kentucky.—The State geologist of Kentucky cooperating, the survey of the Springdale, Morning View, Somerset, Fordsville, Falmouth, Salt Lick, Cynthiana, and Sunnybrook quadrangles was completed, that of the Sadieville quadrangle was continued, and that of the Ekron, Rising Sun, Austerlitz, Vine Grove, Garrison, Vanceburg, and Kirk quadrangles was begun.

Maine.—In cooperation with the Public Utilities Commission of Maine the survey of the Brooks, Portage, Beddington, Phillips, Caribou, and Great Pond quadrangles was completed and that of the Mapleton, Aroostook Mountain, Saponac, Allagash, Strong, Flanders Pond, Ashland, and Pittsfield quadrangles

was begun. In cooperation with the War Department the survey of the Robbinston and Calais quadrangles was completed and that of the Fort Fairfield and St. Francis quadrangles was begun.

Maine-New Hampshire.—The Highway Commission of Maine and the Highway Department of New Hampshire cooperated in completing a survey of the boundary between these two States north of the outlet of Great East Pond.

Michigan.—In cooperation with the Department of Conservation of Michigan, Geological Survey, the survey of the Holland quadrangle was completed, that of the Muskegon, Twin Lake, and Shepherd quadrangles was continued, and that of the Montague quadrangle was begun.

Minnesota.—In cooperation with the Department of Drainage and Waters of Minnesota, the survey of the Juneberry No. 3 and Juneberry No. 4 quadrangles was completed. The survey of the Roseau River Valley for the State Department was completed.

Missouri.—The survey of the Mexico quadrangle was completed in cooperation with the State geologist of Missouri.

Montana.—Preparatory to contemplated geologic mapping, the survey of the Libby quadrangle was continued. To meet the needs of the Biological Survey, Department of Agriculture, the survey of the National Bison Range was completed.

Nevada.—The survey of the Lovelock quadrangle was begun in cooperation with the Bureau of Mines of Nevada.

New Hampshire.—In cooperation with the Highway Department of New Hampshire, the survey of the Moosilauke, Franconia, Thetford, and Littleton quadrangles was completed, and that of the Percy, Dummer, Umbagog Lake, and Mohawk quadrangles was begun.

New Mexico-Texas.—The New Mexico-Texas Boundary Line Commission cooperating, the survey of the area adjacent to the New Mexico-Texas boundary line in the Rio Grande Valley was completed.

New York.—The survey of the Kinderhook and Schunemunk quadrangles was continued in cooperation with the Department of Public Works of New York.

North Carolina.—The survey of the boundary of the proposed Great Smoky Mountains National Park in North Carolina was continued.

North Dakota.—In cooperation with the State engineer of North Dakota the survey of the Souris River was completed.

Oklahoma.—The State Highway Commission of Oklahoma cooperating, the survey of the Kaw, Belford, and Pawnee quadrangles was completed.

Oregon.—The survey of the Pendleton quadrangle was continued and that of The Dalles and Dufur quadrangles was begun in cooperation with the State engineer of Oregon. For the Forest Service the survey of the Three Sisters quadrangle was completed.

Oregon-Washington.—The survey of the lower Columbia River between Vancouver, Wash., and Mayger, Oreg., was begun and a plan and profile survey of the Columbia River from Blalock to Hood River, Oreg., was completed. This work was done in cooperation with the United States Army district engineer, Portland, Oreg.

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, the survey of the Union City, Karthaus, Clearfield, Penfield, Easton, and Coalmont quadrangles was completed, and that of the Starrucca, Ralston, and Loysville quadrangles was begun The survey of the Tyrone quadrangle was completed in preparation for geologic mapping.

Tennessee.—With the cooperation of the State geologist of Tennessee the survey of the Hermitage quadrangle was completed and that of the Pegram quadrangle was begun. The survey of the boundary of the proposed Great Smoky Mountains National Park in Tennessee was continued. The survey of an experiment farm near Lewisburg was completed for the Department of Agriculture.

Texas.—In cooperation with the commissioners of Cameron County the survey of the Laguna Atascosa, Los Fresnos, Laguna Vista, La Coma, Paso Real, Combes, La Paloma, Barreda, La Feria, Santa Maria, Mouth of Rio Grande No. 2, Josephine Island No. 1, Josephine Island No. 2, Josephine Island No. 3, Josephine Island No. 4, Brownsville No. 1, Fort Brown No. 1, Fort Brown No. 2, Fort Brown No. 3, Fort Brown No. 4, and a part of Point Isabel No. 3 quadrangles was completed and the work on the Point Isabel No. 2, M M No. 2, and M M No. 3 quadrangles and the rest of the Point Isabel No. 3 quadrangle was completed by means of aerial photography. In cooperation with the Board

of Water Engineers the survey of the Archer 3–a and Archer 4–b quadrangles and four dam sites on the Colorado River between Austin and Marble Falls was completed and that of the Austin 2–b, Blanco 1–a, Burnet 3–d, and Burnet 4–c quadrangles was begun. In cooperation with the Reclamation Department of Texas the survey of the Harlem project was begun.

Utah.—The survey of the Zion National Park, for the National Park Service, was continued.

Vermont.—In cooperation with the State geologist of Vermont the survey of the Ludlow quadrangle was completed, that of the Townshend quadrangle continued, and that of the Littleton quadrangle begun.

Virginia.—The survey of the Bonsacks, Stony Man, Riders Gap, and Salem quadrangles was completed and that of the Old Town, Independence, Warm Spring Run, Healing Springs, Stanardsville, and Montross quadrangles was begun, all in cooperation with the Conservation and Development Commission of Virginia, Geological Survey. The survey of the boundary of the proposed Shenandoah National Park was continued.

Washington.—The survey of the Colville quadrangle was completed in cooperation with the Department of Conservation and Development of Washington. To meet the needs of the Forest Service the survey of the Mount Constance quadrangle was begun. The aerial photographic survey of the upper Columbia River from the international boundary to Rock Island Rapids near Wenatchee and the survey of the Grand Coulee were completed in cooperation with the United States Army district engineer, Seattle, Wash.

West Virginia.—In cooperation with the State geologist of West Virginia the cultural revision was completed for the Eccles, Beckley, Flattop, Madison, and Peytona quadrangles and that of the Charleston and St. Albans quadrangles was begun.

Wisconsin.—In cooperation with the Geological and Natural History Survey of Wisconsin the survey of the Durand, Gilmanton, Prairie du Chien, and Ferryville quadrangles and the Graves Quarry area was completed, that of the Wabasha, Mondovi, and Boaz quadrangles was continued, and that of the Boscobel quadrangle was begun.

Wyoming.—The survey of the Jackson quadrangle for the Forest Service was continued.

WATER-RESOURCES BRANCH

N. C. GROVER, Chief Hydraulic Engineer

ORGANIZATION AND PERSONNEL

The water-resources branch, like other branches of the Geological Survey, is primarily an agency of research and investigation. It collects systematically for general public information and use facts in regard to the quantity, quality, and utilization of water. The widespread interest in the availability of water for many uses has led to a persistent and increasing demand for reliable data that would serve as a basis for safe and sane developments. During the year the varied work of the branch has been administered under the following units:

Division of surface waters, John C. Hoyt, hydraulic engineer, in charge.
Division of ground water, O. E. Meinzer, geologist, in charge.
Division of quality of water, W. D. Collins, chemist, in charge.
Division of power resources, A. H. Horton, hydraulic engineer, in charge.

The technical force at the end of the year comprised the chief hydraulic engineer, 1 principal hydraulic engineer, 29 senior hydraulic engineers, 15 hydraulic engineers, 140 associate, assistant, and junior engineers, 1 engineering field aide, 3 senior geologists, 1 geologist, 6 associate, assistant, and junior geologists, 1 senior chemist, 6 associate, assistant, and junior chemists, 4 laboratory assistants and apprentices—a total of 208. The clerical force comprised 39 clerks. The changes in personnel during the year show a net increase of 41.

FUNDS

The funds available for Geological Survey work on water resources were as follows:

Gaging streams	$275,000.00
Transfers from Federal agencies	428,853.00
Repayments by Federal agencies	8,158.76
Funds furnished by States and municipalities	397,971.25
Funds furnished by permittees and licensees of the Federal Power Commission	38,603.39
	1,148,586.40

COOPERATION

Work in the branch is largely conducted in cooperation with Federal bureaus; State, county, municipal, and other governmental agencies; and permittees and licensees of the Federal Power Commission. A major part of this cooperation is set forth below.

States.—The following amounts were expended by States from cooperative allotments. In addition, several State agencies cooperated by furnishing office quarters and occasional services in field and office.

Alabama		$2,725.32
Arizona		16,075.00
Arkansas		6,568.13
California:		
State	$44,899.63	
Municipal	21,887.99	
		66,787.62
Colorado		388.51
Connecticut		7,000.00
Hawaii:		
Territory	19,687.38	
Municipal	4,613.86	
		24,301.24
Idaho		16,467.18
Illinois		3,973.86
Kansas		5,103.32
Maine		7,204.34
Maryland:		
State	4,199.38	
Municipal	1,868.21	
		6,067.59
Massachusetts		7,623.71
Minnesota		322.46
Missouri		10,578.64
Montana		7,484.64
Nevada		1,788.00
New Hampshire		1,999.40
New Jersey		12,063.15
New Mexico		4,444.79
New York		17,850.82
North Carolina:		
State	11,627.73	
Municipal	190.05	
		11,817.78
Ohio:		
State	31,594.94	
Municipal	892.36	
		32,487.30

Oregon:		
State	$9,391.07	
Municipal	806.13	
		$10,197.20
Pennsylvania		1,566.64
South Carolina:		
Municipal		235.66
Tennessee		16,512.60
Texas:		
State	41,538.18	
Municipal	390.00	
		41,928.18
Utah		6,534.48
Vermont		7,110.21
Virginia		20,626.31
Washington:		
State	1,682.26	
Municipal	2,153.66	
		3,835.92
West Virginia		5,000.00
Wisconsin		7,232.19
Wyoming		6,069.06
		397,971.25

Bureau of Reclamation.—The measurement of streams that are to furnish water to reclamation projects was continued in cooperation with the Bureau of Reclamation on the Black Canyon project and on the lower Colorado River. The study of the conditions at the Avalon Dam of the Carlsbad irrigation project in New Mexico were continued, and reservoir sites at Red Bluff, Tex., and Owyhee, Oreg., were investigated.

Indian Service.—Stream gaging was continued for the Indian Service in the Western Shoshone Reservation and on the Gila and San Carlos Rivers. Examinations were made of available sources of ground-water supplies for the Rosebud Indian Agency.

National Park Service.—Streams in the Yellowstone National Park were measured during the year at stations maintained in cooperation with the National Park Service.

Department of the Navy.—A study of a water supply for the proposed naval ammunition depot at Lualualei, Oahu, was made for the Bureau of Yards and Docks.

Forest Service.—A study of stream flow in the Angeles National Forest, in southern California, was continued in cooperation with the Forest Service.

Weather Bureau.—Stream gaging has been continued on the Colorado River in Arizona in cooperation with the Weather Bureau.

Office of Public Buildings and Public Parks of the National Capital.—A study of the flow of Rock Creek was undertaken in cooperation with the Office of Public Buildings and Parks. This study will be of special value in determining the effect of development in the District of Columbia and surrounding suburbs on the flow of the creek.

Department of State.—Stream gaging and investigations concerning water-utilization and flood-control problems have been continued on the Rio Grande on the Mexican boundary and on numerous streams on and near the Canadian boundary from the Lake of the Woods westward. Notable centers of activity on the Canadian boundary have been the Roseau River in Minnesota, the St.

Mary and Milk Rivers in Montana, and the Kootenai River in Idaho. Some of these operations on the Canadian boundary are being conducted jointly with Dominion officials because of the common interest of the two countries in them. The cost of this work is met by funds transferred to the Geological Survey by the Department of State.

Department of Justice.—An investigation of ground-water supplies for the proposed Camp Lee prison farm, Virginia, was made for the superintendent of prisons.

Corps of Engineers, United States Army.—Stream gaging has been continued in cooperation with the Corps of Engineers in connection with flood control and with studies and reports to be made under House Document No. 308 of the Sixty-ninth Congress, first session. This work has been carried on at Boston, Providence, New York, Philadelphia, Baltimore, Washington, Norfolk, Huntington, Wilmington, Charleston, Chattanooga, Nashville, Florence, Montgomery, Mobile, Galveston, Jacksonville, Vicksburg, Louisville, Cincinnati, St. Paul, Kansas City, Seattle, Portland, and San Francisco and includes about 600 gaging stations. The cost of this work is met by transfers from the funds of the Corps of Engineers.

Federal Power Commission.—The stream gaging required by the Federal Power Commission in permits and licenses issued for the development of water power under the Federal water power act has been performed or supervised by engineers of the Geological Survey in Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Iowa, Indiana, Kentucky, Maine, Michigan, Minnesota, Mississippi, Missouri, Montana, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee, Utah, Virginia, Washington, West Virginia, Wisconsin, and Wyoming. The operation of constructed projects or those under construction has been supervised in Arizona, Arkansas, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wisconsin, and Wyoming.

PUBLICATIONS

The publications of the year prepared by the water-resources branch comprised 29 reports by 6 separate chapters. (See pp. 5–6.) At the end of the year 18 other reports were in press.

CHARACTER AND METHOD OF WORK

The study of surface waters, which consists primarily of the measurement of the flow of streams, has been conducted in 47 States and Hawaii at selected gaging stations at which the volume of water carried by the streams is measured and records of stage and other data, from which the daily flow of the stream is computed, are collected. At the end of the year 2,426 gaging stations were being maintained; 241 stations were discontinued and 429 new stations established during the year. Records for about 161 additional stations were received, ready for publication, from Government bureaus and private persons, and several Government and State organizations and individuals cooperated in the maintenance of the regular gaging stations.

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The division of ground water investigates the waters that lie below the surface—their occurrence, quantity, quality, and head; their recovery through wells and springs; and their utilization for domestic, industrial, irrigation, and public supplies and as watering places for livestock and desert travelers. Each year surveys are made of selected areas where problems of water supply are urgent, and the results are generally published in water-supply papers that include maps showing the ground-water conditions. The investigations relating to the chemical composition of the water are made in cooperation with the division of quality of water. Projects involving large expenditures for drilling wells to develop water supplies are considered each year by the several departments of the United States Government, and the ground-water division is called upon to furnish information and advice on many of these projects. During the fiscal year about 48 investigations relating to ground water and reservoir sites were in progress, and work was conducted in 26 States and Hawaii. The demands of the public for precise information in regard to ground-water resources are becoming more and more exacting with increasing need for the water. In recent years considerable research into the principles of ground-water hydrology has been undertaken in the division in order to provide a more secure basis for ground-water investigations.

Cooperation was continued with the eight State associations of water-well drillers and with the newly organized American Association of Water Well Drillers. Mr. Meinzer delivered an address at the meeting of this association in Minneapolis February 6, on the past and future of the water-well drilling industry. A number of papers were delivered at the meetings of the State associations by A. G. Fiedler and R. M. Leggette, most of which have since been published in trade journals. Mr. Fiedler represents the Geological Survey on the advisory council of the American association and has been chosen executive secretary of that council.

A paper by Mr. Meinzer, entitled "Outline of Methods of Estimating Ground-water Supplies," was transmitted for publication by the American Society of Civil Engineers. Abstracts of papers relating to ground-water hydrology were prepared for the Annotated Bibliography of Economic Geology and for foreign abstract journals.

A new apparatus has been constructed by C. H. Au for exploring leaky wells by the electrolytic method for salinity of the water at all depths. Work was resumed in the hydrologic laboratory by V. C. Fishel, working under the direction of F. G. Wells.

The work on quality of water included the analysis of the mineral content of 1,180 samples of water from surface and underground sources. These included some analyses for nearly all the studies of ground water in the different States, as noted below. Studies of dissolved and suspended matter in the Colorado River and its tributaries were continued. S. K. Love spent 10 weeks in the summer of 1929 on an intensive study of suspended matter in the San Juan River at Goodridge, Utah.

The work of the division of power resources comprised the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants, a report on the developed water power of the United States, a report containing the monthly and annual figures of output by States for 1927 and

1928, and compilations of the stocks of coal held by electric public-utility power plants for inclusion in reports of commercial stocks of coal undertaken quarterly by the Bureau of Mines of the Department of Commerce. Cooperation was given to the Bureau of Mines of the Department of Commerce and the Institute of Economics of the Brookings Institution in the preparation of a report on the origin of the coal and the kinds of stokers used by coal-burning electric public-utility power plants.

The monthly and annual figures of output of electricity and fuel consumption are based on reports submitted by concerns producing electricity for public use. On January 1, 1930, 1,628 companies, operating 3,780 power plants with a total capacity of generators of 31,952,396 kilowatts, were on the list of companies requested to submit reports. Plants whose output is less than 10,000 kilowatt-hours a month are generally not included. Reports are received from plants representing over 95 per cent of the capacity of all plants listed. The output of plants not reporting is estimated.

Annual production of electricity by public-utility power plants in the United States, 1919–1929

Year	Total		Water power			Fuel power		
	Kilowatt-hours	Change from previous year	Kilowatt-hours	Per cent of total	Change from previous year	Kilowatt-hours	Per cent of total	Change from previous year
		Per cent			*Per cent*			*Per cent*
1919	38,921,000,000		14,606,000,000	37.5		24,315,000,000	62.5	
1920	43,555,000,000	+11.9	16,150,000,000	37.1	+10.6	27,405,000,000	62.9	+17.7
1921	40,975,000,000	−5.9	14,970,000,000	36.5	−7.3	26,005,000,000	63.5	−5.1
1922	47,654,000,000	+16.3	17,207,000,000	36.1	+14.9	30,447,000,000	63.9	+17.1
1923	55,665,000,000	+16.8	19,343,000,000	34.8	+12.4	36,322,000,000	65.2	+19.3
1924	59,014,000,000	+6.0	19,969,000,000	33.8	+3.2	39,044,000,000	66.2	+7.5
1925	65,870,000,000	+11.6	22,356,000,000	33.9	+11.9	43,514,000,000	66.1	+11.4
1926	73,791,000,000	+12.0	26,189,000,000	35.5	+17.1	47,602,000,000	64.5	+9.4
1927	80,205,000,000	+8.7	29,875,000,000	37.2	+14.1	50,330,000,000	62.8	+5.7
1928	87,850,000,000	+9.5	34,696,000,000	39.5	+16.1	53,154,000,000	60.5	+5.6
1929	97,352,000,000	+10.8	34,629,000,000	35.6	−0.2	62,723,000,000	64.4	+18.0

Annual consumption of fuel in the production of electricity by public-utility power plants in the United States, 1919–1929

Year	Coal		Fuel oil		Gas	
	Short tons	Change from previous year	Barrels	Change from previous year	M cubic feet	Change from previous year
		Per cent		*Per cent*		*Per cent*
1919	35,100,000		11,050,000		21,406,000	
1920	37,124,000	+5.8	13,123,000	+18.8	24,702,000	+15.4
1921	31,585,000	−14.9	12,045,000	−8.2	23,722,000	−4.0
1922	34,179,000	+8.2	13,197,000	+9.6	27,172,000	+14.5
1923	38,966,000	+14.0	14,684,000	+11.3	31,433,000	+15.7
1924	37,556,000	−3.6	16,630,000	+13.3	48,443,000	+54.1
1925	40,222,000	+7.1	10,246,000	−38.4	46,521,000	−4.0
1926	41,311,000	+2.7	9,399,000	−8.3	53,207,000	+14.4
1927	41,888,000	+1.4	6,782,000	−27.8	62,919,000	+18.3
1928	41,350,000	−1.3	7,158,000	+5.5	77,326,000	+22.9
1929	44,937,000	+8.7	10,124,000	+41.4	112,707,000	+45.8

The improvement each year in the utilization of fuel in the generation of electricity by public-utility companies continues, as indicated in the following table:

Average consumption of coal[a] per kilowatt-hour by public-utility power plants in the United States, 1919–1929

Year	Pounds	Per cent of rate in 1919	Year	Pounds	Per cent of rate in 1919
1919	3.2	100	1925	2.1	66
1920	3.0	94	1926	1.95	61
1921	2.7	84	1927	1.84	57
1922	2.5	78	1928	1.76	55
1923	2.4	75	1929	1.69	53
1924	2.2	69			

[a] Oil and gas included as equivalent coal.

Owing to the small amount of precipitation in some sections of the country in 1929 the production of electricity by the use of water power was for the first time since 1921 less than in the previous year.

A report on the amount of developed water power in the United States on January 1, 1930, was released February 17, 1930, and the final report on the annual production of electricity by public-utility power plants in 1929 was released May 24, 1930.

WORK OF THE YEAR BY STATES

The following table shows by States the number of gaging stations maintained for the collection of stream-flow records and the interest in those stations of the agencies cooperating with the Geological Survey:

Gaging stations and cooperating parties for the year ended June 30, 1930

State or Territory	Geological Survey alone	Bureau of Reclamation	Forest Service	Indian Service	Army engineers	Weather Bureau	Other Federal bureaus	State cooperation	Municipal cooperation	Private persons	Counted more than once	Maintained at end of year	Established during year	Discontinued during year	Regular gagings during year	Miscellaneous gagings during year
Alabama	1				27					5	1	32	4	2	236	2
Arizona		1		5				55			6	55	7	1	1,796	51
Arkansas					1	5		13		12	12	19	2	3	84	4
California			20	1	5		3	253	72	87	184	257	34	11	3,538	412
Colorado		2			11			19	9	6	12	35	6	3	234	1
Connecticut					3			9	2	4	4	14	4		91	12
Florida					8					7		15	8	2	128	13
Georgia					15					11		26	8	2	207	13
Idaho		6	6		14	2	39	106	5	204	94	288	119	113	2,438	96
Illinois					6	2		35	3	2	13	35	2	1	126	1
Indiana					14			9			9	14	2	1	114	1
Iowa					4	1			1		1	5			56	
Kansas					20	4		27	1	2	7	47	1		377	2
Kentucky					27					10	10	27	4	1	151	16
Louisiana														4	13	
Maine					14			20		9	15	28	3		275	6
Maryland and District of Columbia	3				6		2	5	7			23	11		179	7
Massachusetts								22	4	1	5	22	2		149	
Michigan									1	1		2			12	
Minnesota					13		16	4		4		37	13	20	336	8
Mississippi	1				7							8	1	4	88	3
Missouri					14	5		79		19	24	93	21	4	654	8
Montana					31		32	38		12		113	7	6	670	2
Nebraska					15							15	2	1	202	
Nevada				1				12		5	6	12		3	28	2
New Hampshire					12			15		12	17	22			134	
New Jersey						1		42	9	7	17	42	2	1	274	27
New Mexico							1					1			160	
New York					12			99	2	53	67	99	11	2	683	14
North Carolina					32			74		10	42	74	10	4	360	8
North Dakota					8		2	1				11	3		95	3
Ohio					6	3		100	16	4	29	100	4	3	556	9
Oklahoma					8					1		9	7	1	59	1
Oregon			1		35	6		93	10	41	93	93	12	3	610	49
Pennsylvania					3					5		8	1	3	57	5
Rhode Island					1							1			6	
South Carolina					10				3	4	1	16	11	1	88	7
South Dakota					18							18	1	1	158	5
Tennessee					55	5		72		9	69	72	15	2	579	7
Texas					16	11	16	90	12	26	64	107	8	13	1,812	83

Gaging stations and cooperating parties for the year ended June 30, 1930—Continued

State or Territory	Geological Survey alone	Bureau of Reclamation	Forest Service	Indian Service	Army engineers	Weather Bureau	Other Federal bureaus	State cooperation	Municipal cooperation	Private persons	Counted more than once	Maintained at end of year	Established during year	Discontinued during year	Regular gagings during year	Miscellaneous gagings during year
Utah	5	3					1	51	1	17	22	56	3	1	405	13
Vermont					3			18		8	6	23	2	1	148	
Virginia					23			65	2	13	23	80	15	3	294	14
Washington			1		55		9	107	22	41	106	129	25	9	1,092	100
West Virginia					29			28	1	9	10	57	17	1	356	13
Wisconsin					3			40		12	14	41	3		184	12
Wyoming		5		4	16	1	7	35		3	6	65	9	2	329	12
Hawaii								80	8	54	62	80	9	8	493	1,149
	10	17	28	11	600	46	128	1,716	191	730	1,051	2,426	429	241	21,114	2,191

Alabama.—Field work was continued, in cooperation with the Geological Survey of Alabama, in the area of Paleozoic rocks, and a report on the ground waters of this entire area, covering 25 counties, was prepared by W. D. Johnston, jr. Mr. Johnston also presented at the Charlottesville meeting of the Society of Economic Geologists a paper on the chemical character of ground water in northern Alabama and prepared papers for publication on the physical divisions of the Paleozoic area, on the caves of the area, with special reference to the work of ground water, and on the growth of stalactites.

Arkansas.—The investigation of the source and quantity of the ground-water supply for irrigation of rice in the area about Stuttgart was continued by D. G. Thompson, who prepared a preliminary report giving the results of the investigation to date. This investigation is conducted in cooperation with the Arkansas Geological Survey and the Arkansas Agricultural Experiment Station. A paper by M. D. Foster on the chemical character of the hot springs of Arkansas and Virginia was published in Industrial and Engineering Chemistry.

California.—Water levels were measured in selected wells in southern California under the direction of F. C. Ebert. The record now covers a period of 26 years. Work was continued, with financial support by the East Bay Municipal Utility District, on the investigation of the ground water in the alluvial fan of the Mokelumne River by H. T. Stearns, G. H. Taylor, C. A. McClelland, and L. K. Wenzel. The results of the investigation to July 1, 1929, were published as Water-Supply Paper 619. Measurement of wells in the Calaveras River area was continued in cooperation with the city of Stockton. Tests of samples of water-bearing material were made by Burt Burlingame at the laboratories of the State University at Davis. A preliminary survey of the quality of surface waters was initiated. Occasional samples for partial analysis will be collected at nearly all the gaging stations to furnish data on which to base a plan for a comprehensive study of the quality of surface waters.

Colorado.—A report on the upper Colorado River and its utilization, by Robert Follansbee, was published as Water-Supply Paper 617.

Hawaii.—A comprehensive investigation of the ground waters on the Island of Oahu was begun, and K. N. Vaksvik was assigned to compile the available data on the subject. A study of a water supply for the proposed naval ammunition depot at Lualualei, Oahu, was begun in cooperation with the Bureau of Yards and Docks of the Navy Department.

Idaho.—Ground-water investigations were continued in cooperation with the Idaho Department of Reclamation and the Idaho Bureau of Mines and Geology. A comprehensive report on the Snake River Plain and adjacent areas that contribute ground water to the Snake River was completed by H. T. Stearns, Lynn Crandall, and G. W. Steward. This report contains a map of the entire region showing 10-foot contours of the water table. A comprehensive report on the Mud Lake region, by H. T. Stearns and L. L. Bryan, was released to the public in manuscript form. Investigations with test drilling were made by Lynn Crandall and H. T. Stearns in the Big Lost River and Little Lost River valleys, and manuscript reports on both valleys, with recommendations for increasing the irrigation supply, were made public. An investigation of the ground-water levels in the Kootenai Valley below Bonners Ferry was begun, and T. R. Newell was assigned to take charge of the investigation.

Illinois.—A. G. Fiedler attended the annual meeting of the State well drillers' association and presented a paper on drilling methods.

Indiana.—A. G. Fiedler attended the annual meeting of the State well drillers' association and presented a paper on the relation of the well drillers to the waterworks field.

Iowa.—R. M. Leggette attended the annual meeting of the State well drillers' association and presented a paper on underground water in glacial drift.

Kansas.—A report on the ground-water conditions in the vicinity of the Haskell Institute, at Lawrence, by W. N. White, was transmitted to the Indian Service.

Kentucky.—A report on ground-water conditions in the vicinity of Madisonville, by W. D. Johnston, jr., was released to the public in manuscript form.

Michigan.—A. G. Fiedler attended the annual meeting of the State well drillers' association and presented a paper on sanitation of ground-water supplies.

Minnesota.—A branch office was maintained in Minneapolis, in charge of Mr. Fiedler, who is investigating well-drilling methods and cooperating with the State well drillers' associations.

Montana.—The study of ground-water levels in an area north of Flathead Lake in relation to fluctuations in the lake levels was continued by A. H. Tuttle, and a preliminary report thereon was transmitted to the Federal Power Commission by O. E. Meinzer, of the Geological Survey, and L. T. Jessup, of the Department of Agriculture. Work was continued by G. M. Hall in the preparation of reports on Big Horn and Fergus Counties.

Nebraska.—A. G. Fiedler attended the annual meeting of the State well drillers' association.

Nevada.—A brief examination of the ground-water conditions in Duck Lake Valley, through cooperation by the State engineer, was made by Mr. Meinzer, who prepared a report on the area that was released in manuscript form.

New Jersey.—A report on the ground-water supplies of the Passaic River Valley, near Chatham, was completed by D. G. Thompson and transmitted to the New Jersey Department of Conservation and Development for publication. Informal cooperation was continued with that department in the ground-water work that is being conducted by H. C. Barksdale.

New Mexico.—Investigations of ground-water resources in different parts of New Mexico were continued in cooperation with the State engineer. A comprehensive report on the Roswell artesian basin was practically completed by A. G. Fiedler and S. S. Nye. A preliminary report relating especially to water in the valley fill and artificial recharge of this artesian basin was prepared for the ninth biennial report of the State engineer. Investigation was continued in the Mimbres Valley by W. N. White, who prepared a preliminary report that has been made public in manuscript form and is to be published as a contribution to hydrology. An investigation of the ground-water resources of the northern part of Lea County was begun by Mr. Nye, who prepared a preliminary report on the area for the report of the State engineer. Further investigations were made by Kirk Bryan on conditions at the Avalon Reservoir of the Carlsbad irrigation project for the Bureau of Reclamation.

North Dakota.—Mr. Fiedler attended the annual meeting of the State well drillers' association and presented a paper on sanitation of water supplies.

Oregon.—Investigations of the ground-water resources of Oregon were continued by A. M. Piper in cooperation with the Oregon Agricultural Experiment Station. Progress was made on the investigation in the Willamette Valley, and a memorandum was transmitted to the director of the experiment station containing recommendations that led to the successful drilling of an experimental well for irrigation in the valley. An investigation of the ground water available for irrigation in the region of The Dalles was begun by Mr. Piper. A paper on ground water for irrigation was presented by Mr. Piper at the Corvallis meeting of the American Society of Agricultural Engineers. Further investigation was made by Kirk Bryan of the reservoir site of the Owyhee irrigation project for the Bureau of Reclamation. Investigations were made by Mr. Piper on about 30 dam sites in the western part of the State, and a report thereon was prepared for the conservation branch.

Pennsylvania.—The systematic survey of the ground-water resources of Pennsylvania was continued in cooperation with the State geologic and topographic survey, and progress was made by Mr. Leggette on his work in the northwestern part of the State.

South Dakota.—An investigation of the ground-water conditions in the Rosebud Indian Reservation was made by A. G. Fiedler for the Indian Service.

Tennessee.—Work was continued on a systematic survey of the ground-water resources of Tennessee in cooperation with the State geologist. A report on ground water in north-central Tennessee was prepared by A. M. Piper for publication, and a report on ground water in the vicinity of Memphis, by F. G. Wells, was made public in manuscript form. A survey was made by Mr. Wells of the ground-water conditions in 10 counties in the northwestern part of the State, and a report was prepared by him on the entire Coastal Plain area of western Tennessee.

Texas.—A systematic survey of the ground-water resources of Texas was undertaken in cooperation with the State board of water engineers under the direction of W. N. White. Field work was done in the Winter Garden region by T. W. Robinson, S. F. Turner, and A. N. Sayre, of the Geological Survey; and J. T. Lonsdale, of the Agricultural and Mechanical College of Texas. An investigation of the artesian conditions and conservation of the artesian-water supply in the vicinity of Glen Rose was made by A. G. Fiedler. The State department of health is also cooperating in the ground-water survey, and special investigations on the sanitary phases of ground water were made by Chester Cohen, of that department. Mr. White addressed the Texas Water-

works Short School at Abilene on methods that are being used in ground-water investigations made in the State. An examination of the Red Bluff and other dam sites on the Pecos River was made for the Bureau of Reclamation by Kirk Bryan.

Utah.—A report on the ground-water supply in the Escalante Valley was completed by W. N. White and is to be published as a water-supply paper. A brief examination of the ground-water supply available in the vicinity of Salt Lake City was made by O. E. Meinzer, and a report thereon was submitted to the city authorities. A report on Green River and its utilization, by Ralf R. Woolley, was published as Water-Supply Paper 618.

Virginia.—Investigation of the thermal springs of Virginia was continued in cooperation with the State Commission on Conservation and Development. Water-stage recorders were operated on the ebbing and flowing spring near Broadway and on the observation well in Arlington County. An examination of the ground-water conditions at Camp Lee was made by R. M. Leggette for the Department of Justice. A reconnaissance of the ebbing and flowing springs in the State was made by O. E. Meinzer. A preliminary report on the quality of surface waters of Virginia was practically completed. It contains analyses of 10-day composites of daily samples taken at 16 gaging stations for the year ended March 31, 1930. Analyses are being made of similar samples from 16 other gaging stations beginning April, 1930.

West Virginia.—A field trip was made by O. E. Meinzer to obtain information concerning the ebbing and flowing springs in West Virginia.

Wyoming.—A water-stage recorder was continued in operation on the ebbing and flowing spring near Afton.

CONSERVATION BRANCH

HERMAN STABLER, Chief

ORGANIZATION AND PERSONNEL

The volume and complexity of the work of the conservation branch, comprising the classification of public lands with respect to mineral, water power, and agricultural value and the technical supervision of mineral and power development on such lands and of mineral development on Indian lands, continued to increase during the fiscal year 1930 and was directed through four administrative divisions, as follows:

Mineral-classification division, J. D. Northrop, geologist, in charge.
Power division, B. E. Jones, hydraulic engineer, in charge.
Agricultural division, J. F. Deeds, hydraulic engineer, in charge.
Mineral-leasing division, H. I. Smith, mining engineer, in charge.

Personnel changes during the fiscal year included 24 separations and 26 additions. On June 30, 1930, the personnel of the branch, both office and field, numbered 151, consisting of 4 geologists, 8 hydraulic engineers, 11 mining engineers, 43 petroleum engineers, 8 agricultural classifiers, 1 chemist, 1 attorney, 20 accountants and draftsmen, and 55 clerical and miscellaneous employees.

FUNDS

The funds appropriated or transferred for the work of the conservation branch in the fiscal year were as follows:

Classification of lands	$180,000
Supervision of leasing operations, public lands	250,000
Supervision of leasing operations, Indian lands	85,000
Supervision of naval-reserve operations	50,000
Plugging abandoned wells (available until June 30, 1931)	50,000
Federal Power Commission	4,500
	619,500

Exclusive of the special appropriation for plugging abandoned wells, this aggregate is $15,000, or about 3 per cent, greater than the corresponding total in 1929.

CORRESPONDENCE

During the year 30,832 letter requests for information or technical reports were received in the Washington office of the branch, together with 30,150 pieces of miscellaneous correspondence for filing or for transmission to the appropriate field office. Within the same period 21,639 letters were answered and 17,600 pieces of miscellaneous correspondence were sent out.

SUMMARY OF LAND-CLASSIFICATION CASES

The activities of the conservation branch with respect to land classification include the preparation of reports in response to requests for data or action on specific cases, the preparation of orders of withdrawal and restoration of lands not involved in specific requests, and the promulgation of broad areal classifications. The following table summarizes activity with respect to requests for data or action on specific cases. The terms "gain" and "loss" signify, respectively, decrease and increase in the number of cases pending. By strenuous effort of an efficient personnel the number of cases acted on was greater by nearly 2,000 than during the preceding year. Nevertheless there were 1,042 more cases pending at the end of the year than at its beginning, an increase of about a third.

General summary of cases involving land classification

Class of cases	Record for fiscal year 1930						Record since receipt of first case	
	Pending July 1, 1929	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1930	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General	300	1,493	1,793	1,386	407	−107		
Time extensions	6	0	6	6	0	+6	2,313	2,313
Oil development	17	18	35	34	1	+16	16,129	16,128
Concurrence	32	649	681	661	20	+12		
Committee cases—Oil	46	5,096	5,142	4,533	609	−563	5,680	5,071
Applications for classification as to mineral:								
Oil	256	5,842	6,098	4,833	1,265	−1,009	13,180	11,915
Miscellaneous	3	13	16	8	8	−5	843	835
Applications for mineral permits	38	293	331	310	21	+17	52,798	52,777
Applications for mineral leases	12	128	140	133	7	+5	1,460	1,453
Applications for patent, potassium	0	0	0	0	0	0	124	124
Federal Power Commission cases:								
Preliminary permits	11	41	52	40	12	−1	119	107
Licenses	0	3	3	3	0	0	28	28
Determinations under sec. 24	2	42	44	31	13	−11	269	256
Applications for classification as to power resources	7	15	22	13	9	−2	[a] 426	417
Applications for agricultural classification	18	155	173	116	57	−39	[a] 844	787
Applications for rights of way	35	177	212	195	17	+18	6,401	6,384
Irrigation-project reports	0	3	3	2	1	−1	914	913
Applications under enlarged-homestead acts	266	389	655	492	163	+103	57,198	57,035
Applications under stock-raising homestead acts	2,341	4,018	6,359	4,507	1,852	+489	130,235	128,383
Applications under ground-water reclamation act	39	15	54	48	6	+33	950	944
Indian Service requests for information	0	31	31	28	3	−3	9,542	9,539
	3,429	18,421	21,850	17,379	4,471	−1,042		

[a] Approximately.

SUMMARY OF FIELD OPERATIONS BY STATES

Alaska.—Expended $10,000 through the Alaskan branch for supervision of 9 leases, 3 licenses, and 21 prospecting permits for coal and 1,022 prospecting permits for oil and gas. Coal produced, 121,825.20 tons; accrued rent and royalty, $12,854.14. Supervised 1 power project.

Alabama.—Investigated the status of oil and gas prospecting operations throughout the State. Examined 5 tracts for mineral classification. Supervised 1 coal lease. Coal produced, 136,661 tons; accrued rent and royalty, $13,666.10.

Arizona.—Examined 44 tracts for agricultural classification and made a special regional study for agricultural classification of the desert in the southwestern part of the State. Supervised 5 coal-prospecting permits, 2 sodium permits, 6 potassium permits, and 145 oil and gas permits involving public land. Investigated and reported on the value of 2 gold, 2 copper, 1 iron-ore, and 1 asbestos deposits, and supervised 5 vanadium leaseholds, 9 coal mines, and 219 oil and gas permits involving lands in 9 Indian reservations. Supervised 11 power projects.

Arkansas.—Supervised 2 prospecting permits for coal and 15 for oil and gas.

California.—Examined 54 tracts for agricultural classification. Investigated the oil-shale resources of 1 tract in Santa Barbara County and the sodium resources of parts of 2 townships in southeastern Kern County. Supervised on public land 191 leases and 519 prospecting permits for oil and gas, 4 leases for potassium, 6 prospecting permits for coal, 15 for sodium, and 1 for potassium. Oil produced, 10,729,586 barrels; natural gas, 13,090,399,000 cubic feet; natural-gas gasoline, 60,647,334 gallons; coal, 62 tons; sodium borate, 7,594 tons; sodium carbonate, 21,142 tons. Total rent and royalty accrued, $1,034,629.91. Supervised on naval petroleum reserves 27 leases for oil and gas. Oil produced, 6,978,922 barrels; natural gas, 6,817,458,000 cubic feet; natural-gas gasoline, 25,567,986 gallons. Total rent and royalty accrued, $1,612,167.05. Supervised 29 power projects.

Colorado.—Examined 136 tracts for agricultural classification, made regional studies of agricultural utility precedent to areal classification in the western part of the State, and published map showing such classifications in eastern and northwestern parts of the State. Examined 1 tract in Jackson County and 2 tracts in Grand County for oil and gas classification and 1 tract in Las Animas County for coal classification. Examined and mapped geologic structure in the Garcia field, Las Animas County, and in the Skull Creek district, Routt County. Supervised on public land 17 leases and 507 prospecting permits for oil and gas, 81 leases, 5 licenses, and 42 prospecting permits for coal, 2 prospecting permits for sodium, and 1 for potassium. Oil produced, 725,040 barrels; natural gas, 877,430,000 cubic feet; natural-gas gasoline, 14,642 gallons; coal, 434,871 tons. Total rent and royalty accrued, $98,639.99. Supervised on tribal lands of the Ute Indians 1 lease for oil and gas, and inspected for the Indian Service 2 coal mines on the Southern Ute Reservation. Supervised 8 power projects.

Florida.—Investigated in the field the status of oil and gas prospecting operations throughout the State.

Idaho.—Examined 48 tracts for agricultural classification. Investigated storage and power possibilities on the South and Middle Forks of the Salmon River. Supervised 122 oil and gas prospecting permits, 8 coal permits, and 2 phosphate leases. Coal produced, 1,367 tons; phosphate rock, 22,101 tons. Total rent and royalty accrued, $2,712.97. Supervised 5 power projects.

Louisiana.—Investigated the status of oil and gas prospecting and development throughout the State. Examined 1 tract for mineral classification. Supervised 12 leases and 8 prospecting permits for oil and gas. Oil produced, 9,963 barrels; natural gas, 498,234,000 cubic feet; natural-gas gasoline, 43,981 gallons. Total rent and royalty accrued, $3,583.40.

Mississippi.—Investigated the status of oil and gas prospecting throughout the State. Examined 1 tract for mineral classification.

Montana.—Examined 171 tracts for agricultural classification. Investigated the stratigraphy and structure of parts of Toole, Teton, Chouteau, and Cascade Counties. Continued through the geologic branch detailed examinations in McCone, Richland, Dawson, Rosebud, Custer, and Powder River Counties for coal classification. Supervised on public land 74 leases and 570 prospecting permits for oil and gas; 51 leases, 17 licenses, and 17 prospecting permits for coal. Oil produced, 511,126 barrels; natural gas, 1,088,197,000 cubic feet; coal, 247,855 tons. Total rent and royalty accrued, $100,988.67. Supervised on

Indian land 13 leases for oil and gas, 3 coal mines, 1 silver-lead leasehold, and 1 vermiculite leasehold. Supervised 25 power projects.

Nebraska.—Supervised 1 prospecting permit for oil and gas and 2 prospecting permits for potassium.

Nevada.—Examined 89 tracts for agricultural classification and made regional investigations of agricultural utility precedent to grazing classification in the northeastern part of the State. Supervised 114 prospecting permits for oil and gas, 6 prospecting permits for coal, 1 lease and 5 prospecting permits for sodium, and 1 lease for phosphate. Sodium sulphate produced, 586 tons. Total rent and royalty accrued, $800. On Indian land investigated 3 silver-lead properties and 1 marl property. Supervised 6 power projects.

New Mexico.—Examined 24 tracts for agricultural classification. Continued through the geologic branch detailed examinations in McKinley and Sandoval Counties for coal classification. Supervised on public land 14 leases and 1,326 prospecting permits for oil and gas, 21 leases and 55 prospecting permits for coal, 3 leases and 43 prospecting permits for potassium, and 7 prospecting permits for sodium. Oil produced, 1,200,057 barrels; natural gas, 5,108,938,000 cubic feet; natural-gas gasoline, 3,089 gallons; coal, 74,858 tons. Total rent and royalty accrued, $129,514.38. Supervised on Indian land 52 oil and gas leases and made technical investigation and report on 1 coal-mining operation in each of the Northern Navajo, Eastern Navajo, and Zuni Reservations. Supervised 3 power projects.

North Dakota.—Examined 7 tracts for agricultural classification. Supervised 58 leases, 4 licenses, and 4 prospecting permits for coal and 25 prospecting permits for oil and gas. Coal produced, 447,627 tons. Total rent and royalty accrued, $28,490.14.

Oklahoma.—Examined 1 tract for agricultural classification. Continued in cooperation with the Oklahoma Geological Survey detailed geologic examination of the coal resources of the Stigler-Muskogee district, in Haskell and Muskogee Counties, begun in 1927. Supervised on public land 17 leases for oil and gas involving land in the bed of the Red River, Tillman County, and 16 prospecting permits for oil and gas. Oil produced, 450,342 barrels; natural-gas gasoline, 1,014,350 gallons. Total rent and royalty accrued, $105,776.14. Supervised on Indian lands 10,128 leases for oil and gas involving 936,529 acres, 5,456 producing wells, and a combined rental, royalty, and bonus value of $6,861,781.25; on segregated Choctaw and Chickasaw lands 65 leases for coal involving 59,849 acres, a production of 477,614 tons of coal, and a royalty value of $41,103.32, and 1 lease for asphalt; on allotted restricted lands of Cherokee, Choctaw, and Creek Indians, 59 leases for coal involving a production of 67,729 tons and a royalty value of $6,140.88, 3 leases for volcanic ash, and 1 for lead and zinc involving production with a royalty value of $180; and on restricted Quapaw lands 50 departmental leases for lead and zinc involving 6,244 acres, a production of 144,805 tons of concentrates, and a royalty value of $587,255.08.

Oregon.—Examined 41 tracts for agricultural classification. Supervised 14 prospecting permits for oil and gas, 2 leases and 4 prospecting permits for coal, 1 lease for oil shale, and 4 prospecting permits for potassium. Coal produced, 3,322 tons. Accrued rent and royalty, $7,464.48. Supervised 2 power projects.

South Dakota.—Examined 3 tracts for agricultural classification. Supervised 22 prospecting permits for oil and gas and 2 leases for coal. Coal produced, 403 tons. Accrued rent and royalty, $130.

Utah.—Examined 126 tracts for agricultural classification. Continued through the geologic branch investigation of the areal geology and structure of southern San Juan County and of the coal resources of eastern San Pete County. Supervised on public land 8 leases and 579 prospecting permits for oil and gas, 45 leases, 2 licenses, and 45 prospecting permits for coal, 17 prospecting permits for potassium, and 2 for sodium. Oil produced, 2,753 barrels; natural gas, 563,471,000 cubic feet; coal, 649,383 tons. Total rent and royalty accrued, $195,546.36. Supervised 1 lease for oil and gas involving land in the Navajo Indian Reservation. Supervised 8 power projects.

Washington.—Examined 13 tracts for agricultural classification. Supervised 6 prospecting permits for oil and gas, 21 for coal, and 1 for sodium. Supervisd 10 power projects.

Wyoming.—Examined 128 tracts for agricultural classification, and made regional investigations of agricultural utility precedent to areal classification in the southwestern part of the State. Collected representative samples of

shale formations in Wyoming for experimental tests. Remapped basal coal from Fort Steele westward and southward to the Colorado boundary to conform with certain township resurveys. Supervised on public lands 343 leases and 1,471 prospecting permits for oil and gas; 34 leases, 3 licenses, and 24 prospecting permits for coal; and 1 prospecting permit for potassium and 2 for sodium. Oil produced, 13,790,644 barrels; natural gas, 17,897,447,000 cubic feet; natural-gas gasoline, 39,746,906 gallons; coal, 914,932 tons. Total rent and royalty accrued, $2,926,186.96. Supervised 43 leases for oil and gas involving tribal and allotted lands of the Shoshone Indians. Made periodic inspection and pressure test of wells shut in on Naval Petroleum Reserve No. 3 (Teapot dome). Supervised 3 power projects.

MINERAL-CLASSIFICATION DIVISION

The work of the mineral-classification division involves the withdrawal, classification, and restoration of public lands according to their mineral value and the determination of all questions of geologic fact or inference arising prior to the issuance of a prospecting permit or a lease for publicly owned mineral lands or mineral deposits. It includes also the planning and execution, through the geologic branch, of field investigations required to provide the basis for appropriate action or recommendation relative to mineral classifications and to orders of withdrawal, modification, and restoration. The results of these field investigations take the form of reports concerning the mineral character of specific lands for the information and guidance of Government bureaus and departments charged with the administration of the public land, Indian land, and naval oil reserves.

By departmental order the Geological Survey reports to the General Land Office on the prospective value for oil and gas of public lands involved in certain types of nonmineral entries and filings in Alabama, Kansas, Louisiana, Mississippi, Nebraska, Oklahoma, and Wyoming and in specified counties of Arizona, Arkansas, California, Colorado, Florida, Idaho, Michigan, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, and Washington, as a basis for the reservation or waiver of the Government's title to deposits of those minerals. During the fiscal year 5,660 requests for reports of this type were received, and reports on 4,430 cases were submitted to the General Land Office.

Little progress was made in 1930 in classifying the vast areas of public land that are still embraced in mineral withdrawals. The results accomplished include, however, net decreases of 58,126 acres in the total area of outstanding coal withdrawals, of 1,881 acres in the total area of outstanding petroleum withdrawals, and of 280 acres in the total area of outstanding phosphate reserves.

The gross areas already classified as valuable for mineral and those remaining withdrawn at the end of the fiscal year for certain minerals under the act of June 25, 1910, are shown in the following table:

Summary of outstanding mineral withdrawals and classifications, June 30, 1930, in acres

State	Coal		Oil		Oil shale		Phosphate		Potash (withdrawn)
	Withdrawn	Classified as coal land	Withdrawn	Classified as oil land	Withdrawn	Classified as oil-shale land	Withdrawn	Classified as phosphate land	
Alaska		56,993							
Arizona	139,415		356						
Arkansas		61,160							
California	17,603	8,720	1,178,392						90,357
Colorado	4,142,233	3,082,272	217,116		64,560	952,239			
Florida							66,796	120	
Idaho	4,761	4,603					391,532	268,299	
Louisiana			466,990	4,233					
Montana	7,863,941	[a]8,563,862	1,350,426	67,651			279,944	3,833	
Nevada	83,673				123				39,422
New Mexico	5,084,069	570,372							9,282,160
North Dakota	5,954,364	11,178,286	84,894						
Oregon	4,361	18,887							
South Dakota		250,093							
Utah	3,578,415	1,267,697	1,341,264		91,464	2,703,755	277,344	2,937	
Washington	691,801	141,444							
Wyoming	2,260,604	[b]6,740,594	541,777			460,103	989,149	25,293	
	29,825,240	31,944,983	5,181,215	71,884	156,147	4,116,097	2,004,765	300,482	9,411,939

[a] Includes 3,151 acres of coal land reserved for use of the United States (Coal Reserve No. 1).
[b] Includes 2,078 acres of coal land reserved for use of the United States (Coal Reserve No. 2).

The following table summarizes the year's work to the extent that it involved technical reports on original applications for permit or lease rights on public lands:

Summary of applications under the mineral leasing acts, fiscal year 1930

Mineral	Prospecting permits				Leases			
	Pending July 1, 1929	Received during fiscal year	Acted on during fiscal year	Pending June 30, 1930	Pending July 1, 1929	Received during fiscal year	Acted on during fiscal year	Pending June 30, 1930
Oil and gas	13	106	102	17				
Coal	12	152	162	2	10	104	107	7
Phosphate					1	4	5	
Sodium	5	6	10	1	1		1	
Potassium	8	29	36	1		20	20	
Oil shale								
	38	293	310	21	12	128	133	7

Under the administrative policy initiated March 12, 1929, there have been submitted to the departmental committee "to pass on claims in connection with oil and gas permits" during the fiscal year 4,533 reports on oil and gas cases, outside Alaska, relative to the status of drilling operations initiated or completed on permit holdings or on the geologic structure affecting them, that had been held for cancellation or were involved in pending applications for extension of time, reinstatement, or assignment, and to the appraisal of geologic showings submitted in support of such applications.

In accordance with the duty delegated to the Geological Survey, definition of the "known geological structure" of one producing gas field was prepared and promulgated during the year—the Bowdoin

field, Montana; 210,041 acres; promulgated June 30, 1930. The net area included in outstanding definitions of the "known geological structure" of producing oil and gas fields on June 30, 1930, was 725,419 acres in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

Geologic field work required in the solution of the problems of the division is performed in part by summer detail of Washington employees, in part by two division geologists with permanent headquarters in Denver, Colo., and in part by the geologic branch at the expense of the conservation branch. The work accomplished in 1929 is included in the branch summary of field operations by States beginning on page 57.

POWER DIVISION

The work of the power division consists primarily in obtaining and making available for use in the administration of the public-land laws information as to the water-power resources of the public lands. The specific problems on which reports are made ordinarily involve the ascertainment of the potential power resources of areas that are or may be subject to disposal under public land laws. The extent of this task is indicated by the fact that areas aggregating more than 6,000,000 acres are now included in power reserves whose use will be required for the development of about 15,000,000 continuous horsepower.

In order that this information may be made substantially complete, areas not thoroughly surveyed are designated for examination by the topographic and water-resources branches. The field projects undertaken during the year are included in the branch summary of field operations by States (pp. 57–59.)

Copies of many of the reports on the power possibilities of the streams examined have been placed in the district offices of the Geological Survey for public inspection, and notices of the availability of the reports have been sent to the press. Manuscript reports on the water-power resources of the McKenzie River Basin, Oreg.; the Wynooche River Basin, the Stilaguamish River, Hall Creek, and the Sanpoil and Nespelem Rivers, Washington; and water utilization in the Boise River Basin, Idaho, were opened to public inspection during the year. A geologic report on proposed dam sites for flood control on the Skagit River, Washington, was prepared in cooperation with the geologic branch. Reports on the Green River and its utilization, the upper Colorado River and its utilization, and the water-power resources of the Umpqua River and its tributaries, prepared in cooperation with the water-resources branch, were published during the year.

Photolithographs showing river surveys were prepared in cooperation with the topographic branch as follows:

Plan and profile of Quillayute River, Bogachiel River to North Fork, Hoh River to mile 51, and South Fork of Hoh River, Wash.

Plan and profile of Soleduck River from mouth to Seven Lakes Basin, Lyre River from mouth to Crescent Lake, Deer Lake Reservoir, and Seven Lakes Basin, Wash.

Plan and profile of Quinault River from mouth to Rustler River and Quinault Lake dam site, Wash.

Plan and profile of Hall Creek from mouth to mile 4 and dam sites on Sanpoil River, Wash.

Arrangements were made to obtain reports based on inspections in the field covering all power projects constructed under permits or grants from the Interior Department.

The work of the division is briefly summarized in the accompanying tables showing power-site reserves and outstanding water-resources withdrawals and classifications and in the general summary.

Pursuant to instructions of the Secretary of the Interior dated August 24, 1916 (45 L. D. 326), permittees under the act of February 15, 1901 (31 Stat. 790), and grantees under the act of March 4, 1911 (36 Stat. 1253), to whom rights have been granted by the Secretary since January 1, 1913, were called upon for detailed reports of the operation or development of their power systems during the calendar year 1929. The total installation of the reporting companies is 3,107,000 horsepower, of which 2,281,000 horsepower is installed at hydraulic plants. The total energy generated was 9,352,000,000 kilowatt-hours of which 7,414,000,000 kilowatt-hours was generated by water power. The energy generated increased 365,000,000 kilowatt-hours during the year.

Power output of permittees and grantees, 1916–1929

Calendar year	Kilowatt-hours	Increase or decrease		Calendar year	Kilowatt-hours	Increase or decrease	
		Kilowatt-hours	Per cent			Kilowatt-hours	Per cent
1916	1,200,000,000			1923	5,910,000,000	+963,000,000	+19
1917	2,000,000,000	+800,000,000	+67	1924	6,100,000,000	+190,000,000	+3
1918	3,200,000,000	+1,200,000,000	+60	1925	6,930,000,000	+830,000,000	+14
1919	3,100,000,000	−100,000,000	−3	1926	7,800,000,000	+870,000,000	+13
1920	4,300,000,000	+1,100,000,000	+35	1927	8,116,000,000	+316,000,000	+4
1921	3,725,000,000	−575,000,000	−13	1928	8,987,000,000	+871,000,000	+11
1922	4,947,000,000	+1,222,000,000	+33	1929	9,352,000,000	+365,000,000	+4

The following table shows the revenue accrued for occupancy and use of public lands by the foregoing power projects:

Accrued compensation for occupancy and use of lands under power permits and grants issued by the Interior Department, 1912–1930

State	1912–1915	1916–1920	1921–1925	1926–1930	1930
Alaska		$6,960	$9,280	$2,900	$580.00
Arizona	$515	1,285	1,900	1,900	425.00
California	3,619	9,274	9,918	9,624	1,976.41
Colorado	315	875	1,765	1,465	250.00
Idaho	20	1,670	1,700	1,640	310.00
Montana	1,255	7,562	13,314	28,183	7,432.00
Nevada	281	2,245	2,570	3,565	1,470.57
New Mexico		20	60	275	80.00
Oregon	60	100	700	700	225.00
Utah		2,568	4,395	4,460	1,150.50
Washington	15	156	631	3,675	1,029.00
Wyoming		70	175	290	65.00
Minnesota		20	25	20	
	6,080	32,805	46,433	58,697	14,993.48
Accumulation	6,080	38,885	85,318	144,015	

Accrued charges for the unauthorized occupancy of public lands by power projects prior to the issuance of licenses therefor by the Federal Power Commission amount to $76,437, of which $37,260 is before the courts for adjudication.

Power-site reserves, in acres

[Includes all areas reserved or classified as valuable for power purposes and withheld subject to disposa only under the Federal water-power act of June 10, 1920 (41 Stat. 1063). Designations, classifications and other types of reserves are included in the total areas without distinction]

State	Reserved prior to July 1, 1929	Eliminated prior to July 1, 1929	Reserves outstanding prior to July 1, 1929	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1930
Alabama	2,377		2,377			2,377
Alaska	282,927	520	282,407	20,554		302,961
Arizona	1,296,356	124,027	1,172,329	42,363	15,817	1,198,875
Arkansas	29,671	360	29,311	3		29,314
California	1,436,875	33,280	1,403,595	19,513	5,842	1,417,266
Colorado	557,620	82,230	475,390	1,432	13,790	463,032
Florida	1,131		1,131			1,131
Idaho	610,703	191,534	419,169	41,993	9,677	451,485
Michigan	1,240		1,240			1,240
Minnesota	19,062	532	18,530			18,530
Mississippi	3		3			3
Montana	305,787	96,579	209,208	1,822	1,074	209,956
Nebraska	761		761			761
Nevada	359,215	480	358,735	98	1,365	357,468
New Mexico	270,927	11,243	259,684	2,053		261,737
Oregon	785,267	143,484	641,783	27,250	15,697	653,336
South Dakota	636		636			636
Utah	779,369	130,238	649,131	2,937	747	651,321
Washington	463,113	67,136	395,977	9,841	40,580	365,238
Wisconsin	1,906	226	1,680			1,680
Wyoming	232,777	76,284	156,493	43,025		199,518
	7,437,723	958,153	6,479,570	212,884	104,589	6,587,865

Summary of outstanding water-resources withdrawals and classifications June 30, 1930, in acres

State	Power reserves					Reservoir withdrawals	Public water reserves
	Withdrawals	Classifications	Designations [a]	Miscellaneous	Total		
Alabama	120	1,735		522	2,377		
Alaska	93,415	114,425		95,121	302,961		
Arizona	374,452	50,599	524,212	249,612	1,198,875	23,040	20,740
Arkansas	21,994	1,590		5,730	29,314		
California	286,097	365,344		765,825	1,417,266	45,264	199,351
Colorado	211,929	194,717		56,386	463,032	1,728	9,645
Florida				1,131	1,131		
Idaho	197,629	236,041		17,815	451,485		15,417
Michigan	1,240				1,240		
Minnesota	12,309			6,221	18,530		
Mississippi				3	3		
Montana	129,264	55,547		25,145	209,956	9,080	9,697
Nebraska	761				761		
Nevada	26,627	85,405		245,436	357,468		14,341
New Mexico	118,527	49	143,161		261,737		10,196
North Dakota						1,091	
Oregon	340,009	209,764	15,250	88,313	653,336	18,603	26,901
South Dakota				636	636		240
Utah	441,592	175,574		34,155	651,321	80	38,230
Washington	98,979	193,897		72,362	365,238	31,797	920
Wisconsin				1,680	1,680		
Wyoming	79,953	77,563		42,002	199,518	1,714	84,145
	2,434,897	1,762,250	682,623	1,708,095	6,587,865	132,397	429,823

[a] Designated and not otherwise withdrawn.

AGRICULTURAL DIVISION

The functions of the agricultural division consist of the classification of lands under the enlarged-homestead law as nonirrigable; the classification of lands under the Nevada ground-water reclama-

tion law as nontimbered and not known to be susceptible of successful irrigation; the preparation of reports on the sufficiency of the water supply and the general feasibility of irrigation projects that require some form of Federal approval in connection with the administration of public land laws; the initiation of withdrawals of land for reservoir sites and for public watering places; the classification as stock-raising lands under the stock-raising homestead law of tracts whose surface is chiefly valuable for grazing and raising forage crops, does not contain merchantable timber, is not susceptible of successful irrigation from any known source of water supply, and is of such character that 640 acres is reasonably required for the support of a family; and the publication of areal-classification reports showing agricultural utility of lands in important public-land regions.

Classifications are made in accordance with the results of field examinations by the members of the division and with information obtained from other sources. The work of the division is planned with the primary purpose of acting on pending applications for classifications under the above-mentioned laws and to provide in advance the basis for appropriate action on new applications. The number of cases received and acted on during the fiscal year is shown in the general summary of cases (p. 56). There was a decrease of about 3 per cent in the number received, and the arrearage was 21 per cent less at the end of the year than at the end of the fiscal year 1929.

Summary of enlarged-homestead designations, in acres

[Areas classified as arid and nonirrigable, residence by entrymen required (act of Feb. 19, 1909 (35 Stat., 639), applicable to Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming; act of June 17, 1910 (36 Stat., 531), applicable to Idaho; act of June 13, 1912 (37 Stat., 132), applicable to California, North Dakota; act of Mar. 3, 1915 (38 Stat., 953), applicable to Kansas; act of Mar. 4, 1915 (38 Stat., 1163), applicable to South Dakota). Areas classified as arid, nonirrigable, and lacking domestic water supply, residence by entrymen not required (act of Feb. 19, 1909 (35 Stat., 639), applicable to Utah; act of June 17, 1910 (36 Stat., 531), applicable to Idaho)]

State	Designations prior to July 1, 1929	Cancellations prior to July 1, 1929	Designations outstanding prior to July 1, 1929	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1930
Arizona	31,532,704	5,884,314	25,648,390	680	7,479,675	18,169,395
California	13,381,433	240,453	13,140,980	760	----------	13,141,740
Colorado	33,972,792	196,428	33,776,364	3,250	----------	33,779,614
Idaho:						
Total	13,756,316	461,365	13,294,951	----------	40	13,294,911
Nonresidence	573,227	4,233	568,994	----------	----------	568,994
Kansas	651,364	----------	651,364	880	----------	652,244
Montana	53,487,661	245,728	53,241,933	7,218	----------	53,249,151
Nevada	50,218,544	3,580,717	46,637,827	760	----------	46,638,587
New Mexico	43,849,007	227,892	43,621,115	4,429	----------	43,625,544
North Dakota	12,280,704	3,848	12,276,856	823	----------	12,277,679
Oregon	21,282,311	989,902	20,292,409	1,440	----------	20,293,849
South Dakota	16,342,841	348,170	15,994,671	500	----------	15,995,171
Utah:						
Total	11,748,070	1,046,317	10,701,753	6,760	[a] 144,290	10,564,223
Nonresidence	1,650,911	426,713	1,224,198	5,240	76,170	1,153,268
Washington	6,660,452	251,842	6,408,610	320	----------	6,408,930
Wyoming	29,777,106	162,043	29,615,063	13,075	----------	29,628,138
	338,941,305	13,639,019	325,302,286	40,895	7,624,005	317,719,176

[a] 3,400 acres previously designated under sec. 1-5, now sec. 6.

Summary of stock-raising homestead designations, in acres

[Areas classified as nonirrigable, nontimbered, chiefly valuable for grazing and raising forage crops, and of such character that 640 acres is reasonably required for the support of a family. Act of December 29, 1916 (39 Stat. 862)]

State	Designations prior to July 1, 1929	Cancellations prior to July 1, 1929	Designations outstanding prior to July 1, 1929	Designations during fiscal year	Cancellations during fiscal year	Designations outstanding June 30, 1930
Arizona	14,154,873	887,580	13,267,293	62,386	135,310	13,194,369
Arkansas	1,120		1,120			1,120
California	8,030,375	3,400	8,026,975	97,590		8,124,565
Colorado	8,872,062	19,840	8,852,222	330,384	560	9,182,046
Florida	480	480				
Idaho	5,597,010	1,854	5,595,156	39,517	40	5,634,633
Kansas	115,779		115,779			115,779
Mississippi	3,491		3,491			3,491
Minnesota				160		160
Montana	15,614,375	17,081	15,597,294	180,358	160	15,777,492
Nebraska	206,161		206,161	3,038		209,199
Nevada	596,626	3,120	593,506	39,462		632,968
New Mexico	31,508,166	636	31,507,530	127,609	120	31,635,019
North Dakota	383,700		383,700	15,759		399,459
Oklahoma	84,918		84,918	1,516		86,434
Oregon	6,384,446	3,128	6,381,318	32,030		6,413,348
South Dakota	6,519,546	550	6,518,996	16,787		6,535,783
Utah	1,938,322	7,800	1,930,522	134,920	75	2,065,367
Washington	694,686	1,174	693,512	8,049		701,561
Wyoming	20,514,241	7,173	20,507,068	326,609	480	20,833,197
	121,220,377	953,816	120,266,561	1,416,174	136,745	121,545,990

By blanket order of withdrawal creating Public Water Reserve 107, which received Executive approval April 17, 1926, every smallest legal subdivision of the public-land surveys which is vacant unappropriated public land and contains a spring or water hole and all land within a quarter of a mile of every spring or water hole located on unsurveyed public land were reserved for public use and in aid of pending legislation. This order obviated the necessity for future withdrawals of specific tracts containing springs or water holes valuable for stock watering, but it requires a determination with respect to all entries of public land whether or not any of the subdivisions involved are in fact affected by it. On the basis of such determination orders of interpretation are issued from time to time listing by legal subdivisions of the public-land survey any tracts found to contain a water supply affected by the order. New withdrawals of this type are made to reserve lands along streams and are also made from time to time for special public purposes. The extent of outstanding reserves of this type and of current action affecting them is shown in the following table:

Public water reserves, in acres

	Reserved prior to July 1, 1929	Eliminated prior to July 1, 1929	Reserves outstanding July 1, 1929	Reserved during fiscal year	Eliminated during fiscal year	Reserves outstanding June 30, 1930
Arizona	21,782	2,357	19,425	1,565	250	20,740
California	206,644	7,138	199,506	365	520	199,351
Colorado	7,900	360	7,540	2,245	140	9,645
Idaho	14,755	410	14,345	1,072		15,417
Montana	10,249	1,232	9,017	840	160	9,697
Nevada	15,351	3,250	12,101	2,240		14,341
New Mexico	11,521	520	11,001	880	1,685	10,196
Oregon	27,229	1,288	25,941	960		26,901
South Dakota	240		240			240
Utah	43,566	7,596	35,970	2,260		38,230
Washington	920		920			920
Wyoming	96,485	14,060	82,425	1,800	80	84,145
	456,642	38,211	418,431	14,227	2,835	429,823

In the field broad areal studies were continued in the Colorado Basin region in southwestern Colorado and southwestern Wyoming, and a land-classification map of northwestern Colorado was published. A reconnaissance report including a series of maps for the 10 principal public-land States was prepared for the information of the President's committee on the conservation and administration of the public domain.

During the fiscal year the area designated under the Nevada ground-water reclamation act was increased 24,080 acres, to a total of 1,643,295 acres. Outstanding withdrawals, aggregating 11,530 acres, under the act of October 2, 1888 (25 Stat. 527), on the basis of a selection by the Director of the Geological Survey, remained unchanged. Other results of the division's work are tabulated in the summaries of enlarged and stock-raising homestead designations and the general summary of cases.

MINERAL-LEASING DIVISION

EARLY LEASING

The earliest suggestion of mineral leasing on the public domain was contained in the ordinance of May 20, 1785, whereby Congress ordered "that there shall be reserved one-third part of all gold, silver, lead, and copper mines to be sold or otherwise disposed of as Congress shall hereafter direct." The supervision was assigned to the War Department. The phrasing of this clause follows the reservations made in some of the Crown charters and suggests a doubt as to the policy of disposal to be adopted. This was probably due to the fact that the mineral resources of the country were practically unknown then, as only small amounts of gold and lead had been found in a few of the Southern States, and not on the public domain but on privately owned lands.

On March 3, 1807, Congress provided for the leasing of "any lead mine which has been or may hereafter be discovered in the Indiana territory, for a time not exceeding five years." This attempt at mineral leasing on the public domain was not a success, as the cost of supervision had far exceeded the income. The acts of July 11, 1846, and March 4, 1847, abolished all mineral leases and established sales, and the act of 1849 transferred the charge of such mineral lands from the War Department to the Department of the Interior. In the preemption act of 1841 it was provided "no lands on which are situated any known salines or mines shall be liable to entry under and by virtue of the provisions of this act." In 1876 the Attorney General of the United States held that "salines, gold, silver, lead, and copper mines" were reserved for the "future disposal of Congress."

DEVELOPMENT OF PRESENT MINERAL LEASING

The act of March 3, 1909, authorized the reservation of coal deposits. The act of June 25, 1910, authorized the withdrawal of public lands for specific purposes, including the reservation of coal, oil, gas, and phosphate.

The acts of June 22, 1910, August 24, 1912, and July 17, 1924, provided for agricultural entry on public lands but withheld certain minerals. On August 1, 1912, Congress by joint resolution ordered

certain coal lands in Wyoming, on which there was an operating coal mine, leased to the then operating company. This lease became effective August 29, 1912. On October 20, 1914, a law providing for the leasing of coal lands in Alaska became effective. The law of August 11, 1916, applied only to the leasing of mineral lands acquired under the so-called Weeks law of March 1, 1911. The act of October 2, 1917, was a war measure and applied only to potash.

The general mineral leasing act of February 25, 1920, provided for leasing oil, gas, coal, sodium, oil shale, and phosphate lands on the public domain and oil and gas lands in Alaska. The act of March 4, 1923, provided for leasing oil and gas lands in the Red River, Okla. The law of April 17, 1926, provided for leasing gold, silver, and quicksilver deposits on certain patented lands acquired from Mexico, and the law of June 8, 1926, covered leasing for sulphur in Louisiana. The act of February 7, 1927, repealed the act of October 2, 1917, and extended potash leasing. The act of December 11, 1928, provided for sodium development, and the act of May 21, 1930, for leasing for oil and gas in or under railroads or other rights of way.

BENEFITS DERIVED FROM MINERAL LEASES

The conservation of natural resources has been the outstanding feature of the mineral-leasing program. Such legislation, including prevention of waste and economy in development and production, can only tend toward the ultimate protection of our undeveloped mineral deposits. Since the act of October 2, 1914, $66,001,615.48 has accrued from royalties, rentals, and bonuses. At the end of the fiscal year 1930 there were in effect 992 leases, 6,846 permits, and 34 licenses involving mineral deposits on public land in 19 States and Alaska.

Under the act of 1920 the public-land States receive, without expense, 37.5 per cent of all money derived from leases and permits within their respective borders and participate in the benefits resulting from the expenditure of an additional 52.5 per cent of the income by the Bureau of Reclamation. Incidental benefits include taxes on production and on property used in the development of leases, which in some States amount to more than one-fifth of the total income. Only 10 per cent of the money received from such leasing operations is retained in the United States Treasury for supervision, which, however, has cost only 3.7 per cent of the total income.

Alaska, by special legislation, receives all net profits from the operations of Government mines and all royalties and rentals derived from mineral leases. The money thus derived is applied to the reimbursement of the Federal Government for the construction of railroads in that Territory.

WORK OF MINERAL-LEASING DIVISION

The work of the mineral-leasing division is supervisory (both inspectional and regulatory) with respect to operations on the public domain for the discovery and development of petroleum, natural gas, oil shale, coal, phosphate, sodium, potassium, and sulphur; on certain land grants for gold, silver, and mercury; on naval petroleum

reserves for petroleum and natural gas; and on Indian lands for coal, oil and gas, zinc, lead, iron, silver-lead, uranium, vanadium, and radium ores, vermiculite, asbestos, asphalt, volcanic ash, and stone. This work is conducted with a minimum of administrative supervision from Washington by means of district offices at or near the primary centers of mining or drilling activities, under the direction of responsible engineers who have full authority to represent the Secretary within their jurisdiction and to order compliance with the law and regulations under which operations are conducted.

PREVENTION OF ACCIDENTS

Many improvements in mining practice, as well as the prevention of both major and minor accidents, result from the careful work of the supervisors of the division. During the year in six States having a combined production of more than 435,000 tons of coal there were no fatal accidents whatever. In Montana there have been no fatal accidents on leased public coal lands since the inception of coal leasing in 1920—more than 1,450,000 tons of coal produced without a fatal accident and with less than 100 minor accidents. In the nine States where there are coal mines on both private land and leased public and Indian land the fatalities per million tons of coal mined were about 20 per cent less in the leased coal mines under the supervision of the engineers of the division than in the private mines.

One zinc mine on leased Indian lands has been worked for more than two years and a half without a "time-lost" accident. At this mine from 40 to 80 men are employed at four different shafts. The record for all the Indian zinc mines in this district under supervision was more than 700,000 tons of ore to the fatality, or less than 1.5 fatalities for each million tons of ore mined.

ACTIVITIES ON THE PUBLIC DOMAIN

Supervision of publicly owned mineral deposits was increased during the fiscal year 1930 by the issuance of leases, licenses, and prospecting permits as follows:

Leases, licenses, and permits issued, fiscal year 1930

	Number	Acres		Number	Acres
Leases:			Permits:		
Oil and gas	88	36,067.89	Oil and gas	181	323,762.66
Coal	29	9,311.87	Coal	68	72,098.22
Potash	3	7,674.39	Potassium	41	67,842.79
Licenses: Coal	15	638.53	Sodium	30	42,590.90

During the same period supervisory work was decreased by the cancellation of 11 coal leases, 11 coal permits, 22 potash permits, 2 sodium permits, 8 oil and gas leases, and 9,141 oil and gas permits, a total of 9,195 cancellations, and the expiration of 20 coal permits and licenses, 53 potash permits, and 16 sodium permits—a grand total of 10,184, compared with the total of 8,758 cancellations for the fiscal year 1929.

The following table shows the total number of leases, licenses, and permits in effect at the end of the fiscal year:

Mineral leases, licenses, and permits on the public domain and naval petroleum reserves under supervision of the Geological Survey June 30, 1930

State	Coal						Oil and gas	
	Leases		Permits		Licenses		Leases (number)	Permits (number)
	Number	Acres	Number	Acres	Number	Acres		
Alaska	9	11,987.28	21	29,362.64	3	30.00		1,022
Alabama	1	1,840.00						
Arizona			5	11,520.00				145
Arkansas			1	2,079.88				15
California			6	8,335.29			[a] 191	519
Colorado	81	12,751.05	42	27,642.20	5	200.00	17	507
Idaho			8	9,137.17				122
Kansas								
Louisiana							12	[b] 8
Montana	51	5,768.17	17	8,201.26	17	674.89	74	570
Nebraska								1
Nevada			6	10,385.92				114
New Mexico	21	14,703.38	55	88,550.97			14	1,326
North Dakota	58	6,536.86	4	520.46	4	159.93		25
Oklahoma							17	10
Red River								6
Oregon	2	1,895.24	4	2,040.00				14
South Dakota	2	119.04						22
Utah	45	32,681.57	45	53,385.67	2	160.00	8	579
Washington			21	18,422.33				6
Wyoming	34	15,036.46	24	23,113.64	3	120.00	343	1,471
	304	103,319.05	259	292,697.43	34	1,344.82	676	6,482

State	Sodium				Potash			
	Leases		Permits		Leases		Permits	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Arizona			2	2,398.74				
California			15	24,342.44	[c] 4	7,783.80	1	2,560.00
Colorado			2	2,160.00				
Idaho								
Nebraska							2	390.00
Nevada	1	1,440.00	5	9,409.37				
New Mexico			7	13,204.33			[c] 2	4,560.00
Do					3	7,674.39	41	81,317.09
North Dakota			3	524.83				
Oregon							4	5,920.00
Utah							17	24,321.33
Washington			1	40.00				
Wyoming			2	1,045.78			1	1,760.00
	1	1,440.00	37	53,125.49	7	15,458.19	68	120,828.42

[a] Includes 15 leases on Naval Petroleum Reserves Nos. 1 and 2 under the act of Feb. 25, 1920, and 10 on Naval Petroleum Reserves Nos. 1 and 2 under the act of Oct. 2, 1917.
[b] Oil and gas permits in Louisiana include the right to lease sulphur deposits discovered while prospecting for oil and gas.
[c] Under the act of Oct. 2, 1917.

Also Idaho, 2 phosphate leases, 1,700 acres; Nevada, 1 phosphate lease, 160 acres; Oregon, 1 oil-shale lease, 2,680 acres. Total leases, 992; licenses, 34; permits, 6,846; grand total, 7,872.

PRODUCTION

Coal.—During the year, 3,033,075.88 tons of coal was produced in 12 States, from which there accrued $489,616.32 in rents, royalties, and bonuses; this was a decrease in production of 4 per cent from the preceding year. Prospecting in the San Pete Valley of Utah revealed coal at a depth of 1,000 feet below the surface. It is estimated that more than 5,000,000 tons of coal was conserved in Utah alone by influencing coal operators to mine the upper beds before attacking the lower beds. Similar work was done in other States, particularly

in Wyoming, where changes suggested by the supervisors have increased the ultimate recovery of coal at least 10 per cent and also the amount of lump coal produced. The new equipment at the open-pit mine of the Northwestern Improvement Co. at Colstrip, Mont., will result in considerable saving of coal owing to the greater depth of overburden handled and the corresponding increase in the width of cuts, with fewer supporting coal walls.

Potash.—No potash was produced during the fiscal year 1930, but prospecting was continued in the Utah and New Mexico districts. In Utah 750 feet of drilling was completed to check potash deposits noted while drilling for oil. A shaft was started on the New Mexico potash leases and sunk to a depth of 380 feet by the end of the year. A potash prospecting permit was issued on land in the vicinity of Alliance, Nebr., near which considerable potash was produced during the World War.

Sodium, etc.—The potash leases in California produced 7,594.47 tons of borax and 21,142 tons of soda ash. The only sodium lease in effect produced 585.59 tons of anhydrous sodium sulphate. There were, however, 37 sodium prospecting permits in effect.

Phosphate.—Only three phosphate leases were in effect at the end of the year, and only one of them in Idaho had any production. On this lease 22,100.65 tons of ore was mined, an increase of 1.6 per cent over the output of 1929 and of 6,339.6 per cent over that of 1926.

Oil and gas.—The production of oil and gas on public lands in the fiscal year 1930 showed the following increases over 1929: Crude oil, 4,960,667 barrels, or 22 per cent; natural gas, 16,353,721,890 cubic feet, or 72 per cent; natural gasoline, 54,087,427 gallons, or 114 per cent. Income from royalties increased as follows: Crude oil, $372,470, or 11 per cent; natural gas, $47,866, or 38 per cent; natural gasoline, $47,926, or 41 per cent. The unit price per barrel of crude oil, based on royalty values, declined from $1.18 in 1929 to 80 cents in 1930; and the unit price per M cubic feet of natural gas declined almost 1 cent.

Coal produced from leases, licenses, and permits on public lands, in tons, by fiscal years

State	1912–1925	1926–1928	1929	1930	Total
Alaska	455,497.43	297,943.54	107,971.62	121,825.20	983,237.79
Alabama		76,433.00	109,832.00	136,661.00	322,926.00
California		6.00	36.00	62.00	104.00
Colorado	2,028,940.29	1,241,636.10	490,446.22	434,871.08	4,195,893.69
Idaho			466.65	1,366.65	1,833.30
Montana	252,973.58	756,384.96	299,813.84	247,854.94	1,557,027.32
Nevada		91.15			91.15
New Mexico	74,427.26	197,829.99	84,441.64	74,857.99	431,556.88
North Dakota	453,695.38	783,530.62	462,285.16	447,627.36	2,147,138.52
Oregon	688.97	2,332.49	3,234.47	3,231.70	9,487.63
South Dakota	1,842.63	2,027.79	342.45	402.58	4,615.45
Utah	487,303.62	887,706.12	580,100.78	649,383.27	2,604,493.79
Washington	164,280.43	81,608.60			245,889.03
Wyoming	4,465,885.23	3,200,185.52	1,022,860.90	914,932.11	9,603,863.76
	8,385,534.82	7,527,715.88	3,161,831.73	3,033,075.88	22,108,158.31

Sodium salts produced from public lands, in tons, by fiscal years

State	1921–1925	1926–1928	1929	1930	Total
California	3,145.30	21,719.43	22,906.47	28,736.47	76,507.67
Nevada	248.25	1,286.06	674.43	585.59	2,794.33
	3,393.55	23,005.49	23,580.90	29,322.06	79,302.00

Phosphate produced from public lands, in tons, by fiscal years

State	1921–1925	1926–1928	1929	1930	Total
Idaho	6,132.44	47,657.76	21,746.61	22,100.65	97,637.46
Nevada			45.45		45.45
	6,132.44	47,657.76	21,792.06	22,100.65	97,682.91

Operating mines, fiscal year 1930

	Coal		Potash	Sodium	Phosphate
	Shipping	Wagon			
Alaska	4	1			
Alabama	1				
California		1	2		
Colorado	15	49			
Idaho		3			2
Montana	2	68			
Nevada				1	1
New Mexico	8	12			
North Dakota	6	53			
Oregon	1	2			
South Dakota		2			
Utah	22	26			
Wyoming	23	150			
	82	367	2	1	3

Petroleum, natural gas, and natural-gas gasoline produced from public lands, by fiscal years

1930, by States

	Petroleum (barrels)	Natural gas (M cubic feet)	Gasoline (gallons)
California	10,729,585.87	13,090,399.00	60,647,334.00
Colorado	725,039.54	877,430.00	14,642.00
Louisiana	9,963.41	498,234.00	43,980.76
Montana	511,125.69	1,088,197.00	
New Mexico	1,200,056.51	5,108,938.00	3,088.89
Oklahoma	450,342.03		1,014,349.68
Utah	2,752.49	563,471.00	
Wyoming	13,790,643.81	17,897,447.00	39,746,906.00
	27,419,509.35	39,124,116.00	101,470,301.33

Total

1921–1925	118,333,954.01	60,298,796.00	63,997,718.97
1926	29,712,876.16	18,535,880.50	35,910,791.54
1927	25,648,101.43	17,723,410.03	40,104,404.57
1928	23,370,549.38	18,922,026.00	39,698,292.82
1929	22,458,842.62	22,770,394.11	47,319,874.32
1930	27,419,509.35	39,124,116.00	101,470,301.33
	246,943,832.95	177,374,622.64	328,501,383.55

ROYALTY, RENT, AND BONUSES

The following tables summarize accrued income from all mineral leases, licenses, and prospecting permits under the various leasing acts applicable to the public lands:

Royalties, rentals, and bonuses accrued from all mineral operations on public lands, by fiscal years

State	1912–1925	1926–1928	1929	1930	Total
Alabama	$86,380.00	$7,643.30	$10,983.20	$13,666.10	$118,672.60
Alaska	35,142.42	40,050.32	13,162.60	12,854.14	101,209.48
California	4,676,746.55	3,582,191.85	677,743.16	1,034,629.91	9,971,311.47
Colorado	216,853.81	343,000.85	106,832.87	98,639.99	765,327.52
Idaho	1,111.38	5,774.26	2,385.14	2,712.97	11,983.75
Louisiana	1,508.59	21,492.65	10,723.06	3,583.40	37,307.70
Montana	891,278.79	635,985.39	110,554.70	100,988.67	1,738,807.55
Nevada	301.07	5,062.79	1,480.00	800.00	7,643.86
New Mexico	13,883.64	60,504.86	50,978.45	129,514.38	254,881.33
North Dakota	29,144.79	57,838.52	24,763.89	28,490.14	140,237.34
Oklahoma		376,617.12	114,160.27	105,776.14	596,553.53
Oregon	952.15	2,968.80	1,187.10	7,464.48	12,572.53
South Dakota	399.60	311.52	80.00	130.00	921.12
Utah	138,932.03	238,292.09	112,271.36	195,546.36	685,041.84
Washington	22,215.91	8,312.83			30,528.74
Wyoming	31,206,133.17	14,533,531.33	2,862,763.66	2,926,186.96	51,528,615.12
	37,320,983.90	19,919,578.48	4,100,069.46	4,660,983.64	66,001,615.48

Royalties, rentals, and bonuses accrued from mining operations on public lands, by fiscal years

	Coal	Sodium	Phosphate	Potash	Oil shale	Bonuses	Total
1930							
Alabama	$13,666.10						$13,666.10
Alaska	12,854.14						12,854.14
California	15.50			$16,216.40			16,231.90
Colorado	55,623.86						55,623.86
Idaho	341.66		$2,371.31				2,712.97
Montana	26,400.16					$100.00	26,500.16
Nevada		$720.00	80.00				800.00
New Mexico	13,510.37			1,919.00		10.00	15,439.37
North Dakota	28,487.14					3.00	28,490.14
Oregon	6,124.48				$1,340.00		7,464.48
South Dakota	130.00						130.00
Utah	193,733.26						193,733.26
Wyoming	138,729.65						138,729.65
	489,616.32	720.00	2,451.31	18,135.40	1,340.00	113.00	512,376.03
SUMMARY							
1912–1925	790,408.19	301.07	1,111.38	24,458.65		148,384.00	964,663.29
1926	319,626.78	2,160.00	695.00	6,031.78		1,566.00	330,079.56
1927	322,308.12	1,440.00	2,549.41	6,217.60		1,237.00	333,752.13
1928	372,949.85	1,440.00	2,529.85	9,402.40		1,095.00	387,417.10
1929	397,964.30	720.00	2,308.48	11,989.33		484.00	414,186.11
1930	489,616.32	720.00	2,451.31	18,135.40	1,340.00	113.00	512,376.03
	2,692,873.56	6,781.07	11,645.43	76,235.16	1,340.00	152,879.00	2,941,754.22

Royalties and bonuses accrued from oil and gas operations on public lands, by fiscal years

1930, by States

	Petroleum	Natural gas	Gasoline	Bonuses	Total
California	$917,449.12	$40,345.05	$60,603.84		$1,018,398.01
Colorado	40,403.58	2,593.38	19.17		43,016.13
Louisiana	1,700.71	1,726.69	156.00		3,583.40
Montana	69,376.05	3,657.46		$1,455.00	74,488.51
New Mexico	86,069.26	27,990.59	15.16		114,075.01
Oklahoma	102,303.10		3,473.04		105,776.14
Utah	379.87	1,433.23			1,813.10
Wyoming	2,592,265.89	95,132.39	99,913.83	145.20	2,787,457.31
	3,809,947.58	172,878.79	164,181.04	1,600.20	4,148,607.61

Total

1921–1925	$32,938,494.47	$398,543.30	$251,197.70	$2,768,085.14	$36,356,320.61
1926	7,951,665.52	93,508.29	154,265.43	250,503.94	8,449,943.18
1927	5,741,485.97	91,796.54	173,172.59	3,980.00	6,010,435.10
1928	3,519,810.55	108,570.86	107,070.00	672,500.00	4,407,951.41
1929	3,437,477.58	125,013.01	116,254.69	7,138.07	3,685,883.35
1930	3,809,947.58	172,878.79	164,181.04	1,600.20	4,148,607.61
	57,398,881.67	990,310.79	966,141.45	3,703,807.35	63,059,141.26

ACTIVITIES ON NAVAL PETROLEUM RESERVES

Production from Naval Petroleum Reserve No. 3, in Wyoming, was definitely suspended December 31, 1927, and the total royalty accrued from 1923 to date of suspension of production amounted to $848,947.91. Supervision on this reserve for the present is confined to observation of gas pressure and consultation with the Navy Department.

Royalties accrued from naval petroleum reserves in California during the fiscal year were as follows: Petroleum, $1,369,861.43; natural gas, $77,029.07; gasoline, $165,276.55. The total receipts from these reserves for the fiscal years 1921 to 1930 amounted to $23,062,196.73.

Petroleum, natural gas, and gasoline produced from naval reserves

	Fiscal year	Petroleum (barrels)	Natural gas (M cubic feet)	Gasoline (gallons)
California	1921–1925	37,882,945.09	35,544,349.81	34,508,751.07
	1926	12,234,702.16	12,917,255.09	19,851,282.68
	1927	12,368,315.70	12,328,208.69	24,052,402.12
	1928	9,690,573.93	9,077,966.68	24,797,263.61
	1929	8,116,635.98	7,711,858.00	24,908,262.82
	1930	6,978,922.16	6,817,458.00	25,567,986.00
		87,272,095.02	84,397,096.27	153,685,948.30
Wyoming	1923–1925	2,523,213.05	950,520.00	7,829.00
	1926	520,680.00	1,458,032.00	291,852.00
	1927	357,049.32	1,958,463.00	1,441,036.00
	1928	149,285.26	795,854.00	743,179.00
		3,550,227.63	5,162,869.00	2,483,896.00
Total	1921–1925	40,406,158.14	36,494,869.81	34,516,580.07
	1926	12,755,382.16	14,375,287.09	20,143,134.68
	1927	12,725,365.02	14,286,671.69	25,493,438.12
	1928	9,839,859.19	9,873,820.68	25,540,442.61
	1929	8,116,635.98	7,711,858.00	24,908,262.82
	1930	6,978,922.16	6,817,458.00	25,567,986.00
		90,822,322.65	89,559,965.27	156,169,844.30

ACTIVITIES ON INDIAN LANDS

Cooperation with the Indian Service during the fiscal year included technical supervision over all mining and drilling operations on tribal, segregated, restricted allotted, and Indian lands set aside by Executive order. This work involved the enforcement of lease terms and operating regulation, technical investigations and advice concerning impairment of mineral deposits and the adequacy of bonus, appraisal of unleased land subject to mineral development, determination of damage to surface improvements, investigations of domestic water supply contaminated by waste from mineral development, and engineering and geologic reports on leased and unleased lands subject to mineral development. Field offices for the performance of these duties were maintained at Miami, McAlester, Muskogee, Oklahoma City, Red River, Shawnee, and Tulsa, Okla.; Billings and Shelby, Mont.; Farmington, N. Mex.; Thermopolis, Wyo.; and Denver, Colo.

In the following summary only outstanding features of economic importance are mentioned:

ARIZONA

Colorado River Reservation: 1 gold lease.

Fort Apache Reservation: 1 application for iron-ore lease, 1 agency coal mine, and 1 asbestos lease.

Hopi Indian Reservation: 2 agency coal mines.

Northern Navajo Reservation: 5 vanadium leases and 1 agency coal mine.

Southern Navajo Reservation: 3 agency coal mines.

Western Navajo Reservation: 2 agency coal mines.

San Carlos Reservation: 2 asbestos leases and 2 copper leases.

Gila River Reservation: 1 gold prospect.

Pima Reservation: 1 application for mineral lease.

Fort Apache Indian Reservation: An engineering and geologic examination of the deposits of iron ore under mineral location in the western part leads to the conclusion that there is awaiting development not less than 10,000,000 tons of high-grade iron ore having a high potential royalty value to the Indians. There are two abandoned wells on Navajo tribal lands and one on Navajo Executive order lands.

COLORADO

Southern Ute Reservation: 2 agency coal mines. Coal and mineral supervision on the ceded Ute lands included 40 coal leases, 5,418.54 acres; 1 coal license, 40 acres; 13 coal permits, 8,139.65 acres; 1 awarded coal-lease application, 2,160 acres; and 1 potash permit, 2,538.67 acres, from which a total of $11,729 in royalties and rentals was credited to the account of the Indians.

The status of oil and gas wells on Indian lands in Colorado is as follows: Ute tribal lands, active wells, 6 oil, 2 gas; shut in, 4 oil, 2 gas; abandonment, 13. Ute alloted lands, abandoned, 1. The oil and gas supervision included one producing lease, one producing permit, and one nonproducing lease. In addition, two nonproducing leases embrace both ceded Ute and public lands. Operation of 12 wells has been indefinitely suspended, and 3 wells are in the process of drilling. On the Southern Ute Indian Reservation the Durango Natural Gas Co. delivered to consumers 206,000,000 cubic feet of natural gas from the Ute dome gas field during its initial year of operation.

MONTANA

Rocky Boy Reservation: 1 application for vermiculite lead-silver lease, 1 silver-lead ore lease, and 1 coal prospect. Crow Reservation: 2 agency coal mines. During one of the examinations by the district mining supervisor a deposit of vermiculite was discovered on the lands included in a silver-lead lease, and considerable royalty returns are expected. The status of oil and gas wells on Crow Indian lands in Montana is as follows: Crow allotted lands,

shut in, 3 oil; abandoned, 11; plugged and abandoned, 1. Crow tribal lands, shut in, 2 oil; abandoned, 5. Private, drilling wells, active 9, suspended 102; producing wells, active, 47 (6 oil, 41 gas), shut in, 106 (8 oil, 98 gas); abandoned, 260; plugged and abandoned, 38. Recommendations were made for offering certain oil and gas tribal lands for lease with appraisals of their value for bonus purposes; operating equipment at the sites of two existing oil wells was appraised. The status of oil and gas wells on Blackfeet Indian lands in Montana is as follows: Indian, drilling wells, suspended, 1; plugged and abandoned, 2. Private, drilling wells, active, 27, suspended, 31; produc ng wells, active, 1,243 (1,102 oil, 141 gas), shut in, 30 gas; abandoned, 824. Engineering report and advice were given in a controversy over the selection of an oil-well site.

NEVADA

Pyramid Lake Indian Reservation: 3 silver-lead leases, 1 application for marl lease.

NEW MEXICO

Eastern Navajo Indian Reservation: 1 agency coal mine.
Northern Navajo Indian Reservation: 1 agency coal mine, 1 coal lease.
Zuñi Indian Reservation: 1 agency coal mine.
The status of oil and gas wells on Indian lands in New Mexico is as follows: Navajo tribal lands, producing wells, active, 28 oil; shut in, 2 oil; abandoned, 14. Navajo allotted lands, producing wells shut in, 6 oil; Navajo Executive order, abandoned, 1.

OKLAHOMA

Five Civilized Tribes: The McAlester office maintains general technical supervision over all mining operations on segregated and restricted allotted leases on Indian coal and mineral lands in Oklahoma, exclusive of Ottawa County. Cooperation with and engineering ass stance to lessees resulted in improved methods of mining, thus increasing the returns on a number of the segregated leases.

During the last two years six companies have introduced the slope panel system of mining in their mines. The Kali Inla Coal Co., at Cambria, has introduced and is operating the panel-long-wall advancing system and is controlling the caving of the roof by means of collapsible jacks. The system provides for a 100 per cent recovery of the area worked and is proving very satisfactory.

The Missouri, Kansas & Texas Coal Co. continues successfully to draw pillars in its No. 19 mine at Wilburton. The drawing of pillars is an innovation in Oklahoma mining, as heretofore it was considered inpracticable. However, 188,402 tons of pillar coal has been produced from this mine by this method and has netted the Choctaw and Chickasaw Indian Nations $15,000 in royalties, which would have been lost had the lessee been permitted to abandon the property without drawing pillars.

A fire was extinguished in an opening on the outcrop of the Craig Coal Mining Co.'s lease No. 2, Pittsburg County.

The 396,386.28 acres of segregated coal lands belonging to the Choctaw and Chickasaw Indian Nations have decreased in value to a marked degree during the last 15 years. This has been due largely to the discovery of new coal deposits and the development of oil and gas in the State, which have changed completely the fuel situation in Oklahoma. All the railroads that traverse the State, with the exception of the Chicago, Rock Island & Pacific, which has its own mines, and the Missouri, Kansas & Texas, are using fuel oil in their locomotives. Practically all manufacturing plants hitherto run by steam are now operated by electric power produced in large central power stations that use gas or fuel oil. These changes have resulted in decreasing the value of all coal lands to such an extent that some tracts upon which $10,000 to $15,000 had been paid have reverted to the Indian nations. The last public auction, held in 1925, resulted in the sale of only four tracts out of the several hundred offered.

Three nonproducing volcanic-ash leases covering 236.97 acres and one nonproducing zinc-lead lease were inspected during the year. Cooperation with the Oklahoma Geological Survey in tracing and mapping the coal outcrop in Muskogee and McIntosh Counties was continued.

Leases and tracts under supervision on segregated and restricted allotted Indian coal lands

	Producing	Nonproducing	Acres
Segregated leases and tracts:			
Coal leases not sold	37	21	54,699.11
Coal leases sold	6	1	5,150.00
Asphalt leases		1	960.00
Purchased unleased tracts	4	11	12,124.34
Remaining unleased tracts		373	318,196.06
Allotted leases:			
Cherokee	3	5	579.69
Choctaw	6	8	871.31
Creek	7	30	3,468.92
Miscellaneous mineral leases:			
Volcanic ash—			
Creek		2	120.00
Choctaw		1	116.97
Lead and zinc—Cherokee		1	99.88
	63	453	396,386.28

Status of oil and gas lands belonging to Five Civilized Tribes

	Leases			Wells	
	Nonproducing	Producing	Total	Producing	Drilling
Cherokee		376			
Choctaw		64			
Creek	6,456	603	7,681	5,200	38
Chickasaw		20			
Seminole		162			
	6,456	1,225	7,681	5,200	38

During the year 61 investigations were made relative to gas waste, improper methods of production, surface conditions on areas covered by expired departmental permits, and correlative appraisal of Indian allotments located near producing wells. A few of the engineering features resulting in augmenting the royalties to the Indians on allotted lands are cited below:

Creek Agency: A gas sand penetrated in the course of drilling for oil and adequately protected by mudding ultimately netted the lessor a bonus of $3,150 paid for the gas rights on expiration of the oil lease. A recommendation to deepen a gas well resulted in an increase in the gas produced from 3,000,000 to 33,000,000 cubic feet a day.

Seminole Agency: Study of subsurface conditions resulted in changing the method of setting well casings and the producing operations of the wells, which gave a lower oil gas ratio, with a consequent daily saving of 54,000,000 cubic feet of gas, having an estimated value of $4,300. Notice was given to the operator of a single well to suspend production until an arrangement was made for economic utilization of the gas; under an approved plan for curtailment and a sales arrangement covering reduced volume of gas the daily revenue from the well increased from $200 to $400. Recommended deepening and shooting a well increased the daily oil production from 47 to 247 barrels, a gain which should net the allottee $4,000 for the year.

Quapaw Indian Reservation: The mining engineers of the Miami office maintain supervision over operations on the restricted Quapaw Indian lands in northeastern Oklahoma. During the fiscal year 1930 an average of 33 mine ore and tailing mills were in operation on these lands. These mills, which represented 40 per cent of the average number of mills in operation in the Tri-State district during the year, produced 23 per cent of the zinc concentrates and 33 per cent of the lead concentrates of the district, or 14.2 per cent of the zinc and 3.9 per cent of the lead mined in the United States. At the end of the year there were in force under departmental supervision 50 lead and zinc mining leases, embracing 6,244 acres, and 43 subleases, embracing 2,214 acres. From these leases, 144,805 tons of lead and zinc concentrates

were sold during the year for $6,166,601.93. The royalty paid to the Indians amounted to $587,255.08, and in addition they received $1,477.30 collected as advance rental, paid in lieu of royalty on nonproducing leases, and $1,363.60 from the sale of mill tailings.

Marked progress was made toward the consolidation of lease units for centralized milling, and the resulting economies of operation, higher recovery, and lower grade of ore thereby made available will add materially to the ultimate income of the Indian owners of the land. Seventeen separate consolidations of two to five producing units each have been consummated, and permits for centralized milling have been granted by the Secretary of the Interior.

Tests made by the Miami office indicate that the loss in tailing piles through leaching and oxidation of recoverable lead and zinc approximates 10 per cent a year. Continued efforts to secure the early re-treatment of tailings have met with success, and practically all the re-treatable tailing piles on restricted allotments have been or are now being remilled. At the end of the year 10 of the 14 tailing mills in operation in the Tri-State district were located upon restricted lands.

Examinations and reports were made relative to lead and zinc mining operations on lands of a Cherokee allottee near Fairland County, a bonus for leasing Cherokee lands near Welsh, and an application for a lead and zinc mining lease on allotted Wyandot Indian lands.

A 1,000-foot geologic section was completed across the Quapaw Reservation to show the principal structural features and the relationship between these features and the ore bodies. This is the first detailed work of this character in this district and is of great assistance to the departmental lessees in their drilling for deeper runs of ore.

An estimate of the tonnage of ore reserves was completed to show the value and expected royalty income from the remaining ore bodies on restricted Quapaw Indian allotments. This information has been summarized for use by the Quapaw Agency in the future disbursement of Indian funds.

There were 15 fatal accidents in the lead and zinc mines of the Tri-State district during the fiscal year, but only 5 of these occurred at mines on restricted Indian lands—one fatality to each 700,000 tons of ore mined.

Zinc and lead produced on Quapaw Indian lands, 1924–1930

Fiscal year	Concentrates (tons)		Total value	Royalty	Other payments
	Zinc sulphide	Lead sulphide			
1924	175,989	45,553	$10,961,885	$901,405.70	----------
1925	210,306	49,126	15,135,569	1,351,720.63	----------
1926	236,971	52,651	17,672,498	1,679,863.75	$106,086.65
1927	210,622	45,890	14,131,113	1,307,114.54	3,208.63
1928	181,139	34,830	9,424,720	894,820.30	2,889.30
1929	150,670	35,752	8,809,442	848,219.49	5,708.31
1930	121,333	23,472	6,166,602	587,255.08	2,840.90

Pawnee and other agencies: The status of oil and gas lands under the Pawnee Agency is as follows:

Status of oil and gas lands under Pawnee Agency

	Leases			Producing wells
	Nonproducing	Producing	Total	
Ponca	154	14	168	54
Otoe	222	2	224	2
Tonkawa	24	----------	24	----------
Pawnee	195	19	214	66
Kaw	48	4	52	33
	643	39	682	155

During the year the four Indian agencies in this district have held 17 oil and gas sales, and technical advice was furnished on the adequacy of the bids received.

Appraised value of tracts involved in oil and gas sales, Pawnee and other agencies

	Sales	Allotments appraised	Acres appraised	Bonus	
				Total	Average per acre
Pawnee	7	173	13,046.56	$116,914.11	$8.96
Shawnee	2	43	3,370.04	41,811.59	12.41
Kiowa	5	601	74,021.41	172,854.67	2.34
Cheyenne and Arapaho	3	169	16,759.88	77,825.08	4.64
	17	986	107,198.89	409,405.45	3.82

Kiowa Agency: The status of oil and gas lands under the Kiowa Agency is shown below:

Status of oil and gas lands under Kiowa Agency

	Leases			Wells	
	Nonproducing	Producing	Total	Producing	Drilling
Kiowa	170	----------	170	----------	----------
Comanche	324	17	341	30	3
Apache	22	5	27	17	----------
Wichita	142	----------	142	----------	----------
Caddo	205	----------	205	----------	----------
	863	22	885	47	3

Appraised 986 allotments embracing 107,148 acres, offered for sale at an estimated bonus value of $409,405, of which 731 tracts, involving 81,593 acres, sold for $268,271. By recommendation of the district engineer that sealed bids be invited instead of conducting auction sales, an increased return of $67,481 was realized by the allottees.

UTAH

Uintah-Ouray Reservation: 1 coal lease. On the Navajo Executive order lands in southeastern Utah 4 wells have been abandoned.

WYOMING

With the exception of one deep test hole at Pilot Butte practically no new development work has been done on the Shoshone Indian Reservation during the year. The Lander and Pilot Butte fields have been productive, although owing to the decreased market demand for black oil, the Lander field has not produced to capacity.

The special investigations and reports made to the benefit of the Indians numbered 62. The value of some of the work can not be determined on the basis of immediate results or estimated in money value pending settlement. Typical investigations are described briefly below:

Ponca Agency: Damage to eight allotments by refinery waste oil was appraised at $10,650 to January 1, 1930. A gas repressuring project in the South Ponca field had been conducted efficiently prior to the merger of the leading operating company. After the merger a change in the operating method involved the removal of all input gas meters; notice was given to discontinue that practice of uncontrolled repressuring and to replace all meters. Replacement of meters is in progress, and the work will be inspected when completed.

Status of oil and gas lands under Shawnee Agency

	Leases			Producing wells
	Nonproducing	Producing	Total	
Iowa	22		22	
Kickapoo	90		90	
Pottawatomie	65	9	74	31
Sac and Fox	165	8	173	23
Shawnee	210		210	
	552	17	569	54

Sac and Fox Agency: Payment of $2,703 was made as a royalty settlement in lieu of drilling required offset wells.

Wells on Indian oil and gas lands in Wyoming

Land	Drilling		Producing		Abandoned	Plugged and abandoned	Total
	Active	Suspended	Active	Shut in			
Tribal		1	[a] 11	36	22	37	107
Allotted:							
Trust patented			24		30	6	60
Patented	1	2	[b] 11	3	22	11	50
	1	3	46	39	74	54	217

[a] 1 water well.
[b] 9 oil, 2 gas (not commercial).

COOPERATIVE WORK

Cooperative work was conducted with the Bureau of Mines and the Bureau of Standards in connection with tests of mine stoppings to withstand explosions of gas and coal dust; with the Bureau of Mines in its rock-dusting, ventilation, and experimental mine programs and oil and gas technologic investigations; with the Bureau of Reclamation in conjunction with its lease on the power and coal mine at Williston, N. Dak.; with the National Research Council on the conservation of the scientific results of drilling and the improvement of drilling methods and equipment; with the Industrial Commission of Utah on explosions in the Standardville and New Peerless mines and the increase in the use of rock dust in Utah coal mines as a preventive against the propagation of local explosions throughout the mines; with the Oklahoma Geological Survey in the study of the zinc and lead ore deposits in northeastern Oklahoma and the preparation for publication of maps showing coal outcrops and related geologic data in the Muskogee-Whitefield area; with the Bureau of Mines and the General Land Office in examining and studying means for extinguishing fires on coal outcrops on the public domain, some of which have been burning for several decades and one, at Coalmont, Colo., has consumed the coal in an area of about 6 acres and threatens destruction of over 4,000,000 tons of coal. Cooperation with the technical committee on the scientific classification of coals of the American Society for Testing Materials was also continued.

WORK ON PUBLICATIONS

TEXTS

BERNARD H. LANE, Editor

During the year 20,885 pages of manuscript were edited and prepared for printing by the section of texts, and 3,494 galley proofs and 16,932 page proofs were read and corrected. Indexes were prepared for 40 publications, covering 9,248 pages. Copy and proof or stencils for 1,901 pages of multigraph and mimeograph matter were read. At the end of the year four persons were employed in this section. The publications issued during the year are listed on pages 4–8.

The editor is serving as a member of the departmental subcommittee to assist in the revision of the Style Manual of the Government Printing Office. The other members of this subcommittee represent the Bureau of Standards, the Smithsonian Institution, the State Department, the Department of Agriculture, and the Library of Congress.

ILLUSTRATIONS

C. A. WECKERLY, Chief Illustrator

The number of drawings and photographs prepared by the section of illustrations was 3,158, including 132 maps, 364 sections and diagrams, 45 charts and plans, 547 photographs, and 2,070 paleontologic drawings; 128 miscellaneous jobs were also done by the section. The illustrations transmitted to accompany 32 reports numbered 754, to be reproduced by chromolithography, photolithography, halftone, and zinc etching. The number of proofs received and examined was 980. At the end of the year material for illustrating 25 reports was in hand. The section consists of eight employees.

GEOLOGIC EDITING AND DRAFTING OF MAPS AND ILLUSTRATIONS

GEORGE W. STOSE, Editor of Geologic Maps

The Fairfield-Gettysburg (Pa.) folio was completed during the year and published as Folio 225. The maps and sections of the Gaffney-Kings Mountain (S. C., N. C.) folio were being prepared on stone for color proof. The maps and structure sections of the Coatesville-West Chester (Pa.) folio made no progress during the year, awaiting transfer to stone. The maps of the Somerset-Windber (Pa.) folio were engraved and made ready for transfer to stone, but no progress was made on the engraving of the structure sections. The maps of the Montevallo-Columbiana (Ala.) folio were in plate proof. No progress was made on the engraving of the maps and structure sections of the Boston folio. The maps of the Hollidaysburg-Huntingdon (Pa.) folio were engraved.

The geologic map of Arkansas was completed and published for the Arkansas Geological Survey, and two topographic maps of the State showing mineral industries and power-transmission lines were in color proof. The geologic map of Kentucky was completed and published for the Kentucky Geological Survey. A block diagram of the Tonopah mining district, Nevada, was drawn and photo-

lithographed and reached color proof. The geologic map of Pennsylvania, compiled in cooperation with the Pennsylvania Geological Survey, was completed and submitted for publication. Compilation of the geologic map of California, in cooperation with the California Division of Mines, and of the geologic map of Texas was begun. The compilation of the geologic map of the United States on the scale of 1:2,500,000 was well advanced.

Illustrations for 25 reports were examined and edited, and geologic advice was given to members of the section of illustrations. Work was done on the maps of the San Juan region of southwestern Colorado for the authors, and oil and gas maps of Texas and Louisiana were compiled and drawn. Illustrations for 23 other reports by geologists were drawn.

INSPECTION AND EDITING OF TOPOGRAPHIC MAPS

W. M. BEAMAN, Chief

During the year 156 new topographic maps were edited and transmitted for engraving, 270 published topographic maps, 15 State maps, and 10 State index circulars were edited for reprint, and 289 maps were edited as illustrations for Geological Survey reports—a total of 740 maps edited. First, second, combined, and woodland proofs of engravings for new topographic maps and reprints numbering 462 and proofs of maps reproduced by photolithography in one to three colors numbering 187 were read. At the end of the year 182 new topographic maps were in progress of engraving and printing and 205 new topographic maps were in preparation for submission for reproduction.

DISTRIBUTION

R. C. SHELSE, Chief

A total of 313 publications, comprising 77 new books and pamphlets, 91 new or revised topographic and other maps, and 145 reprinted topographic and other maps, were received by the division distribution during the year. A number of special pamphlets and forms for administrative use were also delivered and distributed. The total units of all publications received numbered 179,089 books and pamphlets, 5,030 geologic folios, and 660,767 topographic and other maps, a grand total of 845,123.

The division distributed 161,214 books and pamphlets, 5,040 geologic folios, and 828,303 maps, a grand total of 833,343, of which 4,197 folios and 691,610 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was $46,480.18, including $44,779.98 for topographic and geologic maps and $1,700.20 for geologic folios. In addition to this $2,159.38 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were $48,639.56.

The division received and answered 68,858 letters.

ENGRAVING AND PRINTING

S. J. KUBEL, Chief Engraver

TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS

During the fiscal year 78 new topographic maps were engraved and printed, including one revised map, and 13 new maps were photolithographed and printed, making a total of 91 new maps printed and delivered. One fractional map was engraved but not printed. Corrections were engraved on the plates of 216 maps. Reprint editions of 132 engraved topographic maps and 13 photolithographed State and other maps were printed and delivered. In addition, 61 new topographic maps had been engraved and were in press June 30, and the engraving of 24 other new topographic maps, also the United States map on a scale of 1:2,500,000, was nearly completed. Of new and reprinted maps 658,450 copies were delivered. One new geologic folio was printed, its edition amounting to 5,030 copies. Two extra geologic sheets of folios numbering 2,317 copies were also delivered.

OTHER GOVERNMENT MAP PRINTING

A large amount of work was done for the Government Printing Office, the office of the Secretary of the Interior, the Bureau of Reclamation, Office of Education, General Land Office, National Park Service, Indian Service, Alaska Railroad, Bureau of Pensions, Bureau of Public Roads, Bureau of Agricultural Economics, Bureau of Plant Industry, Forest Service, Bureau of Biological Survey, Weather Bureau, Plant Quarantine and Control Administration, Bureau of Standards, Bureau of Lighthouses, Bureau of Foreign and Domestic Commerce, Bureau of Mines, Bureau of Fisheries, Federal Radio Commission, Coast and Geodetic Survey, Department of Labor, Department of State, War Department, Post Office Department, Treasury Department, Department of Agriculture, Department of Commerce, Interstate Commerce Commission, Federal Power Commission, National Capital Park and Planning Commission, Commission of Fine Arts, International Boundary Commission, Children's Bureau, Bureau of Customs, Washington Navy Yard, United States Military Academy, Office of the Chief of Engineers, Coast Artillery School, General Service Schools, Army War College, United States Marine Corps, United States Naval Academy, Federal Board for Vocational Education, United States Veterans' Bureau, Regional Plan of New York and its Environs, and the States of Kansas, Connecticut, Arkansas, Kentucky, California, and Texas. This work done for other branches of the Government and State governments included many reprints, and the charges for it amounted to about $146,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed.

Transfer impressions numbering 469 were made during the year, including 282 furnished to contracting lithographic printers on requisition of the Government Printing Office, 4 furnished to other branches of the Government, 124 furnished to State surveys, and 59 furnished to private firms. The amount turned over to miscellaneous receipts was $553.

Of contract and miscellaneous work of all kinds, 2,525,790 copies were printed. Including topographic maps and geologic folios, a grand total of 3,191,587 copies were printed and delivered.

PHOTOGRAPHIC LABORATORY

The output of the photographic laboratory consisted of 10,649 negatives (4,942 wet (of which 3,994 were for photolithographs), 29 paper, 2,108 dry, and 2,875 field negatives), 695 lantern slides, 28,227 prints (3,816 maps and diagrams and 24,411 photographs for illustrations), 3,467 zinc plates, 266 zinc etchings, 21 celluloid prints, 100 lantern slides colored, 10 transparencies colored, 24 prints colored, and 2,252 prints mounted.

ADMINISTRATION

JULIAN D. SEARS, Administrative Geologist

JOHN J. MADIGAN, Chief Clerk

The administrative geologist assists the director in all phases of general administration, performs special tasks assigned to him by the director from time to time, serves as acting director in the director's absence, and has special supervision over the section of illustrations.

The chief clerk, in addition to performing the duties usually pertaining to that office, serves as budget officer and exercises administrative supervision over the division of engraving and printing, the division of distribution, the section of correspondence and records, the section of accounts, the library, and the division of field equipment.

CORRESPONDENCE AND RECORDS

C. A. KING, Chief

Mails, files, and records.—During the year 99,488 pieces of mail, of which 2,017 were registered, were opened and referred. In addition 116,755 letters were received direct by the other divisions, making a total of 216,243, a decrease of 17 per cent compared with 1929. Of the letters opened in this section 19,136 contained $46,815.22 remitted for Geological Survey publications. The number of ordinary letters mailed through the section was 60,589; of registered letters and packages, 964. In addition, 126,966 pieces of mail were sent out direct from other divisions. The total number of outgoing pieces of mail for the Geological Survey was 188,519.

Freight and express.—During the year 2,665 pieces of freight and express were handled, 1,409 outgoing and 1,256 incoming.

Personnel.—The roll of Secretary's appointees numbered 1,065 at the end of the fiscal year, 68 more than at the end of 1929. The total number of changes in personnel was 1,092, including 215 appointments, 147 separations, and 730 miscellaneous changes.

During the calendar year 1929 17,868 days of annual leave and 3,602 days of sick leave were granted, being 68 per cent of the amount of annual leave that could have been taken and 13 per cent of the sick leave that it would have been possible to grant. In addition 8,475 days of leave without pay and furloughs were also granted.

ACCOUNTS

C. K. FRANCIS, Chief

During the year 18,747 field accounts, 1,687 transportation bills, and 261 telegraph bills were audited and transmitted for payment. In the audit of these accounts 944 suspensions and disallowances were made. The section received 158 printing and binding requisitions, 913 stationery requisitions, 2,424 miscellaneous supply requisitions, 1,462 letters of employment, and 375 contracts.

Condensed statements covering expenditures from Federal funds during the year are given on the following pages. The amounts expended by States for cooperative work are set forth in the reports of the field branches.

Amounts appropriated for, transferred to, and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1930 [a]

	Funds available				Expenditures			
	Amount of appropriation	Repayments on account of work performed		Total	Disbursements	Outstanding liabilities	Total	Balance
		Made	To be made					
APPROPRIATIONS								
Salaries	$134,800.00			$134,800.00	$134,769.66		$134,769.66	$30.34
Topographic surveys	635,000.00	$274,779.88	$74,842.43	984,622.31	965,727.20	$16,834.77	982,561.97	2,060.34
Shenandoah National Park in Virginia	33,924.78	15.00	1,611.24	35,551.02	34,653.51	897.51	35,551.02	
Geologic surveys	350,000.00	26,024.79	9,080.12	385,104.91	375,580.96	8,190.61	383,771.57	1,333.34
Volcanologic surveys	21,000.00			21,000.00	19,840.28	1,110.14	20,950.42	49.58
Alaskan mineral resources	67,500.00	1,754.86	156.87	69,411.73	55,914.31	13,267.33	69,181.64	230.09
Gaging streams	275,000.00	344,749.48	55,843.25	675,592.73	665,856.28	7,984.19	673,840.47	1,752.26
Classification of lands	180,000.00	266.25		180,266.25	177,976.97	2,160.93	180,137.90	128.35
Geologic and topographic maps of the United States	107,000.00	120,569.08	23,864.77	251,433.85	238,090.43	12,540.13	250,630.56	803.29
Preparation of illustrations	20,500.00	664.19		21,164.19	21,163.09		21,163.09	1.10
Mineral leasing	250,000.00	834.13		250,834.13	245,525.43	3,548.03	249,073.46	1,760.67
Plugging wells	50,000.00			50,000.00	6,209.25	600.00	6,809.25	43,190.75
Great Smoky Mountains National Park in North Carolina and Tennessee	57,945.84	233.32		58,179.16	50,122.15	1,036.91	51,159.06	7,020.10
	2,182,670.62	769,890.98	165,398.68	3,117,960.28	2,991,429.52	68,170.55	3,059,600.07	[b] 58,360.21
TRANSFERS								
Engineering, Bureau of Engineering (Navy Department, act Mar. 4, 1929) 1930	50,000.00	127.10		50,127.10	50,089.14		50,089.14	37.96
Federal Power Commission (act Mar. 4, 1929), 1930	5,250.00	16.41		5,266.41	4,024.84	968.00	4,992.84	273.57
Flood control, Mississippi River and tributaries (War Department, act Mar. 4, 1929)	121,007.00	1,006.57		122,013.57	110,696.47	4,858.87	115,555.34	6,458.23
Flood control, Mississippi River and tributaries (War Department, act Mar. 7, 1928)	1,959.35	.09	27.47	1,986.91	1,450.14	536.77	1,986.91	
Investigating potash deposits, Bureau of Mines (Commerce Department, act Jan. 25, 1929), 1930	12,500.00		83.33	12,583.33	12,172.64	377.44	12,550.08	33.25
Maintenance and improvement of existing river and harbor works (War Department, act Mar. 4, 1929)	316,656.00	1,852.39	99.09	318,607.48	267,303.60	14,232.22	281,535.82	37,071.66
Maintenance and improvement of existing river and harbor works (War Department, act Mar. 7, 1928)	17,284.88	105.85		17,390.73	7,907.76	1,819.10	9,726.86	7,663.87

[a] In addition to these appropriations an item of $150,000 for printing and binding for the Geological Survey was contained in the appropriation act, but the account was not kept in the Geological Survey. There was also an allotment of $12,960 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

[b] Of this balance, $43,190.75 for plugging wells and $7,020.10 for Great Smoky Mountains National Park is available for expenditure during the fiscal year 1931, leaving a net balance for the fiscal year 1930 of $8,149.

Amounts appropriated for, transferred to, and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1930—Continued

	Funds available				Expenditures			Balance
	Amount of appropriation	Repayments on account of work performed		Total	Disbursements	Outstanding liabilities	Total	
		Made	To be made					
TRANSFERS—continued								
Maps of the United States (act May 21, 1920), 1930	$11,375.00	----------	$235.00	$11,610.00	$8,851.68	$2,758.32	$11,610.00	----------
Supervising mining operations on leased Indian lands (act Mar. 4, 1929), 1930	75,000.00	$1,802.51	----------	76,802.51	76,228.21	565.02	76,793.23	$9.28
Supervising mining operations on leased Indian lands (act Mar. 26, 1930), 1930	10,000.00	----------	528.33	10,528.33	10,218.44	120.94	10,339.38	188.95
Water boundary, United States and Mexico (State Department, act Jan. 25, 1929), 1930	18,440.00	103.49	----------	18,543.49	18,489.11	54.34	18,543.45	.04
Waterways treaty, United States and Great Britain (State Department, act Jan. 25, 1929), 1930	75,000.00	534.57	136.50	75,671.07	73,964.59	1,265.40	75,229.99	441.08
Waterways treaty, United States and Great Britain (State Department, act Mar. 4, 1929), 1930	15,000.00	3,299.81	----------	18,299.81	17,898.94	210.42	18,109.36	190.45
Ammunition storage facilities, Navy (Navy Department, act Mar. 4, 1929)	1,400.00	----------	----------	1,400.00	----------	997.48	997.48	402.52
Maintenance, Bureau of Yards and Docks (Navy Department, act Mar. 4, 1929), 1930	1,500.00	147.36	----------	1,647.36	1,647.36	----------	1,647.36	----------
	2,915,042.85	778,887.13	166,508.40	3,860,438.38	3,652,372.44	96,934.87	3,749,307.31	111,131.07

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1930

Object of expenditure	Geological Survey salaries	Topographic surveys	Geologic surveys	Volcanologic surveys	Alaskan mineral resources	Gaging streams	Classification of lands	Geologic and topographic maps of the United States	Preparation of illustrations	Mineral leasing	Total
Personal services	$134,769.66	$817,600.24	$332,038.11	$17,508.13	$51,558.21	$672,543.99	$152,268.57	$201,750.75	$20,563.08	$296,865.65	$2,697,466.39
Stationery and office supplies		5,889.08	704.13	158.44	3,439.13	5,762.12	287.11	28,322.02	161.12	1,974.67	46,697.82
Scientific and educational supplies		187.90	1,086.96	24.24		106.62	10.58		1.42	173.79	1,591.51
Sundry supplies		3,288.98	1,026.76	372.77	125.77	3,495.12	188.98	6,238.02	126.30	440.48	15,303.18
Subsistence and care of animals and storage and care of vehicles		2,410.39	866.29			89.50	237.29			59.76	3,663.23
Telegraph service		842.86	234.52	.25	73.97	922.93	57.16	3.62		773.22	2,908.53
Telephone service		252.25	105.90	53.55	25.40	1,351.99	75.30			2,492.86	4,357.25
Other communication service		20.67		.90		18.81				83.00	123.38
Travel expenses		128,980.41	23,947.28	927.15	8,955.13	85,910.90	14,258.71	85.59	2.37	23,948.23	287,015.77
Attendance at meetings		119.03	1,007.42			967.45				1,020.23	3,114.13
Hire, maintenance, operaton, repair of horse-drawn and motor-propelled passenger-carrying vehicles		1,435.76	2,005.98	251.29		26,504.77	6,122.15			21,542.95	57,862.90
Transportation of things		54,340.83	6,305.39	418.03	3,518.33	26,286.40	1,870.10	136.91		2,720.98	95,596.97
Lithographing, engraving, and engrossing		18,161.24	820.82			860.15	1,179.79		70.22	171.59	21,263.81
Stenographic work, typewriting, and duplicating work, etc. (job work)		.50	17.50			14.80	8.50			.50	41.80
Photographing and making photographs and prints		36,283.49	4,556.24	63.85	383.08	2,640.49	1,434.66	7,877.51	206.44	316.63	53,762.39
Heat, light, power, water, and electricity			66.31	50.00	45.16	60.53				4,563.35	4,785.35
Rents		273.07				2,951.00				8,322.34	11,546.41
Repairs and alterations		356.47	131.58	120.42	15.42	1,994.79	40.26	1,928.03		8,434.29	13,021.26
Special and miscellaneous current expenses		807.18	266.46		7.25	758.85	.75			743.19	2,583.68
Purchase of passenger-carrying vehicles		1,106.55	945.40			7,512.00	2,558.80			13,296.76	25,419.51
Furniture, furnishings, and fixtures		1,922.54	769.91	413.56	42.25	5,118.90	201.15	270.30		753.23	9,491.84
Educational and scientific equipment		27,714.69	10,421.29	347.10	780.40	40,640.51	1,485.96	2,114.00		2,064.64	85,568.59
Other equipment		31,772.09	6,555.48	78.52	212.14	18,245.03	1,457.29	12,809.20		378.16	71,507.91
Structures		8,781.77		58.75		42,929.07					51,769.59
Miscellaneous transfers and adjustments		43,920.74	2,441.92	103.47		132,935.81	741.46	704.61	32.14	1,963.96	182,844.11
	134,769.66	1,186,468.73	396,321.65	20,950.42	69,181.64	1,080,622.53	184,484.57	262,240.56	21,163.09	393,104.46	3,749,307.31

LIBRARY

GUY E. MITCHELL, Librarian

The library of the Geological Survey, which forms the greater part of the Interior Department scientific library, is a public library, as provided by law. It serves the members of the Geological Survey, but its service to others is numerically greater—51 per cent according to records kept since January, 1930. This outside public service is but one expression of the general Geological Survey policy to make freely available the information it has collected.

The manuscript of the bibliography of North American geology for 1919–1928 was completed and transmitted during the year, for publication as Bulletin 823. This is a 10-year cumulation that supplements the bibliography for 1785–1918 published as Bulletins 746 and 747 and will form one of the most valuable working tools for geologists. The preparation of the bibliography for 1929 and 1930 is in progress.

The "List of serial publications of foreign countries" has been furnished to this library for checking. This is a project sponsored by the American Library Association, the American Council of Learned Societies, and the National Research Council, and one in which all the important libraries in the United States are cooperating. The purpose is to show where any particular serial publication may be found in the libraries throughout the United States and Canada. During the year the Geological Survey library has found and reported 481 titles of serials published in Mexico, Central and South America, the British Empire overseas, Italy, Spain, Portugal, Switzerland, Belgium, the Netherlands, and the Scandinavian and Baltic countries.

Binding, one of the prime requisites of a library, has been in continual arrears in this library for many years. Several thousand of the older books are badly in need of rebinding, and other thousands of valuable paper-covered foreign publications should be bound. The volumes prepared for regular binding during the year represented an increase of nearly 35 per cent over the average for the last five years. In addition about 500 paper-covered books have been encased in substantial stiff binders with linen backs, made by the engraving division in spare time at an average cost of about 14 cents each. This may be compared with the cheapest binder on the Government schedule, which costs 37 cents each but is not as good.

Leather labeling of books has been discontinued, as the best leather available has an average life of only about 25 years, which is presumably not more than half of the life of good buckram. Titles are now printed in gold direct on buckram.

Bound copies of many Government publications (heretofore bound by the library) have been obtained through arrangement with the publishing offices at an estimated saving thus far of over $400 in binding cost. The arrangement is a continuing and reciprocal one, the Geological Survey having agreed to supply several offices with bound copies of its own publications instead of paper-covered copies.

Some 5,500 books and periodicals have been disposed of, to the Library of Congress and elsewhere, permitting a reorganization of shelving space on all three floors that has given much-needed relief

from shelf crowding. Several out of town university geologic libraries have been supplied with more than 600 surplus publications—books of which this library had duplicate or triplicate copies. The cost of the extra work involved in boxing and shipping these books (outside of office hours) has been borne by these institutions.

The year's accessions comprised 13,340 books, pamphlets, and periodicals and 1,073 maps. The recorded loans were 5,573 books and 171 maps, in addition to those used by 6,743 readers who consulted the library in person. The card catalogue was increased by the addition of 11,314 cards. Title entries to the number of 536 were furnished to the Library of Congress for printing; the proof reading of these titles involved 126 galleys. Correspondence handled included 1,635 letters received and 1,521 letters sent. Communications in foreign languages to the number of 76 were translated for other divisions of the Geological Survey. The volumes prepared for binding numbered 1,296, and 421 newly bound volumes were labeled, plated, and shelved. Numerous loans were made to libraries in Washington and in other places, and a considerable volume of reference work was done in the usual course of the library's service to specialists and students, both in and out of the Geological Survey.

FIELD EQUIPMENT

R. L. ATKINSON, Chief

The instrument shop designed a theodolite, a leveling rod, a precise level, a reel for 300-foot chain tapes, a range pole, and a tripod leg; designed and constructed precise-leveling rods, an airplane-camera mount, temperature apparatus, pressure bombs, a nonmagnetic stainless-steel reticule, a columnation testing apparatus, turning pins, and leveling-cup pins; rebuilt and repaired 2,707 instruments of different kinds; constructed special apparatus and made repairs for the chemical laboratory, petrographic laboratory, and engraving division; tested all New York and precise rods and 300-foot band chains; and did work for the Corps of Engineers, district engineers, National Park Service, Indian Service, Bureau of Reclamation, Forest Service, and Bureau of Mines.

The cabinet shop designed and constructed explorer's alidade carrying cases, a standard copperplate storage case, a case for assorted-size plates, a proof-sheet filing case, a set of three cases for an airplane camera, combination stadia and level rods, shadowgraphs, a case for microcamera set, an enlarging camera, and a projection slide; made and fitted stadia and invar rods and cases; and did repair and upkeep work on cases, rods, tripods, and plane-table boards.

The electrical shop designed and constructed a special rheostat for temperature control; redesigned transformers used in aerial photography, motor drive on plate-grinding machine, mount and feed on diamond-saw motor, and motor control on electrically driven camera; installed a 10-horsepower motor and control system; and inspected and repaired electric motors, heaters, and temperature apparatus.

The express, freight, and mail packages shipped and received by the division amounted to nearly 86 tons.

Overtime amounting to 1,100½ hours was reported by 14 employees.

GEORGE OTIS SMITH, *Director.*

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UNITED STATES DEPARTMENT OF THE INTERIOR

ANNUAL REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY

TO THE SECRETARY OF THE INTERIOR

FOR FISCAL YEAR ENDED JUNE 30, 1950