GEOLOGICAL SURVEY

(WALTER C. MENDENHALL, *Director*)

During the fiscal year 1936 the aggregate expenditures for which the Geological Survey was responsible amounted to about $4,620,000, as compared with nearly $5,328,000 during the preceding year. These aggregates were made up of the regularly appropriated funds, the cooperative funds from States, counties, and municipalities, the funds transferred from other departments of the Government for types of work falling within the Survey's field, and the emergency funds derived chiefly from the Public Works Administration and devoted largely to mapping of various types, to construction of stream-gaging stations, to conservation work on public lands, and in a lesser degree to the study of mineral resources.

Although there was a decline from the preceding year in aggregate funds available, the fiscal situation has nevertheless improved, because the Congress, in view of the decreasing availability of emergency funds, had increased the regular appropriation to $2,285,500 from the $1,631,000 of the preceding year and before the end of the fiscal year 1936 had provided a little more than $2,800,000 for the fiscal year 1937.

As a part of our informal service to the public, 5,000 tests of mineral and rock samples were made and over 1,200 chemical analyses were completed.

Between 18,000 and 19,000 square miles of new area was surveyed in the field topographically. This work will yield 139 new contoured topographic maps of areas in 43 States. In addition, by the aid of aerial photography, 31,600 square miles was surveyed for the production of base maps without contours.

Congressional interest in the inadequate rate at which mapping is proceeding was clearly indicated during the second session of the Seventy-fourth Congress. This interest was expressed in the form of Senate Resolution 281, introduced by Senator Hayden, of Arizona, calling upon the Secretary of the Interior to submit to the Seventy-fifth Congress a report and plan for the completion of the mapping of the United States.

With this better fiscal situation, it has been possible to resume, on a more nearly normal scale, the regular services of the Geological Survey; to improve the personnel situation, which was acute 3 years

ago; and again to issue a gratifying volume of Survey products in the form of reports and maps, thus supplying to the Nation the results obtained by the Survey's skilled staff.

Fifty book publications of the Survey's regular series, aggregating nearly 9,000 pages of printed matter, dealing with geology, mineral resources, and water supplies, were issued during the year, and about 700,000 copies of 281 topographic and other maps were printed. A new geologic map of Colorado, long in demand, came from the presses, and substantial progress was made toward the completion of the geologic map of Texas.

There were 50 geologic parties in the field in 35 States. The field investigations on several continuing projects were completed, and it was possible to initiate a number of new investigations, such as systematic studies of the alunite deposits at Marysvale, Utah, of the lead and zinc deposits of the Metaline district, in Washington, and of the granites of the Northeastern States.

Measurements of stream flow were maintained at 3,163 stream-gaging stations. All the States, the District of Columbia, and Hawaii are affected by this work. A report on the droughts of 1930 to 1934 and a series of notable flood studies resulting from cooperation with other Federal agencies were published during the year.

The work on underground waters, so important in the drought-stricken areas, was continued, much of it in cooperation with the States, and some 50 reports on this topic, many of them informal, were released for public use.

In the land-classification and mineral-leasing activities of the Survey substantial progress was made, although insufficient personnel and expanding mining activities rendered inadequate our work in safeguarding the Government's interest as owner of great resources in coal, oil and gas, potash, phosphate, and other minerals. The situation will be improved in 1937 as a result of more liberal provision for this work by the Congress. Despite the handicaps, 317,000 acres of public lands were classified as nonoil, nearly 200,000 acres were defined as within "known geologic structures" in accordance with the requirements of the mineral land leasing act of 1920, and technical supervision was given to over 8,000 mineral properties on public lands containing oil and gas, nearly 700 containing coal, and 170 containing other minerals, also to nearly 5,600 oil and gas leases on Indian lands.

An event of particular interest during the year was the retirement of Dr. T. W. Stanton, chief geologist, on September 30, 1935, at the age of 75. Dr. Stanton was appointed to the staff of the Geological Survey in 1889 and hence had spent 46 years in the Government service. His special field had been the paleontology of the Cretaceous

system, but his accurate work on stratigraphy gave special validity to his age determinations and early made him the chief reliance of the geologists of this continent on the relations of the rocks of this system. Dr. Stanton was long in charge of the important section of paleontology and stratigraphy in the geologic branch, and in this position he exercised a valuable influence on the development of our concepts of stratigraphic relationships in the United States and through his chairmanship of the committee on geologic names guided procedure in this difficult field for many years. He became chief geologist on February 1, 1932, and retained this position until his retirement. Dr. G. F. Loughlin, long in charge of the section of metalliferous deposits, succeeded Dr. Stanton as chief geologist and was in turn succeeded as chief of the metalliferous section by Dr. D. F. Hewett.

GENERAL SUMMARY OF THE YEAR'S ACTIVITIES

Geologic work.—Fifty field parties were active during the year, and work was done in 35 States. Most of the Federal field projects financed with funds from the Public Works Administration were completed before the beginning of the fiscal year, but some further studies were made in the gold-bearing areas of the Southeastern States and in the quicksilver field of Arkansas. Work was continued throughout the year on the metal-mining districts of Colorado, Idaho, and New Mexico and the oil and gas region of Kansas, in cooperation with the States, and some further assistance was given to the Arizona Bureau of Mines in its survey of the Tombstone district. Physiographic and geologic studies were made in the Yosemite, Sequoia, and Zion National Parks, in cooperation with the National Park Service. Several major projects begun in 1935 were continued, and toward the end of the year new major projects were begun in the Marysvale district, Utah, the Metaline district, Washington, and some of the leading granite districts of the Northeastern States. Areas of forest lands were geologically examined for the Forest Service, and dam and reservoir sites were examined for the Office of Indian Affairs and the Natural Resources Board. Increasing attention was given to fundamental "borderland" problems involving geology, chemistry, and physics. More than 5,000 tests of mineral and rock samples were made, including 1,225 chemical analyses in connection with the Geological Survey's projects and 1,065 tests for persons not officially connected with the Survey. Many tests were made of bleaching clays, two deposits of which are now being developed commercially, largely as a result of tests made in the Survey's laboratory. Temperature measurements of deep wells were made in nine States, mainly in oil fields.

Explorations in Alaska.—In the field season of 1935 seven field projects were carried on in Alaska, two of which were primarily topographic and five primarily geologic. The usual general survey of recent mining developments and the collection of mineral statistics were continued. Five field projects for the season of 1936 were under way at the end of the fiscal year, and two additional geologic projects were planned to begin early in July. These will be continued throughout the open season.

Topographic mapping.—The area covered by new topographic surveys, resurveys, and revision amounted to 18,555 square miles, representing 139 topographic maps with contours. The topographic mapping was done in 43 States.

There was also a large increase in the area covered by planimetric maps without contours, resulting from aerial photography, which covered 31,654 square miles in eight States. In addition, aerial photographs were used as bases for topographic mapping in 20 quadrangles. Stereoscopic plotting apparatus, utilizing single-lens aerial photographs, as a practical demonstration of the use of such equipment in connection with topographic mapping, is being extensively applied in the mapping of the Tennessee River Basin in cooperation with the Tennessee Valley Authority. The sectional transportation map of the United States being made for the Bureau of Public Roads was continued with increased output. The maps of Florida, in 12 sections; New Hampshire, in 2 sections; Maine, in 6 sections; and Vermont, in 2 sections, were published. These transportation maps on the scale of about 4 miles to 1 inch show transportation routes of all kinds in a variety of colors.

Investigations of water resources.—The water-resources branch collected and made available for publication stream-flow records at 3,163 river-measurement stations on rivers in the 48 States, the District of Columbia, and the Territory of Hawaii, obtaining thus authentic information on the behavior of streams in drought, in flood, and in normal conditions—information which is invaluable for intelligent planning of projects for use or control of the surface water supply. It investigated underground water supplies in 21 States and Hawaii and obtained basic information on the occurrence, quantity, and quality of underground water supplies which is essential for the development, conservation, and use of ground water upon which a large part of the population of the country must depend. In collaboration with the Mississippi Valley Committee of the Public Works Administration, and with the assistance of special advisory committees of the American Society of Civil Engineers and the American Geophysical Union, studies were made of floods in the United States, with especial reference to their magnitude and frequency, and of the relation of rainfall and run-off in the United States, and the results were published in Water-Supply Papers 771 and 772. The favorable reception of these two reports indicates that they have filled a need for computations of flood data and for interpretations of the relation of rainfall and run-off. The drought studies have been continued. Investigations of stream-flow and silt movement of streams in eight projects of the Soil Conservation Service and similar studies on the Colorado River have also been continued. Monthly and annual reports on the production of electricity for public use and the consumption of fuel in generating the electricity were made. Engineers of the branch had general supervision of operation of permits and licenses of the Federal Power Commission in connection with 145 projects. Investigations of the water problems along the international boundary between the United States and Canada were continued for the State Department. The collection of information on recent outstanding floods was started. A report on the thermal springs in the United States and a report on ground-water levels and artesian pressures in the United States up to January 1, 1936, were completed and sent to the printer. About 50 reports giving the results of technical investigations relating to ground water were released. Analyses, partial or complete, were made of 1,481 samples of water from surface and underground sources with reference to the suitability of the waters for industrial and agricultural use and for domestic use (not related to questions of health).

Classifying and leasing public land.—The conservation branch made 4,917 formal findings of technical fact involving the mineral resources, water power, or storage possibilities of public lands; classified 317,766 acres of public land as nonoil in character; added 46,174 acres to outstanding water-power reserves

and eliminated 10,934 acres therefrom; defined the "known geologic structure" of 13 producing oil and gas fields, amounting to 196,304 acres; completed 1,615 miles of river-utilization surveys and 520 square miles of reservoir surveys in public-land States; supervised operations and activities under 151 power projects licensed by the Federal Power Commission and 317 permits and grants from the Interior Department; supervised on public lands 8,332 oil and gas holdings involving 3,849 productive wells, 694 coal properties, 95 potash properties, 40 sodium properties, 26 sulphur properties, 9 phosphate properties, and 1 oil-shale property; supervised on naval petroleum reserves 23 leaseholds, involving 533 productive oil and gas wells, and on Indian lands 5,583 leaseholds, involving 4,356 oil and gas wells, 36 lead and zinc properties, 109 coal properties, 1 asphalt property, and 1 lime phosphate property; assisted hundreds of oil and gas permittees and operators in preparation of unit plans of development and operation; acted on 279 such plans; and assisted in the formulation of regulations under the act of August 21, 1935.

Publications.—The publications of the year comprised 50 pamphlets in the regular series, covering a total of 8,901 pages; 114 new or revised topographic and other maps; 167 reprinted topographic and other maps; and several pamphlets for administrative use. Among the notable book publications were professional papers on the Gold Hill mining district, Utah, the Montezuma quadrangle, Colorado, the minerals of Franklin and Sterling Hill, N. J., and the pre-Cambrian rocks of the Lake Superior region (with a revised geologic map); bulletins on the San Juan region, Colorado, the Book Cliffs coal field, Utah, the Casto quadrangle, Idaho, the Bellefonte quadrangle, Pennsylvania, the southern Alaska Range, the Salt Valley anticline, Utah, the Monument Valley-Navajo Mountain region, Utah, and the Coastal Plain of South Carolina; and water-supply papers on water utilization in the Snake River Basin, ground water in south-central Tennessee, droughts of 1930–34, floods in the United States, and relations of rainfall and run-off in the United States. Besides the regular publications, 31 brief papers were issued in mimeographed form as memoranda for the press.

The engraving division printed more than 701,000 copies of maps and did repay work amounting to about $208,000 for more than 75 other Government units and State governments.

NOTE.—Detailed tabular statements are given at the end of the report.

GEOLOGIC BRANCH

SUMMARY

Fifty field parties were actively at work during the year, and work was done in 35 States. Most of the Federal field projects for which funds had been allocated by the Public Works Administration were completed before the beginning of the fiscal year 1936. Small balances, however, remained in the allotments for continuing the mapping of gold-bearing areas in the Southeastern States (project 183), and additional work was done in Georgia and the Carolinas. A brief reexamination of the Arkansas quicksilver field (project 184) was also made. Preliminary reports covering many of the Federal projects have been released as press notices and submitted to State organizations and technical journals for publication.

Work was continued throughout the year on metal-mining districts in Colorado, Idaho, and New Mexico, and in the oil fields of Kansas in cooperation with the States. The geologic map of Colorado, embodying the results of 10 years of cooperative work, was published. Further assistance was rendered to the Arizona Bureau of Mines in a survey of the Tombstone district. Physiographic and geologic studies were made in the Yosemite and Sequoia National Parks, Calif., and in the Zion National Park, Utah, in cooperation with the National Park Service.

Several of the major projects begun in 1935 were continued in 1936, and toward the end of the year new projects were begun in the Marysvale district, Utah, the Metaline district, Washington, and some of the leading granite districts of the Northeastern States. Field work in the Comstock district, Nevada, was nearly completed.

Work for other Federal organizations included the geologic examination of forest lands for the Forest Service and of dam and reservoir sites for the Office of Indian Affairs; also the furnishing of maps and information to the Reconstruction Finance Corporation and the Securities Exchange Commission, the Procurement Division of the Treasury Department, and the Architect of the Capitol.

WORK OF THE YEAR BY STATES

Alabama.—Geologic mapping was continued in the Russellville and other brown iron ore districts in eastern Alabama, including parts of Franklin, Butler, Cleburne, Clay, and Lowndes Counties, and in the manganiferous iron ore area in Cherokee County. A report on the red iron ore formation in northeastern Alabama is well advanced. A press notice giving some results of the investigations for ceramic and bleaching clays in the State was issued, and a more detailed report on clays in Alabama will be included in a report to be published by the Survey on clays in the Southern States. Work on gold in Alabama is mentioned under Southern Appalachians.

Arizona.—A preliminary report on the geology and ore deposits of the Ajo quadrangle was transmitted to the Arizona Bureau of Mines for publication, and a complete report is in preparation for publication by the Survey. Further field examinations were made in the Tucson area in connection with the detailed report in preparation on the geology and mineral resources of the area and in the Tombstone mining district in informal cooperation with the Arizona Bureau of Mines.

Arkansas.—The manuscript of a report on the geology and mineral resources of the western portion of the Arkansas coal field and one on the quicksilver deposits of Arkansas have been completed for Survey publication, and one on the geology of the Arkansas bauxite region was transmitted to the Arkansas Geological Survey. A paper on the stratigraphy of the Arkansas-Oklahoma coal basin has been submitted for publication in the Bulletin of the American Association of Petroleum Geologists. David White's report on fossil plants from the Stanley shale and Jackfork sandstone in southeastern Oklahoma and western Arkansas was completed and submitted for publication as Professional Paper 186–C, and studies were continued on the Morrow formation of Arkansas

and Oklahoma, on the stratigraphy of the Bloyd shale near Fayetteville, and on the manganese carbonate deposits of the Batesville district. A preliminary paper on Radiolaria in the Arkansas novaculite, Caballos novaculite, and Big Fork chert, and a paper on unusual oolites from the Brentwood limestone near Fayetteville were submitted for outside publication.

California.—Studies of the geomorphology of the Sequoia National Park and its environs were made in cooperation with the National Park Service, and an outline of the geologic history of Sequoia National Park and a map of the Pleistocene glaciers in and adjacent to Yosemite National Park were prepared for the Park Service. Geologic studies of the San Andreas rift and of the Death Valley region were continued. Field studies were conducted on the structure, stratigraphy, and oil resources of the lower Tertiary strata in Reef Ridge, in the Coalinga region; on the oil resources and subsurface structure and stratigraphy of the Mountain View and Edison fields, near Bakersfield; on diatom-bearing deposits of the Monterey and Temblor formations in the vicinity of Bakersfield and Coalinga; and on the Monterey shale problem, and additional field data were obtained in the Kettleman Hills oil and gas fields and on the north slope of the San Pedro Hills.

Several reports on the Kettleman Hills oil and gas fields are in preparation, including one on the lithologic descriptions of the subsurface sections, status of wells and zonal correlation, and economic phases; another on the stratigraphy and paleontology of the North Dome; and another on the general geology and oil resources of the Kettleman Hills. A detailed report on mineral resources in the region tributary to the Boulder Dam is in press as Bulletin 871. Papers were submitted to the American Association of Petroleum Geologists on Miocene stratigraphy and paleontology of the Palos Verdes Hills, and the proportion of organic matter converted into oil in the Santa Fe Springs field.

Colorado.—Cooperation was continued with the Geological Survey Board of the State of Colorado and the Colorado Metal Mining Fund in investigations of mining regions of the State. In the San Juan area of southwestern Colorado mapping was continued in the Ouray, Sneffels, and Red Mountain districts and the La Plata Mountain region. Investigations were continued in the Cripple Creek area, the Jamestown district, the Nederland tungsten district, and other areas in the Front Range, and in the Alma and Horseshoe districts in the Mosquito Range. The new geologic map of Colorado, embodying the results of 10 years of cooperative work, was published by the United States Geological Survey. Cooperative reports on ore deposits in the vicinity of the London fault, and on the general geology and mineralization of the Snowmass area, Gunnison County, were completed during the year and will be published as bulletins of the Survey.

A preliminary report on the resurvey of the geology and ore deposits of the La Plata district was submitted to the Colorado Scientific Society for publication. Scientific papers resulting from the cooperative work include Crystallization of Granodiorite Magma (based largely on studies in the Ouray district), Structure of pre-Cambrian Granites in Central Boulder County (American Geophysical Union), Thrusting in Huerfano Park, Colo., and Related Problems of Orogeny in the Sangre de Cristo Mountains (Geological Society of America), and Structure and Mineralization along the London Fault (American Institute of Mining and Metallurgical Engineers). Investigations of dam sites on the Pine River in La Plata County were made for the Office of Indian Affairs. A paper on stratigraphy of the Upper Cretaceous rocks north of the Arkansas River in eastern Colorado will be published in the Survey's

Contributions to General Geology. A report on the Dawson and Laramie formations in the southeastern part of the Denver Basin, Colo., will be published in the Bulletin of the American Association of Petroleum Geologists.

District of Columbia.—A report on gravel and sand in the District of Columbia, resulting from studies made under a Public Works Administration allotment, has been completed and will probably be published as a bulletin of the Survey. A geologic map of the District of Columbia, with descriptive text, is in preparation for Survey publication.

Florida.—A preliminary report on some clays in Florida was issued as a memorandum for the press, and a more detailed report covering investigations will be included in a Survey bulletin on clays in the Southern States. The Tampa and Suwannee limestones are being studied in informal cooperation with the State of Florida. A short paper on additions to the molluscan fauna of the Alum Bluff group will be published by the Florida Geological Survey.

Georgia.—Geologic mapping was done in the Coastal Plain region of Georgia, in informal cooperation with the State, for the purpose of revising the geologic map of the State. A paper giving the general results of a preliminary investigation of the Georgia bleaching clays was published by the Division of Geology of Georgia. Work on the gold deposits of Georgia is mentioned under Southern Appalachians.

Idaho.—In cooperation with the Idaho Bureau of Mines, field work was continued in the Murray, Warren, and Florence mining districts, in the Coeur d'Alene region, and the Boise Basin, and progress was made in the preparation of reports on the Boise Basin, Thunder Mountain, Edwardsburg, Yellow Pine, and Warren mining districts. A party including Survey geologists made an expedition down the gorge of the Salmon River, and a paper on the results of this exploratory trip, entitled "Idaho's river of no return", was submitted to the National Geographic Society. A paper on the geomorphology of south-central Idaho was submitted for publication by the Geological Society of America. A detailed investigation of the geology and mines of the Dickey or Borah Peak quadrangle was begun, and a brief field examination was made in the vicinity of Idaho Falls and Blackfoot for the purpose of reviewing the geology of those areas in connection with the preparation of a report on the geology and mineral resources of the Paradise Valley and Ammon quadrangles.

Illinois.—The complete report on investigation by geologic mapping and geophysical studies of the Cave-in-Rock and Rosiclare districts, southeastern Illinois, is in course of preparation for Survey publication. A preliminary report on the Cave-in-Rock fluorspar reserves was transmitted to the Illinois Geological Survey, and a paper on geologic interpretations of fluorspar reserves in the Illinois-Kentucky field was presented at an industrial conference at Rosiclare. Some progress was made toward bringing to completion the report on the Pottsville flora of the eastern interior basin, mainly in Illinois, a cooperative project with the State, left unfinished by the late David White

Indiana.—A paper on the flora of the New Albany shale is mentioned under Kentucky. The report on the Pottsville flora of the eastern interior basin is mentioned under Illinois.

Kansas.—Under a cooperative agreement with the Kansas Geological Survey an investigation was made of the limestones of Mississippian age found in deep wells in the eastern and southeastern parts of the State. The report on geologic investigations of the Shoestring oil-bearing sands of Greenwood and Butler Counties was transmitted to the Kansas Geological Survey for publication. Work in the Kansas portion of the lead and zinc area is mentioned under Oklahoma.

Kentucky.—A press memorandum giving some preliminary results of the investigation of bleaching and ceramic clays of Kentucky and western Tennessee was issued. A more detailed report of these investigations will be included in a Survey bulletin on clays of the Southern States. The Calamopityeae and Their Relationships, which will form part 2 of the series on the flora of the New Albany shale, was sent to the printer for publication as Professional Paper 186–E. Samples were collected from Lower and Upper Elkhorn coals from Pike County for the purpose of making a study of the effect of regional metamorphism.

Work on the Pottsville flora and on fluorspar in Kentucky is mentioned under Illinois.

Maryland.—Studies of the geology and mineral resources of Frederick County were continued in cooperation with the Maryland Geological Survey, and a paper on revision of the age of the limestone of Frederick County was presented at a meeting of the Geological Society of America. The new excavations along the Chesapeake-Delaware Canal were intermittently examined as the work progressed. The results of the studies of structural materials, chiefly sand and gravel deposits, of eastern Maryland adjacent to Baltimore, will be published as a Survey bulletin. Three papers were presented for outside publication under the following titles: Are the Maryland Terraces Warped? Structure of the Coastal Plain of Southern Maryland, and Some Fossil Conifers from Maryland and North Dakota.

Minnesota.—Some granite and limestone quarries around St. Cloud and Mankato were examined.

Mississippi.—In the study of the areal and structural geology of the Jackson area, the mapping of the Morton, Pelahatchee, Florence, and Jackson quadrangles and a part of the Raymond quadrangle was completed. Some preliminary results of these studies were published in two papers—Upper Cretaceous and Lower Tertiary History of the Jackson Area (Journal of the Washington Academy of Sciences), and Factors Affecting the Geologic History of the Jackson Area, and Carboniferous Rocks at Jackson (Bulletin of the American Association of Petroleum Geologists). A report on the preliminary investigation of the bleaching clays of Mississippi was submitted to the Mississippi Geological Survey. A detailed report on the clays of Mississippi will be included in a Survey bulletin on clays of the Southern States.

Missouri.—A paper on correlation of the Upper Cambrian sections of Missouri and Texas with the section in the upper Mississippi Valley will be published in the Survey's Contributions to General Geology.

Montana.—Geologic mapping for the purpose of completing geologic studies of the Little Rocky Mountain region and making a study of the oil, gas, and mineral resources of the mountains and adjoining area, including the gold deposits in the vicinity of Landusky, was begun in the later part of the year. Continued field studies were made of the Tertiary and Pleistocene faulting in Granite and Lewis and Clark Counties, of the glacial geology and physiography of western Montana and the Glacier National Park, of gold placers of the Pioneer district in Powell County, and of gold-placer operations in the vicinity of Helena and at Virginia City. Reports are in preparation on the geology and ore deposits of the Libby quadrangle, the Pioneer gold district, faults in southwestern Montana, fossil plants from the Fort Union and associated formations, and glacial geology and physiography of western Montana and the Glacier National Park. A report on the geology and mineral resources of north-central Chouteau, western Hill, and eastern Liberty Counties was completed and will be published as Bulletin 847–F.

Nevada.—The resurvey of the Comstock lode, at Virginia City, begun in 1935, was nearing completion at the end of the fiscal year, and further geologic mapping was carried on in the Hawthorne and Tonopah quadrangles, where a detailed study of the geology and ore deposits is being made. Reports on the underground geology of the Tonopah, Tuscarora, Chief, and Delamar districts have been submitted for publication by the Nevada Bureau of Mines and Geology, and one on the Searchlight district is in preparation. A short paper on sedimentary magnesite in the Boulder Dam region was submitted to the Society of Economic Geologists, and one on the scheelite-leuchtenbergite vein in the Paradise Range to the Mineralogical Society. Work in the Boulder Dam region is mentioned under California.

New Mexico.—Studies of the geology and mineral resources of the Little Hatchet Mountains, begun in 1935, were continued. Field investigations of the Mancos and Mesaverde formations around the southern edge of the San Juan Basin were made in connection with a report on conditions of sedimentation in this area, and a preliminary field survey of the geology of the Potash Mines area was completed. A report on the Magdalena district, nearly completed, will be published by the Survey. A paper on the subject of potash in general, with special emphasis on New Mexico-Texas Permian deposits and development, will be published by the Texas Bureau of Economic Geology, and one on the Permian formations of the Pecos Valley, New Mexico and Texas, was submitted to the American Association of Petroleum Geologists.

New York.—Further field investigations were made of the gas resources and geologic structure of the Greenwood, Hornell, Woodhull, and Wellsville quadrangles, south-central New York, and of gas resources and structure of fields in western New York that produce gas from the Medina sandstone. The report on the structure and gas possibilities of south-central New York was under way. Additional studies were made of the geology of the Millbrook quadrangle, New York-Connecticut, and a field study was made of the stratigraphy and fossil flora of the Genesee shale and Genundewa limestone in western New York.

North Carolina.—Studies of Miocene and Pliocene deposits were continued, and a paper on some deep wells near the Atlantic coast in the Carolinas and Virginia will be published as Professional Paper 186–I in the Survey's series of Contributions to General Geology. Gold investigations in North Carolina are mentioned under Southern Appalachians.

North Dakota.—A preliminary report on the geology and coal resources of the Minot area was issued as a press memorandum. A more detailed report is in preparation as a Survey bulletin. The Survey's Contributions to General Geology will include a paper on American Cretaceous ferns of the genus *Tempskya* (Professional Paper 186–F). Work on Fort Union fossil plants is mentioned under Montana, and work on fossil conifers under Maryland.

Oklahoma.—Work in the tri-State lead and zinc area of northeastern Oklahoma, southeastern Kansas, and southwestern Missouri included detailed areal mapping and considerable underground mapping of individual mines. Field investigations were made of the petroleum possibilities, structure, and stratigraphy of the Black Knob Ridge and adjacent areas and in the Ouachita Mountains. Reports were in progress on the geology, coal resources, and oil and gas possibilities of the Lehigh district (Bulletin 874–B), on the Wilburton-Howe-Heavener coal area, the geology and fuel resources of the Quinton-Scipio district, the fauna of the Moorefield formation, the fauna of the Sycamore limestone, and the flora of the coal fields of eastern Oklahoma. Papers on the correlation of the Bluejacket sandstone and the stratigraphy of the Arkansas-Oklahoma coal

basin have been submitted for publication in the Bulletin of the American Association of Petroleum Geologists.

Oregon.—A bulletin on the metalliferous deposits of the Cascade Range is in preparation for Survey publication.

Pennsylvania.—Reports are in preparation on the geology and mineral resources of the Honeybrook and Phoenixville quadrangles and on the York and Hanover quadrangles, the latter in cooperation with the Pennsylvania Survey. A paper on the study of regional metamorphism in the Lower Kittanning coal beds of western Pennsylvania is also in preparation for Survey publication.

South Carolina.—Studies of the Pliocene and Pleistocene material along the intracoastal canal were made and a paper prepared for publication. The investigation of clays in South Carolina will be incorporated in a bulletin on clays of the Southern States to be issued by the Survey. Gold investigations in South Carolina are mentioned under Southern Appalachians.

South Dakota.—The collection of field data for the revision of the geologic map of South Dakota was completed and the first draft of the map was submitted for editing.

Southern Applachians.—A report on the gold deposits of the southern Appalachians is in preparation for Survey publication. This includes areas in Virginia, North Carolina, South Carolina, Georgia, and Alabama, field work for which was done under a Public Works Administration allotment (Federal projects 158, 165, 174, 176, and 183). The results of brief field investigations made this year in Franklin and Stanley Counties, N. C.; Lancaster and Chester Counties, S. C.; and the Dahlonega district, northern Georgia, will be included in the report.

Tennessee.—Assistance was rendered to the Tennessee Valley Authority in examination of marble deposits and iron ores of the Norris Basin and inspection of dam sites of southeastern Tennessee. A preliminary report on bleaching and ceramic clays of Tennessee was included in a press notice on clays in Kentucky and Tennessee. Further details will be included in a Survey bulletin on clays in the Southern States.

Texas.—A report on stratigraphic, structural, and paleontologic studies of the Pennsylvanian and Permian rocks of north-central Texas was sent to the Texas Bureau of Economic Geology for publication. A monograph on the Navarro fauna and reports on the brown iron ores of eastern Texas, the Shafter silver district, the Terlingua quicksilver district, and the geology of the southern Guadalupe Mountains were in progress. Papers on stratigraphic relations of the Austin, lower Taylor, and related formations in Texas (Professional Paper 186–G); a redescription of Roemer's Paleozoic types from Texas (Professional Paper 186–M); and new Upper Cretaceous Ostreidae from the Gulf region (Professional Paper 186–A) were submitted for the Survey's Contributions to General Geology. Field work was continued in a study of the stratigraphic geology of the Sierra Diablo. Potash work is mentioned under New Mexico. A description of the clays of the San Antonio area will be included in the report on clays in the Southern States.

Utah.—In the early part of the fiscal year a field study of the coal resources and oil and gas possibilities of the Hanksville-Cainsville district was begun, and in the spring of 1936 this study was extended to include the structure, igneous rocks, mineral resources, and physiography of the adjoining Henry Mountains. Some additional work was done in the Randolph quadrangle for the purpose of bringing up to date a report on the geology and mineral resources of this quadrangle begun some time ago. Reports were in preparation on the geology and structure of southeastern Utah, the geology of the area between the Green and

Colorado Rivers in Grand and San Juan Counties, a geographic and geologic reconnaissance of southwestern Utah, and the Bull Valley iron-ore area. A descriptive text for the back of the topographic map of the Zion National Park was prepared. A paper on the geologic structure of southeastern Utah was submitted to the American Association of Petroleum Geologists for publication and one on new light on the orogenic history of central Utah was published by Science. A report on the Cottonwood-American Fork mining district was completed and has been forwarded for editing and publication.

Vermont.—A study of the metamorphic rocks in eastern Vermont, in cooperation with the Geological Society of America, was under way. Work was begun on the granites in connection with a study of the granites of New England.

Virginia.—Reports are in preparation on zinc deposits of southwestern Virginia and the origin of titanium deposits. A preliminary report on the gold deposits of the Virginia Piedmont was submitted for publication by the State. A paper on mineralization of the Virginia titanium deposits was published by the American Mineralogist, and another on the relation between structure and ore deposition in the Roseland titanium district was published by the National Research Council. Work on gold is mentioned under Southern Appalachians.

Washington.—Field work on the areal geology and mineral deposits of the Metaline quadrangle, Pend Oreille County, was begun late in the fiscal year.

West Virginia.—A field study was made of the coals in the Kanawha, New River, and Pocahontas fields. A report on manganese deposits of eastern West Virginia was published by the West Virginia Geological and Economic Survey.

Wyoming.—Field studies of the petroleum and coal resources of the Ishawooa-Pitchfork area, in Park and Hot Springs Counties, the geology and mineral resources of the Afton quadrangle, and the physiography and glacial geology of parts of Park County were in progress. Work in the Randolph quadrangle is mentioned under Utah. A report on the structure and stratigraphy of the Black Hills rim is in preparation.

WORK IN CHEMISTRY AND PHYSICS

Borderland problems involving geology, chemistry, and physics have been given increasing attention. Chemical analyses are made to determine the composition of rocks, ores, and minerals, and physical tests involve measurements of temperature, strength, optical behavior, and many other physical properties; but the most valuable results in geology are obtained by correlating all the factors involved in each particular problem. Thus ores are analyzed chemically not only to determine their metal content but to aid the geologist in the interpretation of their origin and concentration; deep-well temperatures are studied to aid in determining the previous history of the strata and to throw light on the physical conditions under which earth processes take place; the atomic structure of minerals is studied to explain their action in affecting natural waters, oil, and ore-forming solutions.

Among materials analyzed in the laboratory during the year were clays from South Carolina and other States, bauxite from Arkansas, phosphate rock from Florida, igneous rocks, mainly from western

mining districts, bentonite from several States, iron ore from Alabama, mercury ore from Texas, garnet from Georgia, arseniosiderite from California, hornblende and ankerite from Georgia, phlogopite from North Carolina, topaz and chloritoid from South Carolina, uraninite from Idaho, and xenotlite from Mexico. Experiments were made to explain the origin of magnesite deposits, and spectrographic tests were made on different minerals, concentrates, and coals.

During the year 5,081 examinations or tests of minerals and rock samples were made, compared with 4,236 in 1935. These included 1,063 specimens tested and identified for persons not officially connected with the Survey, 1,225 chemical analyses made for geologists in aid of general geologic projects, and 678 similar analyses made in connection with studies of methods of analysis and geochemical investigations relating to the formation and alteration of minerals under natural conditions. The remaining 2,115 tests related to core samples, well cuttings, and other samples.

Among the more important items of work in physics were the testing of activable clays in Mississippi and Alabama, two deposits of which are being developed commercially, largely as a result of the tests made in the Survey laboratory. Geothermal surveys of deep wells were made in New York, Pennsylvania, West Virginia, Alabama, Mississippi, Oklahoma, Arkansas, New Mexico, and California. Two wells tested in California had reached depths of more than 9,000 feet and temperatures considerably above the boiling point of water at sea level. The physical properties of serpentine from several localities were studied to explain its origin and uses. Several classes of geologic data were subjected to correlation and elaborate mathematical discussion.

The following papers were completed during the year:

Adsorption and pycnometry (Journal of the Washington Academy of Sciences).

Monticellite from San Bernardino County, Calif., and the monticellite series (American Mineralogist).

Volcanological boron compounds (Transactions of the American Geophysical Union).

Rock temperatures and depths to normal boiling point of water in the United States (American Association of Petroleum Geologists).

Tables of temperature, geothermal gradient, and age of a nonradioactive earth (Bulletin of the Geological Society of America).

Nephelometric determination of fluorine (Industrial and Engineering Chemistry).

Tests of some chemical reagents for lead (National Research Council).

Sodium carbonate and sodium sulfate (American Institute of Mining and Metallurgical Engineers).

Acid and base—their role in history, geology, health, and industry.

ALASKAN BRANCH

The work of the Geological Survey in Alaska is directed primarily toward aiding in the development of the mineral resources of the Territory and involves field examinations of the various factors that pertain to the character, distribution, and development of these resources, and laboratory and office studies by which these field observations are analyzed and the results made available to the public through reports, maps, and other media. In addition to the funds regularly appropriated by Congress for this work, a small balance remaining from funds previously granted through the Public Works Administration was utilized in completing the compilation and publication of maps of portions of southeastern Alaska under Federal project 69. The work of the branch, in addition to serving the prime purpose of assisting in the development of the mining industry, is used extensively by Government organizations engaged in other special fields of investigation within Alaska, such as the Forest Service, the Alaska Road Commission, and the Biological Survey. The Survey's maps of Alaska are indispensable in any enterprise concerned with the development of the Territory.

Manuscripts and publications.—During the year four reports and four maps (one a reprint) have been published. In addition 13 manuscript reports, including maps, and 1 separate manuscript map have been completed by the authors and are in various stages of critical review, proof, or preparation for publication. One map is in press. At the end of the year four manuscript reports and four maps were partly completed.

Work of the year.—In addition to the routine duties, seven principal projects involving new field work were carried on during the season of 1935. The field projects included five that were principally geologic and two that were primarily topographic. The geologic projects involved field work in the Alaska Range region, east of the Richardson Highway and north of Slana; the central and southern part of Kodiak Island; and the Tikchik Lake district of southwestern Alaska; a general study of the permanently frozen ground as affecting mining developments in central and western Alaska, especially in the Fairbanks and Nome districts; and a general study of recent mining developments in the larger camps adjacent to the Alaska Railroad, the Yukon River, and Seward Peninsula. The topographic projects included the continuation of surveying and mapping in the Admiralty Island area of southeastern Alaska, west of Juneau, and in the Alaska Range region, especially in the Tok Valley and adjacent parts of the Tanana region.

Two projects not directly involving new field work were the continuation of the compilation of drainage maps of portions of southeastern Alaska from airplane photographs taken by the Navy Department and the annual canvass of the production of mineral commodities.

In order to utilize effectively the short open season, the Geological Survey parties usually begin work in the spring as early as climate and other conditions permit. The beginning of work in the field season of 1936 was somewhat delayed owing to the late passage of the appropriation act carrying funds for this work. However, one party left for the field late in April and most

of the others in May, and at the end of the fiscal year these parties were out of touch by ordinary means of communication, so that it is not practicable to give here more than a summary of the work that it is expected they will accomplish.

Seven field projects have been authorized for the season of 1936, and their completion, with the essential office work, will occupy all the time until the spring of 1937. These projects include four geologic investigations, two topographic mapping projects, and the usual study in the field of mining conditions and mineral production of the Territory. The four geologic projects include a continuation of the investigation of the geologic features and mineral resources of part of the Alaska Range lying near the head of the Copper River and forming part of the watershed between the river and tributaries of the Tanana River; investigations of mining developments and mineral production in the principal placer camps of the upper Yukon, including Eagle, Circle, Fortymile, and adjacent areas; a study of the principal mining camps adjacent to the Alaska Railroad in central Alaska; and investigation of the mineral resources of the Glacier Bay area, including Glacier Bay National Monument, southeastern Alaska. The two topographic field projects include the continuation of surveying and mapping in the Admiralty Island area of southeastern Alaska, west of Juneau, and in the Alaska Range region, especially in the vicinity of the Robertson and Gerstle Rivers.

TOPOGRAPHIC BRANCH

GENERAL OFFICE WORK

Necessary office work incidental to the field work of the topographic branch consisted in the inking, inspection, and editing of the completed topographic field sheets prior to their submission for reproduction and the computation and adjustment of the results of control field work.

The status of topographic surveys shows that the country as a whole is now 47.1 percent mapped, the year's increment amounting to 0.4 percent. The area covered by topographic base maps without contours, prepared from aerial photographs after field examination, was largely increased.

FIELD SURVEYS

Abbreviations for projects used below: Federal Emergency Administration of Public Works, "P. W."; Tennessee Valley Authority, "T. V. A."; Federal Emergency Relief Administration, State projects, "F. E. R. A." Cooperation with States was continued in about the same amount as in recent years.

Alabama.—Mount Hope 15′ quadrangle (P. W.) completed. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Iuka, Allsboro, Burleson, Gravelly Springs, Barton, Belgreen, Muscle Shoals, Erin, Tuscumbia, Russellville, Haleyville, Rogersville, Town Creek, Mount Roszell, Hillsboro, Danville, Veto, Decatur, Hartsells, Hazelgreen, Talucah, Oleander, Plevna, Gurley, Guntersville, Snead, Blountsville, Larkin, Larkinsville, Albert-

ville, Attalla, Fackler, Hollywood, Portersville, Keener, Long Island, and Valley Head 15′ quadrangles (T. V. A.) and begun for 7½′ quadrangles within Mount Hope 15′ quadrangle (T. V. A.).

Arizona.—Payson No. 3 15′ quadrangle and Grand Canyon National Monument (P. W.) completed and Payson No. 4 15′ quadrangle (P. W.) begun. Summit Valley No. 4 15′ quadrangle completed at request of Forest Service.

Arkansas.—Caddo Gap No. 1 and Caddo Gap No. 2 15′ quadrangles (P. W.), and North Little Rock No. 4 7½′ quadrangle (P. W.), completed.

California.—In cooperation with the county surveyor of Los Angeles County, Mount Emma, Alder Creek, Mount Gleason, and Trail Canyon 6′ quadrangles completed; Crystal Lake, North Baldy, Pine Mountain, and Mount Waterman 6′ quadrangles begun. In cooperation with the State engineer of California, Sebastopol 15′ quadrangle and San Bernardino No. 1 and San Bernardino No. 2 7½′ quadrangles completed; Tobias Peak 30′ quadrangle continued and San Bernardino No. 4 7½′ quadrangle begun. In preparation for geologic mapping Kreyenhagen Hills 7½′ quadrangle completed. Burney and Paynes Creek 30′ quadrangles (P. W.) completed.

Colorado.—In cooperation with the city of Denver, mapping without contours from aerial photographs begun for East Denver 2c, East Denver 3b, West Denver 1d, and West Denver 4a 7½′ quadrangles. Leadville No. 3 15′ quadrangle (P. W.) completed; Leadville No. 2 and Buena Vista No. 2 15′ quadrangles and Chattanooga mining area (P. W.) begun.

Connecticut.—Montville 7½′ quadrangle (P. W.) completed.

Delaware.—Wilmington and vicinity (P. W.) completed.

Florida.—Villa Tasso, Holley, and Point Washington 15′ quadrangles (P. W.) completed.

Georgia.—Thomaston 15′ quadrangle (P. W.) completed. East Ridge 7½′ quadrangle (T. V. A.) begun. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Rock Spring, Sugar Valley, Spring Place, Burton, Rabun Gap, Rossville, Trion, Long Island, and Valley Head 15′ quadrangles (T. V. A.).

Idaho.—Borah Peak 30′ quadrangle (P. W.) completed; Yellow Pine No. 2 and Washington Creek No. 2 15′ quadrangles (P. W.) continued, and Logan No. 3 15′ quadrangle (P. W.) begun. For the Forest Service, Mackay 30 quadrangle completed. At the request of the Office of Indian Affairs, Pocatello No. 2 15′ quadrangle was begun.

Illinois.—Delavan, Keithsburg, and Miles 15′ quadrangles completed; Mount Carroll, Shelbyville, Lena, and Stewardson 15′ quadrangles continued; Savanna, New Douglas, Tuscola, and Elizabeth 15′ quadrangles begun in cooperation with the Department of Registration and Education of Illinois, Geological Survey. Lovington, Arcola, Pontiac, and Watseka 15′ quadrangles (P. W.) completed and Ashmore 15′ quadrangle (P. W.) begun.

Indiana.—Oolitic 15′ quadrangle (P. W.) completed.

Kentucky.—Horse Cave 15′ quadrangle (P. W.) completed. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Paducah, Viola, Mayfield, Benton, Smithland, Murray, Eddyville, Golden Pond, and Blood 15′ quadrangles (T. V. A.).

Louisiana.—The Louisiana Board of State Engineers cooperating, mapping without contours from aerial photographs completed for 7½′ quadrangles within Santo, Bond, Mamou, Fenton, Simmons, De Quincy, Hecker, Nezpique, Aubrey, Glenmora, Kipling, and Rena 15′ quadrangles.

Maine.—St. Croix 15′ quadrangle and Acadia National Park (P. W.) completed. Mars Hill 15′ quadrangle completed.

Maryland.—Leonardtown 15′ quadrangle (P. W.) completed.

Massachusetts.—In cooperation with the Department of Public Works, Division of Waterways, Mount Toby, Williamsburg, Scituate, 7½′ Duxbury, Shirley, Pocasset, Cohasset, Abington No. 2, Whitman, Hanover, Nantasket, Greenfield No. 1, and Greenfield No. 4 7½′ quadrangles completed. Boston Bay, No. 3, Warwick No. 2, Warwick No. 3, Dedham No. 1, and Dedham No. 2 7½′ quadrangles begun. Millbury and Ayer 7½′ quadrangles (P. W.) completed.

Michigan.—In cooperation with the State Highway Department of Michigan, mapping without contours for aerial photographs begun for 7½′ quadrangles within Rochester, Mount Clemens, Hicky, Armada, Port Huron, Almont, Milford, and Pontiac 15′ quadrangles. Ithaca and Cement City 15′ quadrangles (P. W.) and Berkey 7½′ quadrangles (P. W.) completed, and Swanton No. 2 7½′ quadrangles (P. W.) begun.

Minnesota.—Rochester 15′ quadrangle (P. W.) completed.

Mississippi.—Edwards 15′ quadrangle (P. W.) completed. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Burnsville, Candler, Iuka, Allsboro, and Burleson 15′ quadrangles (T. V. A.).

Missouri.—In cooperation with the Geological Survey and Water Resources of Missouri, Ava, Herman No. 3, Thornfield, Kearney, and Barry 15′ quadrangles and Butler 3d 7½′ quadrangle completed; Franks, Edgar Springs, Big Piney, Fielden, Richland, Buffalo, Fordland, Long Lane, Protem, and Niangua 15′ quadrangles and Knobnoster No. 4 7½′ quadrangle continued; Independence No. 1, Springfield No. 3, Knoblick, Bradleyville, Vienna, Middlebrook, Bolivar No. 2, Warsaw No. 3 S½, Hannibal, and Louisiana No. 4 15′ quadrangles and Springfield 3b 7½′ quadrangle begun; and cultural revision completed for Alton SW., St. Charles SW., and St. Charles SE. 7½′ quadrangles. Warsaw 1d, Warsaw 1c, Warsaw 2d, Warsaw 3a, Warsaw 4a, Warsaw 4b, Gravois Mills No. 3, Eldon No. 3, Versailles 3b, and Liberty 7½′ quadrangles (P. W.) completed and Warsaw 2c and Warsaw 3b 7½′ quadrangles (P. W.) begun. Morrison and Sullivan No. 2 15′ quadrangles (F. E. R. A.) completed.

Montana.—Jennings 30′ quadrangle (P. W.) completed and Silver Tip 30′ quadrangle (P. W.) begun. Dupuyer No. 3 15′ quadrangle completed for the Office of Indian Affairs.

Nebraska.—Seward No. 4 15′ quadrangle (P. W.) completed.

Nevada.—Gold Creek No. 4 15′ quadrangle and Comstock Lode district (P. W.) completed. At the request of the Forest Service, Gold Creek No. 1 15′ quadrangle completed and Gold Creek No. 2 15′ quadrangle begun.

New Hampshire.—Whitefield (P. W.) and Lovewell Mountain 15′ quadrangles completed.

New Jersey.—Weehawken, Ramapo No. 2 and Ramapo No. 3 7½′ quadrangles (P. W.) completed.

New Mexico.—Hillsboro Peak No. 1 and Arabela No. 4 15′ quadrangles (P. W.) completed. In preparation for geologic mapping Queen No. 3 quadrangle completed.

New York.—Poughkeepsie 15′ quadrangle continued, West Point 15′ and Tarrytown 1, 7½′ quadrangles begun, in cooperation with the Department of Public Works of New York. Chenango Forks, 7½′ Binghamton, Gansevoort, 7½′ Schuylerville, Fort Miller, Corinth, and Weehawken 7½′ quadrangles (P. W.) completed.

North Carolina.—Farner 15′ quadrangle (P. W.) completed; Blowing Rock 15′ quadrangle (P. W.) continued. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Robbinsville, Cullasaja, Caesars Head, Democrat, Edneyville, Tigersville, Bushnell, Wayah Bald, Le

Conte, Bryson, Cataloochee, Fines Creek, Waynesville, Halewood, Biltmore, Arden, Farner, Hot Springs, Newport, and Limestone 15′ quadrangles (T. V. A.) and begun for 7½′ quadrangles within Haw Knob 15′ quadrangle (T. V. A.).

North Dakota.—Dunseith and Kempton No. 2 15′ quadrangles (P. W.) completed, McVille 15′ quadrangle (P. W.) continued, and Alcide 15′ quadrangle (P. W.) begun.

Ohio.—In cooperation with the county commissioners of Lucas County, Whitehouse, Berkey, Grand Rapids, Swanton No. 2, Swanton No. 3, and McClure No. 2 7½′ quadrangles completed. Tontogany, Reno by the Lake, Walbridge, and Genoa 7½′ quadrangles (P. W.) completed.

Oregon.—Disston 30′ quadrangle, Crater Lake National Park, and Squaw Butte ranch (P. W.) completed. At the request of the Forest Service, Crescent 30′ quadrangle completed.

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, Sheffield, Kinzua, and Mount Jewett 15′ quadrangles completed. Loleta, Mattawana, and Slatington 15′ quadrangles begun. Allensville, Hawley, Needmore, and Steubenville 15′ quadrangles (P. W.) completed.

Rhode Island.—East Providence and Providence No. 1 7½′ quadrangles (P. W.) completed.

South Carolina.—Mapping without contours from aerial photographs begun for 7½′ quadrangles within Woodford, Spartanburg, Hopkins, Sumter, Edmund, Rimini, Cowpens, St. Matthews, and Elloree 15′ quadrangles (F. E. R. A.).

South Dakota.—Oacoma No. 2 15′ quadrangle (P. W.) completed.

Tennessee.—Farmer 15′ quadrangle (P. W.) completed. Conasauga No. 1 and Conasauga No. 2 7½′ quadrangles (T. V. A.) begun. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Sequatchie, Pikeville special, Dayton, Apison, Allardt, Spring City, Texas Knobs, Blue Spring, Niota, Conasauga, Vonore, Greenback, Log Mountain, Middlesboro, Straw Plains, Sevierville, Tate Springs, English Mountain, Rogersville, Midway, Hot Springs, Fall Branch, McEwen, Bold Spring, Dark Mills, Selmer, Puryear, Hollow Rock, Wildersville, Warrens Bluff, Right, Adamsville, Faxon, Zach, Holladay, Darden, Saltillo, Gillises Mills, Model, Tennessee Ridge, Waverly, Bakerville, Beardstown, Flatwoods, Lutts, Hohenwald, Allens Creek, Iron City, Dickson, Hampshire, Summertown, Pleasant Point, Blood, Fernvale, Lynnville, Minor Hill, Franklin, Groveland, Culleoka, Aspen Hill, Nolensville, Eagleville, Talley, Harms, Bellbuckle, Haley, Elora, Hollow Springs, Tullahoma, Decherd, Smartt, Pelham, Mont Eagle, Altamont, Jasper, Dunlap, Lookout Mountain, Mayland, Crossville, Deer Lodge, Roddy, Annadel, Harriman, Huntsville, Oliver Springs, Wheat, Farner, La Follette, Coal Creek, Friendsville, McLean Rock, Corryton, Shooks, Walland, Rutledge, Townsend, Newport, Limestone, and Hazelwood 15′ quadrangles (T. V. A.) and begun for 7½′ quadrangles within Centerville and Haw Knob 15′ quadrangles (T. V. A.).

Texas.—Sanford and Longview No. 2 15′ quadrangles (P. W.) completed.

Utah.—Elk Ridge and Theodore 30′ quadrangles (P. W.) completed.

Vermont.—In cooperation with the State geologist of Vermont, Woodsville 15′ quadrangle completed. Lyndonville and Whitefield 15′ quadrangles (P. W.) completed.

Virginia.—Charlottesville and Burkes Garden 15′ quadrangles, Glen Allen and Midlothian No. 4 7½′ quadrangles, and Charlottesville and vicinity completed, and Speedwell and Gerrardstown 15′ quadrangles begun in cooperation with the Conservation and Development Commission of Virginia, Geological

Survey. Amherst and Vesuvius 15′ quadrangles (P. W.) completed. Mapping without contours from aerial photographs completed for 7½′ quadrangles within Middlesboro 15′ quadrangle (T. V. A.).

Washington.—In cooperation with the Department of Conservation and Development, Marcus 30′ quadrangle continued, Yakima No. 3 and Yakima No. 4 15′ quadrangles and Kittitas reclamation project begun. Newport 30′ quadrangle continued at the request of the Forest Service.

West Virginia.—Cultural revision completed for Steubenville 15′ quadrangle (P. W.).

Wisconsin.—Osseo 15′ quadrangle (P. W.) completed and Arkansas 15′ quadrangle (P. W.) continued.

Wyoming.—Big Piney, La Barge, and Cokeville N½ 30′ quadrangles (P. W.) and Grand Teton National Park completed. In preparation for geologic mapping, Cokeville S½ 30′ quadrangle begun.

WATER-RESOURCES BRANCH

SUMMARY

The importance of water and of systematic records related to the quality, chemical quality, and availability of both surface and ground waters becomes increasingly greater each year. The growth of the country in population and industry, with consequent increases in demands for water, and especially the continued series of dry years that included the disastrous and widespread drought of 1934, the current drought of 1936, apparently of rivaling intensity, and the dust storms that have continued in large areas of the central West, have impressed on the people the controlling importance of water in surface streams and in underground basins in relation to many of man's activities. The information collected by the Geological Survey is used extensively by many Federal, State, and private agencies. The Public Works Administration, the National Resources Committee, and related activities have found the Survey records and information with respect to water to be invaluable in studies of projects of all classes and in all sections of the country and have relied on these basic data for determining action on many projects.

Reliable information with respect to supplies of water, both on the surface and in the ground, and to their fluctuations with variations in rainfall, is essential to orderly, sound, and economic development along many lines, as in domestic water supplies, irrigation, flood protection, control of pollution, recreational uses, and water-power development. The work of the water-resources branch thus occupies a position of great importance in the economic affairs of the Nation.

The investigations by the branch are conducted largely in cooperation with Federal bureaus; State, county, municipal, and other gov-

ernmental agencies; and permittees and licensees of the Federal Power Commission. A major part of this cooperation is set forth below.

Federal bureaus.—Investigations of ground and surface water and of the quality of water were conducted, through advance, transfer, or repay of funds, for the following Federal bureaus:

Department of Agriculture:
- Bureau of Biological Survey.
- Bureau of Plant Industry.
- Soil Conservation Service.
- Weather Bureau.

Department of Commerce: Bureau of Fisheries.
Department of the Interior:
- Office of Indian Affairs.
- Bureau of Mines.
- Bureau of Reclamation.
- Division of Grazing.
- National Park Service.
- Petroleum Conservation Division.

Department of Justice: Bureau of Prisons.
Department of State.
Federal Power Commission.
National Resources Committee.
Resettlement Administration.
Tennessee Valley Authority.
Veterans' Administration.
War Department: Office of Chief of Engineers.

States.—Amounts aggregating $587,354.80 were made available by States and municipalities for cooperative surface- and ground-water investigations. In addition to the data obtained as a result of this cooperation, it is estimated that other data valued at over $114,000 were furnished by individuals and other organizations.

Permittees and licensees of the Federal Power Commission.—At the request of the Federal Power Commission, 30 engineers of the branch have been designated as representatives of the Commission to perform such field work as may be assigned to them by the Commission. The operation of about 290 gaging stations was conducted by the branch or was performed by permittees and licensees under the supervision of the branch in connection with 111 projects of the Federal Power Commission. Engineers of the branch have had general supervision of operation under permits and licenses of the Federal Power Commission in connection with 145 projects.

WORK OF THE YEAR, BY DIVISIONS

The division of surface water conducts investigations of surface water, which consist of the measurement of the flow of rivers, conducted in the 48 States, the District of Columbia, and Hawaii at selected gaging stations where the volume of water is measured and records of stage and other data are collected, from which the daily discharge of the rivers is computed. In this work 44 States, the Territory of Hawaii, several Federal bureaus, and several individuals

cooperated in the maintenance of the 3,163 regular gaging stations that were in service at the end of the year. Records for about 114 additional gaging stations were received, ready for publication, from Federal bureaus and from individuals. There were 42,157 regular and miscellaneous discharge measurements made during the year.

The division of ground water investigates the waters that lie below the surface in the zone of saturation (from which the wells and springs are supplied); the source, occurrence, quantity, and head of these waters; their conservation; their availability and adequacy for domestic, industrial, irrigation, and public supplies and as watering places for livestock and desert travelers; and the methods of constructing wells and recovering water from them and of improving springs. 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 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 work was done in 21 States and Hawaii, in cooperation with 13 States or local governmental agencies, the Territory of Hawaii, and other Federal bureaus.

The division of quality of water analyzes water from surface and underground sources with reference to the suitability of the waters for industrial and agricultural uses and for domestic use (not related to questions of health), so far as such use is affected by the dissolved mineral water. The analysis (partial or complete) of 1,481 samples of water, including some for many of the studies of ground water in the different States and for most of the special investigations on water supplies for specific projects, was completed during the year. Close cooperation was continued with the division of ground water in the study of problems relating to quality of ground water and the preparation of the parts of ground-water reports that involve consideration of the chemical character of the waters.

The work of the division of power resources comprises the preparation of monthly and annual reports on the production of electricity for public use and the consumption of fuel in generating the electricity reported. The monthly reports also include, through cooperation with the Bureau of Mines, comparative figures of the stocks of bituminous coal and anthracite on hand at electric public utilities, comparison of the monthly consumption of coal, and the number of days' supply of

bituminous coal and anthracite on hand at the current rate of consumption. The annual report for 1935 contains revised figures of the monthly production of electricity and consumption of fuel previously published in the monthly reports, a summary of the annual reports from 1919 to 1935, the average annual rate of consumption of coal and the coal equivalent of oil and gas in generating 1 kilowatt-hour of electricity from 1919 to 1935, and the annual exports and imports of electricity between the United States and Canada and Mexico for certain years. A report on the capacity of water wheels in the United States on January 1 was also prepared. The final report of the monthly and annual production of electricity for public use in 1935 was released April 2, 1936. The annual report on the capacity of water wheels in water-power plants in the United States was released January 31, 1936. The collection, compilation, and publication of the monthly and annual reports of the production of electricity for public use that have been carried on by the Geological Survey since 1919 will be transferred to the Federal Power Commission July 1, 1936.

The division of water utilization investigates problems affecting the utilization and control of the waters of streams, makes studies for the interpretation of records of stream flow, and performs administrative work relating to supervision and investigation of these problems and to activities conducted by the field organization of this branch pertaining to power projects of the Federal Power Commission and of the Interior Department. The field work is generally conducted by personnel otherwise assigned to the division of surface water. In collaboration with the Mississippi Valley Committee of the Public Works Administration, and with the assistance of special advisory committees of the American Society of Civil Engineers and the American Geophysical Union, studies were made of floods in the United States, with especial reference to their magnitude and frequency, and of the relations of rainfall and run-off in the United States, and the results were published during the year in Water-Supply Papers 711 and 772. The favorable reception of these two reports indicates that they have filled a need. The division has been active during the year in investigations of water problems along the international boundary between the United States and Canada for the State Department, and also in the organization of the collection of information on recent outstanding floods.

CONSERVATION BRANCH

The regular work of the conservation branch was severely handicapped during the fiscal year by lack of funds. Many inspections of operations were omitted, and loss in resources and in royalties has

resulted. Up to the end of the year 850 proposed unit plans of development and operation had been submitted by Federal oil and gas permittees for technical review and revision in compliance with departmental requests. This review made necessary the temporary assignment in Washington of field engineers at a sacrifice of field personnel for regular duties. Detail of personnel for Public Works operations in connection with river-utilization surveys, plugging wells, and general rehabilitation has also retarded the normal functions of the branch, but has made it possible to retain a highly trained staff of engineers and scientists, who will resume more nearly normal operations in the fiscal year 1937.

MINERAL-CLASSIFICATION DIVISION

The work of the mineral-classification division was restricted, as in previous years, largely to office procedure, delayed in part by lack of geologic information due to limited field investigations. The mineral-classification activities of the division were further directed to compliance with the assignment of the responsibility for determining the areas subject to logical unitization under plans for unit or cooperative development submitted by holders of Federal oil and gas prospecting permits and leases. The only formal mineral classification completed involved the classification of 317,766 acres in southern Washington County, Utah, as nonoil in character. Coal lands in Valencia County, N. Mex., amounting to 4,962 acres, were restored from coal-land withdrawal. Action was taken on 500 requests for information as to the mineral character of the land, 748 applications for mineral permit, and 147 applications for mineral lease, involving technical action; consideration was given to 1,176 assignments, coal-permit extensions, lease and license authorizations; 105 decisions were prepared for a departmental committee affecting extensions of oil and gas prospecting permits and potash permits; and 731 permits involved in plans for cooperative unit operation and development for oil and gas fields or areas were considered. Technical reports were submitted on 1,167 requests for classification as to oil; 90 right-of-way applications were reviewed as to interference with coal, oil, gas, potash, and other mineral deposits; and reports were made on 143 requests for oil-development status of Government lands. In all, 4,810 cases requiring technical consideration were disposed of in the mineral-classification division during the year.

In addition, definitions of the "known geologic structure" of 13 producing oil and gas fields were prepared and promulgated as follows:

Definitions of "known geologic structure", fiscal year 1936

State	Field	Date promulgated	Area (acres)
Colorado	Iles	Aug. 5, 1935	1,710
Montana	Cedar Creek (revision)	Sept. 21, 1935	122,323
New Mexico	Lea (revision)	Sept. 6, 1935	1,281
	North Lea	do	1,200
	Northwest Lea	do	1,560
North Dakota	Cedar Creek	Sept. 21, 1935	27,013
Wyoming	North Baxter Basin	Nov. 14, 1935	7,031
	South Baxter Basin (revision)	do	15,463
	Hidden dome (addition)	Nov. 16, 1935	280
	North Oregon Basin (revision)	Dec. 9, 1935	4,632
	South Oregon Basin (revision)	do	7,418
	East Lance Creek field (revision)	Mar. 3, 1936	800
	Lance Creek field (revision)	do	5,593

The area of outstanding definitions of the "known geologic structure" of producing oil and gas fields on June 30, 1936, amounted to 1,154,447 acres in California, Colorado, Montana, New Mexico, North Dakota, Oklahoma, Utah, and Wyoming.

WATER AND POWER DIVISION

The work of obtaining basic information as to the water-power resources and storage possibilities of public lands and of making it available for use in the administration of public-land laws and by Federal and other agencies engaged in planning, constructing, and operating water-power projects was continued in the field, being made possible by the extended availability of Public Works funds. River-utilization surveys covering 1,615 miles of important streams and tributaries were made in 11 public-land States. Surveys of reservoir and dam sites embracing an area of 520 square miles were also completed. Supplemental geologic and geophysical studies of foundation materials and conditions were made at 16 dam sites.

Office activities included action resulting in the addition of 46,174 acres to outstanding water-power reserves in 13 public-land States and the elimination of 10,934 acres from such reserves in 6 States, with a net increase of the total reserved area in 22 States to 6,500,247 acres. The elimination of 40 acres from reservoir-site reserves left a net total of 133,704 acres withdrawn. Two restorations of lands withdrawn under the act of October 2, 1888, were also made. Field supervision of power projects for the Federal Power Commission involved investigations and reports on 11 projects, supervision of construction and operation on 136 projects, and studies of cost accounting on 4 projects. Field supervision of power projects holding permits and grants from the Interior Department involved 317 projects.

Statistics compiled by the division show that the holders and users of rights-of-way granted by the Secretary of the Interior for power purposes had for the calendar year 1935 an aggregate installed

capacity of 4,861,046 horsepower, including 3,370,401 horsepower at hydraulic plants and 1,490,645 horsepower at fuel plants, and an aggregate energy generation of 7,961,000,000 kilowatt-hours, which is an increase of about 15 percent over the production in 1934. Revenues accrued to the Government from these grants aggregated $221,166 from 1912 to 1935, and $15,045 additional has been assessed for the calendar year 1936. Accrued charges for unauthorized occupancy of public lands by power projects prior to the issuance of licenses therefor by the Federal Power Commission amount to $100,536 additional.

MINING AND OIL- AND GAS-LEASING DIVISIONS

The work of the mining and oil- and gas-leasing divisions, consisting of inspectional and regulatory supervision of mineral prospecting and development on public lands, Indian lands, and naval petroleum reserves, increased notably in volume and in difficulty of effective performance during the year.

Public lands.—The number of public-land properties under supervision of the oil- and gas-leasing division increased 13 percent, to a total of 8,332 involving 11,832,767.58 acres in 19 States and Alaska. With the aid of funds allotted in 1933 by the Public Works Administration and a similar allotment in the fiscal year 1936, the supervisory force was maintained intact, though available only in part for regular inspectional and regulatory work, and was enabled to accomplish important conservational and remedial results outlined more fully under the heading "Public Works projects."

The work of the oil- and gas-leasing division has been vastly increased, both in Washington and in the field, by the necessity of assisting oil and gas permittees in fulfilling departmental requirements for the submission of unit or cooperative plans of operation and development involving permit acreage, and of reviewing and revising the engineering and royalty features of such plans after their submission. Six engineers from the field offices were temporarily assigned to the Washington office to assist in the review of unit plans, and three geologists from the geologic branch were given temporary assignments to the mineral-classification division of the conservation branch to assist in delineating the areas appropriately subject to unitization under each plan submitted. The act of August 21, 1935 (49 Stat. 674), amending the mineral leasing law, has required revision of all unit plans submitted for areas that can be logically unitized. At the end of the fiscal year 1936 a total of 800 plans of unit or cooperative development for oil or gas pools, fields, or areas involving public land had been filed with the Geological Survey, of which 20 have been finally approved by the Secretary of the Interior, 73 have been reviewed and returned to their proponents

for revision and resubmission, 186 have been rejected or withdrawn, and 521 are awaiting technical consideration in the conservation branch. The oil- and gas-leasing division assisted in formulating regulations under the act of August 21, 1935 (49 Stat. 674). These regulations were approved by the Secretary of the Interior on May 7, 1936.

Drilling activity on public lands during the year included the spudding of 226 new wells and the completion of 314 others, 191 of which were productive of oil or gas and 123 barren. The total number of wells under supervision at the end of the year was 7,456 in 17 States and Alaska, including 3,849 capable of producing oil or gas. The production of petroleum, natural gas, and natural gasoline from public land in 1936 was substantially greater than in other recent years, and the revenues accrued therefrom were materially increased.

The mining division is charged with supervision of all operations for the discovery and development on public lands of deposits of coal, phosphate, sodium, potassium, and oil shale; in New Mexico and Louisiana of sulphur; on certain land grants of gold, silver, and mercury; and on restricted allotted and tribal Indian lands of all minerals except oil and gas. This supervisory and regulatory work during the fiscal year was accomplished through six field offices in Colorado, Montana, New Mexico, Oklahoma, and Utah, and through a cooperative agreement approved May 4, 1935, with the Territory of Alaska Mining Department.

Coal properties under supervision in 14 States and Alaska decreased 64, to 694; potash properties in 8 States decreased 109, to 95; sodium properties in 7 States decreased 5, to 40; sulphur properties in 1 State remained at 26. The number of phosphate properties increased by 1, to 9, and the oil-shale lease remained at 1 in 1 State. The total number of properties under supervision was 865, a decrease of 177. The reduction in coal properties resulted from the Secretary's instructions of January 24, 1934, and that in potash properties from the Secretary's orders 799, 817, 854, and 914. In prospecting for the above-named minerals 12 bore holes were drilled during the year.

Accidents to employees working in mines under departmental leases are generally fewer than in competitive mines not on Government lands, and it is gratifying to note that of the 51 awards made to bituminous mines or to operators by the Joseph A. Holmes Safety Association for the calendar year 1935 two were made to departmental lessees, and one was made to one of the two potash mines in operation in America. The use of safety appliances and safety clothing is increasing generally throughout mines on Government lands.

Indian lands.—On behalf of the Office of Indian Affairs technical supervision of mineral development was continued in 1936 on tribal and restricted allotted lands within the limits of numerous Indian reservations. Oil and gas supervision involved 5,583 leaseholds, 4,356 wells, and aggregate royalty and rental accruals of $2,652,897.70 for Indian beneficiaries in 8 States and in 28 different tribes and included royalty accounting for certain agencies, appraisals of bonus and royalty offers and of pollution damages, assistance to lessees of Indian land on operating problems and in the preparation of unit plans of development, and assistance to agency officials and tribal councils on technical phases of leasehold development and administration.

Mining supervision involved 36 lead and zinc leaseholds in the Quapaw Reservation, Okla., with aggregate royalty accruals of $360,727.69, an increase of 74.7 percent from the preceding year; 56 coal leaseholds involving Choctaw, Chickasaw, and Five Tribes lands in Oklahoma, with an aggregate production increased from 465,780.95 tons in 1935 to 568,725.92 tons in 1936, and revenue accruals from royalties, bonuses, and sale of coal lands amounting to $73,798.97; 1 asphalt lease involving segregated Choctaw and Chickasaw lands in Oklahoma; 1 lime-phosphate lease involving restricted allotted Five Tribes land in Oklahoma; and 53 properties in other States, 18 of which are agency mines. It included also special investigations of 21 properties for minerals other than fuels.

Naval petroleum reserves.—On behalf of the Navy Department supervision was continued during the year over operations for the production of oil and gas within Naval Petroleum Reserves Nos. 1 and 2, in California, and for the conservation of shut-in production within Naval Petroleum Reserve No. 3, in Wyoming. Production from the California reserves aggregated 3,777,607.53 barrels of petroleum, 2,903,396 M cubic feet of natural gas, and 12,248,006.08 gallons of natural gasoline and had an aggregate royalty value of $683,256.32. Under a Works Progress Administration allotment of $9,913, approved September 3, 1935, derricks were repaired, roads were built and repaired, well sites fenced, and fire hazards removed from the California reserves.

PUBLIC WORKS PROJECTS

Under the supervision of the conservation-branch personnel, aggregate expenditures of $200,902.75 were made during the fiscal year 1936 from funds allotted by the Administrator of Public Works for field investigation in conservation work pertinent to branch functions. On 11 projects $146,783.76 was expended for river utilization surveys of power and storage resources of important streams in 11 States. On 16 projects $54,118.99 was expended in 12 States

in the plugging and abandonment or conditioning for use as a source of water of numerous wells drilled for oil and gas on public lands and thereafter improperly abandoned or merely deserted; in extinguishing or controlling coal-outcrop fires and in filling, bulkheading, or otherwise safeguarding abandoned mines or prospective openings on public and Indian lands; and in surface studies of coal occurrence and subsurface studies of oil and gas occurrence in Indian lands in Oklahoma.

SUMMARY OF FIELD ACTIVITIES, BY STATES

Alabama.—Investigated oil and gas prospecting operations throughout the State in aid of mineral classification. Examined 2 tracts in Tuscaloosa County and 1 tract in Walker County for adjudication of conflicting mineral and nonmineral filings and 1 tract in Colbert County for minerals. Supervised 1 lease and 1 prospecting permit for oil and gas, and 1 coal lease.

Alaska.—Supervised 1 power project, 128 prospecting permits for oil and gas, and 2 leases, 2 licenses, and 10 prospecting permits for coal.

Arizona.—Supervised 25 power projects; completed 150 miles of river-utilization surveys on the Gila, Little Colorado, and Verde Rivers and tributaries; and surveyed in detail 140 square miles in 8 dam and reservoir sites. Supervised 76 prospecting permits for oil and gas on public land and 1 oil and gas lease on Indian land.

Arkansas.—Investigated oil and gas prospecting operations in southeastern Arkansas and in the western part of the Arkansas Valley in aid of mineral classification, and examined for minerals 1 tract in Franklin County. Supervised 1 power project. Supervised 8 prospecting permits for oil and gas.

California.—Investigated occurrence and use of carbon-dioxide gas in Imperial County. Through the geologic branch examined land in the Castac Creek area, Los Angeles County, for purposes of mineral classification. Supervised 92 power projects; completed 335 miles of river-utilization surveys on the American, Kings, Trinity, Carson, and Yuba Rivers and Cache, Clear, and Putah Creeks; surveyed in detail 70 square miles in 16 dam and reservoir sites; and made detailed surveys of 10 dam sites. Supervised 215 leases and 1,160 prospecting permits for oil and gas on public land and 23 leases on naval petroleum reserves. Supervised 3 coal and 12 sodium permits, 1 sodium lease, and 3 potash leases.

Colorado.—Made an areal and structural reconnaissance of land in Archuleta County for purposes of mineral classification. Supervised 12 power projects; completed 41 miles of river-utilization surveys on the Little Snake and Roaring Fork Rivers and tributaries; and surveyed in detail 4 square miles in 2 dam and reservoir sites. Supervised 30 leases and 632 prospecting permits for oil and gas on public land and 6 oil and gas leases on Indian land. Supervised on public land 85 leases, 15 licenses, 49 permits, and 5 awarded lease applications for coal; 1 sodium lease; and 1 potash permit. Supervised on Indian lands 2 agency coal mines.

Florida.—Investigated oil and gas prospecting operations throughout the State and examined 1 tract each in Glades, Jefferson, and Lake Counties for purposes of mineral classification.

Idaho.—Examined land in the Rainy Creek area, Bonneville County, for purposes of mineral classification. Supervised 33 power projects; completed 120 miles of river-utilization surveys on the Coeur d'Alene, Moyie, and Snake

Rivers; and surveyed in detail 2 dam sites. Supervised 76 prospecting permits for oil and gas; 1 lease and 15 permits for coal; and 2 phosphate leases.

Kansas.—Investigated oil and gas prospecting operations in western Kansas in aid of mineral classification. Supervised 18 prospecting permits for oil and gas.

Louisiana.—Investigated oil and gas prospecting operations throughout the State in aid of mineral classification. Supervised 11 leases and 1 prospecting permit for oil and gas.

Mississippi.—Investigated oil and gas prospecting operations throughout the State and examined 1 tract each in Greene, Jackson, and Pearl Counties. Supervised 1 prospecting permit for oil and gas.

Montana.—Supervised 34 power projects; completed 40 miles of river-utilization surveys on the Flathead River and its North and South Forks; and surveyed in detail 72 square miles in 2 reservoir sites. Geologic and geophysical examinations were also made at these reservoir sites. Supervised 105 leases and 833 prospecting permits for oil and gas on public land and 43 oil and gas leases on Indian land; 97 leases, 37 permits, and 52 licenses for coal; 6 phosphate leases; 1 potash permit; 2 Indian agency coal mines; and 10 coal leases and 2 silver-lead, and gold leases on Indian land.

Nebraska.—Supervised 1 potash prospecting permit.

Nevada.—Supervised 22 power projects; completed 200 miles of river-utilization surveys on the Carson, Humboldt, Little Humboldt, and Marys Rivers and in Pahranagat Valley; and made detailed surveys of 3 dam and reservoir sites. Supervised 79 prospecting permits for oil and gas, 3 coal permits, 1 phosphate lease, 1 sodium lease, and 7 potash permits.

New Mexico.—Investigated occurrence of carbon-dioxide gas in northeastern and central New Mexico. Examined, for the Indian Service, land in the pueblo of Isleta, Bernalillo County, for the purpose of mineral classification. Initiated an areal stratigraphic and subsurface structural investigation in southeastern New Mexico. Supervised 3 power projects; completed 243 miles of river-utilization surveys on the Pecos and Peñasco Rivers and Rio Chama and tributaries; surveyed 3 washes in the vicinity of Shiprock in connection with erosion studies; and surveyed 28 square miles in 2 dam and reservoir sites. Supervised 149 leases, 4 suspended preference rights, 1,754 prospecting permits for oil and gas on public land, and 7 oil and gas leases on Indian land. Supervised on public land 23 leases and 24 prospecting permits for coal, 12 prospecting permits for sodium, 9 leases and 134 prospecting permits for potash, and 26 sulphur permits. Supervised 1 coal lease on Indian land and 9 Indian agency coal mines.

North Dakota.—Supervised 25 prospecting permits for oil and gas on public land. Supervised 70 leases, 1 permit, and 21 licenses for coal and 1 sodium permit.

Oklahoma.—Investigated oil- and gas-prospecting operations in western Oklahoma, including development in and adjacent to the river bed of the Red River, and examined one tract in Beckham County for purposes of mineral classification. In cooperation with the geologic branch, continued the mapping of the Osage and adjoining Indian lands with special attention to subsurface structure. Supervised 3 power projects, 15 leases and 62 prospecting permits for oil and gas on public land, and 5,495 oil and gas leases on Indian land. Supervised on segregated tribal and restricted allotted Indian lands 32 leases, 17 permits, and 2 temporary mining permits for coal, 1 asphalt lease, 1 lime-phosphate lease, and 1 right-of-way lease; on Quapaw Indian lands, 36 lead and zinc leases.

Oregon.—Supervised 40 power projects; completed 150 miles of river-utilization surveys on the Applegate, Hood, Luckiamute, and Santiam Rivers, the

Middle Fork of the Willamette River, and Cow, Evans, Jump-Off Joe, Little Butte, and Mud Creeks; surveyed in detail 84 square miles in 10 dam and reservoir sites; and made detailed surveys of 3 dam sites. Supervised 122 prospecting permits for oil and gas on public land, 1 lease and 1 permit for coal, 2 sodium permits, and 1 oil-shale lease.

South Dakota.—Supervised 53 prospecting permits for oil and gas on public land and 5 oil and gas leases on Indian land. Supervised 5 leases, 2 permits, and 3 licenses for coal.

Utah.—Supervised 31 power projects; completed 100 miles of river-utilization surveys on the East and West Forks of the Sevier River and tributaries and in the Bear River Valley. Supervised 11 leases and 688 prospecting permits for oil and gas on public land and 1 oil and gas lease on Indian land. Supervised 43 leases, 71 permits, and 2 licenses for coal, 11 sodium permits, and 8 potash permits.

Washington.—Supervised 9 power projects; completed 205 miles of river-utilization surveys on the Cowlitz, Green, Sauk, Skagit, and Toutle Rivers and the East and North Forks of the Lewis River and tributaries; surveyed in detail 50 square miles in 9 dams and reservoir sites; and made detailed surveys of 7 dam sites. Supervised 10 prospecting permits for oil and gas on public land, 1 lease and 17 permits for coal, 1 sodium permit, and 3 silver and gold leases (Indian).

Wisconsin.—Supervised one power project.

Wyoming.—Examined land in Blind Bull-Deadman Creek area, Lincoln County, for purposes of mineral classification and one tract in Carbon County for classification as to sodium. Supervised 10 power projects; completed 44 miles of river-utilization surveys on the Laramie and Bear Rivers and tributaries; and surveyed in detail 30 square miles in 2 dam and reservoir sites. Supervised 431 leases, 1 suspended preference right, 1,632 prospecting permits for oil and gas on public land, and 25 oil and gas leases on Indian land; 56 leases, 66 permits, 25 licenses, and 4 awarded coal leases; and 2 prospecting permits for sodium.

WORK ON PUBLICATIONS

Texts.—The book publications of the year numbered 50, covering 8,901 pages. Besides these publications 31 brief papers in mimeographed form were issued as memoranda for the press. During the year 20,777 pages of manuscript were edited and prepared for printing, 1,237 galley proofs were read, and 5,743 page proofs were revised. Indexes were prepared for 29 publications, covering 5,438 pages. Copy and proof or stencils for 971 pages of multigraph or mimeograph matter were read. In addition to the Survey work the proof reading for the report of the Sixteenth International Geological Congress and the volume on copper resources of the world published by that Congress was completed. The fourth edition of "Suggestions to authors", much revised and enlarged, was published during the year.

Illustrations.—The section of illustrations prepared 1,695 drawings and photographs, transmitted 766 illustrations to accompany 47 reports, received and examined 706 proofs, and examined 71 editions.

Geologic editing and drafting.—The geologic map of Colorado, scale 1:500,000, was completed and published. The geologic map of

Texas in four parts, scale 1:500,000, was engraved and transferred to stone, and color sheets were prepared. The geologic map of South Dakota was received for publication. Illustrations for 37 papers were edited, proofs of 15 maps and sections were read and criticized, and 140 drawings, ranging from large maps with structure sections to text figures, were made to illustrate papers by Survey geologists to be published by State surveys or other non-Federal organizations. Editorial and other assistance was rendered to several State surveys in the preparation for publication of geologic maps of the respective States.

Distribution.—A total of 331 publications, comprising 50 new books and pamphlets, 114 new or revised topographic and other maps, and 167 reprinted topographic and other maps, were received during the year. Several special pamphlets and forms for administrative use were also delivered and distributed. The total units of all publications received numbered 107,059 books and pamphlets and 697,995 topographic and other maps, a grand total of 805,054. The division distributed 93,708 books and pamphlets, 2,511 geologic folios, and 730,200 maps, a grand total of 826,419, of which 2,271 folios and 587,697 maps were sold. The net proceeds (gross collections less copying fees and amounts refunded) from the sales of publications were $36,958.88, including $36,345.03 for topographic and geologic maps and $613.85 for geologic folios. In addition to this $7,709.42 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were $44,668.30.

Engraving and printing.—During the year 84 newly engraved topographic maps, including 7 revised maps, and 30 special maps were printed, making a total of 114 new or revised maps printed and delivered. Of the newly engraved maps 37 were completed under the Public Works allotment. Corrections were engraved on the plates of 153 maps. Reprint editions of 150 engraved topographic maps, 5 special maps, and 12 photolithographed State and other maps were printed and delivered. In addition, 56 new topographic maps had been engraved and were in press June 30, including 32 under Public Works allotment, and the engraving of 112 other new topographic maps was nearly completed, including 72 under Public Works allotment. One new geologic map was printed, the edition amounting to 4,625 copies. Of new and reprinted maps, 282 different editions, amounting to 701,549 copies, were delivered.

A large amount of work was done for more than 75 other units of the Government and State governments, and the charges for it amounted to about $208,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed. Of topographic maps, geologic maps, and contract and miscellaneous

work of all kinds a grand total of 4,849,142 copies were printed and delivered.

The photographic laboratory made 14,179 negatives (including 6,816 wet plates for photolithographs, 685 wet plates for photographic prints, 14 paper negatives, 1,316 dry plates, 471 lantern slides, and 4,877 field negatives developed), 17,355 prints (including 3,025 maps and diagrams, 13,337 photographs for illustrations and records, and 993 bromide enlargements), 6,507 zinc plates, 325 intaglio etchings, and 9 celluloid prints, and mounted 4,006 prints.

LIBRARY

The volume of work performed by the library during the year has again been abnormally heavy. Of the 11,201 readers who used the library, more than half were not members of the Geological Survey. A register of distinguished readers recently begun shows, among foreign visitors, representatives of the Geological Institute of the South Manchurian Railway, the Union of Soviet Socialist Republics, the Amtorg Trading Corporation, and the Bodleian Library, Oxford University. Members of the staff of many colleges and learned institutions in the United States also visited the library in furtherance of their research projects.

The bibliography of North American geology for 1933–34 was issued in February as Bulletin 869. This volume contains 3,836 entries, as compared with 3,454 in the volume for 1931–32. As an overtime project "A list of references since 1928 on National and State planning in the United States", comprising some 280 items, was prepared in cooperation with a representative of the National Resources Committee and issued as United States Geological Survey Library Bibliographical List No. 5. Bibliographical List No. 2, on the Public Works Administration, was also revised and republished.

Perhaps the most satisfactory feature of the library's work for the year was the authorization for the binding of 2,642 volumes, as compared with only 239 for 1935. Last year the library contained some 20,000 volumes badly in need of immediate binding, and the work done this year represents an excellent start on a much-needed binding program.

The accessions during the year were 19,368 books, pamphlets, and serial parts and 1,221 maps and charts. The total circulation during the year amounted to 40,420 copies.

APPROPRIATIONS AND EXPENDITURES

The appropriations made directly for the work of the Geological Survey for the fiscal year 1936 included 10 items, amounting to $2,285,560, of which $57,256.60 remained unobligated on June 30, 1936. In

addition, $6,500 was allotted from appropriations for the Interior Department for miscellaneous supplies.

Classification of obligations incurred by the United States Geological Survey during the fiscal year ended June 30, 1936

	Salaries	Topographic surveys	Geologic surveys	Alaskan mineral resources	Gaging streams
Salaries of permanent employees	$127,952.09	$579,991.87	$373,205.09	$40,293.00	$870,555.08
Wages of temporary employees		646,073.25	25,160.00	11,244.20	24,779.82
Supplies and materials		14,698.59	4,574.37	1,186.75	30,979.67
Dead storage of passenger-carrying vehicles			9.00		34.32
Other storage and pasturage of animals		2,228.39	389.63		680.52
Communication service		1,551.66	153.91	19.09	4,876.01
Travel expenses		131,035.40	25,590.76	11,071.57	74,667.51
Hire, maintenance, repair, and operation of passenger-carrying vehicles		2,021.69	2,785.60		26,541.18
Transportation of things		3,993.71	1,544.50	4,525.07	8,103.01
Hire, maintenance, repair, and operation of freight-carrying vehicles		77,206.41	7,446.63	64.75	29,519.68
Printing and binding		98,659.94	7,978.04	511.41	8,551.73
Furnishing of heat, light, power, water, and electricity		13.09	17.65		148.74
Rents		168.73	67.69	615.99	3,069.04
Repairs and alterations		6,704.29	2,470.56	150.74	20,487.62
Special and miscellaneous current expenses		44.00	33.56	65.68	61.15
Purchase of passenger-carrying vehicles		429.29	1,519.08		11,892.92
Purchase of freight-carrying vehicles		4,056.28	3,872.92		13,497.10
Purchase of scientific instruments and parts		25,448.55	2,252.08	59.00	43,567.75
Other equipment		18,822.88	3,365.54	1,238.40	13,695.54
Structures and parts					25,523.19
Miscellaneous refunds, adjustments, and transfers	69.96	105,032.69	2,726.51	609.33	120,616.06
Total	128,022.05	1,718,180.71	465,163.12	71,654.98	1,331,847.64

	Classification of lands	Printing and binding	Preparation of illustrations	Geologic and topographic maps	Mineral leasing	Total
Salaries of permanent employees	$131,457.23		$17,397.99	$229,845.84	$253,593.59	$2,624,291.78
Wages of temporary employees					46,291.56	753,548.83
Supplies and materials	925.59		21.60	54,700.44	1,786.22	108,873.23
Dead storage of passenger-carrying vehicles						43.32
Other storage and pasturage of animals	4.00				37.72	3,340.26
Communication service	211.81			6.38	2,341.62	9,160.48
Travel expenses	10,250.72		3.00	364.57	16,382.71	269,366.24
Hire, maintenance, repair, and operation of passenger-carrying vehicles	2,875.87				11,402.16	45,626.50
Transportation of things	711.45			520.65	1,678.77	21,077.16
Hire, maintenance, repair, and operation of freight-carrying vehicles	52.40				675.48	114,965.35
Printing and binding	502.16	$110,000	155.97	137.50	2,208.34	228,705.09
Furnishing of heat, light, power, water, and electricity					4,135.32	4,314.80
Rents	6.00				643.05	4,570.50
Repairs and alterations	79.95			9,438.37	1,305.20	40,636.73
Special and miscellaneous current expenses					103.63	308.02
Purchase of passenger-carrying vehicles	750.91				5,121.69	19,713.89
Purchase of freight-carrying vehicles	834.00					22,260.30
Purchase of scientific instruments and parts	74.00			215.28	108.83	71,725.49
Other equipment	946.92			22,436.00	5,344.16	65,849.44
Structures and parts					4,546.92	30,070.11
Miscellaneous refunds, adjustments, and transfers	290.19		19.34		4,975.43	234,339.51
Total	149,973.20	110,000	17,597.90	317,665.03	362,682.40	4,672,787.03

In addition to the amounts indicated above, cooperating agencies expended directly $39,540.84 for topographic surveys and $354,655.48 for stream gaging.

Topographic surveys of the United States, July 1, 1935, to June 30, 1936, and total area surveyed in each State

State	Contour interval (feet)	Mapped in fiscal year (square miles). (For engraved publication unless otherwise stated.) On scale of 1 to —						Total area mapped in fiscal year (square miles)				Total area mapped to June 30, 1936 (square miles)	Percentage of total area of State mapped to June 30, 1936	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied
		12,000	24,000	31,680	48,000	62,500	125,000	Planimetric mapping [1]	Standard mapping with contours							
									Revision [2]	Resurvey [3]	New survey [4]					
Alabama	20		[1] 6,376			149		6,376			149	21,983	42.3	77	52	
Arizona	50				133	387				147	373	60,542	53.1	90	58	
Arkansas	10, 20			22		365				387		23,631	44.3	24	93	
California	5, 25, 100		228	60		126	1,195		51	1,044	514	133,561	84.4	471	122	21
Colorado	25, 50	33				228				257	4	56,984	54.8	28		7
Connecticut	10			28						28		4,965	100.0	17		
Delaware	10			59						59		2,370	100.0	16	14	
District of Columbia												70	100.0			
Florida	10					195					195	6,144	10.5			
Georgia	20		[1] 172	2		102		772		2	102	225,202	42.5	70	253	
Idaho	50, 100					94	684				778	35,061	41.8	48		8
Illinois	10, 20					1,101				88	1,013	39,981	70.6	534	10	
Indiana	20					195					195	4,287	11.8	32	132	
Iowa												13,710	24.4			
Kansas												64,446	78.4	54	6	
Kentucky	20		[1] 1,251			238		1,251			238	27,358	67.4	73	187	
Louisiana				[1] 3,077				3,077				11,330	23.4			
Maine	10, 20			15		182				15	182	21,876	66.2	17		
Maryland	20					160				160		12,327	100.0	31	71	
Massachusetts	10			625					82	543		8,266	100.0	3		
Michigan	5, 10			12		139				12	139	14,833	25.6	733	982	
Minnesota	20					109					109	8,890	10.5	4	140	
Mississippi	20		[1] 144			14		441			14	7,258	15.5	5	214	
Missouri	10, 20		112	14		2,335			112	1,188	1,161	50,869	73.3			
Montana	25, 100					200	506				706	45,137	30.7	159		9
Nebraska	10					64					64	27,931	36.0	87	20	
Nevada	25, 50		9			368				9	368	54,724	49.4	178		9
New Hampshire	20					368				368		9,302	100.0			
New Jersey	10			70						70		8,224	100.0			
New Mexico	20, 50					305					305	44,980	36.7			
New York	10, 20			35		561				596		49,204	100.0		22	
North Carolina	50		[1] 2,548			64		2,548		64		19,040	36.3	221	40	
North Dakota	10, 20					377					377	14,382	20.3	120	73	
Ohio	5			234						234		41,040	100.0	85	379	
Oklahoma												41,927	59.8	44	28	
Oregon	5, 50, 100		[5] 48			101	1,193		101	263	1,241	39,125	40.5	102	33	22
Pennsylvania	20					900			17	23	620	39,776	88.1	113	155	3
Rhode Island	10			23								1,248	100.0			
South Carolina											75	14,967	48.3	80		
South Dakota	20					75						19,887	25.6	234	217	
Tennessee	5, 25, 50		[1] 17,057	46		135		17,097	60	121	33	23,633	56.2			
Texas	20					33				908	230	89,923	33.8			
Utah	100						1,138			30	175	20,780	24.4	103		
Vermont	20					205				774		8,739	91.4	3		
Virginia	10, 20, 50		[6] 136	70		676		92	16	6	234	37,897	88.9	77	205	6
Washington	5, 25, 50, 100	[5] 32				35	173			75		39,896	57.7	329	47	
West Virginia	20					75					145	24,170	100.0	30		
Wisconsin	20					145				158	748	19,754	35.2	47	16	
Wyoming	50, 100				158		748					33,370	34.1	120		
Total continental United States (exclusive of Alaska)		65	29,018	4,392	291	10,806	5,637	31,654	514	7,554	10,487	1,425,000	47.1	4,459	3,569	85
Hawaii												6,435	100.0			
Puerto Rico												154				

[1] Prepared from aerial photographs with field examination and showing culture, drainage, and woodland, but no contours (planimetric mapping). Advance-sheet reproduction by three-color photolithography.
[2] Revision mostly of culture only.
[3] Resurveys in large part cover areas previously surveyed on a smaller scale.
[4] New surveys cover areas not heretofore mapped.
[5] Advance-sheet reproduction by one-color photolithography.
[6] Includes 92 square miles planimetric mapping (see footnote 1) and 44 square miles with contours, advance-sheet reproduction by three-color photolithography.

Summary of outstanding mineral withdrawals and classifications, June 30, 1936, in acres

State	Coal		Oil		Oil shale		Phosphate		Potash
	Withdrawn	Classified as coal land	Withdrawn	Classified as oil land	Withdrawn	Classified as oil-shale land	Withdrawn	Classified as phosphate land	Withdrawn
Alaska		56,993							
Arizona	139,415								
Arkansas		61,160							
California	17,603	8,720	1,178,392						90,324
Colorado	4,142,233	3,082,272	215,370		1,172,778	952,239			
Florida							66,796	120	
Idaho	11,520	4,603					276,239	270,036	
Louisiana			466,990	4,233					
Montana	6,259,193	[1] 9,373,884	1,336,697	67,651			289,089	3,833	
Nevada	83,673								39,422
New Mexico	4,119,616	984,829							9,282,160
North Dakota	5,954,364	11,178,286	84,894						
Oregon	4,361	18,887							
South Dakota		250,093							
Utah	3,404,043	1,267,697	[2] 1,344,473		2,737,274	2,703,755	277,344	2,937	
Washington	691,801	141,444							
Wyoming	2,143,991	[3] 6,847,235	541,777		2,079,897	425,214	989,133	25,293	
Total	26,971,813	33,276,103	5,168,593	71,884	5,989,949	4,081,208	1,889,601	302,219	9,411,906

[1] Includes 3,151 acres of coal land reserved for use of the United States (coal reserve no. 1).
[2] Includes 13,578 acres withdrawn as helium reserve.
[3] Includes 2,078 acres of coal land reserved for use of the United States (coal reserve no. 2).

General summary of cases involving land classification

Class of cases	Record for fiscal year 1935-36						Record since receipt of first case	
	Pending July 1, 1935	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1936	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General	81	438	519	500	19	+62		
Time extensions							2,313	2,313
Oil development	14	134	148	143	5	+9	17,523	17,518
Concurrence	58	1,139	1,197	1,176	21	+37		
Committee cases—Oil and potash	1	117	118	105	13	−12	12,868	12,855
Applications for classification as to mineral:								
Oil	176	1,121	1,297	1,167	130	+46	28,541	28,411
Miscellaneous	1	2	3	3		+1	935	935
Applications for mineral permits	33	724	757	748	9	+24	62,051	62,042
Applications for mineral leases	20	336	356	147	209	−189	2,481	2,272
Applications for patent, potassium							124	124
Federal Power Commission cases:								
Preliminary permits	12	50	62	57	5	+7	398	393
Licenses							28	28
Determinations under sec. 24	2	54	56	37	19	−17	592	573
Applications for classification as to power resources	1	9	10	9	1		551	550
Applications for rights-of-way	9	96	105	90	15	−6	7,188	7,173
Irrigation project reports	2	3	5	3	2		944	942
Indian Office requests for information		1	1	1			9,549	9,549
Unit or cooperative agreements:								
Cases involved	1,454	1,805	[1] 3,259	731	2,528	−1,074	3,259	731
Total	1,864	6,029	7,893	4,917	2,976	−1,112		

[1] 792 units involved.

Mineral production from public lands and revenues accrued therefrom, fiscal year 1936

State	Petroleum (barrels)	Natural gas (M cubic feet)	Gasoline (gallons)	Coal (short tons)	Potassium (short tons)	Sodium (short tons)	Phosphate (short tons)	Accrued revenues
Alaska								
Alabama				49,156				$4,997.92
Arizona				2.50				.63
California	18,894,251	41,539,464	66,839,619	98		54,215		2,901,746.27
Colorado	1,141,737	2,243,987	82,405					
Idaho				988.65			50,207	5,016.72
Louisiana								
Montana	468,305	2,698,750		427,546.81				110,177.06
Nevada								160.00
New Mexico								
North Dakota				453,600.38				27,892.09
Oklahoma								
Oregon				166				211.00
South Dakota				2,028.52				410.81
Utah	1,547	27,314	1,442	1,143,939.68				134,144.10
Washington				29,472.35				2,947.24
Wyoming	8,918,335	15,630,429	27,425,803					
Total							50,207	
1935	28,269,714	73,033,325	97,864,356	3,434,672.61	334,367	55,307	38,184	4,388,203.93