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GEOLOGICAL SURVEY

(WALTER CURRAN MENDENHALL, Director)

The appropriations made directly for the work of the Geological Survey for the fiscal year 1933 included 12 items, amounting to \$2,181,000. Of the balance remaining in the 1932 appropriation for topographic surveys, \$150,000 was continued available for expenditure during the fiscal year 1933, and the sum of \$284,400 was transferred to the Geological Survey under the provisions of section 317 of the legislative appropriation act of June 30, 1932, making a total of \$2,615,400 available for expenditure. In addition, \$12,424.50 for miscellaneous supplies was allotted from appropriations for the Interior Department.

A detailed statement of the amounts appropriated and expended is given at the end of the report. The balance on July 31 was \$192,265.07.

The total amount of funds made available for disbursement by the Geological Survey, together with State funds directly disbursed for work administered by the Federal officials, was \$4,032,552.62.

THE YEAR'S OPERATIONS

Geological work.—The geologic work done during the year included economic and general studies of metal-mining districts in Colorado, Idaho, Nevada, New Mexico, Utah, and Virginia; of coal fields in Montana, Utah, and New Mexico; of oil and gas fields in Kansas, California, Montana, Colorado, and Utah; and of phosphate, oil shale, and other mineral deposits in Wyoming. In much of this work State surveys and other organizations cooperated. One of the most notable achievements of the year was the completion and publication of the new geologic map of the United States on the scale of 1:2,500,000. Potash investigations were continued as part of the regular work, no special funds being available. Cuttings from oil wells and samples from private core tests on Government permit areas were studied mineralogically and petrographically, and the analyses and other tests for potash numbered 2,445. This work disclosed a third source of commercial sylvite in New Mexico. Areal mapping or other general geologic work was done in 30 States and volcanologic work in Hawaii.

Explorations in Alaska.—In the season of 1932 eight field projects in Alaska resulted in the geologic mapping of 2,730 square miles and the topographic mapping of 3,571 square miles. On one of these projects the Alaska Railroad cooperated. Of the total area of Alaska 44.8 percent has now been covered by geologic surveys and 47.8 percent by topographic surveys. The usual general survey of recent mining developments, collection of mineral statistics, and supervision of operations under coal and oil leases on Government lands were continued. Three field projects for the season of 1933 had been started at the end of the

fiscal year. The work done in cooperation with the Alaska Railroad included, in addition to the survey project already mentioned, core drilling to test two coal areas in the railroad belt. This work indicated that the areas do not warrant development under present conditions. In the office a little more than 1,000 square miles of new drainage base was compiled from aerial photographs taken by the Navy Department in 1926 and 1929.

Topographic mapping.—The area mapped topographically during the year amounted to 20,191 square miles and the total area now mapped, exclusive of Alaska, is 1,387,207 square miles. Ten States, the District of Columbia, and Hawaii are completely mapped, and the percentages in the other States range from 8 in Florida to 88.9 in Virginia. Of the continental United States, exclusive of Alaska, 45.6 percent has been mapped. Cooperative funds furnished by States for topographic mapping during the year amounted to \$370,309.71 and came from 16 States and 2 counties. Cooperation was also rendered by the War Department and the Department of Justice. The office work included the completion of stereophotogrammetric mapping from aerial photographs of Bryce Canyon National Park, the mounting of 4,000 multiple-lens photographs for the Guatemala-Honduras Boundary Tribunal, corrections to State maps for use in assembling a map of the Tennessee River Basin, and other routine or special projects.

Investigation of water resources.—The work on water resources is done largely in cooperation with other Government organizations, with State, county, and municipal agencies, and with permittees and licensees of the Federal Power Commission. The amount expended by State, county, and municipal agencies for such work during the year, in part directly and in part through the Geological Survey, was \$524,988.53. Including the cooperative work, the study of surface waters, which consists primarily of the measurement of the flow of streams, was carried on in 48 States, the District of Columbia, and Hawaii, in which at the end of the year 2,801 gaging stations were being maintained. In this work 40 of the States and Hawaii cooperated. Investigations relating to ground water or power and reservoir sites were made in 19 States and Hawaii. The number of water-stage recorders in operation over observation wells has now reached 125. In the hydrologic laboratory 496 samples of water-bearing material were analyzed. The work on quality of water involved the examination of 1,034 samples of water. Studies of the dissolved and suspended matter in the Colorado River and its tributaries were continued. The investigations of power resources included the preparation of monthly and annual reports on the production of electricity and consumption of fuel by public-utility power plants, a report on the developed waterpower of the United States, and compilations of the stocks of coal held by electric public-utility power plants. The studies of water utilization and flood control included investigations relating to the apportionment of water on international streams and studies of the effect of a dam in Canada on the behavior of surface and ground water in the United States. Special field work was done in connection with 120 projects of the Federal Power Commission.

Classifying and leasing public lands.—The classification of public lands with respect to their mineral, waterpower, and agricultural value, and the technical supervision of mineral and power development on such lands and of mineral development on Indian lands, were continued in 21 States and Alaska. The number of cases involving land classification, acted on during the year was 12,568, and the results accomplished include net decreases of 597,479 acres in outstanding withdrawals for coal and of 356 acres in outstanding withdrawals for oil and a net increase of 191,851 acres in areas classified as coal land. At the end of the year the total area classified as mineral in character amounted to 37,081,414 acres in 14 States and Alaska, and the outstanding mineral with-

drawals to 50,918,765 acres in 14 States. Definition of the "known geologic structure" of producing oil and gas fields was continued, and at the end of the year the net area so defined was 944,951 acres in 7 States. Investigations to obtain information for classifying public land with respect to its value for the development of waterpower were made in 2 States. There was a net increase of 105,625 acres in the area included in power reserves, making a total of 6,682,810 acres in 21 States and Alaska, on which about 15,000,000 continuous horsepower can be developed. The net decrease in enlarged-homestead designations was 4,850,782 acres, making a total outstanding of 309,498,084 acres in 14 States, and the net increase in stock-raising homestead designations was 705,440 acres, making a total outstanding of 124,302,026 acres in 19 States. There was a net increase of 39,365 acres in public water reserves, and the total outstanding is now 487,201 acres in 12 States and Alaska.

The supervisory work on public lands subject to the mineral leasing laws was increased by the issuance of 71 leases, 32 licenses, and 1,180 permits, and decreased by 646 cancellations and expirations of leases, permits, and licenses. The production of petroleum on such lands during the year was 24,662,589.46 barrels, of natural gas 56,637,196,000 cubic feet, and of gasoline 91,549,635.62 gallons, on which the royalty, rentals, and bonuses amounted to \$3,292,712.38. The production of coal on such lands was 2,947,384 tons, of phosphate rock 1,643.04 tons, of potash 173,563.16 tons, and of sodium salts 37,314 tons, on which the royalty, rentals, and bonuses amounted to \$356,264. Supervision over oil and gas operations on naval petroleum reserves was continued, and the total production was 3,672,408.11 barrels of petroleum, 3,917,098,000 cubic feet of natural gas, and 15,876,707 gallons of gasoline, on which the royalty value was \$706,107.47. Inspectional, regulatory, and advisory service was rendered in connection with the leasing of mineral deposits on Indian lands in eight States.

Publications.—The publications of the year consisted of 53 books and pamphlets of the regular series, 29 guidebooks for the excursions of the International Geological Congress, 99 new or revised maps, 149 reprinted maps, 1 geologic folio, and numerous circulars, lists of publications, etc. The total number of pages in the new book publications, including the guidebooks, was 10,572. In addition to these publications, 48 brief papers, several of them accompanied by maps, were issued in mimeographed form as memoranda for the press. The publications distributed numbered 712,904, of which 3,776 folios and 477,867 maps were sold for \$29,969.21.

GEOLOGICAL BRANCH

Geologic work in the usual classes of economic surveys and investigations and general or special research problems was actively carried on throughout the year, but the amount of field work done was considerably less than in recent years. Rigid economy was necessary because the total available funds for the work of the geologic branch for the year were about \$100,000 less than for the fiscal year 1932. Many geologists who ordinarily spend 3 to 5 months of each year in field work remained in the office and prepared reports on projects that had previously been investigated in the field.

The preliminary uncolored edition of the geologic map of Texas was printed early in the year and was distributed to geologists and oil companies of the region for criticism and correction. The compilation of the resultant new data for the map in its final colored form is nearing completion, but lack of funds for engraving and printing may

postpone publication for some time. The publication in June of a new geologic map of the United States on the scale of 1:2,500,000 is one of the most notable achievements of the year. An important continuous service to the public is rendered in the geologic branch by the identification of rocks, ores, minerals, and fossils and by carefully prepared letters in answer to numerous daily inquiries on geologic topics.

WORK OF THE YEAR, BY STATES

Alabama.—Studies of the brown iron ores of the Russellville district and of the iron ore in the Red Mountain formation in northeastern Alabama, cooperative projects with the Geological Survey of Alabama, were continued. A report on Iron Ore in the Red Mountain Formation in Greasy Cove was issued as circular 1.

Arizona.—The guidebook of the Southern Pacific lines, New Orleans to Los Angeles, was completed for publication as Bulletin 845. Geologic investigations included field mapping of the Tucson quadrangle, brief examination of manganese deposits near Artillery Peak, study of the geology and ore deposits of the Ajo copper district, and examination of a dam site in the San Carlos project for the Office of Indian Affairs.

Arkansas.—Field work in the Ouachita Mountains of Oklahoma and Arkansas was continued. A preliminary report on the cooperative study of the zinc and lead deposits of northern Arkansas was issued during the year, and work on a paper on recent developments in the Batesville manganese district was completed. Stratigraphic and paleontologic studies included the Morrow formation and the Batesville sandstone, echinoderm microfaunas from the Mississippian, microfossils from the Carboniferous, and Wedington flora of the Fayetteville shale and of the Jackfork sandstone and Stanley shale.

California.—The study of the Kettleman Hills oil and gas field was continued. Field work in the San Pedro Hills was begun, and field work on the siliceous sediments and associated rocks of the Monterey group was completed. Studies of source rocks of petroleum in several oil fields of southern California were continued. Office work was also continued on the reports on the Ivanpah quadrangle, on the Grass Valley district, and chromite deposits in northern California. Studies were continued on the San Andreas rift and the southern part of Death Valley. Work was prosecuted in connection with the report on the geomorphology of the upper San Joaquin Basin.

Colorado.—Study of the mining regions of the State was continued in cooperation with the Geological Survey Board of Colorado and the Colorado Metal Mining Fund, though the work was curtailed owing to decrease of funds. A general report on the geology and ore deposits of the State is in preparation to accompany the geologic map, which is now almost ready for engraving. An intensive field study was made of the Arrastre Basin of the San Juan region, and the report was sent to the Colorado Scientific Society for publication. Field work was carried on in the Jamestown district, in the Snowmass area and in the Nederland tungsten area. A study of the Independence Pass district was made with special reference to the driving of tunnels for diversion of water from the west to the east slope of the Continental Divide.

The geologic mapping of the Tertiary and Upper Cretaceous formations of eastern Colorado, north of the Arkansas River and south of the Platte River, was completed and progress was made on a detailed report.

Florida.—Studies were continued of pelecypods and gastropods from the Alum Bluff group (Miocene) including work on the preparation of the report on the Tampa limestone (Miocene), in cooperation with the Florida Geological Survey.

Hawaii.—The work of the section of volcanology at Volcano House, Hawaii National Park, was carried on during the year and included observing volcanoes, operating local seismographs, doing oceanographic work, especially on tidal waves, measuring horizontal and vertical movements of the ground by surveying methods, building and improving instruments of research for volcano and earthquake study, carrying on special researches for publication suggested by the back records, etc. At Lassen, Calif., other systematic measurements include hot-spring temperatures and land slipping. The Hawaiian Volcano Research Association has assisted the Geological Survey in the past and carried all the expenses of the Hawaiian station except salaries of the professional staff in 1933.

Idaho.—Studies of some mining districts in Idaho were continued in cooperation with the Idaho Bureau of Mines and Geology. Field work was done in the Buffalo Hump, Elk City, and adjoining districts, and several reports were prepared. Work in the Boise Basin in the Yellow Pine, Edwardsburg, and Thunder Mountain districts was prosecuted. A report on some lode deposits in the northwestern part of the Boise Basin is ready for publication.

Illinois.—Work on the Pottsville fossil floras of the eastern interior coal basin of Illinois, including small areas in adjoining States, which is being carried on in cooperation with the Illinois Geological Survey, was well advanced.

Indiana.—The Survey continued its work on new crinoid genera from the Mississippian, Devonian, and Silurian.

Iowa.—Studies of the typical Kinderhook fauna were continued.

Kansas.—A report on the origin of the shoestring oil sands of Greenwood and Butler Counties and adjacent areas was completed. This is a cooperative project between the State and Federal surveys.

Kentucky.—A report on fossil flora of the New Providence shale with notes on a new representative of the Calamopityeae from Junction City is in preparation.

Louisiana.—Studies of the cap rock of salt domes of southern Louisiana were continued. The Southern Pacific Guidebook is noted under Arizona.

Maine.—The Geological Survey cooperated with the State geologist of Maine in the preparation of a State geologic map, which will be issued by the State.

Maryland.—Work on the geology of the Appalachian Mountain region of Maryland, in cooperation with the Maryland Geological Survey, was continued.

Massachusetts.—A field and office review of the stratigraphy and structure of the Taconic quadrangle were made in connection with general geologic studies in the region.

Michigan.—The preparation of material for a revised report on the Lake Superior iron-ore region was continued.

Minnesota.—See Michigan: Lake Superior iron-ore region.

Mississippi.—A report on the geology of the Jackson, Florence, and Pelahatchee quadrangles is in preparation. A study of Cretaceous volcanism and structural history of the Jackson gas field was inaugurated.

Missouri.—Informal cooperation with the Missouri Bureau of Geology and Mines in the identification of fossils was carried on. Paleontologic studies were continued on some early Paleozoic fossils, on echinoderm microfauna from the Mississippian formation, on the Kinderhook fauna, on the Warsaw fauna of the Boone limestone from the Joplin district, and on the fauna of the Louisiana limestone of northeastern Missouri. The Geological Survey in cooperation with members of the Missouri Bureau of Geology and Mines discovered outcrops of fossiliferous Upper Cretaceous beds near Ardeola.

Montana.—Reports on the geology of the Rosebud Creek coal field, Rosebud and Custer Counties, and of the Richey-Lambert coal field, Richland and Dawson Counties, have been approved for publication. A party extended the detailed mapping of the coal beds of a portion of Custer County begun in 1932. A report

for survey publication on the Mizpah coal field of Custer County was almost completed. A reconnaissance areal and structural geologic survey was made of parts of Hill, Chouteau, and Liberty Counties.

The report on the lignite fields of McCone County was advanced, and the report on the geology of the Little Rocky Mountains and the surrounding plains was completed. Studies of the glacial geology and physiography of western Montana, northern Idaho, and eastern Washington were continued in connection with a comprehensive report on the subject. Field and office studies of the gold placers of the Pioneer district were continued, including the examination of phosphate lands near Marysville. Areal mapping and study of mines in the Libby and Troy districts of northwestern Montana were continued and considerable progress was made on detailed reports on the districts. Travertine deposits were examined near Gardner, the report on which will appear as a circular under the title "Some Deposits of Ornamental Stone in Montana." An examination and report on the Mission Creek dam site, Lake County, was made for the Office of Indian Affairs. A geologic map of the State is being compiled in cooperation with the Montana Bureau of Mines and Geology. A correlation chart in two sheets was issued. Work on Fort Union fossil plants is noted under North Dakota, and on source sediments of petroleum under "General studies."

Nebraska.—A reconnaissance of certain Pleistocene deposits in Nebraska was made in connection with a cooperative study of ground-water supplies by the water-resources branch and the State conservation and survey division.

Nevada.—In cooperation with the Nevada Bureau of Mines investigations of some mining districts in the State were continued. Field work was conducted in a resurvey of the Eureka district begun last year and examinations were made in the Tuscarora district and in the Mountain City district in Elko County. The geysers near Beowawe were also studied. A report on the Mountain City district was transmitted to the State bureau. Work was continued on the geology and ore deposits of the Tonopah and Tuscarora areas. Field work in the Chief and Delamar mining districts near Caliente was carried on including the collection of specimens for the purpose of determining the extent of magnesite at the brucite deposits. Examinations were made, in cooperation with the Nevada Bureau of Mines, of the effects of Cedar Mountain earthquake of December 1932 and its bearing on the genesis of Basin Range structure.

The report on the Tybo area for publication by the Nevada Bureau of Mines was completed. Progress was made on the detailed reports on the geology and ore deposits of the Ivanpah quadrangle, California and Nevada, and on the geology of the Great Basin. Several investigations were made for the Office of Indian Affairs including an examination and report on the Rio Vista and Weber Dam sites, in the Walker Indian Reservation, a preliminary examination of two dam sites in the western Shoshone Indian Reservation, and a final examination and report on these sites. A special examination of mining claims in the Duck Valley project was also conducted.

New Jersey.—Several localities in New Jersey for the purpose of collecting Cretaceous and Tertiary Foraminifera were visited.

New Mexico.—The report on the geology and mineral resources of the Santa Rita district was completed and submitted for publication as a survey bulletin. Work was continued on the report of the geology and ore deposits of the Magdalena district. The Geological Survey continued its studies of the Central mining district, Grant County, in cooperation with the New Mexico Bureau of Mines and Mineral Resources. The report on the Mount Taylor coal field, which will form part of a bulletin on the geology and fuel resources of the southern San Juan Basin, was completed, and a report on the coal fields of that part of the San Juan area extending from the Nacimiento Mountains westward including portions of

McKinley, Sandoval, and San Juan Counties, is nearing completion. A map showing the geologic structure of an area in the basin covering parts of McKinley, San Juan, Sandoval, Bernalillo, and Valencia Counties, was issued during the year. Preparation of the report on the Mount Taylor volcanic field, which comprises a study of the structural geology, was continued. Further field studies in the San Juan Basin region begun early in the summer of 1933 and consisting of detailed mapping for the purpose of determining the coal resources and oil possibilities of an area along the east flank of the basin from Cuba north to the State line were prosecuted.

The work on the Abo fauna of the Sacramento Mountains was continued during the year. Studies of the Permian of eastern New Mexico are included under Texas.

New York.—Work in the Taconic quadrangle is noted under Massachusetts.

North Carolina.—The diatoms, mollusks, and foraminifers from test water wells in and near Elizabeth City are being studied, the results to be published in an unofficial medium.

North Dakota.—Work was continued in the preparation of a report on fossil plants from the Fort Union and associated formations, based on collections from North Dakota, Montana, and Wyoming.

Oklahoma.—Revision of the report on the geology and economic resources of the McAlester coal field was completed during the year and work was also continued on a report on the Howe-Wilburton field. A preliminary map showing the coal beds and mines of the McAlester district was issued. Studies of the fossil flora of the coal fields of eastern Oklahoma were continued. A paper on the Moorefield fauna is in the course of preparation. Desirable drilling sites for gas wells in an area in Osage County, for the Office of Indian Affairs were reported upon by the Survey.

Oregon.—Several reports were in course of preparation or publication during the year as a result of studies previously carried on in cooperation with the Oregon State Mining Board. The report on the Robertson, Humdinger, and other mines of southwestern Oregon was issued as Bulletin 830-B. The report on the Takilma-Waldo and Blue Creek districts is in press as Bulletin 846-B, and the report on copper deposits in the Squaw Creek and Silver Peak districts and at the Almeda mine, southwestern Oregon, with notes on the Pennell & Farmer and Banfield prospects, will appear as circular 2. A report on some mining districts of eastern Oregon with a chapter on the Ochoco district is in press as Bulletin 846-A, and a bulletin on quicksilver deposits of southwestern Oregon has been submitted for publication. A report is also nearly finished on the geology of the Baker quadrangle including a short paper on greenstones of eastern Oregon. The report on metalliferous mineral deposits of the Cascade Range in Oregon was completed for official publication. Studies of diatoms of eastern Oregon were continued.

Pennsylvania.—Work on cooperative projects with the Pennsylvania Topographic and Geologic Survey included preparation of a report on the geology of the York and Hanover quadrangles, and field work in a study of the structure of the Reading and Boyertown Hills, for a detailed report in preparation on the geology of the Reading and Boyertown quadrangles. Progress was made on the reports on the geology and mineral resources of the Butler and Zelienople quadrangles and the geology and mineral resources of the Tyrone quadrangle. Studies on the effect of progressive metamorphism in the Lower Kittanning coal beds of Pennsylvania were continued.

South Carolina.—Manuscript of report on the geology of the Coastal Plain of South Carolina was completed.

South Dakota.—A paper on a lower Lance florule from Harding County was completed for survey publication.

Tennessee.—In connection with the studies of the Appalachian lead and zinc deposits, visits were made to some zinc mines at Mascot and Jefferson City. A map showing the mineral resources of the Tennessee River Basin has been compiled and is in press.

Texas.—The compilation of the cooperative geologic map of Texas progressed during the year. A monograph on the Midway fauna of Texas was completed and transmitted to the Texas Bureau of Economic Geology for publication. Stratigraphic studies in the Tertiary near Laredo were also continued in cooperation with the water-resources branch. Further studies of the geology of the Diablo Plateau region, southwestern Texas, are in progress. Work on source sediments of petroleum is noted under "General studies" (Trask), on the genus *Diploschiza* under Alabama, and on the Southern Pacific guidebook under Arizona.

Utah.—Reports on the geology of the Salt Valley anticline and the northwestern flank of the Uncompahgre Plateau, Grand County; on the Monument Valley-Navajo region of San Juan County; on the geomorphology of the north flank of the Uinta Mountains; and on the Gold Hill quadrangle were completed for survey publication. A preliminary map showing the geologic structure of parts of Emery, Wayne, and Garfield Counties was issued.

Work was continued in preparation of the report on the Green River Desert and the eastern flank of the San Rafael Swell and the field work necessary for the preparation of a preliminary geologic structure contour map of southeastern Utah was completed. Additional field mapping of the geology of a portion of the Wasatch Plateau, with special reference to the coals, was done. Field work was conducted for a short time in connection with studies on correlation of the geologic formations of the Colorado Plateau region of southern Utah. A correlation chart in two sheets was issued. Work on the Paradox formation is noted in other sections of the report.

Vermont.—Studies were continued on the geologic structure of the State. Field work was conducted and study made of certain problems in metamorphic geology in east-central Vermont. Work in the Taconic quadrangle is noted under Massachusetts.

Virginia.—In cooperation with the State Geological Survey further field and office studies were made for a report on the geology of the Appalachian Valley in Virginia to be published by the State. Detailed mapping of the Abingdon quadrangle was continued and a brief field examination in southwestern Virginia was made in connection with investigations of the lead and zinc deposits, the report on which has been transmitted to the State. Preparation was continued of a paper on the titanium deposits of Nelson and Amherst Counties.

Washington.—A chapter on copper in Washington was written for the volume on copper by the International Geological Congress. Investigations of the glacial geology and geomorphology of eastern Washington are noted under Montana.

Wisconsin.—Work in the Lake Superior iron-ore region is noted under Michigan.

Wyoming.—Field and office work were continued on the geology of the Afton quadrangle with special reference to the occurrence of phosphate. The work of preparing the report on the Tertiary rocks of the Green River Basin was also continued. In the summer of 1933 a field study was started of the oil-shale deposits of the Fossil and Washakie Basins of southwestern Wyoming. Studies of the Tempskyas of the Wyan and Aspen deposits of southwestern Wyoming and southeastern Idaho were prosecuted during the year.

WORK IN CHEMISTRY AND PHYSICS

The work in chemistry and physics includes the chemical analysis of rocks, ores, and minerals collected by geologists, tests necessary to identify specimens received by the Survey, descriptive mineralogy, including studies of the physical and chemical properties of minerals and ores, their genesis and geochemical relationships, and measurements of deep earth temperature. Among the materials analyzed in the laboratory during the year were 15 igneous rocks from mining districts in Colorado and Nevada, 2 tallow clays from Arkansas, 7 siderites from Idaho, and about 30 dolomites, 14 clays, 29 phosphates, and 40 separate minerals, including potash minerals, from different localities throughout the country.

During the year 5,464 examinations were made by the section of chemistry and physics, of which 1,722 were identifications of potash and related minerals by the petrographic microscope. The potash work also required 437 qualitative tests and 286 quantitative analyses, making in all 2,445 tests for potash. Identifications of specimens submitted by persons not officially connected with the Survey numbered 1,051. The remaining 1,489 qualitative tests and 479 quantitative analyses were made chiefly in response to direct requests by geologists and partly in connection with chemical and physical studies involving methods of analysis and geochemical investigations.

ALASKAN BRANCH

The Geological Survey's work in Alaska has two rather distinct phases—one of a general investigational and research type and the other of a semiadministrative type in connection with the technical supervision of the leases granted by the Government covering coal, oil, or other mineral lands.

Manuscripts and publications.—During the year 5 reports and 1 map have been published and the following maps were issued in preliminary photolithographic editions:

Wrangell district ($55^{\circ}26'-56^{\circ}31'$; $131^{\circ}45'-133^{\circ}15'$).

Tonsina district ($61^{\circ}2'-62^{\circ}$; $144^{\circ}55'-146^{\circ}25'$).

Anthracite Ridge ($61^{\circ}46'31''-61^{\circ}51'1''$; $148^{\circ}3'52''-148^{\circ}11'21''$).

Kodiak and vicinity ($57^{\circ}21'-58^{\circ}1'$; $152^{\circ}8'-153^{\circ}12'$).

In addition, 23 manuscript reports (including maps) and 2 separate manuscript maps have been completed by their authors and are in various stages of proof or preparation for publication. At the end of the year 7 manuscript reports and 4 manuscript maps were partly completed.

Work on mineral resources.—In addition to the routine duties of administration 11 principal projects, 7 of which involved field work, were carried on during the season of 1932. The 7 field projects were reconnaissance topographic mapping in the northern part of the Ketchikan and Wrangell districts, southeastern Alaska; mineral investigations in the Taku district, southeastern Alaska; reconnaissance geologic mapping in the Tonsina district, in the west-central part of the Copper River Valley; reconnaissance topographic mapping in the Slana-

Suslota Pass district, at the head of the Copper River Valley, and at scattered points along the Richardson Highway; reconnaissance topographic mapping in the northern part of Kodiak Island, southwestern Alaska; reconnaissance of portions of southwestern Alaska and the Aleutian Islands, in connection with a Navy Department expedition; general reconnaissance of recent mining developments, particularly in central Alaska and Seward Peninsula.

During the year a little more than 1,000 square miles of new drainage base was compiled from aerial photographs taken by the Navy Department in 1926 and 1929. This covered part of the region north and west of Wrangell, in southeastern Alaska, and was prepared for one of the topographic projects for the season of 1933. Work on the comprehensive report on the large tract of country lying west of the international boundary and between the Yukon and Tanana Rivers, based on the field work done in the past 30 years, was continued.

Owing to the severe curtailment of funds for the fiscal year 1932-33 and the even more drastic curtailments for 1933-34, together with the necessity of suspending new work until various pending matters of policy and procedure were settled, only three field projects were started before the end of the fiscal year, and the personnel of two of these had not reached the field by June 30. One of these projects involved detailed topographic mapping in the Aleutian Islands in connection with investigations by the Navy Department. The other two projects are a continuation of the reconnaissance topographic mapping in the Wrangell and Ketchikan districts of southeastern Alaska, and a geologic reconnaissance of the mining camps in central Alaska, especially in the Ruby, Poorman, Innoko, and Iditarod districts.

At the end of the fiscal year the preparation of a comprehensive summary of all the available information regarding the geology and mineral resources of the Chitina Valley and adjacent parts of the Copper River region had been begun.

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 45.6 percent mapped, the year's increment amounting to 0.4 percent. There was a large increase in the area covered by topographic base maps without contours prepared from aerial photographs after field examinations and an increase in the area mapped by stereophotogrammetric methods. The resurveys in large part covered areas previously surveyed on a smaller scale.

New topographic surveys of the United States, July 1, 1932, to June 30, 1933, and total area surveyed in each State

State	Publication contour in- terval (feet)	Mapped in fiscal year (square miles) (engraved publication unless otherwise stated) for publication on scale of 1 to—						Total area mapped in fis- cal year (square miles)			Total area mapped to June 30, 1933 (square miles)	Percentage of total area of State mapped to June 30, 1933	Spirit levels (miles)	Transit traverse (miles)	Triangu- lation sta- tions oc- cupied
		12,000 or larger	24,000	31,680	48,000	62,500	125,000	250,000	Revi- sion	Resur- vey	New sur- vey				
Alabama											21,491	41.3			
Arizona	25, 100					212	200			223	189	59,339	52.1	39	9
Arkansas	5, 10, 50					711					711	22,685	42.5	440	
California	5, 25, 50, 100		269	544		425	4,018		2,834	1,332	1,090	132,137	83.5	1,589	68
Colorado	50				b65	29				22	72	56,342	54.2		
Connecticut												4,965	100.0		
Delaware												2,370	100.0		
District of Columbia												70	100.0		
Florida												4,718	8.0		
Georgia												24,937	42.1		
Idaho	100						190		69		121	32,684	39.0	416	26
Illinois	5, 10, 20		73			1,534			1	467	1,139	36,601	64.6	269	
Indiana												3,668	10.1		
Iowa												13,167	23.5		
Kansas												64,159	78.1		
Kentucky												26,620	65.6		
Louisiana	5, 10		b3,964		12						12	9,933	20.5		
Maine	20				1,806						1,806	20,773	62.9	491	40
Maryland												12,327	100.0		12
Massachusetts	10			29						29		8,266	100.0		
Michigan				b3,118								14,069	24.3		62
Minnesota	2, 10, 20	(b d)				117					117	8,157	9.6		
Mississippi												6,754	14.4	18	1
Missouri	5, 10, 20		193			1,355			4	741	803	46,793	67.4	677	
Montana	100				b e 840		364				364	43,452	29.6		
Nebraska												27,117	35.0		
Nevada	100							2,654			2,654	53,334	48.2		
New Hampshire	20					534				534		9,302	100.0	61	
New Jersey												8,224	100.0		
New Mexico	20, 100					112	355				467	42,917	35.0		
New York	5, 10, 20		286	13		212				511		49,204	100.0	85	28
North Carolina	50					79				79		19,040	36.3	58	
North Dakota												13,148	18.6		19
Ohio												41,040	100.0		
Oklahoma												41,927	59.8		

a Includes 192 square miles mapped from aerial photographs by means of stereophotogrammetry.

b Lithographic publication only.

c Culture, drainage, and woodland prepared from aerial photographs, after field examination. Contours not added.

d 0.3 square mile mapped on scale of 1:1,200.

New topographic surveys of the United States, July 1, 1932, to June 30, 1933, and total area surveyed in each State—Continued

State	Publication contour interval (feet)	Mapped in fiscal year (square miles) (engraved publication unless otherwise stated) for publication on scale of 1 to—							Total area mapped in fiscal year (square miles)			Total area mapped to June 30, 1933 (square miles)	Percentage of total area of State mapped to June 30, 1933	Spirit levels (miles)	Transit traverse (miles)	Triangulation stations occupied
		12,000 or larger	24,000	31,680	48,000	62,500	125,000	250,000	Revision	Resurvey	New survey					
Oregon	100						1,139			885	254	36,460	37.7	103		
Pennsylvania	20					389					389	38,228	84.7	313	116	6
Rhode Island												1,248	100.0			
South Carolina												13,737	44.3	13	24	
South Dakota												19,243	24.8			
Tennessee	50					143				143		23,627	56.2			
Texas	20, 50					209					209	88,493	33.3	149		15
Utah	50			• 77		218					295	19,822	23.3			
Vermont	20					179				9	170	8,139	85.1	33		
Virginia	10, 20	b / 6		28		481				515		37,897	88.9		323	128
Washington	100						402				402	37,215	53.8			
West Virginia												24,170	100.0			
Wisconsin	10					5				5		19,155	34.2			
Wyoming	100						524			225	299	31,608	32.3	21		
Total continental United States (exclusive of Alaska)																
Hawaii		6	821	7,773	905	8,762	7,192	2,654	2,908	5,720	11,563	1,380,772 6,435	45.6 100.0	4,775	3,622	413

b Lithographic publication only.

• Includes 32 square miles mapped from aerial photographs by means of stereophotogrammetry.

f Mapped on scale of 1:12,000.

FIELD SURVEYS

Arizona.—The survey of the Camp Verde 30' quadrangle for the Forest Service was completed. The survey of the Quartzite No. 3 15' quadrangle was begun for the Office of Indian Affairs.

Arkansas.—In cooperation with the United States Army district engineer at Vicksburg, Miss., the survey of the Felsenthal, Moro Bay, Ingalls, and Dilolo 15' quadrangles was begun. For the Forest Service the survey of the Mount Judea 15' quadrangle was begun.

California.—In cooperation with the State engineer of California the survey of the Healdsburg 15' quadrangle, the No. 39, No. 40, No. 41, Treadwell, Gujarral Hills, Huron, Corona 1-a, Corona 1-b, Corona 1-c, Corona 1-d, Cucamonga No. 2, Cucamonga No. 3, and Cucamonga No. 4 7½' quadrangles was completed, that of the Tobias Peak 30' quadrangle, the Lakeport 15' quadrangle, and the Cucamonga No. 1 7½' quadrangle was begun, and the revision of the Colfax, Truckee, and Bartle 30' quadrangles was completed. In cooperation with the county surveyor of Los Angeles County the survey of the Mint Canyon, Bear-trap Canyon, Fairmont, Hughes Lake, Lake, Neenach, Quail, Palmdale, Manzanita, Black Mountain, and Gorman 6' quadrangles was completed and that of the La Crescenta, Sierra Madre, La Verne, and Glendora 6' quadrangles was continued. At the request of the Forest Service the survey of the Hoaglin 30' quadrangle was completed, that of the Yreka 30' quadrangle was continued, and that of the Dixie and South Fork Peak 30' quadrangles was begun.

Colorado.—In cooperation with the Colorado Metal Mining Fund and the Colorado Geological Survey Board, the survey of Independence Pass and vicinity was completed and that of the Como No. 1 and Como No. 2 15' quadrangles was begun. For the Forest Service the survey of the Mount Powell No. 2 15' quadrangle was continued.

Idaho.—The survey of the Trout Creek 30' quadrangle was completed at the request of the Forest Service. In preparation for geologic mapping the survey of the Irwin 30' quadrangle was completed.

Illinois.—The survey of the Pecatonica, Harvard, Marshall, Lomax, Nashville, Keokuk, Jacksonville, Orion, Potomac, Virginia, Prophetstown, and Fort Madison 15' quadrangles and the Collinsville, O'Fallon, Lebanon, and New Athens No. 2 7½' quadrangles was completed, that of the Morrison, Lacon, Petersburg, Mendon, Toledo, Camp Grove, Mount Vernon, Hoopeston, Carthage, and Genoa 15' quadrangles was continued, and that of the Toluca 15' quadrangle was begun. This work was done in cooperation with the Department of Registration and Education of Illinois, Geological Survey.

Louisiana.—The Louisiana Board of State Engineers cooperating, the ground control, field examination, and preparation from aerial photographs of culture, drainage, and woodland was completed for topographic base maps without contours for the 7½' quadrangles within the New Orleans, Cut-Off, Houma, Hahnville, Thibodaux, Lac des Allemands, Gibson, Schooner Bayou, Bossier, Shreveport, Plain Dealing, Hosston, Boyce, Abbeville, and Colfax 15' quadrangles and begun for the 7½' quadrangles within the Pecan Island, Redfish Point, Hayes, Bayou Bois Courier, Port Arthur, Sabine Pass, Johnsons Bayou, Hackberry, Lake Arthur, Lake Charles, Orange, Vincent, Marsh Island, Lake Miserie, BBB, CCC, and FFF 15' quadrangles. In cooperation with the United States Army district engineer at Vicksburg, Miss., the survey of the Felsenthal 15' quadrangle was begun.

Maine.—In cooperation with the Public Utilities Commission of Maine, the survey of the Nicasious Lake, Allagash Falls, Umsaskis Lake, Musquacook Lakes, Dover-Foxcroft, Kennebago Lake, Presque Isle, and Guilford 15' quadrangles

was completed and that of the Rangeley 15' quadrangle was begun. In cooperation with the War Department the survey of the Frenchville, Arnold Pond, and Fort Kent 15' quadrangles was completed and that of the Grand Isle and Mars Hill 15' quadrangles was begun.

Massachusetts.—In cooperation with the Massachusetts Department of Public Works, Division of Waterways, the survey of the Sagamore 7½' quadrangle was begun.

Michigan.—In cooperation with the Department of Conservation of Michigan, Geological Survey, the ground control, field examination, and preparation from aerial photographs of culture, drainage, and woodland was executed in 7½' quadrangles for topographic base maps without contours for Mackinac County, within the St. Ignace and Bois Blanc 15' quadrangles and the county parts of the Ozark, Rudyard, Pickford, Beavertail Point, and Raber 15' quadrangles; for Lake County, completing the county parts of the Baldwin, Chase, Peacock, Freesoil, and Luther 15' quadrangles; for Mason County, completing the county parts of the Manistree and Freesoil 15' quadrangles; for Delta County, completing the Burnt Bluff, Peninsula Point, Escanaba, Gladstone, Rapid River, and Garden 15' quadrangles and the county parts of the Bark River, Whitney, Rock, Trenary, and Skeels Lake 15' quadrangles; for Marquette County, completing the Helena and Harvey 15' quadrangles and the county parts of the Rock, Skandia, and Whitney 15' quadrangles and beginning the Ishpeming, Michigamme, Eagle Mills, Witbeck, Marquette, and Humboldt 15' quadrangles; and for Wexford County beginning the Mesick 15' quadrangle and the county parts of the Cope-mish, Manton, Tustin, Kingsley, Thompsonville, Fife Lake, Luther, and Peacock 15' quadrangles.

Minnesota.—At the request of the Forest Service the survey of the Ely 15' quadrangle was continued. In cooperation with the Department of Justice the site of a proposed Federal detention farm near Sandstone was surveyed.

Missouri.—The survey of the Piedmont and Iberia 15' quadrangles and the Granite City and Cahokia 7½' quadrangles was completed, that of the Manchester, Sleeper, Long Lane, Upalika, Buffalo, Grove Spring, Thornfield, Niangua, Steelville, Topaz, Gatewood, Edgar Springs, and Big Piney 15' quadrangles was continued, and that of the Springfield No. 1, Springfield No. 4, Tuscumbia No. 1, Tuscumbia No. 4, Versailles No. 4, Sullivan No. 3, Sullivan No. 4, Morrison, Linn, Stone Hill, Berryman, Mokane, Canaan, Richland, Grandin, and Marble Hill 15' quadrangles and the West St. Louis No. 1, West St. Louis No. 2, West St. Louis No. 3, and West St. Louis No. 4 7½' quadrangles was begun, in cooperation with the State geologist of Missouri.

Montana.—The survey of the Trout Creek 30' quadrangle was completed and that of the Thompson 30' quadrangle was begun at the request of the Forest Service. The Bureau of Mines and Geology of Montana cooperating, the compilation from aerial photographs of the culture and drainage was completed for the Nye No. 1, Nye No. 2, Red Lodge No. 1, and Red Lodge No. 2 15' quadrangles.

Nevada.—The survey of the Sonoma Range 1° quadrangle was completed and that of the Morey Peak 1° quadrangle was begun in cooperation with the Bureau of Mines of Nevada.

New Hampshire.—In cooperation with the Highway Department of New Hampshire the survey of the Keene, Monadnock, Newburyport, Winchendon, Warwick, Brattleboro, Berwick, and Newfield 15' quadrangles was completed.

New Mexico.—For the Forest Service the survey of the Talpa 30' quadrangle was continued. At the request of the Office of Indian Affairs the survey of the Shiprock No. 2 15' was continued.

New York.—The survey of the Tarrytown No. 4 7½' quadrangle was completed and that of the Catskill and Rhinebeck 15' quadrangles was begun in cooperation with the Department of Public Works of New York. In cooperation with Monroe County and the Department of Public Works of New York the survey of the Spencerport, Brockport, Churchville, Clifton, Webster, Fairport, Hilton, Hamlin, Honeoye Falls, Caledonia No. 1, Caledonia No. 2, and Canandaigua No. 2 7½' quadrangles within Montoe County was completed.

North Carolina.—The survey of the Sassafras Mountain 15' quadrangle was completed and that of the Ranger 15' quadrangle was begun at the request of the Forest Service.

Oregon.—The survey of the Medford 30' quadrangle was completed in cooperation with the State engineer of Oregon. In preparation for geologic mapping the survey of the Dayville 30' quadrangle was completed.

Pennsylvania.—In cooperation with the Department of Internal Affairs of Pennsylvania, Topographic and Geologic Survey, the survey of the Susquehanna and Genesee 15' quadrangles was completed and that of the Smethport and Coudersport 15' quadrangles was begun.

Tennessee.—The survey of the Sassafras Mountain and Ranger 15' quadrangles was completed at the request of the Forest Service.

Texas.—In preparation for geologic mapping the survey of the Guadalupe Peak No. 2 15' quadrangle was begun.

Utah.—The survey of the Bryce Canyon National Park and an extension of Zion National Park was completed for the National Park Service. In preparation for geologic mapping the survey of the Sevier 15' quadrangle was completed.

Vermont.—In cooperation with the State geologist of Vermont the survey of the Littleton, Keene, and Warwick 15' quadrangles was completed and that of the Guildhall 15' quadrangle was begun.

Virginia.—The survey of the Lexington, Blacksburg, Peterstown, and Pearisburg 15' quadrangles and the Yellow Tavern 7½' quadrangle was completed and that of the Radford, Pulaski, Waiteville 15' quadrangles and the Gaines Mill, Cold Harbor, and Mechanicsville Battlefields was begun in cooperation with the Conservation and Development Commission of Virginia, Geological Survey.

Washington.—For the Forest Service the survey of the Eatonville 30' quadrangle was continued. In preparation for geologic mapping the survey of the Metaline 30' quadrangle was continued.

Wisconsin.—The survey of the Harvard 15' quadrangle was completed.

Wyoming.—The survey of the Savery Creek 30' quadrangle was continued at the request of the Forest Service.

WATER-RESOURCES BRANCH

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

States.—The following amounts were expended by States and municipalities from cooperative allotments for surface- and ground-water investigations. In addition, it is estimated that data valued at over \$141,000 were furnished by cooperating officials.

Cooperative funds expended by States and municipalities for work on water resources

State	State expenditures		Municipal expenditures		Total
	Surface water	Ground water	Surface water	Ground water	
Arizona.....	\$20,977.08				\$20,977.08
Arkansas.....	1,091.62	\$400.79			1,492.41
California.....	34,990.02		\$6,050.73	\$13,753.00	54,793.75
Connecticut.....	7,890.60				7,890.60
Florida.....	2,980.74	3,522.53	2,638.96		9,142.23
Idaho.....	22,947.83				22,947.83
Illinois.....	8,915.53				8,915.53
Indiana.....	3,999.11		428.31		4,427.42
Iowa.....	3,191.44				3,191.44
Kansas.....	7,240.83				7,240.83
Louisiana.....	887.63				887.63
Maine.....	6,348.47				6,348.47
Maryland.....	6,716.34		1,550.76		8,267.10
Massachusetts.....	4,345.10				4,345.10
Michigan.....	2,006.61	2,705.72			4,712.33
Minnesota.....	1,378.20				1,378.20
Mississippi.....	1,000.00				1,000.00
Missouri.....	7,462.29		173.40		7,635.69
Montana.....	9,430.24				9,430.24
Nebraska.....	14,470.38	3,321.70	248.45		18,040.53
Nevada.....	1,344.16				1,344.16
New Hampshire.....	3,277.50				3,277.50
New Jersey.....	11,471.49	6,564.36			18,035.85
New Mexico.....	12,919.50	2,057.67			14,977.17
New York.....	9,019.28	2,502.14	10,501.91	3,000.00	25,023.33
North Carolina.....	9,857.80	1,437.34			11,295.14
North Dakota.....	3,739.38				3,739.38
Ohio.....	15,250.86		2,009.08		17,259.94
Oregon.....	32,302.10	2,468.01	670.55		35,440.66
Pennsylvania.....	19,464.85	323.39			19,788.24
South Carolina.....	3,993.96		317.77		4,311.73
Tennessee.....	14,961.86	294.39			15,256.25
Texas.....	27,543.99	23,190.39			50,734.38
Utah.....	6,017.90		180.18	7,797.24	13,995.32
Vermont.....	5,625.65				5,625.65
Virginia.....	18,907.75	1,613.57			20,521.32
Washington.....	8,491.28		5,268.25		13,759.53
West Virginia.....	3,500.99				3,500.99
Wisconsin.....	6,758.95				6,758.95
Wyoming.....	11,472.52				11,472.52
Hawaii.....	19,973.06	5,833.05			25,806.11
	414,164.89	56,235.05	30,038.35	24,550.24	524,988.53

The study of surface waters, which consists of the measurement of the flow of rivers, has been conducted in 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 the maintenance of the regular gaging stations 40 States, the Territory of Hawaii, and several Government organizations and individuals cooperated. At the end of the year 2,801 gaging stations were being maintained. Records for about 129 additional stations were received, ready for publication, from Government bureaus and private persons.

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 area where problems of water supply are urgent, and the results are generally published in water-supply papers that include maps showing the ground-water conditions. The investigations relating to the chemical composition of the water are made in cooperation with the division of quality of water. Projects involving large expenditures for drilling wells to develop water supplies are considered each year by the several departments of the United States Government, and the ground-water division is called upon to furnish information and advice on many of these projects. During the fiscal year about 50 investigations relating to ground water and reservoir sites were in progress, and work was done in 19 States and the Territory of Hawaii, nearly all of it in cooperation with State or local governmental agencies. In the hydrologic laboratory 496 samples of water-bearing material were analyzed.

The work on the quality of water included the analysis of the mineral content of 1,034 samples of 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 matter. The analyses included some for nearly all the studies of ground water in the different States.

The work of the division of power resources comprised the preparation of monthly reports on the production of electricity for public use and the consumption of fuel in generating the electricity reported, an annual report containing revised figures of the monthly production of electricity and consumption of fuel in 1932 previously published in the monthly reports, a report on the developed water power of the United States, and compilations of stocks of coal held by public-utility power plants for inclusion in reports of commercial stocks of coal undertaken quarterly by the Bureau of Mines. The annual report on the capacity of water wheels in water-power plants in the United States was released January 20, 1933, and the final report on the monthly and annual production of electricity for public use in 1932 was released April 27, 1933.

The division of water utilization investigates problems affecting the utilization of the waters of streams and performs administrative work relating to supervision and investigation by the field organization of the water-resources branch and of 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.

The operation of about 300 gaging stations was conducted by the branch or was performed by permittees and licensees under the

supervision of the branch in connection with 120 projects of the Federal Power Commission. Engineers of the branch have had general supervision of operations under permits and licenses of the Federal Power Commission in connection with 105 projects.

WORK OF THE YEAR BY STATES

Alabama.—The report on Ground Water in the Paleozoic Rocks of Northern Alabama, prepared in previous years by the survey, was published by the Geological Survey of Alabama as Special Report 16.

Arkansas.—The investigation in the Grand Prairie region was continued in cooperation with the Arkansas Geological Survey and the Arkansas Agricultural Experiment Station. Records were obtained of water levels in numerous observation wells, and these records were released to the public in manuscript form.

California.—Water levels were measured in selected wells in southern California. The record now covers a period of 29 years. The investigation of the ground water in the alluvial fan of the Mokelumne River was continued with the financial support of the East Bay Municipal Utility District. A detailed report on the geology of the area and other results obtained in the investigation were released in manuscript form.

Florida.—Investigation of ground-water resources was continued in cooperation with the Florida Geological Survey. Explorations of artesian wells were made in Sarasota County and other areas by use of the deep-well current meter, salinity apparatus, and samplers. An investigation was made of the ground-water conditions in the Lake Okeechobee area.

Hawaii.—The survey of the ground-water resources of the Hawaiian Islands was continued. A comprehensive report on the Island of Oahu was nearly completed, and a concise statement of results was released in manuscript form. Ground-water work was begun on the Island of Maui.

Idaho.—Progress was made on the final reports on ground water in the Mud Lake region and in the Snake River plain.

Kansas.—An investigation and report on a ground-water supply for the Federal prison at Leavenworth was made.

Maryland.—A brief investigation and report was made to the Bureau of Standards in regard to a ground-water supply for that Bureau at Beltsville.

Michigan.—An investigation was conducted in cooperation with the Michigan Department of Conservation in regard to ground-water conditions in Roscommon County, with special reference to protection from forest fires.

Montana.—Progress was made on a report on ground water in Fergus County. Observations were continued on water levels in observation wells at the north end of Flathead Lake.

Nebraska.—The investigation of the ground-water resources of the Platte River Valley was continued in cooperation with the Nebraska Conservation and Survey Division.

New Jersey.—Investigation of ground-water resources was continued through cooperation with the New Jersey Water Policy Commission. A report on Ground-water Supplies in the Camden Region, New Jersey was published as bulletin 39.

New Mexico.—Cooperation was continued with the State engineer in studies of ground-water resources. A comprehensive report on the Roswell artesian basin is in press as Water-Supply Paper 639.

New York.—The investigation of the ground-water resources of Long Island was continued in financial cooperation with the joint legislative committee on water resources and with Nassau and Suffolk Counties.

North Carolina.—Observations were continued on fluctuations of water levels in wells with special reference to their effects upon stream flow, and an investigation of the ground-water resources of Elizabeth City region was made in cooperation with the North Carolina Division of Water Resources and Engineering.

Oregon.—Investigations of ground-water resources were continued in cooperation with the Oregon Agricultural Experiment Station. Progress was made on the final report on the Harney Basin, and work was begun in the Milton-Freewater area.

Pennsylvania.—Cooperation was continued on ground-water investigations with the Pennsylvania Topographic and Geologic Survey. Weekly records were obtained of water levels on about 35 observation wells and were released in manuscript form.

Tennessee.—The project of obtaining records of ground-water levels and pumpage in Memphis was continued in cooperation with the Tennessee Division of Geology.

Texas.—Investigations of ground-water resources were continued in cooperation with the Texas Board of Water Engineers. The Texas Department of Health and the Engineering Experiment Station of the Agricultural and Mechanical College also continued to cooperate. Work was continued in the Houston-Galveston, Winter Garden, San Antonio, and west Texas regions, and an investigation of ground-water problems was undertaken in Jim Wells, Kleburg Brooks, Kennedy, and Hidalgo Counties.

Utah.—The investigation of the ground-water resources of the Jordan Valley with special reference to an increased water supply for Salt Lake City was continued in cooperation with Salt Lake City. An investigation of the Ogden artesian basin was begun in cooperation with the city of Ogden.

Virginia.—The investigation of ground-water resources was continued in cooperation with the Virginia Geological Survey. An investigation of the ground-water resources of the Shenandoah Valley was begun. Water-stage recorders were in operation on four observation wells in Arlington and Fairfax Counties and on the ebbing and flowing spring near Marion.

CONSERVATION BRANCH

SUMMARY OF CASES

The activities in the Washington office with respect to land classification include the preparation of reports in response to requests for data or action on specific cases, the preparation of orders of withdrawal and restoration of lands not involved in specific requests, and the promulgation of broad areal classifications.

The following table summarizes activity with respect to requests for data or action on specific cases. The terms "gain" and "loss" signify, respectively, decrease and increase in the number of cases pending. The number of cases received was less by 2,492 (18.6 percent) and the number acted on was less by 545 (2.7 percent) than during the preceding year. The number of cases pending at the end of the year was decreased by about 52 percent.

Summary of cases involving land classification

Class of cases	Record for fiscal year 1933						Record since receipt of first case	
	Pending July 1, 1932	Received during fiscal year	Total	Acted on during fiscal year	Pending June 30, 1933	Gain or loss during fiscal year	Received	Acted on
General Land Office requests:								
General.....	327	1,203	1,530	1,223	307	+20	2,313	2,313
Time extensions.....	24	130	154	144	10	+14	17,216	17,206
Oil development.....	24	766	778	759	19	-7	39	39
Concurrence.....	39		39	39		+39	9,418	9,415
Section 27 cases.....	147	113	260	257	3	+144		
Committee cases—Oil and potash.....								
Applications for classification as to mineral:								
Oil.....	460	2,619	3,079	3,005	74	+386	23,812	23,738
Miscellaneous.....	4	37	41	34	7	-3	907	900
Applications for mineral permits.....	776	3,240	4,016	3,938	78	+698	57,747	57,669
Applications for mineral leases.....	2	133	135	130	5	-3	1,877	1,872
Applications for patent, potassium.....							124	124
Federal Power Commission cases:								
Preliminary permits.....	6	54	60	43	17	-11	283	266
Licenses.....							28	28
Determinations under section 24.....	8	73	81	59	22	-14	425	403
Applications for classification as to power resources.....	21	22	43	33	10	+11	513	503
Applications for agricultural classification.....	74	145	219	182	37	+37	1,352	1,315
Application for rights-of-way.....	15	127	142	104	38	-23	6,876	6,838
Irrigation project reports.....		11	11	9	2	-2	935	933
Applications under enlarged homestead acts.....	76	118	194	178	16	+60	57,789	57,773
Applications under stock-raising homestead acts.....	1,137	2,144	3,281	2,422	859	+278	139,452	138,593
Applications under ground-water reclamation act.....	1	10	11	9	2	-1	981	979
Indian Office requests for information.....							9,547	9,547
Total.....	3,129	10,945	14,074	12,568	1,506	+1,623		

SUMMARY OF FIELD OPERATIONS BY STATES

Alaska.—Supervised 1 power project. Expended \$7,000 through the Alaskan branch for supervision of 4 leases, 2 licenses, and 18 prospecting permits for coal, and 91 prospecting permits for oil and gas.

Alabama.—Examined 8 tracts in Conecuh, Madison, Morgan, Winston, Tuscaloosa, Marion, and Colbert Counties for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State. Supervised 1 coal lease.

Arizona.—Supervised 11 power projects and prepared for publication maps of 196 miles of river. Examined 34 tracts for agricultural classification and began a cooperative land-classification study for the State. Supervised on public land 1 lease and 3 prospecting permits for sodium, 6 prospecting permits for potash, and 68 prospecting permits for oil and gas.

Arkansas.—Examined 1 tract each in Crawford and Johnson Counties for mineral classification. Supervised 1 prospecting permit for coal and 15 for oil and gas. No production reported.

California.—In cooperation with the geologic branch continued geologic investigation of the north, middle, and south domes of the Kettleman Hills anticline in Kings and Kern Counties. Supervised 31 power projects and prepared for publication maps of 58 miles of river. Examined 19 tracts for agricultural classification and entered into a cooperative agreement with the city of Los Angeles to continue detailed studies of grazing conditions in Mono Lake

and Owens Valley as an aid in administration of lands withdrawn by the act of March 4, 1931 (46 Stat. 1530). Supervised on public land 3 prospecting permits for coal, 9 prospecting permits for sodium, 4 leases and 5 prospecting permits for potash, 222 leases, 5 suspended rights to leases, and 568 prospecting permits for oil and gas. Prospecting for sodium borate deposits was continued during the year. Drilling was done on 4 holes to a total depth of 2,703 feet. Supervised on naval petroleum reserves 24 leases for oil, and gas.

Colorado.—Made stratigraphic, structural, and economic survey of the North and South McCallum anticlines in Jackson County and prepared structure-contour map of the area examined. In cooperation with the geologic branch completed a stratigraphic and structural reconnaissance of the southern part of the Denver Basin. Supervised 11 power projects. Examined 56 tracts for agricultural classification. Supervised on public land 84 leases, 8 licenses, 49 prospecting permits, and 14 awarded lease applications for coal; 1 prospecting permit for potash; and 25 leases, 3 suspended preference rights to leases, and 428 prospecting permits for oil and gas.

Florida.—Examined 1 tract in Walton County for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State.

Idaho.—In cooperation with the geologic branch continued a detailed geologic survey of the Afton quadrangle, Caribou County. Supervised 6 power projects. Examined 69 tracts for agricultural classification. Supervised 11 coal prospecting permits, 2 phosphate leases, and 71 prospecting permits for oil and gas.

Kansas.—Investigated the status of oil and gas prospecting operations affecting certain Federal lands in Scott and Wallace Counties. Supervised 1 prospecting permit for oil and gas.

Louisiana.—Examined 1 tract each in Beauregard and Calcasieu Parishes for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State, with particular reference to operations affecting Federal lands in Caldwell, Caddo, and Grant Parishes. Supervised 10 leases and 1 prospecting permit for oil and gas.

Mississippi.—Examined 1 tract each in Harrison, Holmes, and Lamar Counties for mineral classification. Investigated in the field the status of oil and gas prospecting operations throughout the State, particularly operations affecting certain Federal lands in Amite, George, Jackson, and Wilkinson Counties.

Montana.—Examined parts of 7 townships in Flathead County for coal classification. Completed detailed areal, structural, and economic surveys of the Cedar Creek anticline in Fallon and Carter Counties and of the Sweetgrass Hills in Toole and Liberty Counties. In cooperation with the geologic branch made areal, structural, and economic surveys of 72 townships in Liberty, Hill, and Chouteau Counties for oil and gas classification and of 13 townships in Custer County for coal classification. Supervised 29 power projects and prepared for publication maps of 120 miles of river. Examined 64 tracts for agricultural classification. Supervised on public land 86 leases, 65 licenses, 40 prospecting permits, and 11 awarded lease applications for coal; 1 prospecting permit for potash; 6 phosphate leases and 3 awarded phosphate leases; and 77 leases, 1 suspended preference right to lease, and 551 prospecting permits for oil and gas. The first shipment of phosphate from Government lease land in Montana was made during the year. Supervised on Indian land on 2 reservations 126 leases for oil and gas.

Nebraska.—Supervised 1 prospecting permit for potash and 1 prospecting permit for oil and gas.

Nevada.—Supervised 6 power projects. Examined 26 tracts for agricultural classification and completed regional investigations of agricultural utility prec-

edent to grazing classification in the northeastern part of the State. Supervised 5 prospecting permits for coal, 2 leases, and 6 prospecting permits for sodium, 1 lease for phosphate, 10 prospecting permits for potash, and 51 prospecting permits for oil and gas.

New Mexico.—Examined parts of 8 townships in Taos County and of 2 townships in McKinley County for coal classification. In cooperation with the geologic branch resumed surveys for coal classification in the eastern part of the San Juan Basin in Rio Arriba and Sandoval Counties. Supervised 3 power projects. Examined 37 tracts for agricultural classification. Supervised on public land 21 leases, 36 prospecting permits, and 1 awarded lease application for coal; 10 prospecting permits for sodium; 9 leases and 160 prospecting permits for potash; 68 leases, 24 suspended preference rights to leases, and 1,054 prospecting permits for oil and gas. Supervised on Indian land 1 coal lease, 13 Indian agency coal mines, and 13 leases for oil and gas. Prospecting for potash in New Mexico resulted in drilling of 20 holes to a total depth of 15,706 feet. Two shafts were started for potash, and one was completed. The total depth of shafts sunk during the year was 1,250 feet. A refinery was completed in September 1932 for treating potash salts, and the first shipment of muriate was made September 22.

North Dakota.—Completed a detailed areal, structural, and economic survey of the Cedar Creek anticline in Billings and Bowman Counties. Supervised 69 leases, 20 licenses, 1 prospecting permit, and 4 awarded lease applications for coal, 1 prospecting permit for sodium, and 19 prospecting permits for oil and gas.

Oklahoma.—Investigated oil and gas prospecting operations affecting certain Federal lands in Cimarron, Dewey, Ellis, Harper, Kingfisher, Major, and McClain Counties. Supervised 1 power project. Supervised on public land 17 leases and 13 prospecting permits for oil and gas. Supervised on Indian lands on 21 reservations 65 coal leases, 7 coal prospecting permits, 41 lead and zinc leases, and 5,003 leases for oil and gas. Made 6,588 investigations of oil and gas leases on Indian lands for regulatory, inspectional, and appraisal purposes.

Oregon.—Examined and reported on the geologic features of two dam sites on the Walla Walla River in Umatilla County. Prepared manuscript report on water-power resources of the Walla Walla River and prepared for publication maps of 80 miles of river, investigated power and storage possibilities of the White and Hood Rivers and surveyed 75 miles of river. Made reconnaissance investigation of power possibilities of the Chetco River. Investigated depth to bedrock at three dam sites by geophysical methods. Supervised 4 power projects. Examined 37 tracts for agricultural classification. Supervised 2 leases and 10 prospecting permits for coal, 1 lease for oil shale, 2 prospecting permits for potash, and 24 prospecting permits for oil and gas.

South Dakota.—Completed a detailed areal, structural, and economic survey of the Cedar Creek anticline in Harding County. Examined 1 tract in Perkins County for oil and gas classification. Supervised 4 leases, 2 prospecting permits for coal, and 25 prospecting permits for oil and gas.

Utah.—Made detailed areal and structural survey of the Harley dome, Grand County, and of the part of Petroleum Reserve No. 7 in Washington County, and prepared and published a structure-contour map of the Harley dome. In cooperation with the geologic branch continued areal and structural surveys in Emery and Wayne Counties. Supervised 8 power projects. Examined 68 tracts for agricultural classification. Supervised on public land 41 leases, 2 licenses, and 75 prospecting permits for coal; 43 prospecting permits for potash; 11 leases, 2 suspended preference rights to leases, and 513 prospecting permits for oil and gas. Supervised on Indian land on 1 reservation 3 agency coal mines, and under Navajo Executive order 1 lease for oil and gas.

Washington.—Investigated status of oil and gas drilling operations. Supervised 10 power projects and surveyed 175 miles of river. Investigated storage

and power possibilities on the Queets, Clearwater, Duckabush, Dosewallips, Hamma Hamma, and North Fork of Nooksack Rivers, Wells Creek, and Glacier Creek. Investigated depth to bedrock at two dam sites by geophysical methods. Examined 4 tracts for agricultural classification. Supervised 22 prospecting permits for coal, 1 prospecting permit for sodium, and 5 prospecting permits for oil and gas.

Wyoming.—Examined 1 tract each in Sublette and Teton Counties for phosphate classification and 1 coal area in Johnson County for leasing-law administration. In cooperation with the geologic branch continued a detailed geologic survey of the Afton quadrangle, Lincoln County. Supervised 4 power projects. Examined 163 tracts for agricultural classification. Supervised on public land for coal 41 leases, 22 licenses, 51 prospecting permits, 9 awarded lease applications, 402 leases, 16 suspended preference rights to leases, and 945 prospecting permits for oil and gas. Made 231 analyses of water, 45 of oil, 14 of gas, and 25,750 determinations of oil gravity. Made periodic inspections and pressure test of wells shut in on Naval Petroleum Reserve No. 3 and supervised operations for mudging and plugging certain wells that were in an unsatisfactory condition. Supervised on Indian land on 1 reservation, 41 leases for oil and gas.

MINERAL CLASSIFICATION DIVISION

The work of the mineral classification division includes field determination of the economic geology of lands belonging to the United States and office conversion of the technical data obtained into forms adapted to the needs of public land law administration.

Field investigations made for purposes of mineral classification during the fiscal year 1933 by division personnel or on a cooperative basis by personnel of the geologic branch are included in the preceding summary of field operations by States. Office activities show a decrease of 1,318, or 15 percent, in the number of requests for mineral determination received and an increase of 745, or 9 percent, in the number of such reports rendered. Progress during the year in classifying the vast areas of public land still withdrawn for mineral classification is shown in the following table:

Summary of outstanding mineral withdrawals and classifications, June 30, 1933, in acres

State	Coal		Oil	
	Withdrawn	Classified as coal land	Withdrawn	Classified as oil land
Alaska.....		56,993		
Arizona.....	139,415			
Arkansas.....		61,160		
California.....	17,603	8,720	1,178,392	
Colorado.....	4,142,233	3,082,272	215,370	
Idaho.....	11,520	4,603		
Louisiana.....			466,990	4,233
Montana.....	6,442,830	¹ 9,254,927	1,336,697	67,651
Nevada.....	83,673			
New Mexico.....	5,061,011	579,638		
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	1,341,264	
Washington.....	691,801	141,444		
Wyoming.....	2,260,604	² 6,740,594	541,777	
Total.....	28,213,458	32,645,314	5,165,384	71,884

¹ Includes 3,151 acres of coal land reserved for use of the United States (coal reserve no. 1).

² Includes 2,078 acres of coal land reserved for use of the United States (coal reserve no. 2).

Summary of outstanding mineral withdrawals and classifications, June 30, 1933,
in acres—Continued

State	Oil shale		Phosphate		Potash
	Withdrawn	Classified as oil-shale land	Withdrawn	Classified as phosphate land	Withdrawn
California.....					90,324
Colorado.....	1,172,778	952,239			
Florida.....			66,796	120	
Idaho.....			276,239	270,036	
Montana.....			279,944	3,833	
Nevada.....	123				39,422
New Mexico.....					9,282,160
Utah.....	2,737,274	2,703,755	277,344	2,937	
Wyoming.....	2,328,370	406,003	989,149	25,293	
Total.....	6,238,545	4,061,997	1,889,472	302,219	9,411,906

Action required during the year on original filings under the mineral-leasing laws is indicated in the following table and shows an increase of 3,294, or 425 percent, in the number of reports rendered on such filings.

Applications under the mineral-leasing laws, fiscal year 1933

[Includes cases pending July 1, 1932]

Mineral	Prospecting permits		Leases	
	Received	Acted on	Received	Acted on
Oil and gas.....	3,650	3,578		
Coal.....	236	231	123	119
Phosphate.....			6	6
Sodium.....	17	17	2	2
Potassium.....	86	85	4	3
Sulphur.....	27	27		
	4,016	3,938	135	130

Pursuant to paragraphs 2 and 25 (k) of the Oil and Gas Regulations (47 L.D. 437), definitions of the "known geologic structure" of 22 producing oil and gas fields were prepared and promulgated during the year, as follows:

Definitions of "known geologic structure", fiscal year 1933

State	Field	Date promulgated	Acres
California.....	(Buena Vista Hills (revision).....	Feb. 14, 1933	29,123
	Kern River (revision).....	Feb. 28, 1933	11,772
	Kern Front.....	do.....	4,640
	West Kern Front.....	do.....	1,400
	Mount Poso.....	do.....	2,800
	Round Mountain.....	do.....	3,951
	Dominion.....	do.....	680
	Dorsey.....	do.....	360
	Thornberg.....	July 1, 1932	1,738
Colorado.....	Hiawatha.....	July 6, 1932	3,691
	West Hiawatha.....	do.....	1,757
	Piceance Creek.....	do.....	11,431
Montana.....	Cut Bank.....	Mar. 15, 1933	76,351
New Mexico.....	Bloomfield.....	Dec. 2, 1932	4,520
	Kutz Canyon.....	do.....	3,956
Utah.....	Harley.....	May 29, 1933	1,323
	Hiawatha.....	July 6, 1932	926
	Garland (revision).....	Nov. 2, 1932	6,780
	Byron (revision).....	do.....	3,841
Wyoming.....	Badger Basin.....	Nov. 3, 1932	4,400
	West Mule Creek.....	Nov. 26, 1932	1,404
	Bison Basin.....	Dec. 2, 1932	440
	Salt Creek (revision).....	Jan. 12, 1933	26,919

The aggregate area of outstanding definitions of the "known geologic structure" of producing oil and gas fields on June 30, 1933, was 944,951 acres in California, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming.

POWER DIVISION

The work of power classification consists primarily in obtaining and making available for use in the administration of the public-land laws information as to the water-power resources of the public lands. The extent of this task is indicated by the fact that areas aggregating nearly 7,000,000 acres are now included in power reserves whose use will be required for the development of about 15,000,000 continuous horsepower. The field projects undertaken during the year are included in the preceding summary of field operations by States.

River surveys to the aggregate length of 250 miles were made of the White and Hood Rivers, Oreg., and the North and Middle Forks of Nooksack River, Wells Creek, and Glacier Creek, tributary to North Fork of Nooksack River, Queets River, and Clearwater River, Wash. Geologic examinations were made at two dam sites in Oregon. The depth to bedrock was investigated at 2 dam sites in Washington and 3 in Oregon. Five dam sites and three reservoir sites were surveyed in Washington.

Administration of the field supervision of power projects for the Federal Power Commission is carried on in this office. Investigations and reports have been made on 10 projects, construction and operation are supervised on 129 projects, and cost accounting is being supervised on 8 projects.

Pursuant to instructions of the Secretary of the Interior, dated August 24, 1916 (45 L.D. 326), reports were obtained on field inspections of 24 power projects under permit from the Interior Department and permittees under the act of February 15, 1901 (31 Stat. 790), and grantees under the act of March 4, 1911 (36 Stat. 1253), were called upon for detailed reports of the operation or development of their power systems during the calendar year 1932. The total installation of the reporting companies is 3,540,000 horsepower, of which 2,407,000 horsepower is at hydraulic plants and 1,133,000 horsepower at fuel plants. The total energy generated was 7,150,000,000 kilowatt-hours, which was 546,000,000 kilowatt-hours less than in 1931 and was the smallest output since 1925. The energy generated by water power increased 1,214,000,000 kilowatt-hours, or nearly 23 percent; and that generated by fuel decreased 1,760,000,000 kilowatt-hours, or nearly 74 percent. The changes from year to year in the percentages of the total power generated by water and by fuels are due principally to changes in run-off in wet or dry years.

AGRICULTURAL DIVISION

The principal functions of the agricultural division consist of the classification of lands as to irrigability, timber character, grazing value, and capacity for crop production under the enlarged and stock-raising homestead laws and the Nevada ground-water reclamation law; the preparation of reports on irrigation projects that require some form of Federal approval in connection with the administration of public-land laws; the initiation of withdrawals of land for reservoir sites and for public watering places; and the preparation of reports showing the agricultural utility of lands in important public-land regions, including a classification of the grazing lands as to forage types and yields and suggestions as to the proper use thereof to maintain a natural ground cover, prevent waste of the forage growth by overgrazing, and incidentally eliminate avoidable erosion losses, especially in grazing districts on the public domain.

Classifications are based on the results of field examinations by members of the division and on information obtained from other sources. The work is planned with the primary purpose of acting on pending applications for classification under the above-mentioned laws and of providing in advance the basis for appropriate action on new applications. There was a decrease of nearly 34 percent in the number received, and the arrearage was nearly 41 percent less at the end of the year than at the end of the fiscal year 1932. Substantially all of the decrease was in applications under the enlarged and stock-raising homestead laws.

Public Water Reserve No. 107, of April 17, 1926, embraces all vacant, unreserved public land that contains a spring or water hole needed or used for public purposes. This order requires a determination with respect to all entries of public land whether any of the subdivisions involved are affected by it. On the basis of such determination, orders of interpretation are issued from time to time, listing by legal subdivisions of the public-land survey any tracts found to contain a water supply affected by the order. New public-water reserves covering lands along streams and for special public purposes are also made from time to time.

In the field, broad areal studies were completed in northeastern Nevada. Intensive grazing studies were continued in Mono Lake and Owens Valleys, Calif., in connection with the administration of lands withdrawn under the act of March 4, 1931 (46 Stat. 1530). A land-classification report and map was completed for western Colorado, showing irrigated and dry-farming land, together with different range types and a summary of the aggregate forage resources as compared with the livestock population.

During the fiscal year the area designated under the Nevada ground-water reclamation act was increased 14,160 acres, to a total of 1,720,695 acres. Outstanding withdrawals under the act of October 2, 1888 (25 Stat. 527), on the basis of a selection by the Director of the Geological Survey, aggregating 61,397 acres, remained unchanged. Other results of the division's work are tabulated in the summaries of enlarged and stock-raising homestead designations and the general summary of cases.

MINING, AND OIL AND GAS LEASING DIVISIONS

The work of the mining and oil- and gas-leasing divisions is supervisory (both inspectional and regulatory) with respect to operations on the public domain for the discovery and development of petroleum, natural gas, oil shale, coal, phosphate, sodium, potassium, and sulphur; on certain land grants for gold, silver, and mercury; on naval petroleum reserves for petroleum and natural gas; and for all minerals on tribal and restricted allotted Indian lands subject to lease.

During the fiscal year there were 251 leases, licenses, and prospecting permits issued covering 241,843.14 acres. The number was less by 28 and the area less by 83,387.14 acres than in the preceding year. Cancellations, relinquishments, and expirations numbered 183 for 1933, compared with 180 for 1932.

Leases, licenses, and permits issued, fiscal year 1933

	Num- ber	Acres		Num- ber	Acres
Licenses: Coal.....	32	1,360.25	Permits:		
Leases:			Coal.....	84	48,175.03
Coal.....	35	3,316.13	Potash.....	78	161,724.78
Potash.....	3	8,478.71	Sodium.....	14	15,665.34
Phosphate.....	4	2,482.90		176	225,565.15
Sodium.....	1	640.00	Grand total.....	251	241,843.14
	43	14,917.74			

There were 951 mining leases, licenses, and permits involving 838,025.49 acres of public land that were under supervision at the end of the year, an increase over the previous year of 68 leases, licenses, and permits and of 72,962.95 acres.

Prospect wells numbering 29 and drilled to a total depth of 21,472 feet, were supervised during the year, as compared to 39 wells, with a total depth of 29,931 feet, during the preceding year. The number of operating mines was greater by 69 than in 1932. Production of coal was less by 28,945 tons than in 1932. The number of coal mines increased from 432 to 498, or 15.3 percent. The value of the coal produced was \$6,156,200, a decrease of \$366,104. The condition of the wagon mines has shown continued improvement. More

orderly mining plans have increased the life of mines and reduced the cost of mining.

The value of phosphate mined on public lands was \$5,203.66, a decrease of \$100,602.34 over 1932. Production decreased 31,455.99 tons. In Montana, a 1,300-foot crosscut tunnel, started last year to intersect the phosphate rock on a Government lease, was completed, and the initial shipment of phosphate rock was made.

From the potash leases there were produced and sold sodium salts valued at \$533,324.85 and potash valued at \$1,023,232.05. The production of potash increased 127,596.38 tons. During the year drilling was done on 20 test holes for potash in New Mexico to a total depth of 15,706 feet, and in Utah 1 hole was deepened 1,495 feet. Two mine shafts in New Mexico were started during the year. One was completed at a depth of 1,000 feet and the other sunk to a depth of 250 feet. The capacity of the New Mexico potash mines will be ample to meet the American demand for potassium muriates for many years. The accident rate of the United States Potash Co. was reduced 82 percent.

Active prospecting for sodium borates was conducted in the Kramer district in California by a geophysical survey of about 2 square miles and by 3 test holes completed and 1 partly completed; total depth of tests, 4,703 feet. Prospecting for anhydrous sodium sulphate was continued in the Verde Valley, Ariz.

Twenty-five applications for sulphur prospecting permits in New Mexico involving about 15,308 acres, have been received, but no permits have yet been issued.

MINING OPERATIONS ON INDIAN LANDS

The greater part of the mining on Indian lands is in Oklahoma, where there are zinc and lead mines on restricted Quapaw land; coal mines on segregated Choctaw and Chickasaw coal and asphalt lands and on restricted Indian coal lands; and scattered deposits of volcanic ash, building stone, gravel, lead, zinc, and other minerals of less value on other Indian lands. The Geological Survey functions as an agent for the Indian Service in the engineering phases of supervision over these operations.

OIL AND GAS OPERATIONS ON PUBLIC LAND

Engineering and geologic details were completed and departmental approval obtained for the cooperative or unit plan of development of the Pitchfork oil field, Wyoming, pursuant to the act of March 4, 1931 (46 Stat. 1523), amending the Mineral Leasing Act of February 25, 1920. Detailed consideration was given to a proposed

unit plan of development of the Middle dome, Kettleman Hills oil and gas field, California.

Investigations were made regarding the matter of computing Government royalty oil on the basis of 100-percent volume measurement, and engineering reports were submitted to the department. On the basis of reports made by the Geological Survey, the Department September 10, 1932, modified the minimum price requirements for royalty settlements on crude oil produced in the Oregon Basin field. Studies were made in the matter of computing reduction of royalties on crude oil authorized under section 17 of the Mineral Leasing Act of February 25, 1920 (41 Stat. 437), and of allowances to cover the cost of treating emulsified oils.

Oil and gas leases and permits on the public domain

State	Received during fiscal year 1933				Under supervision of the Geological Survey June 30, 1933					
	Leases		Permits		Leases		Permits		Suspended preference rights to leases	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Alaska.....			8	18,250.24			91	184,602.63		
Arizona.....			6	12,483.88			68	161,389.62		
Arkansas.....							15	23,502.60		
California.....	6	1,081.61	159	117,739.05	198	52,740.48	568	447,289.41	5	3,526.21
Colorado.....	1	640.60	82	118,946.80	25	18,953.37	428	754,472.73	3	5,610.82
Idaho.....			12	20,807.06			71	134,904.77		
Louisiana.....					10	770.82	1	40.00		
Montana.....	3	716.23	159	158,473.87	77	15,995.17	551	545,618.36	1	1,358.82
Nebraska.....			1	280.00			1	280.00		
Nevada.....			5	12,671.27			51	122,861.74		
New Mexico.....	8	5,204.75	243	453,114.94	68	44,532.06	1,054	2,230,767.14	24	40,099.03
North Dakota.....			8	2,201.29			19	22,913.70		
Oklahoma.....			8	3,220.91	17	730.20	13	4,902.91		
Oregon.....			9	14,253.46			24	45,932.92		
South Dakota.....			12	10,922.66			25	25,966.42		
Utah.....			48	65,387.33	11	3,740.74	513	1,059,333.58	2	3,720.00
Washington.....			5	8,690.46			5	8,690.46		
Wyoming.....	5	3,440.00	239	386,116.63	402	120,600.52	945	1,609,037.53	16	15,507.40
Total.....	23	11,083.19	1,004	1,403,559.85	808	258,063.36	4,443	7,382,506.52	51	69,822.28

WORK ON PUBLICATIONS

Geological editing and drafting of maps and illustrations.—The geologic map of the United States, scale 1:2,500,000, was read in plate proof and color proof, and the printing was directed by the editor. The map was published during the year.

The final drawing of the geologic map of Colorado was begun and about a quarter of the map was drawn. The compilation of the geologic map of Montana in cooperation with the State Bureau of Mines was well advanced. The Somerset-Windbar (Pa.), Montevallo-Columbiana (Ala.), and Hollidaysburg-Huntingdon (Pa.) folios are in hand, and a little progress on them was made during the year.

The geologic map of the Valley of Virginia, scale 1:250,000, prepared in cooperation with the Virginia Geological Survey, was edited, engraved, and read in color proof, and printing was begun. The map of the Tennessee Basin, showing mineral resources, scale 1:500,000, compiled in the fuel section, was drawn for photoengraving, and color proof was read; the map was approved for printing.

DISTRIBUTION

A total of 331 publications, comprising 82 new books and pamphlets (including 29 guidebooks for the excursions of the International Geological Congress), 99 new or revised topographic and other maps, 1 geologic folio, and 149 reprinted topographic and other maps, were received by the division of distribution during the year. A number of special pamphlets and forms for administrative use were also delivered and distributed. The total units of all publications received numbered 148,553 books and pamphlets, 3,776 geologic folios, and 660,456 topographic and other maps, a grand total of 812,785.

The division distributed 109,511 books and pamphlets, 4,285 geologic folios, and 599,108 maps, a grand total of 712,904, of which 3,187 folios and 477,867 maps were sold. The sum received for publications and deposited in the Treasury was \$29,969.12, including \$29,372.52 for topographic and geologic maps and \$596.60 for geologic folios. In addition, \$1,640.85 was repaid by other establishments of the Federal Government at whose request maps or folios were furnished. The total receipts, therefore, were \$31,609.97.

DIVISION OF ENGRAVING AND PRINTING

During the fiscal year 90 newly engraved topographic maps were printed, including 2 revised maps, and 8 new maps were photolithographed and printed, making a total of 98 new maps printed and delivered. Corrections were engraved on the plates of 133 maps. Reprint editions of 149 engraved topographic maps and 10 photolithographed State and other maps were printed and delivered. In addition, 44 new topographic maps had been engraved and were in press June 30, and the engraving of 30 other new topographic maps was nearly completed. Of new and reprinted maps, 257 different editions, amounting to 659,429 copies, were delivered. One new geologic folio was printed, its edition amounting to 3,776 copies. The geologic map of the United States (4 sheets), scale 1:2,500,000, was printed, its edition (first printing) amounting to 1,087 copies.

A large amount of work was done for 47 other units of the Government and 11 State governments, including many reprints, and the charges for it amounted to about \$138,000, for which the appropriation for engraving and printing geologic and topographic maps was reimbursed.

The output of the photographic laboratory consisted of 14,744 negatives (including 4,483 wet plates for photolithographs, 900 wet plates for photographic prints, 13 paper negatives, 2,683 dry plates, 555 lantern slides, and 6,110 field negatives developed), 27,824 prints (including 2,548 maps and diagrams, 24,628 photographs for illustrations and records, and 648 bromide enlargements), 3,944 zinc plates, 320 intaglio etchings, 19 celluloid prints, and 13,238 prints mounted.

LIBRARY

The outstanding feature of the year in the library was the acquisition, through the friendly intercession of Mr. Walter E. Reid, of the great collection of works on precious stones, gems, and jewels assembled by the late George Frederick Kunz, of New York City, who for many years was associated with the Geological Survey. This acquisition was made possible through the generosity of Mrs. Opal Logan Kunz, of New York City, and Mrs. Hans Zinsser, of Boston, to whom the library was bequeathed by Dr. Kunz. The collection is by far the most comprehensive in the world on this subject. The accessions during the year comprised 11,197 books, pamphlets and periodicals, and 1,091 maps.

	Funds available				Expenditure			Balance
	Amount of appropriation	Repayments on account of work performed		Total	Disbursements	Outstanding liabilities	Total	
		Made	To be made					
APPROPRIATIONS								
Salaries.....	\$143,750.00	\$7,246.34		\$150,996.34	\$150,938.36		\$150,938.36	\$57.98
Topographic surveys.....	554,400.00	290,864.50	\$51,224.11	896,488.61	819,131.24	\$3,587.11	822,718.35	73,770.26
Geologic surveys.....	373,750.00	41,842.87	7,613.77	422,706.64	407,397.63	1,731.67	409,129.30	13,577.34
Fundamental research in geologic science.....	46,000.00	5,150.91		51,150.91	50,439.22	9.84	50,449.06	701.85
Volcanologic surveys.....	17,250.00	3,000.00		20,250.00	20,175.67	24.71	2,200.38	49.62
Alaskan mineral resources, 1933.....	9,000.00			9,000.00	9,000.00		9,000.00	
Alaskan mineral resources, 1932-33.....	60,000.00	9,046.91		69,046.91	57,437.40	1,675.10	59,112.50	9,934.41
Gaging streams.....	675,000.00	239,158.72	74,134.99	988,293.71	950,913.56	9,994.12	960,907.68	27,386.03
Classification of lands.....	190,000.00	197.42		190,197.42	181,447.26	2,018.47	183,465.73	6,731.69
Printing and binding.....	138,000.00	11.82		138,011.82	68,876.90	26,005.65	94,882.55	43,129.27
Preparation of illustrations.....	23,000.00	986.62		23,986.62	23,696.95		23,696.95	289.67
Geologic and topographic maps.....	126,500.00	158,878.36	12,565.06	297,943.42	289,170.46	936.43	290,106.89	7,836.53
Mineral leasing.....	258,750.00	403.11		259,153.11	249,692.17	660.52	250,352.69	8,800.42
	* 2,615,400.00	756,287.58	145,537.93	3,517,225.51	3,278,316.82	46,643.62	3,324,960.44	192,265.07
TRANSFERS								
Alaska Railroad appropriated fund (act Feb. 14, 1931).....	d 15,686.79	527.21		16,214.00	16,145.94	68.06	16,214.00	
Engineer operations in the field (War Department, act Feb. 14, 1931, 1931-Dec. 31, 1932).....	d e 173.28			173.28	173.28		173.28	
Federal Power Commission (act Apr. 22, 1932), 1933.....	800.00			800.00	561.48		561.48	238.52
Field investigations of public health (Treasury Department, act Apr. 22, 1932), 1933.....	400.00			400.00	400.00		400.00	
Flood control, Mississippi River and tributaries (War Department act Feb. 14, 1931).....	d f 57,028.29	400.12		57,428.41	55,941.39	176.72	56,118.11	e 1,310.30
George Washington Bicentennial Commission (act May 21, 1920).....	d 61.78			61.78	61.78		61.78	
Irrigation, Indian reservations (reimbursable; act Apr. 22, 1932), 1932-33.....	250.00			250.00	246.57		246.57	3.43
Irrigation, San Carlos and Florence-Casa Grande projects, Arizona (reimbursable; act Apr. 22, 1932), 1932-33.....	2,750.00			2,750.00	2,750.00		2,750.00	
Maintenance and improvement of existing river and harbor works (War Department, act Feb. 14, 1931).....	d h 3,978.31		38.24	4,016.55	3,479.60	58.38	3,537.98	e 478.57
Maintenance and improvement of existing river and harbor works (War Department act Apr. 22, 1932).....	25,650.00	36.79	15.05	25,701.84	21,605.82	2.52	21,608.34	f 4,093.50
Maintenance irrigation system, Wapato project, Washington, act Aug. 1, 1914, special fund (act Apr. 22, 1932).....	575.00	8.00		583.00	582.30		582.30	.70
Operation and conservation of naval petroleum reserves (Navy Department, act Apr. 22, 1932), 1933.....	45,000.00			45,000.00	44,488.18		44,488.18	511.82
Supervising mining operations on leased Indian lands (act Apr. 22, 1932), 1933.....	i 69,000.00	2,766.76		71,766.76	70,459.18	12.49	70,471.67	1,295.09
Waterways treaty, United States and Great Britain (State Department, act July 1, 1932), 1933.....	55,700.00	2,286.09		57,986.09	57,474.08	478.68	57,952.76	33.33
Grand total.....	2,802,453.45	762,312.55	145,591.22	3,800,357.22	3,552,686.42	47,440.47	3,600,126.89	200,230.33

^a In addition to these appropriations, there was an allotment of \$12,424.50 for miscellaneous supplies from the appropriation for contingent expenses of the Interior Department.

^b Of this balance \$40,000 unexpended due to limitation on printing and binding imposed by sec. 302, part II, of the Legislative Appropriation Act approved June 30, 1932.

^c Included in this total is \$284,400 transferred from the roads and trails appropriation of the National Park Service.

^d Balance unobligated on June 30, 1932, and continued available for expenditure in the fiscal year 1933.

^e Of the \$1,016.15 balance as of June 30, 1932, \$842.87 has been returned to the War Department.

^f Of the \$58,115.29 balance as of June 30, 1932, \$1,087 has been returned to the War Department.

^g These balances continue available for expenditure in the fiscal year 1934, subject to the approval of the War Department.

^h Of the \$11,292.24 balance as of June 30, 1932, \$7,313.93 has been returned to the War Department.

ⁱ Included in this amount is \$9,000 transferred from the roads and trails appropriation of the National Park Service.

^j Included in these amounts is \$200,496.12 covering work performed by Geological Survey units for other Geological Survey units; supplies furnished by one branch to another; credits to appropriations on account of impounded salaries which have been released; adjustment vouchers between transferred funds and Geological Survey appropriations; and other adjustments necessarily reported in combining totals but otherwise a duplication.

Object of expenditure	Geological Survey salaries	Topographic surveys	Geologic surveys	Fundamental research	Volcanologic surveys	Alaskan mineral resources	Gaging streams	Classification of lands	Printing and binding	Preparation of illustrations	Geologic and topographic maps of the United States	Mineral leasing	Total
Personal services	\$150,133.36	\$676,567.24	\$381,355.21	\$47,993.00	\$18,772.92	\$65,747.94	\$775,571.20	\$154,494.98		\$23,103.10	\$249,775.22	\$317,000.17	\$2,860,514.34
Stationery and office supplies		2,995.03	598.82	160.79	19.56	275.28	9,803.26	299.69		161.93	2,807.99	722.73	17,845.08
Scientific and educational supplies		364.68	1,428.36		13.25	89.31	1,218.42	98.15		.92	4,267.87	571.60	8,052.56
Sundry supplies		5,986.23	344.36	3.20	7.59	33.29	18,044.20	78.00		.60	19,207.96	548.29	44,253.72
Subsistence and care of animals and storage and care of vehicles		1,781.23	576.75			70.50	349.32	77.60				106.31	2,961.71
Telegraph service		509.26	106.44			4.36	780.18	58.32			2.68	340.91	1,802.15
Telephone service		212.25	104.25		12.30	13.40	2,580.18	88.90				1,942.18	4,953.46
Other communication service		188.09	6.94	30.27	1.15	39.57	231.06	1.15				103.69	601.92
Travel expenses		65,773.42	7,561.57	438.47	1,075.87	5,645.37	62,816.14	13,180.14			31.91	11,822.58	168,345.47
Attendance at meetings		88.63	958.63				391.31					95.11	1,533.68
Hire, maintenance, operation, repair of horse-drawn and motor-propelled passenger-carrying vehicles		2,839.74	1,203.42	107.57	139.11		30,409.32	4,501.30				15,154.60	54,355.06
Transportation of things		37,410.93	3,677.42	9.84	66.70	1,104.70	17,011.04	1,916.05			227.05	722.60	62,146.33
Printing and binding		3.30					5.33		\$94,870.73		6,656.61		101,535.97
Lithographing, engraving, and engrossing		15,016.57	1,523.42	72.67		718.16	1,274.09	664.35		40.41	22.46	9.82	19,341.95
Stenographic work, typewriting, and duplicating work, etc. (job work)		348.03	43.74	8.87		295.41	305.84	113.22		3.12		20.97	1,139.20
Photographing and making photographs and prints		18,678.44	1,567.61	758.39	17.17	404.15	2,500.10	2,131.19		96.15		106.38	26,259.58
Heat, light, power, water, and electricity		24.02	32.11			40.16	312.31					3,906.16	4,314.76
Rents		466.27	1.56				4,797.23	.84				2,929.10	8,195.00
Repairs and alterations		305.41	96.19			12.30	3,952.73	12.10			618.08	1,227.71	6,224.52
Special and miscellaneous current expenses		5.20				37.45	85.07					185.56	313.28
Purchase of passenger-carrying vehicles		583.86					7,752.43	1,126.40				1,570.70	11,033.39
Furniture, furnishings, and fixtures		483.64	27.64				1,906.25	233.41			9.00	3,098.10	5,758.04
Educational and scientific equipment		5,081.65	2,845.62	28.35	3.75	258.74	40,213.71	923.92		15.36	3,855.57	519.71	53,746.38
Other materials and equipment		12,321.44	521.48		29.32	107.88	10,441.44	328.77			1,075.69	291.87	25,117.89

Structures		236.02					7,751.63					31.50	8,019.15
Miscellaneous transfers and adjustments	805.00	30,246.18	4,547.76	837.64	41.69	9,428.53	48,417.44	3,317.89	11.82	275.36	1,548.80	2,284.19	101,762.30
Total	150,938.36	878,516.76	409,129.30	50,449.06	20,200.38	84,326.50	1,048,921.23	183,646.37	94,882.55	23,696.95	290,106.89	365,312.54	3,600,126.89

In addition to the above amounts, there was expended directly by cooperating agencies \$119,654.28 in connection with cooperative topographic surveys and \$313,037.24 in connection with cooperative stream gaging.

OFFICE OF EDUCATION

(GEORGE F. ZOOK, Commissioner)

Dr. William John Cooper, the eighth Commissioner of Education, terminated his period of service in the Office of Education on July 10, 1933, very soon after the closing of the year for which this annual report is prepared. It is therefore a report of the activities of the office under Dr. Cooper's administration.

EDUCATION DURING THE DEPRESSION

To a very great extent the whole program of study of the office has been modified by the present economic situation in the selection of problems, the program of service, the types of publications issued. It has been the serious intent to give prompt, specific, practical help in today's pressing problems.

While the effects of the depression were reflected in school budgets a year or so after they were felt by the industrial and commercial world, this past year has been a critical one for schools of all types and in all parts of the country. Budget reductions for the year averaged about 7 percent in city school systems and 5½ percent in rural schools, representing a reduction of at least \$112,000,000 in current expenditures at a time when enrollments were still increasing rapidly. Budgets for capital outlay, such as new grounds, buildings, and equipment, were cut more than 40 percent. This means spending approximately \$108,000,000 less this year on school buildings, although there are still more than a quarter of a million children going to school on a part-time basis or being housed in portables. These reductions have been reflected in shorter school terms, the closing of many schools, larger classes, employment of about 14,000 fewer teachers this year than last, elimination of many school departments and services, and reduction in teachers' pay ranging from 5 percent to 50 percent or more. Along with these curtailments there has been evident a widespread spirit of criticism of the schools, their programs, and their officials which has expressed itself in demands for drastic cuts and changes.

To be of service to school officials, legislative committees, and laymen interested in education the Office of Education has carried on a series of investigations and issued publications of various types. They have been of three principal kinds: