DEPARTMENT OF THE INTERIOR

ALBERT B. FALL, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

FORTY-SECOND ANNUAL REPORT

OF THE

DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

FOR THE FISCAL YEAR

ENDED JUNE 30

1921

WASHINGTON

GOVERNMENT PRINTING OFFICE

1921

DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

FORTY-SECOND ANNUAL REPORT

OF THE

DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

FOR THE FISCAL YEAR
ENDED JUNE 30

1921

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

CONTENTS.

ILLUSTRATION.

FORTY-SECOND ANNUAL REPORT OF THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY.

GEORGE OTIS SMITH, *Director.*

The direct appropriations for the work under the Geological Survey for the fiscal year 1921 comprised items amounting to $1,730,700. In addition $140,000, to be disbursed under the direction of the Public Printer, was appropriated for printing the reports of the Survey.

SPECIAL TOPICS.

ECONOMY THROUGH EFFICIENCY.

There is economy in the public service that does not show on the books of the Treasury. Bookkeeping deals with dollars expended, not with work done, and unexpended balances may express either money well saved or urgent work left undone. The difficulty is that fiscal accounts tell only part of the story, and the parts untold too often can not be found in the administrative record. To pass intelligent judgment whether or not the nonexpenditure of public funds is truly economical there must be taken into account more weighty considerations than the obvious dollars and cents alone.

The public always demands from a Government scientific bureau more investigative work than it can do under the appropriations provided for it by Congress. Therefore a choice must be made of the most pressing items in a large program and other items that are hardly less pressing must be indefinitely postponed, although it is generally realized that the Nation can well afford to invest money in the scientific and engineering results that would be obtained. The dangers incurred by this inability of the Geological Survey to meet the demands on it for service were suggested in the Forty-first Annual Report (pp. 7–10) under the heading "Planning for the future."

Always facing this excess demand for service, a bureau like the Geological Survey, however sympathetic it may be with the appeal for economy in the Government departments, naturally seeks to give more for the dollar—to accomplish more with the same expenditure, not to reduce the expenditure. Indeed, so far as such comparisons are possible, experience has shown that the gradual increase in the appropriations for the Survey through forty-odd years has been accompanied by a much higher increase in service rendered, so that a reduction in expenditure would be more than offset by a larger reduction in accomplishment. With this fact in mind the Director of

the Survey recently informed the Director of the Budget that though any desired reduction of the Survey's appropriations was possible, any reduction at all would be undesirable, and indeed unwise, in terms of real economy; that, roughly, a 25 per cent cut in appropriations would entail a 33⅓ per cent cut in work, or 33⅓ per cent less money would mean 50 per cent less work. Therefore a more profitable endeavor would be that of so planning the expenditure of the inadequate funds available as to obtain the maximum results in service rendered.

This type of economy, which can be attained only through increased efficiency, is not new; it is the engineering ideal set up in every productive industry; but in the Government bureau, where service is the product, such economy and efficiency are difficult to measure and to appraise. Here no balance can be struck between pounds of fuel consumed and kilowatt-hours generated, yet many of the principles that apply to the production of electrical energy apply equally to the production of scientific results.

The sources of wastage in the public service have been constantly studied and repeatedly discussed in these administrative reports. In the Thirty-third Annual Report detailed mention was made of the loss in efficiency, with some quantitative estimates, resulting from the crowding of a large office force into utterly inadequate as well as unsafe quarters. Congress then removed this limitation upon efficiency by providing for the erection of an office building adapted to the needs of the Survey. Yet, in the Fortieth Annual Report (p. 13) attention had to be directed to the effects of a retrenchment measure, whereby two years ago a large force from another department was quartered in the Interior Department Building, crowding scientist and clerk alike into 75 square feet of floor space each. The loss in efficiency thus caused, which still continues, does not appear on the books of the Treasury, but there is good reason to believe that it amounts to several times the apparent saving in rentals.

Another limitation of efficiency that defeats economy in administration is found in restrictions placed upon the selection of personnel (Thirty-fourth Annual Report, pp. 10–11). The State apportionment feature of the civil-service law usually bars from the classified service the clerks that ranked highest in the examinations. Rules limiting the number of Government employees from the same family, like this limitation of the number from the same State, simply express the old idea—old but unfortunately not yet obsolete—that the civil service is a "trough" at which favors must be widely distributed. The tendency seems to be to throw more and more protection about the holder of a Government job regardless of his relative capacity for work; but all this disregard of the basal principle that the public service needs and deserves the best workers is radically opposed to the demand for more businesslike methods in the Government departments; it does not make for either economy or efficiency.

Scientific work can be organized with the business idea of efficiency, and indeed the report made to Congress in 1878 by the National Academy of Sciences advocating the creation of the United States Geological Survey proposed as its ideal plan for a scientific bureau that which would yield the "best results at the least possible cost." Since then economy in science has become a still more pressing issue,

and in the Thirty-seventh Annual Report an appeal was made to bureau chiefs and their advisers that the public scientific work should be properly coordinated, so as to avoid wasteful use of public money and to conserve scientific effort by preventing duplication both in research and in publication. Competition between scientific bureaus is as wasteful as competition between electric-light companies or other public-service agencies. The public can be best served by requiring each bureau in specialized science to occupy its own field.

The relatively small salaries paid by the Government constitute a further handicap in the Survey's efforts for economy. The competition of outside employers has been keen and has resulted in the resignations of specialists who occupied key positions in the field investigations, so that the loss in efficiency due to interrupted work has far outweighed any possible savings figured on the basis of the lower pay scale. Reduction in the salaries paid to the best trained and most experienced scientists in the Government service would not be a move toward economy.

Constructive efforts in the direction of true economy have continued through many years, but few of these efforts can be cited as yielding measurable results. In the scientific work new field or laboratory methods have both shortened the procedure and improved the product. The invention of new surveying instruments has added to the field man's productivity, but at the same time the field standards have advanced so that the cost of mapping per square mile has not been materially reduced; the net result, prior to the recent large increase in the living expenses of the field force, was that much better work was done for approximately the same unit cost as 20 years before. This improvement in quality of service rendered is an example of economy through greater efficiency, even though the economy does not express itself in either unexpended balances or larger areas surveyed.

Similarly, new processes devised for use in map publication have resulted in a larger output of the map-printing plant, so that each year more and better maps are issued for the same expenditure of funds. Yet the larger public demand for these maps, which expresses itself in increased sales, necessitates larger appropriations, so that although at first glance the outlay for this work seems to be greater, it should be remembered that in reality the service rendered is greater still. The returns from the larger sales in fact appear on the other side of the ledger, but receipts are rarely taken into account in estimating the cost of Government bureaus.

Another example of special interest at this time is afforded by the appropriation for printing the Survey book publications. The unpublished manuscripts accumulated through the war period represent completed investigations on which the public can not realize until the results are put in print. With a current printing appropriation smaller and unit costs higher than before the war, it is plain that the Geological Survey is not able to fulfill its obligations to the public by prompt publication. Any voluntary retrenchment by turning back a part of this inadequate appropriation would be a most fanciful type of economy. The course adopted, however, has been to condense manuscripts, reduce editions even below what may seem to be the probable demand, and cut costs in every possible way. This

painstaking economy will not result in a single dollar being turned back to the Treasury unexpended nor greatly increase the number of pages printed for the year, but more reports will be issued and the results of more investigations for which the public has already paid will be made available for public use.

The type of economy through efficiency set forth above is neither novel nor unique in the public service, but it is not always recognized and is rarely appreciated. Economy in administration can be a matter of internal growth as well as a product of external force; possibly the best result will come from the sympathetic coordination of both agencies.

THE SUPERPOWER SURVEY.

Congress made an appropriation to the Geological Survey for a special investigation and a report, to be completed during the fiscal year 1921, on the possible economy of fuel, labor, and material that would be gained by the operation in the region between Boston and Washington of a comprehensive system for the generation and distribution of electricity to railroads and other industries. This investigation had been urged by Secretary Lane and was assigned to the Geological Survey as a continuation of its war studies of the country's available power. An organization of engineers to make this investigation and report was accordingly set up under the administrative control of the Geological Survey, with offices at New York City, and the report was completed June 30, 1921, as required by law, and is now in press as Professional Paper 123.

The engineers appointed to perform this work carried it through with high professional and public spirit, and the industries to be affected rendered unstinted cooperation, furnishing data and engineering aid and contributing voluntarily to the work the sum of $26,000. Voluntary cooperation in the work was also rendered by an advisory board appointed by Secretary Payne, consisting of well-known men of wide vision and large experience in business.

The report shows the amount of power now required in the superpower zone for railroads and other industries and the amount that would have to be furnished to supply the requirements by 1930, indicates the desirable locations for the large superpower plants and their attendant transmission lines, and gives figures to show the probable cost of the proposed system and the probable returns on the investment.

SURVEYS IN THE WEST INDIES.

The Geological Survey has continued to supervise topographic surveys in the Dominican and Haitian republics. The topographic engineers making these surveys were furloughed for this service, and the total expense of the work has been borne by these republics.

About 5,000 square miles of topographic mapping, on a scale of 1:100,000, has been completed in the Dominican Republic and the maps are being prepared for engraving. No topographic mapping has been undertaken in the Haitian Republic, but triangulation control has been begun preparatory to topographic mapping in the fiscal year 1921–22.

In these topographic surveys the United States Marine Corps has cooperated by furnishing a pilot and airplane for the use of an engineer of the Geological Survey to obtain aerial photographs to be used in making the topographic maps. The area photographed amounted to 12,098 square miles and was covered by flights amounting to 2,856 miles and the exposure of approximately 20,000 films, from which 15,451 satisfactory prints were obtained. So far as known, this is the most extensive governmental photographic survey yet made.

A geologic reconnaissance of the Republic of Haiti was made during the fiscal year at the request of the civil authorities by geologists of the Survey on furlough. The results will be embodied in a report now in preparation, to be published by the Republic.

A report on the geologic work done in the Dominican Republic in 1919 by geologists of the Survey on furlough is now in course of publication by the Republic.

NECROLOGY.

During the year the Survey has suffered losses through the death of Arthur J. Ellis, Ralph W. Howell, Joseph P. Iddings, and Louis V. Pirsson. Mr. Iddings, who had been a member of the Survey for more than 40 years, had gained an international reputation through his researches in petrography; Mr. Pirsson, although he had not for some years given much of his time to the work of the Survey, had become a conspicuous figure in the science of geology, particularly in petrography; Mr. Ellis had been engaged in work on ground water since 1911; Mr. Howell, while on leave of absence from the Survey, engaged in a search for oil and gas in northwestern India on behalf of a private enterprise, was shot and instantly killed by outlaws.

WORK OF THE YEAR.

PUBLIC STATEMENTS BY THE DIRECTOR.

The Director has continued his efforts to translate the results of the Survey's investigations into popular language for more general presentation than can be attained through the printed pages of a Government report. His purpose has been to show the bearing of scientific facts and conclusions upon public policy and every-day questions. This marketing of the Survey product is regarded as an essential part of the scientific and engineering work in the public service. It is not enough simply to learn the truth; the truth must be applied practically in the public interest.

In addition to attending congressional hearings, the Director addressed meetings of technical and other societies as follows: "The way to the sea—the St. Lawrence gateway to the continent," International Joint Commission, New York, October 20, 1920; "Thrift in coal," American Iron and Steel Institute, New York, October 22, 1920, also Portland Cement Association, New York, December 15, 1920; "Revive the public service," Washington Academy of Sciences, October 23, 1920; "The strategy of minerals," General Staff College, United States Army, Washington, October 28, 1920; "A world view of the oil supply," American Petroleum Institute, Washington, No-

vember 17, 1920; "Industry's supply of energy," Chicago section, American Society of Mechanical Engineers, November 22, 1920, also Hartford section, February 7, 1921; "Scientific by-products of applied geology," Society of Economic Geologists, Chicago, December 29, 1920, and Geological Society of Washington, April 13, 1921; "The superpower survey," Phi Beta Kappa Association, Washington, March 21, 1921; "Geology in partnership with American industry," Franklin Institute, Philadelphia, April 7, 1921; "What the coal business means to us," Indiana Retail Coal Merchants' Association, Indianapolis, May 6, 1921.

These addresses were published in the technical journals and proceedings of the societies. Other special articles were prepared on request as follows: "Planning for to-morrow—a message from the United States Government to the American people," Independent, September 25, 1920; "Our need of new sources of power," Munsey's Magazine, October, 1920; "Power multiplication," The Nation's Business, October, 1920; "Soft-coal requirements for 1920," Coal Review, October 13, 1920; "Are we buying coal enough?" Coal Review, March 30, 1921; "The cost of a ton of coal," Coal Age, May 12, 1921; "Where can we drill next? America's chances abroad," California Oil World, May 26, 1921; "The place of petroleum in the world," translated into Spanish and Portuguese for the Bulletin of the Pan American Union, issue for July, 1921.

Two letters addressed to Senator Walter E. Edge in response to his request for information should also be mentioned, because of their wide circulation. The first, dated December 13, 1920, discussed the bituminous coal situation, and the second, dated May 20, 1921, discussed anthracite. These letters represented an earnest effort to educate the consuming public on the coal issue. In the preparation of all these articles and addresses the necessary assistance was generously given by the specialists of the Survey, who recognized the Director as their spokesman in thus reaching the public.

PUBLICATIONS.

The publications of the year consisted of 1 annual report, 2 professional papers, 7 separates from 3 professional papers, 12 bulletins, 35 separates from 6 bulletins, 17 water-supply papers, 2 separates from 2 water-supply papers, 1 volume of Mineral Resources of the United States, 52 separates from 4 annual volumes of Mineral Resources, 2 new geologic folios, 1 world atlas of commercial geology, 1 list of United States Geological Survey publications, 2 texts for topographic maps, 1 advance statement on lead in 1919, 7 index-map circulars, 1 list of geologic folios available, 1 list of State maps, 1 pamphlet entitled "The preparation of illustrations for reports of the United States Geological Survey," 1 circular describing a set of 50 atlas sheets showing physiographic types, 23 press bulletins, and 12 monthly lists of new publications. The total number of pages in these publications was 10,619. Reprints of 34 publications were made.

Brief notices of the publications in the regular series and of the new maps issued during the year are given on the following pages.

FORTY-FIRST ANNUAL REPORT of the Director of the United States Geological Survey to the Secretary of the Interior for the fiscal year ended June 30, 1920. 180 pages, 3 plates.

A detailed account of the work of the Geological Survey during the fiscal year 1920. Among the special features set forth is the larger use that is being made of this branch of the public service by citizens of all classes, as shown in the increase in requests for specific information and for publications and maps. The Director emphasizes the fact that every activity of the Survey is forward-looking—that the facts which are being collected serve not only to guide present action but to plan for future action in the development of the country's resources. Never before have legislators and executives, business men, and citizens generally had greater need of exact information of the sort which the Geological Survey is constantly accumulating. During the year the Director has presented some of the results of the Survey's investigations in a number of public addresses and published articles designed to translate those results into popular language and set forth their relation to present-day issues.

PROFESSIONAL PAPER 121. Helium-bearing natural gas, by G. S. Rogers. 113 pages, 4 plates.

Hydrogen, the gas commonly used for inflating balloons, when mixed with air is explosively combustible. For this reason a balloon filled with hydrogen is very liable to be set afire, and a single incendiary bullet is usually sufficient to destroy a great airship. During the first year of the World War a British scientist conceived the idea of inflating balloons with the gas helium, whose buoyancy is 93 per cent of that of hydrogen, and which has the great advantage that it can not explode or burn. In 1915 a vigorous search for the gas was begun in England, and later it was extended to Canada without success. On the entrance of the United States into the war the project was revived and the Government undertook an energetic campaign for the production of helium in large quantities. As soon as the technologic feasibility of the project was assured the Geological Survey was called upon to investigate the helium resources of the country in order to locate the richest supplies of the gas and to form estimates of the quantity available. The results of that investigation are set forth in this paper, which describes the chief sources of helium in the United States and discusses briefly some of the broader scientific problems involved in its origin.

PROFESSIONAL PAPER 125–D. The American species of *Orthophragmina* and *Lepidocyclina*, by J. A. Cushman. 70 pages, 29 plates.

Orbitoid Foraminifera, on account of their short stratigraphic range, have proved to be excellent horizon markers, and because of their wide geographic distribution they are valuable in correlation. This paper describes all the known American species of the two genera named in the title.

PROFESSIONAL PAPER 125. Shorter contributions to general geology, 1919. 108 pages, 35 plates, 3 text figures, 1 insert.

Contains four papers by four authors, published separately in 1919 and 1920. These papers discuss fossils in Texas, Alaska, the Southeastern States, and the West Indies and conditions of sedimentation in Montana during a part of Cretaceous time.

PROFESSIONAL PAPER 128–A. The fauna of the Cannonball marine member of the Lance formation, papers by T. W. Stanton and T. W. Vaughan. 66 pages, 10 plates.

The Cannonball member is the latest marine deposit known in the Great Plains province and is intimately associated with some of the continental deposits which lie near the boundary between Cretaceous and Tertiary and concerning whose exact age there is difference of opinion. This paper describes the fossil fauna of the Cannonball member, considers its relation to other faunas, and discusses other facts that may bear on the determination of its age.

PROFESSIONAL PAPER 128–B. Lower Miocene Foraminifera of Florida, by J. A. Cushman. 8 pages, 1 plate. Describes 18 species collected in the Alum Bluff formation in Florida.

PROFESSIONAL PAPER 128–C. The origin of the faults, anticlines, and buried "granite ridge" of the northern part of the Mid-Continent oil and gas field, by A. E. Fath. 10 pages, 3 plates, 3 text figures.

A geologic study of the origin of certain features that have a bearing on the occurrence of oil and gas in the Mid-Continent field.

PROFESSIONAL PAPER 128–D. The use of geology on the western front, by Alfred H. Brooks. 40 pages, 3 plates, 10 text figures.

Although the science of geology was definitely recognized in the World War it was by no means developed to its full usefulness. Few officers of the high commands of the armies that employed geologists had any adequate conception of the application of geology to military and engineering problems. The geologists had to spend much time and energy in combating ignorance and prejudice, and they often saw the undertaking of impossible projects, involving needless effort and perhaps sacrifice of lives, which could have been avoided by a little elementary knowledge of geology. Before the end of the war, however, the direct military value of geologic knowledge was recognized by nearly all the great powers. This paper sets forth the many possible applications of geology to war and describes the work done in France by the different geologic staffs. It also summarizes the kind of geologic training that should form an essential part of military preparation. Mr. Brooks was chief geologist of the American Expeditionary Forces, and his paper is written from first-hand information.

PROFESSIONAL PAPER 128–E. American species of *Operculina* and *Heterostegina* and their faunal relations. and New species of *Orthophragmina* from Louisiana; papers by J. A. Cushman. 18 pages, 5 plates.

Two short paleontologic papers on Eocene and Oligocene fossils.

PROFESSIONAL PAPER 129–A. Lithologic subsurface correlation in the "Bend series" of north-central Texas, by M. I. Goldman. 22 pages, 1 plate, 1 text figure.

Presents the results of an attempt to obtain by a study of well drillings criteria for correlation. The criteria are based on the character of the beds encountered, and the work is directly applicable to the needs of the oil-well operator.

BULLETIN 682. Marble resources of southeastern Alaska, by Ernest F. Burchard, with a section on the geography and geology by Theodore Chapin. 118 pages, 26 plates, 6 text figures.

Marble is widely distributed in southeastern Alaska, but the quarries so far opened are in one general region. This report sets forth in detail the available information concerning the deposits. describes the geography and geology of the region, gives a brief summary of elementary facts concerning limestone and marble, and presents commercial considerations that affect exploitation of the deposits.

BULLETIN 686–W. Structure and oil and gas resources of the Osage Reservation, Okla., T. 29 N., Rs. 11 and 12 E., by M. I. Goldman. 24 pages, 1 plate, 4 text figures.

BULLETIN 686–X. Structure and oil and gas resources of the Osage Reservation, Okla., T. 20 N., R. 10 E., by M. I. Goldman. 6 pages, 1 plate, 2 text figures.

BULLETIN 686–Y. Structure and oil and gas resources of the Osage Reservation, Okla., T. 28 N., Rs. 11 and 12 E., by M. I. Goldman and H. M. Robinson. 36 pages, 4 plates, 2 text figures, 1 map, 1 insert.

Three chapters in the series of reports on the Osage Reservation.

BULLETIN 697. Gypsum deposits of the United States, by R. W. Stone and others. 326 pages, 37 plates, 57 text figures.

Prepared to take the place of the Survey's Bulletin 223, "Gypsum deposits in the United States," which was published in 1904. Between 1904 and 1918 the total value of crude and calcined gypsum produced in the United States increased over 300 per cent, and much new information has been obtained as to the quantity and the distribution of the gypsum deposits of the country. The available information, some of which has not previously been published, is set forth in this bulletin.

BULLETIN 702. Oil possibilities in and around Baxter Basin, in the Rock Springs uplift, Sweetwater County, Wyo., by A. R. Schultz. 107 pages, 17 plates, 9 text figures, 3 inserts.

As the stratigraphy and structure in Baxter Basin are favorable to the accumulation of oil and gas, and as these features are well shown on the maps in several published reports on that region, the Geological Survey frequently receives requests for information concerning the possible recurrence of oil and gas in the basin. This report presents the information on file in regard to Baxter Basin, much of which has not previously been

published. It also contains a brief summary of the occurrence of oil shale in the late Tertiary beds about the Rock Springs uplift and reviews the facts which indicate that the central part of the uplift probably contains oil and gas.

BULLETIN 703. The iron and associated industries of Lorraine, the Sarre district, Luxemburg, and Belgium, by A. H. Brooks and Morris F. La Croix. 131 pages, 2 plates, 12 text figures.

The World War showed that the American people should have full knowledge of European industries, and especially of the iron and steel industry of Lorraine, which has been and will be the strongest competitor with our export trade in iron and steel products. This report in its original form was prepared at Paris for the use of the American Commission to Negotiate Peace. It has been revised to some extent to accord with the new conditions created by the signing of the peace treaty, though parts of the report remain as originally written. It shows that France will control the iron of continental Europe and Germany to a large extent will control the coking coal. The report describes the iron and steel industries of the districts that used Lorraine iron ore during the prewar decade, and forecasts the future of an industry based on Lorraine ore. It gives detailed information on ownership, especially with reference to control by German capital.

BULLETIN 704. Geology of the igneous rocks of Essex County, Mass., by C. H. Clapp. 132 pages, 8 plates, 4 text figures, 1 insert.

Embodies the results of several years of geologic work in northeastern Massachusetts. The area more particularly discussed includes about 200 square miles in the southern part of Essex County and is geologically well known, for besides presenting local problems it illustrates certain general features of the geology of igneous rocks.

BULLETIN 706. The iron-ore resources of Europe, by Max Roesler. 152 pages, 19 plates, 33 text figures.

Most of the commercially available iron-ore deposits of the world lie on one or the other side of the North Atlantic. A wealth of literature has been published on the European deposits, but it is the product of many writers in many languages, and much of it is available in only a few libraries. The author of this report has undertaken to reduce this large and diverse record to nearly common scale and to present its contents as briefly as possible to the American reader. Such information is valuable in throwing light on the extent and the possible development of those foreign deposits with which our own must compete in international trade.

BULLETIN 709–C. Primary traverse in Georgia, 1916–1918. 124 pages, 1 plate.

BULLETIN 709–D. Triangulation in Idaho and Montana, 1914–1916. 12 pages, 1 plate.

BULLETIN 709–E. Primary traverse in Illinois and Wisconsin, 1916–1918. 28 pages, 1 plate.

BULLETIN 709–F. Primary traverse in Michigan, 1916–1917. 31 pages, 1 plate.

BULLETIN 709–G. Primary traverse in Iowa, Kansas, Missouri, Nebraska, and Oklahoma, 1916–1918. 55 pages, 1 plate.

BULLETIN 709–H. Triangulation and primary traverse in Kentucky and Tennessee, 1916–1918. 44 pages, 1 plate.

BULLETIN 709–I. Triangulation in Maine and New Hampshire, 1916–1918. 36 pages, 1 plate.

BULLETIN 709–J. Primary traverse in New York, 1916. 24 pages, 1 plate.

BULLETIN 709–K. Triangulation and primary traverse in Oregon and Washington, 1916–1919. 74 pages, 1 plate.

Nine chapters of the bulletin giving results of triangulation and primary traverse by the Survey during the years 1916–1918. Each pamphlet contains an index and a plate showing station marks.

BULLETIN 710. Contributions to economic geology, 1919. Part I, Metals and nonmetals, except fuels. 257 pages, 10 plates, 39 text figures.

Contains seven papers by four authors. These papers were published separately in 1919 and 1920. Six of them describe deposits of manganese ore investigated as a result of the war demand for alloy metals.

BULLETIN 711. Contributions to economic geology, 1919, Part II, Mineral fuels. 171 pages, 21 plates, 7 text figures.

Contains eight papers by six authors, previously published separately in 1919 and 1920.

BULLETIN 712. Mineral resources of Alaska; report on progress of investigations in 1918, by G. C. Martin and others. 219 pages, 6 plates, 10 text figures.

The fifteenth in the series of annual reports on the Geological Survey's work in Alaska. Contains ten papers by six authors and a list of recent Survey reports on Alaska.

BULLETIN 713. Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho, by G. R. Mansfield, with a chapter on water resources by W. B. Heroy. 152 pages, 13 plates, 4 text figures.

A part of the Fort Hall Indian Reservation, in southeastern Idaho, has been included in the Idaho phosphate reserve. This area is estimated to contain about 738,500,000 tons of high-grade phosphate rock, or nearly one-seventh of the total in the whole western field. This report describes the geography and geology of the Fort Hall Reservation and sets forth the phosphate resources in detail by townships. The section on water resources treats of the use of the water for irrigation and the development of power.

BULLETIN 714–A. The future of Alaska mining and The Alaskan mining industry in 1919, papers by A. H. Brooks and G. C. Martin. 103 pages, 3 plates, 1 text figure.

The principal paper in this pamphlet gives a conspectus of what the future holds forth for mining in Alaska as indicated by a study of the accessible mineral reserves, the production in the last 40 years, and the conditions that will affect the mining industry in the future. The author concludes that the Alaska mining industry has a most promising outlook. The pamphlet contains also a summary of mining operations in 1919, an administrative report, and a list of recent Survey publications on Alaska.

BULLETIN 714–B. Mining developments and water-power investigations in southeastern Alaska; papers by J. B. Mertie, jr., and G. H. Canfield. 83 pages, 2 plates.

BULLETIN 714–C. Mining in Chitina Valley, Alaska, by F. H. Moffit. 8 pages.

BULLETIN 714–D. Mining in the Matanuska coal fields and the Willow Creek district, Alaska; papers by Theodore Chapin. 10 pages, 1 plate, 1 text figure.

BULLETIN 714–E. Mineral resources of the Goodnews Bay region, Alaska, by G. L. Harrington. 22 pages, 1 plate.

BULLETIN 714–F. Mining on Seward Peninsula, Alaska, by G. L. Harrington. 9 pages.

Five chapters of the annual report on the mineral resources of Alaska for 1919.

BULLETIN 715–C. A deposit of manganese ore in Wyoming, by E. L. Jones, jr. 3 pages.

Describes one of the few manganese deposits known in Wyoming, on the western flank of the Laramie Mountains, 38 miles from Medicine Bow, a station on the Union Pacific Railroad.

BULLETIN 715–D. Some deposits of manganese ore in Colorado, by E. L. Jones, jr. 12 pages.

The search for deposits of manganese ore stimulated by the war disclosed many new deposits in Colorado and other western States, and older deposits were reexamined. This paper describes the principal features of some of these deposits and summarizes their types and modes of occurrence.

BULLETIN 715–E. Geology of the Yellow Pine cinnabar-mining district, Idaho, by E. S. Larsen and D. C. Livingston. 11 pages, 2 text figures.

Describes the quicksilver deposits of the Yellow Pine district, in Valley County, Idaho, about 70 miles by road northwest of Cascade. Cinnabar was discovered here in 1902, but prospecting for it was considerably stimulated by the high prices that prevailed during the war. The district contains some good ore, though no very large deposits have yet been found.

BULLETIN 715–F. Deposits of iron ore near Stanford, Mont., by L. G. Westgate. 8 pages, 4 text figures.

Describes deposits of hematite in Cascade and Fergus counties, Mont., 12 miles southwest of Stanford, a town on the Great Northern Railway. The availability of this ore depends largely on the cost of transportation to manufacturing points and the possibility of economic production of iron in the Rocky Mountain region.

BULLETIN 715–G. Preliminary report on the deposits of manganese ore in the Batesville district, Ark., by Hugh D. Miser. 36 pages, 3 plates, 4 text figures.

One of the reports on the Survey's war investigations of deposits of manganese ore. Describes the geology and the ore deposits in considerable detail. Since 1849 the Batesville district has produced over 75,000 tons of ore carrying at least 35 per cent of manganese and nearly as much more of lower grade.

BULLETIN 715–I. Potash resources of Nebraska, by W. B. Hicks. 15 pages, 1 text figure.

In the sand-hill region of western Nebraska there are more than 100 shallow lakes containing saline water. The potash content of these lakes is estimated at about 215,000 tons. The available information regarding the lakes is set forth in this paper, which includes a section on the origin of the potash.

BULLETIN 715–J. Phosphate rock near Maxville, Granite County, Mont., by J. T. Pardee. 5 pages, 1 plate, 1 text figure.

Some of the most extensive and easily accessible phosphate deposits of Montana occur near Maxville, on a branch of the Northern Pacific Railway, about halfway between Helena and the Idaho boundary. This paper describes these deposits, which are estimated to contain more than 100,000,000 tons of minable phosphate rock of high grade.

BULLETIN 715–K. The Divide silver district, Nev., by Adolph Knopf. 24 pages, 1 plate, 1 text figure.

Describes one of Nevada's newest silver camps, which centers 5 miles south of Tonopah. Soon after the signing of the armistice, when the price of silver was soaring, this district had an intense boom, but subsequent work has revised the estimates of ore reserves, and the boom has very materially subsided.

BULLETIN 715–L. The Mogollon district, N. Mex., by H. G. Ferguson. 30 pages, 6 plates, 2 text figures.

The Mogollon district, in Socorro County, N. Mex., had yielded by the end of 1917 nearly 1,000,000 tons of ore containing gold, silver, copper, and lead valued at more than $15,000,000. This paper gives a sketch of the geology and describes the mines and prospects.

BULLETIN 715–M. Permian salt deposits of the south-central United States, by N. H. Darton. 19 pages, 4 plates, 10 text figures.

Describes a vast deposit of salt in Kansas, Oklahoma, Texas, and New Mexico extending fully 650 miles from north to south and 150 to 250 miles from east to west—probably the largest known salt deposit in the world.

BULLETIN 716–C. The Mule Creek oil field, Wyo., by E. T. Hancock. 19 pages, 1 plate, 1 text figure.

The recognition of an anticline in the Mule Creek field led to exploratory drilling for oil, and in 1919 oil was discovered near the top of a second anticline. This paper describes the geologic features of the field, especially the structure and the porous beds that may possibly yield oil.

BULLETIN 716–D. Natural-gas resources available to Dallas and other cities of central north Texas, by E. W. Shaw and P. L. Ports. 39 pages, 2 plates, 10 text figures.

Report of an investigation made by the Survey at the request of the mayor of Dallas on account of the shortage of natural gas in that and neighboring cities during the winter of 1919–20. Describes the fields now supplying north Texas and other fields from which gas might be obtained.

BULLETIN 716–E. The Lance Creek oil and gas field, Niobrara County, Wyo., by E. T. Hancock. 32 pages, 4 plates.

Drilling was begun in the Lance Creek field in 1912, but the first few holes were either abandoned or yielded only water. Oil was struck in March, 1918, and since then a number of other wells have been drilled and obtained good yields. This paper sets forth the information obtainable relating to the composition and structure of the sedimentary rocks and the conditions controlling the accumulation of oil and gas.

BULLETIN 716–F. Coal in eastern Idaho, by G. R. Mansfield. 31 pages, 2 plates, 3 text figures, 1 insert.

Gives the results of an examination made after the coal shortage of 1916–17 at the request of citizens of eastern Idaho. Though small quantities of coal may be obtained here and there in this region, commercial development seems to be impracticable.

BULLETIN 716–G. Coal in the middle and eastern parts of San Juan County, N. Mex., by C. M. Bauer and J. B. Reeside, jr. 83 pages, 19 plates.

Ever since the earliest settlement of southwestern Colorado the great coal bed, nearly 50 feet thick, in the canyon of Animas River below Durango, has attracted attention, but until recently little exact information has been available concerning the bed in the inhospitable region south of San Juan River. The writers of this report visited that region a few years ago and traced the coal-bearing formation to the point where it ceases to carry coal beds of commercial value.

BULLETIN 716–H. Character of coal in the Thomas bed near Harrison, W. Va., by M. R. Campbell. 3 pages.

Gives recent analyses of a coal described in an earlier report, showing a lower sulphur content than that indicated by the single analysis previously published.

BULLETIN 719. Preliminary report on petroleum in Alaska, by G. C. Martin. 83 pages, 11 plates, 6 text figures.

Although petroleum was among the first of the useful minerals found in Alaska, it received comparatively little attention there until the passage of the oil and gas leasing act February 25, 1920. The provisions of this act that apply to Alaska appear to be liberal and will permit the prospecting of the fairly accessible localities near the Pacific Ocean, where petroleum seepages have been found. These include all the areas that now give promise of becoming commercially important. This bulletin presents a summary of the available information relating to the oil resources of Alaska.

BULLETIN 721. Geology and petroleum resources of northwestern Kern County, Calif., by W. A. English. 48 pages, 2 plates, 2 text figures.

A study of an area of 550 square miles in which there are several developed oil fields and in which it appears possible that other fields may be developed. The discussion is confined mainly to the areal geology and to the possibilities of finding oil in untested areas.

BULLETIN 726–A. The New Salem lignite field, Morton County, N. Dak., by E. T. Hancock. 39 pages, 5 plates, 4 text figures.

The lignite of North Dakota is a fuel of rather low grade, but owing to the distance of the field from better coal, knowledge of the quantity and quality of the local fuel is important, so that if necessary it can be utilized intelligently and without needless waste. This report sets forth the results of a detailed examination of the New Salem field, which lies on the east margin of the great lignite region of North Dakota, South Dakota, and Montana, and is a northern extension of the Cannonball River lignite field, described in an earlier report.

WATER-SUPPLY PAPER 447. Surface water supply of the Pacific slope of southern California, by H. D. McGlashan. 557 pages, 18 plates. Prepared in cooperation with the State of California.

Since 1848, when gold was discovered in California in the course of repairs to a mill race near Georgetown, in Eldorado County, the industrial growth of the State has been closely linked with the development and utilization of its water resources. Information concerning the quantity of water carried by the streams is essential to the development of these resources, and this report gives records of flow at about 500 stations on streams in southern California. The Geological Survey began measurements in 1894, but a few stream studies had been made previously by the State engineer. These investigations have been supplemented by studies of the climatic and other conditions affecting stream flow, and a mass of valuable information has thus been collected affording data for all phases of hydraulic work.

WATER-SUPPLY PAPER 449. Ground water in the Meriden area, Conn., by G. A. Waring. 83 pages, 7 plates, 10 text figures.

One of eight reports resulting from a detailed study of ground water in Connecticut carried on in cooperation by the United States Geological Survey and the Connecticut State Geological and Natural History Survey. This paper covers an area of about 137 square miles in the central lowland. The work consisted chiefly in collecting records of a sufficient number of wells in each town to furnish adequate data concerning the ground water. It included also a study of the surface deposits, which are nearly all of glacial origin.

WATER-SUPPLY PAPER 451. Surface water supply of the United States, 1917, Part I, North Atlantic Slope drainage basins; C. H. Pierce, C. C. Covert, and G. C. Stevens, district engineers. 200, xxxvii pages, 2 plates.

WATER-SUPPLY PAPER 452. Surface water supply of the United States, 1917, Part II, South Atlantic slope and eastern Gulf of Mexico basins; G. C. Stevens and W. E. Hall, district engineers. 92, xxviii pages, 2 plates.

WATER-SUPPLY PAPER 453. Surface water supply of the United States, 1917, Part III, Ohio River basin; A. H. Horton and W. E. Hall, district engineers. 205, xxxii pages, 2 plates.

WATER-SUPPLY PAPER 456. Surface water supply of the United States, 1917, Part VI, Missouri River basin; W. A. Lamb and Robert Follansbee, district engineers. Prepared in cooperation with the States of Colorado, Montana, Wyoming, and Kansas. 242, xlii pages, 2 plates.

WATER-SUPPLY PAPER 461. Surface water supply of the United States, 1917, Part XI, Pacific slope basins in California; H. D. McGlashan and F. F. Henshaw, district engineers. 351, xxxvii pages, 2 plates.

WATER-SUPPLY PAPER 462. Surface water supply of the United States, 1917, Part XII, North Pacific slope drainage basins; A, Pacific basins in Washington and Upper Columbia River Basin; G. L. Parker and W. A. Lamb, district engineers. Prepared in cooperation with the States of Washington, Montana, and Idaho. 181, li pages, 2 plates.

WATER-SUPPLY PAPER 464. Surface water supply of the United States, 1917, Part XII, North Pacific slope drainage basins; C, Lower Columbia River basin and Pacific slope drainage basins in Oregon; F. F. Henshaw and G. L. Parker, district engineers. 200, li pages, 2 plates.

Seven of the annual progress reports giving results of stream gaging during the year ending September 30, 1917.

WATER-SUPPLY PAPER 466. Ground water in the Southington-Granby area, Conn., by H. S. Palmer. 219 pages, 7 plates, 30 text figures.

Another of the cooperative reports on ground water in Connecticut, of similar scope to Water-Supply Paper 449, noticed above. Covers over 500 square miles in the central lowland and western highland.

WATER-SUPPLY PAPER 467. Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nev., by W. O. Clark and C. W. Riddell, with an introduction by O. E. Meinzer. 70 pages, 6 plates, 6 text figures.

The agricultural conquest of vast areas of arable land belonging to the public domain forms a brilliant chapter in the history of the United States. Apparently boundless expanses of Government land have been converted into productive farms within the last few decades, but to-day the country is beginning to realize that practically all the tracts that can readily be made productive without irrigation have been occupied and that practically all the streams that can be cheaply utilized for irrigation have been appropriated. Greater attention is therefore being paid to the possibility of obtaining water for irrigation by means of wells. As the ground water is hidden beneath the surface, there is necessarily much uncertainty as to its occurrence and quantity, and projects for utilizing it should not be undertaken without adequate investigation. This paper describes such an investigation in one of the desert valleys that lie between the mountain ranges of Nevada. This investigation was the first to be undertaken under a special appropriation by Congress for the fiscal year 1918. The paper throws light on the problem of obtaining ground water in other areas where the conditions are similar.

WATER-SUPPLY PAPER 468. Records of water levels in wells in southern California, by F. C. Ebert. Prepared in cooperation with the Department of Engineering of the State of California. 156 pages, 4 plates, 1 text figure.

The prosperity of the valley of southern California depends largely on its ground-water resources. More than two-thirds of the irrigated land in that region is supplied with ground water. Records of the fluctuations of the water table extending over long periods are particularly valuable, because they show the depletion of the underground supply during times of light precipitation and heavy pumping and the replenishment of the supply during times of heavy precipitation. Observations of the water level in typical wells have been made from time to time, and the records thus obtained are presented in this paper, which contains also a discussion of the causes of the fluctuations and the general conditions shown by the records.

WATER-SUPPLY PAPER 470. Ground water in the Norwalk, Suffield, and Glastonbury areas, Conn., by H. S. Palmer. 171 pages, 12 plates, 18 text figures.

Another of the series of cooperative reports on the water resources of Connecticut, similar to Water-Supply Paper 449, noticed above. Covers thirteen towns in three distinct areas—one in the southwest corner of the State, one in the central part, and one at the north boundary.

WATER-SUPPLY PAPER 472. Surface water supply of the United States, 1918, Part II, South Atlantic slope and eastern Gulf of Mexico basins; G. C. Stevens and C. G. Paulsen, district engineers. 85, xxix pages, 2 plates.

WATER-SUPPLY PAPER 474. Surface water supply of the United States, 1918, Part IV, St. Lawrence River basin; W. G. Hoyt, A. H. Horton, C. G. Covert, and C. H. Pierce, district engineers. 142, xxxii pages, 2 plates.

WATER-SUPPLY PAPER 481. Surface water supply of the United States, 1918, Part XI, Pacific slope basins in California; H. D. McGlashan and F. F. Henshaw, district engineers. Prepared in cooperation with the States of California and Oregon. 314, xxxviii pages, 2 plates.

Three of the annual reports on stream gaging, giving measurements made during the year ending September 30, 1918.

WATER-SUPPLY PAPER 490–A. Routes to desert watering places in the Salton Sea region, Calif., by J. S. Brown. 86 pages, 7 plates, 2 text figures.

The so-called desert region of the United States, a huge triangle with an 800-mile base along the Mexican border and its apex in Oregon, contains prosperous cities, fertile agricultural districts, forest-clad mountains, and rich mines. But the localities that have water supplies in this region are widely separated oases in a vast expanse of unproductive desert, whose chief evidences of human occupation are the long roads that lead from one watering place to another. The need of making the desert safe and accessible by mapping, marking, and improving its watering places has long been appreciated, and in 1916 Congress authorized a beginning of this work. The driest, hottest, and least explored part of the region, comprising 60,000 square miles in California and Arizona, has now been mapped, most of the watering places were examined, and over 600 signs directing travelers to water were erected. Reports are being prepared that will give detailed information about the watering places and other features of the region, but to supply the most urgently needed information in advance of the publication of these reports a series of abbreviated guides has been prepared, each giving a brief sketch of a portion of the region, road logs, suggestions to travelers, and the detailed maps that will appear in the complete report. The present paper, the first of these abbreviated guides, covers about 10 000 square miles in the southeast corner of California.

WATER-SUPPLY PAPER 491. Water supply of St. Mary and Milk rivers, 1898–1917, by B. E. Jones and R. J. Burley. 590 pages, 26 plates.

Reprint of a report published by the International Joint Commission, giving records of flow of streams and canals in the St. Mary and Milk River basins, collected by the United States Geological Survey in cooperation with the United States Reclamation Service and by the Reclamation Service of Canada.

WATER-SUPPLY PAPER 500–A. Coeur d'Alene Lake, Idaho, and the overflow lands, by R. W. Davenport. 31 pages, 3 plates, 4 text figures.

A controversy regarding the use of Coeur d'Alene Lake, Idaho, as a storage reservoir has existed for several years between the Washington Water Power Co. and owners of overflow lands near the lake and its tributaries. Because of the functions of the Department of the Interior in administering public lands, the controversy has been placed several times before the department for consideration. A recent request made of the Geological Survey for technical advice necessitated a field investigation, and the engineer who made it gives in this paper a brief report on the conditions existing and the conclusions reached.

MINERAL RESOURCES OF THE UNITED STATES, 1917, Part I, Metals. 1059 pages, 8 plates, 18 text figures, 1 insert.

The chapters of this volume were published separately at different dates between June, 1918, and August, 1920. It contains maps of the world showing districts producing tin, quicksilver, and copper, and many other maps and diagrams. One advance chapter was also published during the year.

MINERAL RESOURCES OF THE UNITED STATES, 1918. Fifteen advance chapters.

MINERAL RESOURCES OF THE UNITED STATES, 1919. Thirty-five advance chapters.

MINERAL RESOURCES OF THE UNITED STATES, 1920. One advance chapter.

GEOLOGIC FOLIO 211. Elkton-Wilmington, Md., Del., N. J., Pa., by F. Bascom and B. L. Miller. 22 folio pages of text, 4 maps, 5 text figures, and generalized section.

The Elkton and Wilmington quadrangles cover an area of 460 square miles lying mainly in Delaware and Maryland but including also narrow strips of the adjacent portions of New Jersey and Pennsylvania. The northwestern third of the area lies in the Piedmont province of the Appalachian Highlands and the southeastern two-thirds in the Coastal Plain. The Piedmont division is described in this folio by Prof. Bascom; the Coastal Plain division by Prof. Miller. The oldest formations belong to the island stage of continental development, when a long, narrow island extended along the border of the Continental Plateau from northern Florida to Canada. From this island, which has been called Appalachia, were eroded the materials that were laid down in beds which ultimately, after they had been folded, uplifted, and in their turn eroded, formed the Appalachian Highlands. The sediments of the Coastal Plain record alternating periods of uplift and depression, and there is evidence to show that along Delaware River a slow downward movement still continues.

GEOLOGIC FOLIO 212. Syracuse-Lakin, Kans., by N. H. Darton. 10 folio pages of text, 6 maps, 7 text figures, 6 plates.

The Syracuse and Lakin quadrangles cover 1,888 square miles in southwestern Kansas and lie entirely in the Great Plains province. The region is semiarid and is thinly populated. The principal industry is cattle raising, but small areas are cultivated, and forage and sugar beets are raised by irrigation. The strata that crop out in these quadrangles include Cretaceous sandstones, shales, and limestones and Tertiary and Quaternary sands and gravels. The area is underlain by Cretaceous and Carboniferous strata but contains no igneous rocks. The only mineral resource of any great value is the underground water, which can be obtained in satisfactory quantity in most parts of the area by wells of shallow depth. This folio contains the records of several wells and analyses of their waters. It gives a general account of the geology of the Great Plains province, as well as a description of the two quadrangles.

WORLD ATLAS OF COMMERCIAL GEOLOGY, Part I, Distribution of mineral production. 72 pages, 72 plates.

The study of the world's supply of essential minerals was begun during the World War as a part of the task of keeping American industries supplied with raw material. A preliminary world atlas of commercial geology was prepared in manuscript form for the use of the State Department and the Peace Commission, and the present publication is issued in the belief that it will be found helpful in directing both the mineral industry and the commerce of the United States.

TOPOGRAPHIC AND OTHER MAPS as indicated below. (The maps marked * were also published with a green overprint showing woodland areas.)

Alaska.

Alaska: Scale, 1 inch=80 miles.

Revised edition of base map of Alaska showing in black the positions and names of the principal places and features and in blue the larger water bodies and streams. Also printed in an edition showing by colors and symbols the distribution of the principal known mineral deposits of Alaska.

California.

Daulton: Scale, 1 inch=½ mile; contour interval, 5 feet. Latitude, 37° to 37° 10′; longitude, 119° 52′ 30″ to 120°.

Map of part of Madera County, showing the eastern margin of the Great Valley of California and the foothills a short distance northeast of Madera and 20 miles north of Fresno.

* Gilroy Hot Springs: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 37° to 37° 15′; longitude, 121° 15′ to 121° 30′.

Map of part of Stanislaus and Santa Clara counties, a hilly region forming part of the Diablo Range.

* Indian Gulch: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 37° 15′ to 37° 30′; longitude, 120° to 120° 15′.

Map of parts of Mariposa and Merced counties. It shows in its southwestern part the eastern border of the Great Valley of California.

* Lucia: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° to 36° 15′; longitude, 121° 30′ to 121° 45′.
  Map of part of the coast line of California, in Monterey County, and the Santa Lucia Range and associated highlands on the east.
* Metz: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 15′ to 36° 30′; longitude, 121° to 121° 15′.
  Map of parts of Monterey and San Benito counties, an area which in its southwestern part includes the broad flood plain of Salinas River, which is succeeded on the northeast by slopes leading upward to the crest of the Gabilan Range.
* Pacheco Pass: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 37° to 37° 15′; longitude, 121° to 121° 15′.
  Map of parts of Merced, Stanislaus, and Santa Clara counties, a region which contains in its eastern part the nearly flat plain west of San Joaquin River and in its central and western parts the mountains of the Diablo Range.

Yosemite National Park: Scale, 1 inch=2 miles; contour interval, 100 feet. Latitude, 37° 30′ to 38° 15′; longitude, 119° to 120°.
  A new edition of the topographic map of Yosemite National Park, revised and brought up to date, with numerous additions and corrections.

Georgia.

[See also Georgia–South Carolina.]

* Appling: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 33° 30′ to 33° 45′; longitude, 82° 15′ to 82° 30′.
  Map of parts of Columbia, Lincoln, and McDuffie counties, in eastern Georgia, a short distance northwest of Augusta.
* Irwinton: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 32° 45′ to 33°; longitude, 83° to 83° 15′.
  Map of parts of Wilkinson, Baldwin, and Washington counties, in the east-central part of Georgia, a region of low relief whose lowest points lie along Oconee River.
* Oliver: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 30′ to 32° 45′; longitude, 81° 30′ to 81° 45′.
  Map of parts of Screven, Bulloch, and Effingham counties, in eastern Georgia, a region of relatively slight relief, traversed by Ogeechee River.
* Pembroke: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° to 32° 15′; longitude, 81° 30′ to 81° 45′.
  Map of parts of Bryan, Bulloch, Liberty, and Evans counties, in eastern Georgia, 15 to 30 miles west of Savannah.
* Rocky Ford: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 30′ to 32° 45′; longitude, 81° 45′ to 82°.
  Map of parts of Bulloch, Screven, Jenkins, and Candler counties, in eastern Georgia, a region of rolling, dissected topography, whose greatest differences of elevation are less than 250 feet.
* Stapleton: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 33° to 33° 15′; longitude, 82° 15′ to 82° 30′.
  Map of parts of Jefferson, Burke, and Glasscock counties, in eastern Georgia, a region whose surface ranges in elevation from about 200 feet to 500 feet above sea level.
* Statesboro: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 15′ to 32° 30′; longitude, 81° 45′ to 82°.
  Map of parts of Bulloch, Candler, and Evans counties, in east-central Georgia, a region of low relief whose highest points stand less than 300 feet above the sea and whose lowest points are about 100 feet above the sea.

Georgia–South Carolina.

* Ellenton: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° to 33° 15′; longitude, 81° 30′ to 81° 45′.
  Map of part of Barnwell County, S. C., and Burke and Screven counties, Ga. Savannah River, which forms the boundary between the two States, is bordered both to the north and south by rolling, considerably dissected upland standing from 150 to 250 feet above the river.

*Hilltonia: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 45′ to 33°; longitude, 81° 30′ to 81° 45′.

Map of part of Screven and Burke counties, Ga., and a very small area in Barnwell County, S. C.

Illinois.

Jonesboro: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 37° 15′ to 37° 30′; longitude, 89° 15′ to 89° 30′. (Part of quadrangle.)

Map of part of Union and Alexander counties in extreme southwestern Illinois. The western part of the area contains Mississippi River and the flood plain about 4 miles wide east of it. Farther east very much dissected uplands rise 400 feet above the river.

*Vermont: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 40° 15′ to 40° 30′; longitude, 90° 15′ to 90° 30′.

Map of part of Fulton, McDonough, and Schuyler counties, in west-central Illinois, a rather low plain, in places minutely dissected by tributaries of Illinois River and their side streams.

Kansas.

Oil and gas fields of the State of Kansas: Scale, 1 inch=12 miles.

Map prepared under the direction of G. B. Richardson on base compiled by General Land Office, which shows by distinctive colors and symbols the productive oil and gas fields, trunk oil pipe lines, and oil refineries.

Louisiana.

Oil and gas fields of the State of Louisiana: Scale, 1 inch=12 miles.

Map prepared under the direction of G. B. Richardson on base compiled by General Land Office, which shows by distinctive colors and symbols the productive oil and gas fields, trunk oil pipe lines, and oil refineries.

Maine.

*Columbia Falls: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° 30′ to 45°; longitude, 67° 30′ to 67° 45′.

Map of part of Washington County, in southeastern Maine, a region which has an irregular coast line, with numerous islands offshore, and inland a diversified topography in which rocky knobs and gravelly knolls and swamps are intricately intermingled.

*Great Wass Island: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° 15′ to 44° 30′; longitude, 67° 30′ to 67° 45′.

Map of part of the coast of Maine in Washington County. A fringe of islands, of which Great Wass Island is the largest, occupies the northern quarter of the area.

*Winn: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 45° 15′ to 45° 30′; longitude, 68° 15′ to 68° 30′.

Map of part of Penobscot County, in the east-central part of Maine, a region of lakes or ponds of irregular size and outline and low, smoothly rounded hills, the highest of whose summits stand at elevations of less than 900 feet above the sea.

Missouri–Nebraska.

*Craig: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 40° to 40° 15′; longitude, 95° 15′ to 95° 30′.

Map of part of the flood plain of Missouri River and the bordering uplands in Holt County, Mo., and Richardson County, Nebr. The boundary between the two States is an irregular line whose position seems to follow what was formerly the course of the channel.

Montana.

*Drummond: Scale, 1 inch=2 miles; contour interval, 100 feet. Latitude, 46° 30′ to 47°; longitude, 113° to 113° 30′.

Map of part of Missoula, Powell, and Granite counties, in west-central Montana, a mountainous region drained by Clark Fork and Blackfoot River and their tributaries.

Nebraska.

[See Missouri–Nebraska.]

New Mexico.

*Animas Peak: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 31° 30′ to 31° 45′; longitude, 108° 45′ to 109°.

Map of part of Grant County, in the extreme southwestern part of New Mexico, affording a splendid example of a dissected lowland (Animas Valley) between two mountains (the Peloncillo Mountains and the Animas Mountains).

New York.

Rochester: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 43° to 43° 20′; longitude, 77° 30′ to 77° 45′.

Map formed by combining and printing as one sheet the maps formerly issued for the Rochester and Ontario Beach quadrangles. The map is based on old surveys, and the culture has not been revised since 1911.

North Carolina.

[See Virginia–North Carolina.]

North Dakota.

State map: Scale, 1 inch=8 miles; no contours.

Base map of the State of North Dakota in one color (black). It shows county and township boundaries, location and names of all towns, and most of even the smaller settlements, as well as the railroads, the rivers, and many of the smaller streams and water features.

Oregon.

*Brownsville: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 44° 15′ to 44° 30′; longitude, 122° 45′ to 123°. (Part of quadrangle.)

Incomplete map of the east-central border of the fertile Willamette region, in Linn County, western Oregon. Only the lowlands adjacent to the larger streams, Calapooya and South Santiam rivers, are mapped.

*Corvallis: Scale, 1 inch=1 mile; contour interval, 25 feet. Latitude, 44° 30′ to 44° 45′; longitude, 123° 15′ to 123° 30′. (Part of quadrangle.)

Map of part of Benton and Linn counties, showing part of the celebrated Willamette Valley region.

*Heceta Head: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 44° to 44° 15′; longitude, 124° to 124° 15′.

Map of part of Lane County, showing the nearly smooth coast line bordering on the Pacific Ocean, which is broken by the outjetting headlands of Heceta Head and Sea Lion Point.

*Siltcoos Lake: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 43° 45′ to 44°; longitude, 124° to 124° 15′.

Map of parts of Lane and Douglas counties, which shows from west to east a smooth north-south shore line, east of which is a low sandy plain, succeeded by hilly country.

Pennsylvania.

*Meyersdale: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 39° 45′ to 40°; longitude, 79° to 79° 15′.

Map of part of Somerset County, in southwestern Pennsylvania, a region of considerable relief, whose highest points stand at elevations of more than 3,200 feet, and whose lowest points are less than 1,600 feet above the sea.

South Carolina.

[See also Georgia–South Carolina.]

* Bamberg: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 81° to 81° 15′.

Map of parts of Bamberg, Orangeburg, and Barnwell counties, 35 to 50 miles south of Columbia.

*Chicora: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 80° to 80° 15′.

Map of parts of Berkeley, Clarendon, and Orangeburg counties, in eastern South Carolina. A great deal of the region is swampy; the courses of almost all the streams are lined with swamps, and even on the uplands there are extensive swamps, locally called "bays."

*Eutawville: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 15′ to 33° 30′; longitude, 80° 15′ to 80° 30′.

Map of part of the Coastal Plain in Orangeburg, Clarendon, Berkeley, and Dorchester counties, in eastern South Carolina.

*Lodge: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° to 33° 15′; longitude, 80° 45′ to 81°.

Map of parts of Colleton, Bamberg, Orangeburg, and Dorchester counties in south-central South Carolina. The region is part of the Atlantic Coastal Plain province and is characterized by large expanses of nearly flat uplands cut here and there by southeastward-flowing streams.

*Manning: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 30′ to 33° 45′; longitude, 80° to 80° 15′.

Map of part of Clarendon, Williamsburg, and Berkeley counties, in east-central South Carolina, a region in which the upland is a plain sloping gently eastward, whose highest points are only about 130 feet above sea level.

*Mayesville: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° 45′ to 34°; longitude, 80° to 80° 15′.

Map of parts of Sumter, Clarendon, and Lee counties, a region whose surface slopes gently eastward and is traversed by trenches which apparently represent old stream courses that are now occupied by swamps.

*Ravenels: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 32° 45′ to 33°; longitude, 80° to 80° 15′.

Map of parts of Charleston, Dorchester, and Berkeley counties, in the eastern part of South Carolina, near Charleston. The region lies close to the coast and is traversed by parts of several large rivers.

*St. George: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° to 33° 15′; longitude, 80° 30′ to 80° 45′.

Map of parts of Dorchester, Colleton, and Orangeburg counties, a low plain about 100 feet above the sea, whose upland slopes gently eastward.

*Summerville: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 33° to 33° 15′; longitude, 80° to 80° 15′.

Map of parts of Berkeley and Dorchester counties, in the east-central part of South Carolina, near Charleston. All of the region is low, no point rising to an elevation of as much as 100 feet.

Texas.

Bone Spring: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 29° 30′ to 29° 45′; longitude, 103° to 103° 15′. Previous issue, photolithograph. (See Fortieth Annual Report.)

*Burnett Bay: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 29° 45′ to 29° 52′ 30″; longitude, 95° to 95° 7′ 30″.

Map of part of eastern Harris County, which is a plain traversed by Buffalo Bayou and San Jacinto River. The southern part of the region is only about 7 miles from Galveston Bay, and the lower courses of the larger streams have been submerged.

*Fauna: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 29° 45′ to 29° 52′ 30″; longitude, 95° 7′ 30″ to 95° 15′.

Map of part of Harris County, a short distance east of the city of Houston. In general the region is a plain sharply trenched by Greens Bayou and other tributaries of Buffalo Bayou.

*Genoa: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 29° 30′ to 29° 37′ 30″; longitude, 95° 7′ 30″ to 95° 15′. (Part of quadrangle.)

Map of southern part of Harris County, a plain of such slight relief that the railroads that cross the region follow perfectly straight courses for 7 or 8 miles.

*Huffman: Scale, 1 inch=½ mile; contour interval, 1 foot. (Part of quadrangle.) Latitude, 30° to 30° 10′; longitude, 95° to 95° 7′ 30″.

Map of northern Harris County, a plain traversed by San Jacinto River and its tributaries, the largest of which in the area mapped is Luce Bayou.

*La Porte: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 29° 37′ 30″ to 29° 45′; longitude, 95° to 95° 7′ 30″.

Map of part of Galveston and San Jacinto bays and the region adjacent thereto, in the eastern part of Harris County. Most of the upland is a smooth, nearly featureless plain, but near the bays or the larger streams it is cut by numerous deep, narrow gulches.

*Louetta: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 30° to 30° 7′ 30″; longitude, 95° 30′ to 95° 37′ 30″.

Map of part of northwestern Harris County, a region of relatively low relief, the difference in elevation between its highest and lowest points being only a little more than 100 feet.

*Moonshine Hill: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 30° to 30° 7′ 30″; longitude, 95° 7′ 30″ to 95° 15′. (Part of quadrangle and a small adjoining area at the north.)

Map of part of northern Harris County, a plain traversed by San Jacinto River and its tributaries.

*Satsuma: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 29° 52′ 30″ to 30°; longitude, 95° 30′ to 95° 37′ 30″.

Map of part of the general southeastward-sloping plain in Harris County, an area of relief so slight that the greatest difference in elevation is only 50 feet.

*Spring: Scale, 1 inch=½ mile; contour interval, 1 foot. (Part of quadrangle.) Latitude, 30° to 30° 7′ 30″; longitude, 95° 22′ 30″ to 95° 30′.

Map of part of northern Harris County, a plain which is considerably dissected by streams but in which the greatest difference in elevation is only about 75 feet.

*Waller: Scale, 1 inch=½ mile; contour interval, 1 foot. Latitude, 30° to 30° 7′ 30″; longitude, 95° 52′ 30″ to 96°. (Part of quadrangle, with adjacent small areas.)

Map of extreme northwestern part of Harris County, a region of slight relief which, however, owing to the small contour interval used in mapping has every minor depression and elevation strongly emphasized.

United States.

Relief map: Scale, 1 inch=50 miles.

A map of the United States on which is indicated by depth of brown and blue colors the relative heights of the land and the depths of the sea. The position of the principal cities and the boundaries of the States are shown. The original of this map was prepared by J. H. Renshawe from all authoritative data available.

Vermont.

*Lincoln Mountain: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 44° to 44° 15′; longitude, 72° 45′ to 73°.

Map of part of Washington, Addison, and Chittenden counties, in central Vermont, which is part of the famous Green Mountains. Several of the peaks, among them Lincoln Mountain, rise over 4,000 feet.

Virginia.

[See also Virginia–North Carolina.]

*Coeburn: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 36° 45′ to 37°; longitude, 82° 15′ to 82° 30′. (Part of quadrangle.)

Map of that part of the Coeburn quadrangle that lies north of Clinch River. Includes parts of Wise, Dickenson, Scott, and Russell counties. It is a hilly region, considerably cut by streams.

*Homeville: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 36° 45′ to 37°; longitude, 77° to 77° 15′.

Map of part of Sussex and Southampton counties, in southeastern Virginia, a dissected plain that stands about 100 feet above the sea and slopes gently eastward.

*Lawrenceville: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 36° 45′ to 37°; longitude, 77° 45′ to 78°.

Map of parts of Brunswick, Dinwiddie, and Nottoway counties, in southeastern Virginia, a dissected plain whose upland stands at an elevation of about 400 feet in the western part.

*McKenney: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 36° 45′ to 37°; longitude, 77° 30′ to 77° 45′.

Map of parts of Greensville, Dinwiddie, Brunswick, and Sussex counties, in southeastern Virginia, which adjoins the Lawrenceville quadrangle on the east and shows much the same kind of topography except that its elevation is less.

*Newport News: Scale, 1 inch=1 mile; contour interval, 5 feet. Latitude, 36° 45′ to 37°; longitude, 76° 15′ to 76° 30′.

Map of Hampton Roads and the adjacent land and water. The land area is a plain of low elevation, little of it standing more than 25 feet above sea level, intersected by numerous partly depressed valleys, whose lower courses are occupied by the sea.

Virginia–North Carolina.

*Arringdale: Scale, 1 inch=1 mile; contour interval, 10 feet. Latitude, 36° 30′ to 30° 45′; longitude, 77° 15′ to 77° 30′.

Map of part of Southampton and Greensville counties, in southeastern Virginia, and Northampton County, in northeastern North Carolina; a part of the Coastal Plain province and a region of low relief.

*White Plains: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 36° 30′ to 36° 45′; longitude, 77° 45′ to 78°.

Map of parts of Brunswick and Greensville counties, Va., and Northampton, Warren, and Halifax counties, S. C. A region considerably dissected but of low relief, the highest points standing at little more than 400 feet.

*Wickersham: Scale, 1 inch= 1 mile; contour interval, 50 feet. Latitude, 48° 30′ to 48° 45′; longitude, 122° to 122° 15′.

Map of part of Whatcom and Skagit counties, in northwestern Washington, a mountainous area west of Mount Baker. The highest peak rises over 6,000 feet, and much of the region is over 4,000 feet above the sea.

West Virginia.

*Greenland Gap: Scale, 1 inch=1 mile; contour interval, 50 feet. Latitude, 39° to 39° 15′; longitude, 79° to 79° 15′.

Map of part of Grant and Hardy counties, in northeastern West Virginia, a region characterized in the eastern part by northeastward-trending, rather narrow ridges, separated by rolling lowlands, and in the northwestern part by the nearly straight escarpment of the Allegheny Front, which is succeeded to the west by a plateau sloping gently westward.

Wisconsin.

*Mauston: Scale, 1 inch=1 mile; contour interval, 20 feet. Latitude, 43° 45′ to 44°; longitude, 90° to 90° 15′.

Map of part of Juneau County, in south-central Wisconsin. The eastern and northern part of the area is a broad plain in which flow Lemonweir and Yellow rivers and their tributaries. The southwestern part of the area is a highland considerably dissected by small streams.

Wyoming.

*Afton: Scale, 1 inch=2 miles; contour interval, 100 feet. Latitude, 42° 30′ to 43°; longitude, 110° 30′ to 111°.

Map of part of Lincoln County, in extreme western Wyoming, a region characterized by north-south ranges, most of whose peaks rise to elevations of more than 10,000 feet above the sea.

GEOLOGIC BRANCH.

SCOPE AND ORGANIZATION OF WORK.

The work of the geologic branch comprises all phases of geology and related investigations in mineralogy, chemistry, and physics, as well as a census of the country's mineral resources. Many special investigations are made for and in cooperation with other depart-

ments of the Government, commissions, States, and municipalities. The results are published in printed official reports or in professional or technical journals.

The geologic branch, under the supervision of David White, chief geologist, consists of four divisions:

1. The division of geology (Sidney Paige, geologist in charge) conducts areal geologic surveys and special scientific and economic investigations and researches. It is engaged in preparing the geologic map of the United States and in studying the geology of mineral deposits; and through field examinations it cooperates in the classification of the mineral lands of the public domain.
2. The division of Alaskan mineral resources (Alfred H. Brooks, geologist in charge) carries on geologic, topographic, and hydrologic surveys in Alaska. This division, which essentially constitutes a completely organized Geologic Survey of Alaska, is in most respects autonomous.
3. The division of mineral resources (G. F. Loughlin, geologist in charge) keeps the public informed as to the state of the mineral industries and the rate of production of mineral commodities in the United States. This division also compiles and prepares for publication information concerning foreign mineral deposits—their geology, quality, reserves, state of development, output, and trade distribution. Branch offices of this division are maintained at San Francisco, Salt Lake City, and Denver.
4. The division of chemical and physical research (George Steiger, chief chemist, acting in charge) makes the chemical analyses that are essential to the work of the geologic branch and conducts physical and chemical researches bearing on geologic problems.

DIVISION OF GEOLOGY.

ORGANIZATION AND PERSONNEL.

At the beginning of the year the scientific force of the division of geology consisted of 86 geologists, 17 associate geologists, 12 assistant geologists, 12 geologic aids, and 3 junior geologists, a total of 130. During the year 6 geologists, 2 associate geologists, 3 assistant geologists, 4 geologic aids, and 1 junior geologist resigned; 2 geologists were retired, and 2 geologists and 1 geologic aid died, making a total of 21 separations. There were appointed during the year 3 geologists, 4 assistant geologists, 10 geologic aids, and 1 mineral geographic aid. Two were transferred to the division from other divisions of the Survey. As the result of these changes and of promotions, the total at the end of the year was 129, including 86 geologists, 12 associate geologists, 15 assistant geologists, 13 geologic aids, 2 junior geologists, and 1 mineral geographic aid.

The division is organized in sections, named below, and it also exercises administrative supervision of the section of geologic map editing, a part of the publication branch. The principal activities of the sections are described in the annual reports for 1917 and 1919.

1. Section of eastern areal geology; Arthur Keith, geologist in charge.
2. Section of western areal geology; Sidney Paige, geologist in charge.
3. Section of Coastal Plain investigations; T. Wayland Vaughan, geologist in charge. Subsection of sedimentary investigations; E. W. Shaw, geologist in charge until his resignation in March, 1921.
4. Section of glacial geology; W. C. Alden, geologist in charge.
5. Section of paleontology and stratigraphy; T. W. Stanton, geologist in charge.
6. Section of geology of metalliferous deposits; F. L. Ransome, geologist in charge.
7. Section of petrology; E. S. Larsen, jr., geologist in charge.
8. Section of geology of iron and steel alloy metals; E. F. Burchard, geologist in charge.

9. Section of the geology of nonmetalliferous deposits; H. S. Gale, geologist in charge prior to his resignation in August, 1920; G. R. Mansfield, geologist acting in charge.

10. Section of the geology of coal fields; M. R. Campbell, geologist in charge.

11. Section of the geology of oil and gas fields; in charge of the chief geologist, with K. C. Heald, assistant chief of section, acting in charge, until January 1, 1921, when Mr. Heald was placed in full charge.

PUBLICATIONS.

The publications emanating from this division issued during the year (see pp. 9–14, 17) comprise two professional papers and six chapters of three others, seven complete bulletins, twenty parts of four other bulletins, and two geologic folios. Besides the official publications, twenty-six papers were, with the permission of the Director, published by scientific societies or in scientific or technical journals. Four reports based on work done in cooperation with State geological surveys have been transmitted to the States for publication.

AREA SURVEYED.

The area covered in geologic mapping during the year, in square miles, was as follows: Detailed, 4,607; reconnaissance, 21,713; exploratory, 18,000.

FINANCIAL STATEMENT.

The total funds available for the geologic work of the Survey in the United States for the fiscal year 1920–21 were as follows:

Geologic surveys	$352,000.00
Repayments	2,875.00
Classification of lands	25,500.00
Scientific assistants	17,700.00
Search for potash deposits (part of appropriation for chemical and physical researches)	7,500.00
	405,575.00

The authorized expenditures, classified by subjects, were approximately as follows:

Economic geology of metalliferous deposits	$50,000
Economic geology of nonmetalliferous deposits	23,575
Economic geology of fuels (oil, gas, coal)	110,000
Scientific researches not directly connected with economic purposes (paleontology, glaciation, Coastal Plain formations, etc.)	117,000
Supervision, administration, salaries of clerical, technical, and skilled-labor forces, purchase and repair of instruments, office supplies, etc	105,000
	405,575

Of the amounts available for geologic work, $122,000 was used directly for field expenses, including the search for potash. About 75 per cent of this amount was expended west of the one hundredth meridian, and about 25 per cent east of it.

COOPERATION.

The fullest cooperation with other bureaus, departments, State surveys and mining bureaus, and universities and institutions of scientific research has been maintained. The demands on the Sur-

vey's paleontologists for examinations of collections of fossils from foreign countries, particularly those under investigation by American oil companies, have been greater than ever.

A brief outline of the scope of the Survey's activities, in both formal and informal cooperation, which are largely continuous from year to year, will be found on page 45 of the Forty-first Annual Report. The principal cooperative projects are noted in the account of the work by States. Cooperation in the geologic surveys of Haiti and the Dominican Republic is described on pages 6–7, 48.

GENERAL REVIEW OF THE WORK OF THE YEAR.

Comparison of the personnel summary given on page 24 with that of the previous year shows a smaller turnover in the geologic staff and nominal replacement of current losses. Slight numerical gains have been made in the sections on coal and metalliferous deposits, which were at the lowest stage. The staff of oil and gas geologists has suffered some further depletion. The Coastal Plain section has held its own, the section of paleontology and stratigraphy has been strengthened, and the areal sections have been slightly increased, mainly by the return of geologists from work on the economic geology of war minerals.

There is, however, a net loss in efficiency resulting from the loss of Survey training of those who have left and the long time required to develop equal specialized training in the new accessions to the staff. Further losses, in effect, result both from the more rapid advancement of young men to grades with higher salaries, which is necessary to retain them in the service, without corresponding increase of experience and ability, and from the increase in the cost of field operations. Field expenses are so high as to restrict the recruiting of that complement of young men—assistants and understudies—requisite to the utilization of the older and more experienced men of the staff so as to assure the largest and most economical aggregate production.

Some diminution of output that may be noted is due in part to the lower efficiency just mentioned and in part to the resumption of work on research problems that are less fruitful of short reports, many of which are the result of brief or minor investigations. Loss of productivity is also due to the cramped and inadequate quarters in which the geologists are now compelled to carry on their office work in Washington. Nevertheless there has been no deterioration in the product. Thanks to the scientific zeal of the chiefs of sections, the standards of achievement have in general been raised rather than suffered to decline.

Among the more important reports in progress during the year that on the Sauropoda deserves particular mention. This monographic work, embodying the results of many years of research by Dr. Henry Fairfield Osborn, like that on the Titanotheres; is based in part on the early paleontologic explorations of the Western States, many of which antedate the present Geological Survey. These comprehensive and monumental monographs, requiring the learning of many paleontologists, have been prepared at relatively little cost to the Survey in recent years. Their continued progress is due mainly to the steadfast devotion to science of America's most distinguished paleontologist.

The completion of the guide to the geography, geology, and natural resources along the Denver & Rio Grande Western Railroad in Colorado and Utah, by M. R. Campbell, now nearly ready for the printer, will add another volume to the series of popular educational bulletins prepared by the Survey for the traveler and teacher. Work on the geographic handbooks of the New England States and the Virginian region, taken up during the World War, has been temporarily laid aside for the completion of other projects of prior origin or in more urgent demand.

A notable feature of the year is the issue of short descriptions of prospective oil fields in the form of mimeographed press notices, with structure contour maps, as soon as the maps are drawn, the most important and salient economic results of the field investigations being thus placed in the hands of the public and the industry with the least possible loss of time.

The long search for beds of potash salts interstratified with deposits of salt and gypsum in the Permian "Red Beds" region of the Southwest now gives promise of success. The discovery of two or more potash-bearing beds at three localities within a distance of about 150 miles vindicates the faith, founded upon scientific deduction, held by the Survey. It remains to be seen, however, whether these deposits are of workable thickness, for it has not yet been proved that they are more than a few inches thick in the aggregate, though indefinite evidence suggests a greater thickness. It now seems very likely that the presence of potash deposits of workable thickness and of notable extent will be found at some point in this region, probably in its southern half. In view of the very few borings for oil in the region where potash may be found and the unsatisfactory observations—unsatisfactory except at great difficulty—attending drilling with the rotary rig, which is now used, the determination of this question may be long delayed. It may be necessary to drill with a core drill at public expense if private initiative does not yield sufficient information.

As will be seen in the review by States of the more important work carried on during the year, the geologic activities of the Survey are now on as nearly a normal basis as they can be put in view of the serious depletion of its former highly trained and specialized staff and the high cost of field operations. Many investigations that were under way in 1915–1917 and many reports that were in progress when the United States entered the World War have not been and can not be finished at present, on account of the loss of the geologists who were acquainted with the details in the field or who alone were qualified for the proper writing up of highly specialized and in some cases incomplete researches then abruptly terminated. Most of the unfinished field projects have been completed, however, and the scientific as well as economic results of the special investigations of mineral deposits essential to the prosecution of the war are now embodied in reports.

On the other hand, it is most unfortunate that these reports, embracing more particularly the scientific and general geologic conclusions of permanent value, have not yet been placed in the hands of the public on account of the insufficiency of the funds for printing.

At the end of the fiscal year 66 geologic manuscripts were in the hands of the editors or at the Government Printing Office. A num-

ber of other manuscripts are nearly or quite finished, and a considerable additional number, mainly folios and economic papers by geologists who have left the Survey, have now been brought practically or wholly to completion in the division of geology.

WORK OF THE DIVISION, BY STATES.

The activities of the division of geology have in one way or another extended to every State of the Union and, mainly through its paleontologic investigations, to many outlying territories and foreign countries. In most of the States that have geological surveys or bureaus of mines investigations have been made in cooperation with those bureaus.

ALABAMA.

A reconnaissance of the stratigraphy of the area embracing the Eocene and Oligocene formations in Houston, Henry, Dale, Geneva, Coffee, and Covington counties, Ala., was made by C. W. Cooke and J. A. Gardner. The location and salient features of an anticline observed in Coffee County in the course of this study were promptly given to the press. A more formal presentation of the results of the stratigraphic work is now in preparation.

Studies of Paleozoic fossils have been made by E. O. Ulrich and of Tertiary Foraminifera by J. A. Cushman. Drill cuttings from Tertiary formations at a number of localities were examined by W. C. Mansfield and H. D. Miser.

Work on the preparation of a report on the iron-ore deposits of the State was resumed by E. F. Burchard.

ARIZONA.

Reconnaissance examinations of the Pima and Papago districts, south of Tucson, were made by F. L. Ransome, and a report on these districts is in preparation. After a brief examination of the Cave Creek district, Mr. Ransome was engaged during the greater part of the winter in a detailed study of the geology and ore deposits of the Oatman district. In this work he was assisted by M. G. Gulley. Mr. Ransome has in preparation a general report on the ore deposits of Arizona. This report will include the results of original field work by the author and of investigations by other geologists, together with a history of mining in Arizona, compiled from many sources. A folio by Mr. Ransome on the Ray quadrangle is in course of publication.

An examination of the asbestos deposits in the Apache and San Carlos reservations and in the Grand Canyon region was made in the summer of 1920 by Edward Sampson, who subsequently prepared a preliminary report on the geology and asbestos deposits of Arizona, which was submitted to the State Bureau of Mines for publication.

A report on the stratigraphy of northwestern Arizona has been nearly completed by L. F. Noble. Carboniferous invertebrates from

the region were examined by G. H. Girty. Stratigraphic sections in southwestern Utah and northwestern Arizona are briefly treated by J. B. Reeside, jr., and Harvey Bassler in Professional Paper 129–D, now in press.

A number of geologically important late Tertiary or early Pleistocene deposits containing fossils, located by Kirk Bryan, were examined with the cooperation of the United States National Museum, and collections of bones in great variety, throwing much light on the geographic conditions and climate of this part of the United States in very late Tertiary time, were gathered and shipped to the National Museum by J. W. Gidley, paleontologist of the Museum.

Invertebrate fossils from the Triassic system were examined by T. W. Stanton and from the Paleozoic by Edwin Kirk.

Reconnaissance mapping of the general geology of parts of eastern Arizona, in cooperation with the State Bureau of Mines, was resumed early in the spring by N. H. Darton. The results will be utilized primarily in the construction, in the office of the Director of the State Bureau of Mines, of a geologic map of Arizona.

ARKANSAS.

Detailed investigation of the geology and structure of the Eldorado oil and gas field, Ark., was begun in May by W. W. Rubey, with the object of preparing a report.

A paper on tuff in the De Queen quadrangle is being written by H. D. Miser, who revised his mapping of the Hot Springs quadrangle. A bulletin by Mr. Miser on the "Manganese deposits in the Batesville district" awaits publication. The fossil Nuculas of the Morrow formation were reviewed by G. H. Girty, and collections from the Silurian of northern Arkansas were made by R. D. Mesler.

CALIFORNIA.

A study of the copper deposits at Engelmine, Quincy, and near Onion Valley, Plumas County, Calif., was begun by J. M. Hill and will be continued by him as he can find opportunity in connection with his duties at the San Francisco office of the Survey. A general report on chromite in California and Oregon, by J. S. Diller, L. G. Westgate, and J. T. Pardee, appears in Part A of Bulletin 725.

The preparation of the Weaverville folio was resumed by J. S. Diller, who in June returned to his study of the recent volcanic phenomena of Lassen Peak. Extensive tungsten deposits of contact-metamorphic origin near Mecca and Riverside were examined by E. S. Larsen, jr., and deposits of reported oil shale in the vicinity of Elsinore were examined and sampled by David White. Parts of the Tertiary areas were examined in July by T. W. Vaughan, who collected fossils, and invertebrate collections from the Triassic of the State were studied by T. W. Stanton.

"The origin of the Yosemite Valley" is the title of a manuscript submitted by F. E. Matthes for publication as a bulletin.

The nitrate-bearing clays in the Mohave Desert and in the valley of Colorado River and adjoining parts of southeastern California are described in a manuscript now in preparation by L. F. Noble,

who also investigated the relations of the borate-bearing Tertiary sediments to the Tertiary clay-hill nitrate sediments of the Amargosa region. Early in the spring Mr. Noble also examined the borate district near the Funeral Range.

The northwestern part of the Santa Ana quadrangle and the north end of the San Joaquin Hills were mapped in detail by W. S. W. Kew, who in the spring resumed the thorough study of the structure and stratigraphy of the Los Angeles district with reference to oil. The manuscript on the Los Angeles-Ventura oil region has been submitted by Mr. Kew for publication. In May Mr. Kew, assisted by Chester Stock and H. V. Howe, resumed mapping in the Fernando quadrangle.

COLORADO.

In the San Juan region of Colorado the comprehensive investigation extending over a number of years was brought essentially to completion. The field study of the igneous rocks and their history was prosecuted by Whitman Cross and E. S. Larsen, jr., assisted by C. S. Ross; and the physiographic studies, including reconnaissance areal mapping of the Quaternary formations of the Creede, Cochetopa, Del Norte, and Summitville quadrangles, were completed by W. W. Atwood, assisted by P. E. James and R. F. Webb. Portions of the Conejos quadrangle were mapped in detailed reconnaissance by Messrs. Atwood, Larsen, and Ross, and an area in the San Luis quadrangle was examined by Mr. Atwood.

The late Cretaceous and early Tertiary sedimentary formations along the north rim of the San Juan Basin in the Ignacio quadrangle were studied by J. B. Reeside, jr., and T. C. Hopkins, with special reference to the structural relations of the formations and their stratigraphic adjustments with the igneous effusives. The southeastern part of the Red Mesa quadrangle was studied by Mr. Reeside in June. A folio covering the San Cristobal quadrangle is in preparation by Mr. Larsen. Collections from the Ignacio quadrangle are being studied by Mr. Reeside.

The oil-shale deposits along the southern border of the Uinta Basin and the outcropping Green River formation with intercalated oil-impregnated sands along the northern border of the basin were examined by David White and K. C. Heald in October. A general description of the oil-shale deposits of the State is contained in a manuscript on "Oil shale in the Rocky Mountain region," by D. E. Winchester, now awaiting publication. Mr. Heald also made a brief study of the geologic structure near Ordway and Las Animas.

The monograph on the fossil flora of the Denver formation was completed by F. H. Knowlton, who has in preparation a report on the fossil flora of the Tertiary lake beds in south-central Colorado. Cretaceous fossils from the State were examined by T. W. Stanton.

A field study of the stratigraphy of the Paleozoic formations along the foothills of the Rocky Mountains in northern Colorado was made by W. T. Lee, assisted by H. S. Cave, and fossils bearing critically on the correlation of the formations were collected for study by the paleontologists. Particular attention was paid to accuracy of measurement of the formations with the object of deter-

mining more precisely the stratigraphic relations of the sands productive of oil in other regions. A paper by Mr. Lee on peneplains of the Front Range of the Rocky Mountains has been submitted for publication in the new series, "Contributions to the geography of the United States."

A study of the stratigraphy and structure of portions of Moffat County with reference to the classification of lands as oil or coal lands was begun at the end of June by J. D. Sears, assisted by C. P. Ross.

A report on the Twentymile Park district of the Yampa coal field, Routt County, was completed and transmitted for publication by M. R. Campbell. The revision and completion of the Leadville monograph left unfinished by the late Capt. J. D. Irving occupied the attention of G. F. Loughlin in June.

CONNECTICUT.

The differentiation of calcitic and dolomitic members of the Stockbridge limestone belt in western Connecticut and eastern New York, carried on by T. Nelson Dale to the date of his retirement in August, 1920, was continued for a part of the field season by Chester R. Longwell and J. C. Martin. Preparation of a report by Mr. Martin was terminated by his resignation January 31, 1921, but the field mapping was resumed by Mr. Longwell for a few days in June.

DELAWARE.

The geography of a part of Delaware has been studied by W. T. Lee.

DISTRICT OF COLUMBIA.

In connection with the preparation of the geographic handbook of the Virginia region, field work in the vicinity of Washington was carried on by W. T. Lee, who also studied geographic features in the vicinity by airplane photography.

FLORIDA.

The Oligocene formations in Washington, Calhoun, and Jackson counties, Fla., were studied in April by C. W. Cooke and J. A. Gardner. Reports on molluscan fossils from wells near Chipley were made by W. C. Mansfield, on Foraminifera from different parts of the State by J. A. Cushman, and on Oligocene fossils by W. H. Dall.

GEORGIA.

Reconnaissance field studies of the older Tertiary rocks of Decatur County and neighboring areas in Georgia were made in June by C. W. Cooke and J. A. Gardner.

IDAHO.

A comprehensive report on the geology, geography, and mineral resources of southeastern Idaho is being written by G. R. Mansfield, who spent a short period in the season of 1920 in the field. Papers on the "Climate of southeastern Idaho," on "Igneous geology," and on

"Types of Rocky Mountain structure in southeastern Idaho" have been transmitted by Mr. Mansfield for unofficial publication.

A preliminary report on the copper deposits of the Seven Devils and adjacent districts, prepared under cooperative auspices by F. B. Laney, has been published as Bulletin 1 of the Idaho Bureau of Mines and Geology. More detailed field work is now in progress, and a more elaborate report is planned for publication by this Survey.

A detailed geologic reconnaissance of the Pend Oreille region was begun by Edward Sampson, assisted by J. L. Gillson, in cooperation with the Idaho Bureau of Mines and Geology.

The relations of the glacial deposits to the placer deposits in Bonneville County were studied by J. T. Pardee. A report on the geology of the Snake River Canyon was prepared for the water-resources branch by Mr. Pardee.

Carboniferous fossils from Idaho were examined by G. H. Girty.

The Tertiary lake beds in the Weiser and Boise region were studied under cooperative arrangement by J. P. Buwalda, of the faculty of Yale University. The preparation of a report on the work has been seriously interrupted by university duties.

ILLINOIS.

Mississippian and earlier Paleozoic sections in southern Illinois were examined in June for purposes of correlation by E. O. Ulrich and Charles Butts. The portions of the texts for the Carlyle-Centralia and Gillespie-Mount Olive folios relating to Pleistocene geology were revised by E. W. Shaw gratuitously, subsequent to his resignation in March.

INDIANA.

Field studies of the limestone at Spergen Hill, Ind., with reference to its faunal peculiarities and its time equivalents in other areas, were carried on by E. O. Ulrich and Charles Butts, accompanied by R. D. Mesler.

IOWA.

Studies of the earlier drift sheets of Iowa were made by Frank Leverett in connection with a study of the age of the gorge of Mississippi River at Keokuk and of the glacial history of Minnesota and the other Lake States. Investigations of the amount of erosion that has taken place since the Illinoisan and since the Wisconsin stage in Iowa, Minnesota, and South Dakota were made by Mr. Leverett.

Cretaceous fossils from the State were studied by T. W. Stanton.

KANSAS.

The flora of the Cheyenne sandstone is described in a report submitted by E. W. Berry. The Prosser collection of Carboniferous fossils was arranged and prepared for reference by G. H. Girty, and fossiliferous deep-well cuttings were examined by E. O. Ulrich. Microscopic fossils from some of the outcropping formations of the State were studied by P. V. Roundy in connection with his determination of the paleontologic characteristics of certain oil-bearing formations.

A map showing oil and gas fields, pipe lines, and refineries in Kansas was published during the year.

KENTUCKY.

The reconnaissance study, with mapping, of the Mississippian formations in eastern Kentucky was continued by Charles Butts during the field season of 1920, and a report embodying the results is ready for transmission to the Kentucky Geological Survey, in cooperation with which the work has been done.

A brief description of the coal fields of Kentucky was prepared by M. R. Campbell for the use of the Bureau of Mines.

Lower Paleozoic and Mississippian formations in central and western Kentucky were studied by E. O. Ulrich and Charles Butts.

LOUISIANA.

Cuttings from numerous wells drilled in Louisiana have been examined by C. W. Cooke, J. A. Cushman, and W. C. Mansfield to determine the geologic formations penetrated. Pleistocene material was examined by W. H. Dall and Eocene plants by E. W. Berry.

The formations surrounding and capping the salt domes at several localities were examined by M. I. Goldman, with reference to the conditions of deposition of the sediments and in a search for new criteria that may lead to the discovery of salt domes and accompanying oil deposits where their presence can not now be recognized. Observations were made by Mr. Goldman at Pine Prairie, Anse la Butte, Avery Island, Weeks Island, Jefferson Island, Cote Blanche, the delta of Mississippi River, and the Winnfield marble quarry.

A paper on "Llanoria, the Paleozoic land area in Louisiana and eastern Texas," by H. D. Miser, has been published in the American Journal of Science.

A map showing the oil and gas fields, pipe lines, and refineries in Louisiana was published during the year.

MAINE.

The work of finishing the handbook of the geography of New England, by Arthur Keith, which is more than three-fourths done, has been suspended for a time pending the completion of the description by Mr. Keith of the structure of the Taconic region.

MARYLAND.

A report, with map, describing the geology of Baltimore County, Md., has been prepared by E. F. Bliss Knopf, in collaboration with Anna I. Jonas, representing the Maryland Geological Survey, for publication by the State. The geology at certain points in the county was given special examination by Sidney Paige and Arthur Keith.

Portions of the Piedmont and Blue Ridge areas of the State were examined by Laurence LaForge in connection with the preparation of the geologic handbook for the Virginia region, work on which has been temporarily postponed. The terraces in portions of Montgomery County were studied in June by C. K. Wentworth.

Brief examinations of the type localities of the Loudon, Weverton, and Catoctin formations were made by G. W. Stose. Fossils from the middle Paleozoic of Maryland are described by E. O. Ulrich in a monograph on Silurian Ostracoda now in preparation.

MASSACHUSETTS.

A map showing the Quaternary geology of Massachusetts was compiled by W. C. Alden and Laurence LaForge for the use of the Massachusetts Department of Agriculture in the preparation of a soil map of the State. Field studies of the Pleistocene deposits essential to the completion of the mapping and text for the Boston folio were begun in June by Mr. LaForge. Additional mapping was done by L. M. Prindle in the Greylock quadrangle, which will be described with the Berlin quadrangle in a folio now in preparation.

A professional paper on the geology of Cape Cod, the Elizabeth Islands, Marthas Vineyard, No Mans Land, Nantucket, and Block Island, by J. B. Woodworth and E. W. Wigglesworth, is in preparation.

The text describing the Sheffield and Sandisfield quadrangles, by Joseph Barrell, has been completed by Arthur Keith and submitted for publication.

The text of the handbook of the geography of New England is reported by Mr. Keith to be about 80 per cent complete.

MICHIGAN.

A monographic treatment of the Quaternary geology of the Lake Superior region, by Frank Leverett, is nearly ready for submission. The geology of the Perrinton, Elsie, St. Charles, Chesaning, Bay City, Saginaw, Burt, and Flint quadrangles has been mapped and described by Mr. Leverett in a bulletin to be published by the Michigan Geological Survey, in cooperation with which the work was done. An investigation of the tilting or differential uplift of the old shore lines of the glacial lobes that occupy the region was included in the project. Pleistocene fossils from Mud Lake were reported on by W. H. Dall.

MINNESOTA.

A report based upon the examination of the Quaternary geology of Minnesota, made in cooperation with the State Geological and Natural History Survey, has been completed by Frank Leverett for publication as a professional paper. A monographic description of the Quaternary geology of the Lake Superior region has been prepared by Mr. Leverett, who has also transmitted a paper on the Pleistocene history of the Mississippi Valley for outside publication.

MISSISSIPPI.

The manuscripts of two comprehensive reports on Mississippi, one entitled "Physiography and geology of Mississippi" and the other "Ground waters of Mississippi," both based on work done in cooperation with the State Geological Survey, are now complete and are awaiting editorial preparation before transmission to the printer. For the former, L. W. Stephenson revised his chapter on the stratigraphy of the Cretaceous deposits and also reviewed the manuscript on the Eocene formations below the Jackson, by E. N.

Lowe, State geologist; E. W. Shaw wrote a summary account of the general physiographic features of the State; and C. W. Cooke revised his chapters on the Jackson formation and the Vicksburg group.

Some of the older Tertiary and Cretaceous formations of the State were examined early in the spring by C. W. Cooke and J. A. Gardner. Descriptions of Foraminifera from the Byram marl and from the Mint Spring marl of Mississippi by J. A. Cushman and a paper on the stratigraphy of the Byram marl by C. W. Cooke are in course of publication in the "Shorter contributions to general geology." Studies of large collections of fossil plants from the Claiborne and Jackson of the State have been made by E. W. Berry. Samples from oil-prospecting wells were studied by C. W. Cooke, and well samples from Pascagoula were reported on by W. C. Mansfield.

MISSOURI.

The Pennsylvanian faunas of the Joplin district were described by G. H. Girty, and older Paleozoic fossils collected by the Missouri Bureau of Geology and Mines were reported on by E. O. Ulrich. The Mississippian section in southeastern Missouri was studied at several points by Charles Butts.

MONTANA.

The most important of the oil investigations in different parts of Montana in the season of 1920 was the beginning of a study of portions of Fergus and Musselshell counties by Frank Reeves, assisted by Bruce White and J. M. Vetter. A report by Mr. Reeves covering parts of these counties is partly completed, and structure contour maps with descriptions of the most essential features have been issued to the press. Field work in Fergus County was resumed by Mr. Reeves, assisted by L. C. Fenstermacher, M. N. Bramlette, and James Gilluly, in June.

The region in east-central Montana between Miles City and Prairie Elk was covered by reconnaissance examination by W. T. Thom, jr., assisted by H. S. Cave. This examination supplemented reconnaissance work of other seasons and, augmented by published and unpublished work of other geologists, permitted the preparation of a report on the geology and oil prospects of eastern Montana. Summaries of many features that are important with reference to oil and gas were incorporated in two press notices issued in the spring of 1921. Assisted by Mr. Cave, Mr. Thom has completed the detailed mapping of a part of McCone County; assisted by C. E. Dobbin, he has compiled a report on the geology of portions of Montana for transmission to the State geologist and director of the School of Mines for use in preparing a general geologic map of the State.

Toward the end of June Mr. Thom, assisted by G. F. Moulton, began a review, with detailed mapping, of the geologic structures and stratigraphy of portions of the Crow Indian Reservation. This work is a continuation of studies begun several years ago by C. H. Wegemann and R. W. Howell, prior to their resignation. For a short time the party was joined by T. W. Stanton. In conjunction

with Mr. Dobbin Mr. Thom did further reconnaissance work in central Montana, visiting the Venanda, Alice, and Ingomar domes. A report with sketch map showing the principal structural and stratigraphic features of the Alice dome has been communicated to the public. A similar report on the Ingomar dome was submitted for publication in June.

The coal lands along Powder River were examined by C. E. Dobbin, assisted by W. W. Rubey and C. Y. Hsieh, in the summer of 1920, and a reconnaissance of the structure of a part of southeastern Montana was carried forward with the object of procuring data as to oil prospects and coal resources. A report to serve as a basis for the classification of the coal lands was submitted by Mr. Dobbin. In May, 1921, work in Garfield County was resumed by Mr. Dobbin, assisted by E. W. Berry and J. E. Hoffmeister, and in June this party made detailed examinations for the purpose of classifying the coal lands and determining the structure of eleven townships in Garfield County.

Data relating to regional carbonization were collected by David White in the Lewistown region and in the vicinity of Lombard and Three Forks.

A report on the Scobey lignite field has been revised by A. J. Collier, and a manuscript by the late G. S. Rogers and Wallace Lee on the Tullock Creek coal field has been completed by M. R. Campbell. These papers will be published as bulletins of the Survey.

In accordance with the requirements of the law providing for the classification of the lands in the Fort Belknap Indian Reservation, a field examination of the reservation was begun in May by A. J. Collier and S. H. Cathcart. A brief inspection of the stratigraphic conditions in the Havre gas field was made by Mr. Collier for reference in the Fort Belknap work. Some paleontologic problems of the work were investigated by T. W. Stanton.

A study of the glaciation and terrace deposits and of their relations to the placer deposits by J. T. Pardee was carried over portions of Powell, Granite, Deer Lodge, Missoula, and Ravalli counties. Field examinations in the vicinity of Lewistown and Glacier National Park were resumed by Mr. Pardee in June. Reports on "Glaciation and the origin of the gold-bearing gravels in the Pioneer region" and on the "Pleistocene glacial features of northwestern Montana and eastern Washington" are in preparation by Mr. Pardee.

A reconnaissance study of the Tertiary River gravels and Quaternary glacial phenomena on the plains of northern Montana east of the Rocky Mountains was carried on throughout the season of 1920 by W. C. Alden. A professional paper by Mr. Alden on the glacial phenomena, the gravels, and the physiography of the northern part of Montana is now in preparation.

The fauna of the Eagle sandstone of Montana and its equivalents in the Rocky Mountain region was studied by J. B. Reeside, jr., and the Cretaceous and Fort Union invertebrates of the State were examined by T. W. Stanton.

A report on manganese ore in Montana and other States by J. T. Pardee has been published as Bulletin 725–C, and a report on "Chromite deposits in Stillwater and Sweetgrass counties," by L. G. Westgate, forms part of Bulletin 725–A.

NEBRASKA.

Paleozoic and Cretaceous fossils from Nebraska were reported on, respectively, by G. H. Girty and T. W. Stanton.

NEVADA.

Studies of the Simon and Omco districts, Nev., were made by Adolph Knopf assisted by E. F. Bliss Knopf during the season of 1920. A report by Mr. Knopf on the ore deposits of Cedar Mountain, which includes these districts, has been submitted for publication. The Candelaria district will be described by Mr. Knopf, who made a reconnaissance examination of it in the summer of 1920. Mr. Knopf also has in preparation a report on the Rochester district, based upon field examinations made before the war.

The Manhattan district was revisited in June by H. G. Ferguson, who examined also a potash-alum mine near Blair Junction. A brief report on this mine was prepared by Mr. Ferguson for the Survey's files. A report on the Manhattan district is in preparation, and a report on the geology and ore deposits of the Round Mountain district will be published as a chapter of Bulletin 725.

A paper on the limestone ore of the Manhattan district has been transmitted by Mr. Ferguson for outside publication.

Further examinations of the Carson Sink region were made by F. C. Schrader with a view to bringing his observations up to date for the completion of his report on the region. Additional field observations were made by Mr. Schrader in the Jarbidge district, partly examined by him prior to the war. Mr. Schrader has in preparation a report on this district.

Examinations of the Boulder and Black canyons of Colorado River, with reference to the security of dam sites, were made in February by F. L. Ransome in the interests of the Reclamation Service. The geology of the dam site of the Spanish Spring Reservoir, near Fallon, was examined as to possible leakage by J. S. Diller.

Pleistocene fossils from Nevada were studied by W. H. Dall, Jurassic invertebrates from the Augusta Mountains were examined by T. W. Stanton, and Paleozoic material from Nevada was reported on by G. H. Girty.

A newly discovered deposit of colemanite in the Muddy Mountains was examined in May by L. F. Noble. The salient features of the deposit were presented in a press notice, and a more complete description is in preparation.

The deposits of oil shale in the vicinity of Elko are briefly described by J. P. Buwalda in a section of the report by D. E. Winchester on "Oil shales of the Rocky Mountain region," which is nearly ready for the printer. A more detailed description of the Nevada deposits is now in preparation by Mr. Buwalda.

NEW HAMPSHIRE.

Studies of the glaciation in the White Mountains were made by J. S. Diller.

The preparation of a report on the geology of the Ammonoosuc district, by C. P. Ross, has been interrupted by the necessary assign-

ment of Mr. Ross to another project. Slight progress was made by Arthur Keith on the geographic handbook of New England.

NEW JERSEY.

A report on the physical and chemical character of the New Jersey greensands by G. R. Mansfield awaits publication.

NEW MEXICO.

The study of the Gallup district, with detailed mapping and classification of the lands, was continued in the summer of 1920 by J. D. Sears, assisted by W. L. Russell and Langdon White. Reports on a large number of tracts were submitted to the land-classification board, and progress was made in the preparation of a general report, including a geologic map of the Gallup-Zuni region. The field work, extending into the Zuni Basin district, was resumed in May by Mr. Sears, with the assistance of C. P. Ross, W. H. Bradley, and K. K. Landes.

Reconnaissance examinations in the Abiquire and Tusas quadrangles were carried on by Whitman Cross, E. S. Larsen, jr., and C. S. Ross in the summer of 1920 to determine the relations of the sedimentary formations of the region to the igneous centers of northwestern New Mexico and southwestern Colorado. Messrs. Larsen and Ross mapped in detail a part of the Rio Brazos canyon. At the same time the Rio Brazos region was examined by W. W. Atwood with reference to its bearing on San Juan physiography. A paper on the geology of the western part of the San Juan Basin of Colorado and New Mexico is in preparation by J. B. Reeside, jr., who has revised a paper by C. M. Bauer and himself on coal in San Juan County, N. Mex., for publication in a Survey bulletin.

A paper by N. H. Darton on the "Red Beds" and associated formations in New Mexico, a by-product of the study of the stratigraphy and conditions of the salt region, made with special reference to the possible deposition of potash, has been submitted. Cuttings and brines from several wells in eastern New Mexico were examined and tested by O. C. Wheeler and D. D. Christner in the course of the search for potash in the "Red Beds" region of Texas, New Mexico, Oklahoma, and southern Kansas by the Survey in cooperation with the Texas University Bureau of Economic Geology and Technology. The report on "Geologic structure of parts of New Mexico," by Mr. Darton, is in press as Bulletin 726–E.

The paleontology of the Lake Valley limestone was studied by G. H. Girty with reference to the equivalents of this formation in other areas. The Devonian rocks in the vicinity of Silver City were examined as to their stage of regional carbonization by David White, who also studied and sampled several carbonaceous deposits reported to embrace rich oil shales in the Sacramento Mountains.

Contact-metamorphic tungsten deposits near Hanover were examined by E. S. Larsen, jr. A report on the Taylor Creek tin deposits was submitted by J. M. Hill, who examined the region in July, 1920. Cretaceous fossils from northwestern New Mexico were examined by T. W. Stanton, and Carboniferous fossils from southeastern New Mexico by G. H. Girty.

NEW YORK.

Differentiation, with mapping, of the calcitic and dolomitic members of the Stockbridge limestone belt was continued by T. Nelson Dale until his retirement from the service in August.

The geologic mapping in the Hoosick quadrangle was completed by L. M. Prindle, and his field study was transferred to the Berlin quadrangle, the results to be primarily embodied in folios.

Physiographic studies of the vicinity of Mineola, Long Island, were made by W. T. Lee in connection with tests of airplane photography in geologic and geographic interpretations.

A small portion of western New York adjacent to McKean County, Pa., was examined by W. C. Alden for report to the Forest Service regarding a proposed national forest.

NORTH CAROLINA.

The field investigation of the iron-ore resources of the State and the office preparation of a report thereon were continued by W. S. Bayley, so far as his collegiate duties permitted, the work being done in cooperation with the State Geological and Economic Survey. A report on the titaniferous ores of the State has been completed by Mr. Bayley, and reports by him on the iron ores of western North Carolina and on the limonites of Cherokee County are in progress. A short paper on marble-magnetite ore at Lansing was also submitted by Mr. Bayley. A cooperative report by Mr. Bayley on the high-grade clays of the State is now in the hands of the State geologist for publication.

Deposits of chrome ore are described by J. Volney Lewis in Bulletin 725–B.

Portions of a monograph on the Cretaceous fossils of North Carolina submitted to the State some years ago for publication having been lost, some of the material has been replaced by L. W. Stephenson, the author. The work was cooperative. Late Tertiary fossils from various localities have been examined by W. H. Dall and J. A. Gardner. Miss Gardner is preparing a report on the Miocene and Pliocene Mollusca of Virginia and North Carolina. Foraminifera from the upper Eocene were studied by J. A. Cushman.

The Kings Mountain-Gaffney folio, by D. B. Sterrett and Arthur Keith, after revision by Mr. Keith, was transmitted in June for publication.

NORTH DAKOTA.

Studies of the Upper Cretaceous formations of a portion of western North Dakota were made in June by T. W. Stanton. A report by C. Max Bauer and F. A. Herald on the coal deposits in the Fort Berthold Indian Reservation has been revised for publication as Bulletin 726–D.

OHIO.

A description of the surface features of the Cleveland, Berea, and Euclid quadrangles, Ohio, was prepared by Frank Leverett for inclusion in the Cleveland folio. Fossils were examined by G. H. Girty for the Ohio State University.

OKLAHOMA.

The study of the structure and oil resources of the Osage Reservation, Okla., was continued in November and December, 1920, when P. V. Roundy and K. C. Heald, assisted by W. W. Rubey and Paul H. Moyer, mapped Tps. 26 and 27 N., R. 12 E., with structure contouring on a large scale. The Pershing field, in Tps. 24 and 25 N., Rs. 9 and 10 E., was studied by Mr. Rubey, who prepared a map showing locations and elevations of oil wells and procured data for the study of underground conditions. Reports are in preparation by Messrs. Roundy and Rubey. A number of oil fields in Osage County were visited by Mr. Rubey, who collected samples of oil and gas for a detailed study of the character of the Osage oil. Mr. Roundy attended the Osage sale of leases held in June and advised the Office of Indian Affairs regarding the adequacy of bids received.

The geology and oil resources of parts of Grant County, including the recently discovered Deer Creek field, were studied during June by R. S. Knappen and H. W. Hoots.

The geologic structure and oil and gas prospects of a part of Jefferson County are described by H. M. Robinson in a manuscript to be published as Bulletin 726–F.

A report on the Madill-Denison area of Oklahoma and Texas, by O. B. Hopkins, Sidney Powers, and H. M. Robinson, received final revision and was submitted for publication.

Field studies of the oil sands in Oklahoma, with reference to their porosity, permeability, and productivity, were made by A. F. Melcher in cooperation with the United States Bureau of Mines.

A map showing oil and gas fields, pipe lines, and refineries in Oklahoma is being printed.

Samples of cuttings and brines from several wells in the salt bed region of western Oklahoma were collected and subjected to field tests by D. D. Christner as a part of the search for potash in the "Red Beds" region of the Southwest. Fossils from well cuttings and outcrops in different parts of the State were examined by E. O. Ulrich, G. H. Girty, and P. V. Roundy. Efforts were exerted to stimulate the microscopic study of well cuttings by the geologists of the larger oil companies.

The physiographic features of the plains border of Oklahoma, including portions of Osage, Kay, Grant, Alfalfa, Woods, Woodward, Major, Ellis, Dewey, Blaine, Kingfisher, Canadian, Grady, Caddo, Custer, Washita, and Beckham counties, were studied in June by N. M. Fenneman, assisted by Waldo S. Glock.

A report on manganese deposits near Bromide was completed by D. F. Hewett (Bulletin 725–E).

OREGON.

Additional field observations necessary to the completion of a folio covering the Riddles quadrangle were made in June by J. S. Diller.

A report, based on field examinations made in the summer of 1919 of the structure of the Cretaceous and Tertiary basins east of the Cascade Mountains, with special reference to oil and gas possibilities, has been completed by J. P. Buwalda and transmitted to the State Bureau of Mines and Geology, in cooperation with which

the work was done. Miocene fossils from this area were examined by W. H. Dall. Invertebrate collections of Triassic age from Oregon were examined by T. W. Stanton.

A report by J. T. Pardee on manganese ore in Oregon and other States forms part of Bulletin 725–C.

PENNSYLVANIA.

Additional field examinations of the McCalls Ferry and Quarryville quadrangles, Pa., were made by E. F. Bliss Knopf, associated with A. I. Jonas, representing the cooperating State Geological Survey. Portions of the area were investigated by G. W. Stose, who during short periods in the summer of 1920 and spring of 1921 carried forward his mapping of the Newville and Carlisle quadrangles. Mr. Stose also made special investigations of parts of Lancaster and York counties for the State Survey.

The detailed mapping of the New Kensington quadrangle was resumed in the summer of 1920 by K. K. Kimball, assisted by L. C. Fenstermacher and P. L. Yuan, a portion of the cost being borne by the State Geological Survey. The work was done under the general supervision of G. B. Richardson. The geologic structure of parts of the northern anthracite field was studied in March by N. H. Darton for the completion of a map showing the structure of this field.

Some progress in the preparation of a folio covering the Quakertown and Doylestown quadrangles was made by F. Bascom, assisted, through cooperation of the State Survey, by Miss Jonas.

The folio by G. B. Richardson on the Somerset and Windber quadrangles is delayed, pending the settlement of certain correlation problems affecting the Pottsville-Allegheny boundary and the nomenclature of the coals in these quadrangles and in the western Maryland coal field.

Oil sands were sampled in outcrop and in drill cuttings by A. F. Melcher with reference to the porosity, permeability, and productivity of the rocks. Paleozoic fossils of the State were examined by E. O. Ulrich.

RHODE ISLAND.

Field observations of the metamorphic rocks of the Narragansett Basin, R. I., were made by G. F. Loughlin. The effects of weathering were studied and samples of coal taken at the Portsmouth and Cranston mines by David White.

SOUTH CAROLINA.

Progress has been made by C. Wythe Cooke on a report on the geology and ground waters of the Coastal Plain area of South Carolina, but the completion of the manuscript requires further field investigations.

A well with reported showings of oil near Summerville was examined in February by E. W. Shaw, whose conclusions were promptly issued to the press. Well cuttings have been examined by W. C. Mansfield and Eocene fossils by W. H. Dall.

Papers by F. C. Schrader on pyrite at the Haile mine and pyritization at the Brewer mine have been submitted for publication as Bulletin 725–F.

SOUTH DAKOTA.

The structure and ore deposits of the Homestake mine were examined in the summer of 1920 by Sidney Paige, whose report thereon is now near completion.

The Cretaceous deposits in a portion of western South Dakota were examined in the season of 1920 by T. W. Stanton, and fossils then collected have been studied by him for purposes of correlation.

TENNESSEE.

For the completion of the cooperative bulletins on the Holston marble belt of Tennessee, to be published by the State, and on the marbles of the southern Appalachian region, to be published by the United States Geological Survey, detailed large-scale mapping of the topography and geology of the quarry districts near Knoxville and Friendsville was completed in the spring of 1921 by K. K. Kimball.

The report by W. H. Emmons on the geology and copper deposits of the Ducktown district has been reviewed and transmitted for publication. A paper by E. S. Larsen, jr., "Notes on bentonite and related beds in Bedford County, Tenn.," has been placed with the State Survey for printing.

A report by H. D. Miser on the mineral resources of the Waynesboro quadrangle, based on a survey in cooperation with the State Geological Survey, was transmitted to the State for printing. The Carboniferous faunas of the quadrangle were studied by G. H. Girty.

A cooperative monographic description of the Upper Cretaceous fauna on Coon Creek, by Bruce Wade, has been transmitted by the State Survey for publication as a bulletin. Nearly the entire project was carried out at State expense.

Additional studies of the stratigraphy and field paleontology of the older Paleozoic formations in eastern Tennessee were made in the spring of 1921 by E. O. Ulrich, accompanied by Charles Butts and R. D. Mesler.

Fossil plants from the Ripley formation of eastern Tennessee were examined by E. W. Berry, and microfossils encountered in drill cuttings were studied by P. V. Roundy.

TEXAS.

The inspection with testing of drill cuttings and of brines obtained through the courtesy of some of the oil companies from wells in the region of thick deposits of rock salt in the "Red Beds" country of Texas has been continued jointly by the Bureau of Economic Geology and Technology of the Texas State University and this Survey. In August, 1920, Orby C. Wheeler was succeeded by D. D. Christner as field observer, with a laboratory for rough field tests of samples at Amarillo until the spring of 1921, when it was transferred temporarily to Big Spring. Drill cuttings and brines from many wells have been tested in the field and if found promising have been analyzed in the Washington laboratory, with the result that small

lumps of potash-rich salts, including polyhalite, were found in the cuttings saved at the Burns and Bryant wells, in Dawson and Midland counties, and in salt crusts found in the slush pool of the River well, drilled by the A. Pitts Oil Co. about 8 miles east of Barstow, in Ward County. The results, which were promptly contributed to the press, show that potash salts were laid down at one or more horizons in association with thick beds of rock salt and gypsum at points about 150 miles apart in the "Red Beds" region of western Texas.

In the spring of 1921 an additional field observer, R. Sternbergh, was detailed to watch the progress of drilling and to study cuttings obtained from one of the wells that appeared to be most favorably located.

Potash-rich brines and muds in the basins of a number of alkali lakes in Lamb, Terry, and Lynn counties were collected and subjected to field tests.

The study of the Coastal Plain region between the Rio Grande and Nueces River was continued during the field season of 1920 by A. C. Trowbridge, assisted by W. S. Glock. A preliminary report on the geology and water resources of the area has been prepared by Mr. Trowbridge, and a more elaborate report by him is in preparation.

The result of the micropaleontologic studies of cuttings from several of the wells in the Ranger district, with the object of defining features characteristic of the several formations and of interpreting the conditions of deposition of the different types of sediments, were completed by M. I. Goldman and published in Professional Paper 129–A. A paper for outside publication on the same subject was prepared and presented at the meeting of the American Association of Petroleum Geologists. Field work confirming the results of deductive studies along the same line was carried out in April in the San Saba region by Mr. Goldman, accompanied by R. C. Moore. Mr. Goldman made field examinations, with collection of samples, of the sedimentary formations and deposits overlying and in the immediate vicinity of a number of the salt domes in the Coastal Plain. These samples are now being studied by Mr. Goldman in an effort to discover characteristics useful in the identification of new localities underlain by salt plugs that will possibly have associated oil pools.

The structure and oil prospects of the Madill-Denison area in Texas and Oklahoma are discussed by O. B. Hopkins, Sidney Powers, and H. M. Robinson in a bulletin now in press.

A report on Steen, Brooks, and Grand salines of northeastern Texas, by O. B. Hopkins, Sidney Powers, and H. M. Robinson, was submitted for publication.

Reports describing geologic structure and oil development in the Ranger district, by Frank Reeves, and on the geologic structure in the vicinity of Lacasa, in central Texas, by C. S. Ross, have been revised and transmitted for publication, and a manuscript on the structure and stratigraphy of the Wiles area, in Stephens County, was submitted by C. E. Dobbin.

In order to bring to date the estimates of helium remaining available in the Petrolia field the district was reexamined in May by E. W. Shaw, and the results were contributed for the use of the Bureau of Mines and other Government organizations.

The structure mapping and recommendations regarding oil possibilities in the vicinity of Mexia, Limestone County, by G. C. Matson,

published in Bulletin 629 (1915), were demonstrated to be accurate by the discovery and development of the Mexia oil field.

A paper on the occurrence of a Paleozoic land area in Louisiana and eastern Texas, by H. D. Miser, has been published in the American Journal of Science.

The flora of the Woodbine sand at Arthurs Bluff is described in a manuscript by E. W. Berry, who also has in preparation a report on the plants from the Yegua and Fayette formations. A general description of the fauna of the Comanche series is in progress by T. W. Stanton. Eocene Foraminifera from the State have been studied by J. A. Cushman; Eocene Mollusca have been examined by J. A. Gardner and W. H. Dall; and invertebrate fossils from the Bend series have been described by G. H. Girty and P. V. Roundy.

Brief geologic observations in the vicinity of El Paso and Big Spring were made by T. W. Vaughan.

UTAH.

The manuscript of a report on the mining geology of the Cottonwood district was submitted under agreement in June by B. S. Butler. Some additional mapping will be necessary for the report on the general geology of this region, on account of which field examinations were resumed near the end of June by F. C. Calkins. The manganese deposits of the State are described in a report by J. T. Pardee, in press as Bulletin 725–C.

A general reconnaissance with detailed studies of local structure in Kane and Garfield counties was begun in June by R. C. Moore, assisted by A. C. Tester and Platt Benedict, who gave special attention to the possible occurrence of oil and obtained data for the classification of the public lands.

Paleozoic sections in southwestern Utah are described by J. B. Reeside, jr., and Harvey Bassler, in Professional Paper 129–D, now in press, and a paper on "Phases of the Carboniferous and Triassic of southern Utah" was prepared by Mr. Reeside for outside publication. A report on the stratigraphy and petroleum resources of Washington County was prepared by Messrs. Reeside and Bassler. Paleozoic fossils from the State were studied by G. H. Girty, and Cretaceous invertebrates by T. W. Stanton.

On account of the urgent demand for detailed stratigraphic and structural information and for more precise data as to the coal resources of the Wasatch Plateau, a party in charge of E. M. Spieker began the detailed mapping of portions of the Book Cliffs and Huntington Canyon regions in June.

Preparatory to the examination of the geologic structure and stratigraphy and to the study of proposed dam sites in portions of Colorado and San Juan rivers, H. D. Miser, Kirk Bryan, and C. R. Longwell were in June engaged in the study of the stratigraphic relations of the Paleozoic sections in the vicinity of Green River, Lees Ferry, and Bluffs.

Oil-impregnated sandstones in the lower part of the Green River formation east of Jensen, on the north side of the Uinta Basin, were examined in October by David White and K. C. Heald. A report on the "Oil shales of the Rocky Mountain region," by D. E. Winchester, awaits publication.

VERMONT.

The structure of the Taconic region in Vermont was the subject of additional field studies by Arthur Keith prior to the completion of a report on the Taconic Range.

The field mapping of the geology of the Bennington quadrangle was resumed by L. M. Prindle near the end of the field season of 1920.

VIRGINIA.

Detailed field examination and mapping of the southwestern Virginia coal field have been completed, the work during the field season of 1920 being in the hands of C. K. Wentworth and J. B. Eby, of this Survey, and A. W. Giles, of the Virginia Geological Survey, with which this project has been carried forward in cooperation. Charles Butts spent a portion of December in mapping a part of the Pound quadrangle, which is included in Wise County. Further examinations in portions of the field were made by Mr. Eby in the spring of 1921, when he was for a part of the time accompanied by M. R. Campbell, who also examined parts of the coal-bearing Pocono belt in the Valley region. Reports on those portions of the coal field that lie in Russell County and in Dickenson County are in course of publication by the State, and the report on Wise County is now nearly ready for publication.

Studies of the stratigraphy of the pre-Carboniferous formations in several areas of southwestern Virginia were carried on in May by G. W. Stose, E. O. Ulrich, and Charles Butts, accompanied by R. D. Mesler, the object being to procure stratigraphic and paleontologic information for use in correlation. A report on the manganese deposits of western Virginia, by G. W. Stose and H. D. Miser, is nearly ready for publication by the State Survey. The manganese ores from the Crimora and Mount Torry mines were examined by D. F. Hewett. E. S. Larsen, jr., studied corundum deposits in the vicinity of Chatham, Pittsylvania County, in June. The submerged beaches and terraces on the coast and in several of the principal estuaries were studied by means of airplane photography by W. T. Lee.

The examination of the pebbles in the terraces of the Coastal Plain near Washington was begun by C. K. Wentworth in June. Miocene and Pliocene Mollusca of the State are described in a manuscript now under revision by Julia A. Gardner.

The preparation of the chapter of the handbook of the geography of the Virginia region covering the Piedmont Plateau, by Laurence LaForge, was discontinued early in the year, and Mr. LaForge was assigned to other more pressing unfinished investigations.

WASHINGTON.

The geologic structure of the Rattlesnake Hills, Wash., was examined and mapped by J. P. Buwalda, and a short preliminary report was prepared on the folds in the region. Pleistocene features of eastern Washington were studied by J. T. Pardee, in connection with the examinations of the glacial deposits and placers of western Montana. Pleistocene fossils from the Puget Sound region were reported on by W. H. Dall.

WEST VIRGINIA.

Manganese deposits in the eastern part of West Virginia were reported on by G. W. Stose and H. D. Miser.

The coal measures in the vicinity of Harrison were examined and sampled by M. R. Campbell, the results being published in Bulletin 716–H. Local studies of the Greenbrier limestone, with collection of fossils, were made for purposes of correlation by G. H. Girty. Older Paleozoic fossils were examined by E. O. Ulrich.

WISCONSIN.

The glacial history of Wisconsin has been treated in a monographic report by Frank Leverett on the glaciation of the Great Lakes region, which is now essentially completed.

In cooperation with the State Geological and Natural History Survey field examinations of early Paleozoic and pre-Cambrian rocks in various parts of the State were made by E. O. Ulrich, who was accompanied in the field by R. D. Mesler.

WYOMING.

A report on the geologic structure and oil prospects of the Osage district, Weston County, Wyo., was completed by A. J. Collier, assisted by M. G. Gulley, who submitted data for the classification of the lands. Similar studies of the Wakeman, Moorcroft, and Rocky Ford districts, in Crook County were made, and reports on these districts are in preparation. A reconnaissance of part of the Mesozoic outcrops in the northwestern part of the Devils Tower quadrangle, with special reference to the structural features, was made by Mr. Collier, assisted by Mr. Gulley, and an inspection of the Cretaceous formations along the west front of the Black Hills from Moorcroft to the Montana line was made by Mr. Collier and K. C. Heald. Exploratory drilling near the Osage field, but outside the producing area, was inspected by Mr. Gulley, who submitted data for the classification of lands.

Notes by Mr. Heald on the Lance Creek and Mule Creek fields, in Niobrara County, calling attention to the publication of the bulletins on these fields and also incorporating previously unpublished conclusions, were issued to the press.

Anticlines along the eastern flank of the Big Horn Basin were visited by Mr. Heald in October, and data on the Spence, Torchlight, and Lamb fields and outlying districts were supplied to the land-classification board.

The Kirby Creek anticline, in eastern Hot Springs County, was mapped in October by Mr. Heald, assisted by Mr. Gulley and H. F. Clark. A report on this work is now in preparation.

Scattered drill holes on several anticlines in central Wyoming were inspected by Mr. Gulley, who submitted reports on the location and progress of tests and the importance of discoveries. Locations of wells on the Bolton Creek anticline, in southeastern Natrona County, were determined by Mr. Heald, assisted by Messrs. Gulley and Clark. The geologic structure in the Bolton Creek field was determined by Mr. Gulley in June. A map of the Dallas field, southeast of Lander,

in Fremont County, showing locations of wells, was prepared by Mr. Gulley, assisted by Mr. Clark. Records of wells, productions, samples of oil, etc., were also procured.

Manuscripts, with detailed descriptions and maps, on the Oregon Basin, Meeteetse, and Grass Creek quadrangles have been nearly completed by D. F. Hewett, who was assisted in the office by C. P. Ross.

Mapping in the Rock Creek oil field to supplement previous work by E. T. Hancock, was done by Mr. Heald, assisted by Messrs. Gulley and Clark and G. F. Moulton. The report on this field by E. T. Hancock has been postponed pending revision based on this additional mapping.

A press bulletin prepared by Mr. Heald, calling attention to the publication of Bulletin 702, on Baxter Basin, with additional conclusions drawn from the facts presented in the bulletin, was issued in March.

Field examinations embracing the Lost Soldier, Ferris, and Mahoney oil fields, in Carbon County, were made in the season of 1920 by A. E. Fath, assisted by G. F. Moulton, N. W. Bass, and C. Y. Hsieh. A preliminary draft of a report based on this work was prepared by Messrs. Moulton and Bass and is now being revised and completed by Mr. Fath.

A paper on the oil-bearing formations in Wyoming has been submitted by Mr. Heald for outside publication.

The oil shales of southwestern Wyoming are briefly treated in a report on "Oil shale in the Rocky Mountain region," by D. E. Winchester, in a manuscript awaiting publication.

Outcropping oil sands in the Osage and Salt Creek districts were examined, and samples from outcrops and well cuttings were collected for investigation by A. F. Melcher, with special reference to their porosity, permeability, and productivity.

Detailed studies involving careful tracing of typical horizons and detailed measurement of stratigraphic sections along the eastern front of the Laramie Mountains, with a view to determine the extent and thickness of the oil-bearing strata of Wyoming, were made during June by W. T. Lee, assisted by H. F. Cave.

A map of the State of Wyoming showing oil and gas fields, pipe lines, and anticlinal axes, was brought close to completion during June.

The Sodium Lakes, southwest of Laramie, were examined by R. C. Wells. A description of the phosphate deposits near Lander, by D. Dale Condit, is in hand for publication. Cretaceous and Jurassic invertebrates were examined by T. W. Stanton, and the flora of the Green River formation was systematically reviewed and brought up to date by F. H. Knowlton.

HAWAIIAN ISLANDS.

Field studies on the islands of Oahu, Hawaii, and Maui were carried on during August by T. W. Vaughan, who served as chairman of the section of geology of the First Pan-Pacific Conference, held in Honolulu. A paper entitled "The basis of the correlation of the Tertiary and Quaternary geologic formations in the Pacific" was

read by Mr. Vaughan at this conference. Hawaiian invertebrates have been reported on by W. H. Dall.

DOMINICAN REPUBLIC.

In the spring of 1919 a geologic reconnaissance of the Dominican Republic was made under the direction of the United States Geological Survey for the Military Government of the Republic. During the fiscal year the manuscript of a report giving the results of the investigations was edited and a contract was let for printing it. The report is now in proof.

HAITI.

In compliance with the request from the civil authorities of the Republic of Haiti that a geologic reconnaissance of the Republic be undertaken under the supervision of the United States Geological Survey, W. P. Woodring, J. S. Brown, and W. S. Burbank left New York for Port au Prince September 21, 1920. A reconnaissance of the entire Republic was made during the period from October to April. The geologic formations were mapped, and rocks, ores, water samples, and fossils were collected for laboratory study. The field work was inspected in February by T. W. Vaughan, geologist in charge of West Indian geological surveys. The results of the reconnaissance will be embodied in a report on the geology, mineral resources, and water resources of the Republic.

OTHER COUNTRIES.

Mainly through cooperation with governmental and scientific institutions, a number of members of the geologic staff, especially the paleontologists, have been called upon for special examinations, determinations, or compilations relating to the geology of Trinidad, Cuba, Mexico, Panama, Argentina, Bolivia, Brazil, Colombia, Patagonia, Peru, Chile, Uruguay, Ireland, Spain, Russia, Spitzbergen, the East Indies, the Philippine Islands, and Australia.

By special request of the Director of the Pan American Union, articles on oil in South America were prepared by the Director of the Survey and the chief geologist. The manuscripts were translated and printed in the July issues of the bulletin of the Union.

DIVISION OF ALASKAN MINERAL RESOURCES.

PERSONNEL.

On June 30, 1920, the division of Alaskan mineral resources consisted of 1 geologist in charge, 6 geologists, 2 topographic engineers, 1 hydraulic engineer, 1 draftsman, and 2 clerks on annual salaries and 1 geologist on monthly salary. On June 30, 1921, the personnel included 1 geologist in charge, 4 geologists, 2 topographic engineers, 1 draftsman, and 3 clerks on annual salaries, 2 geologists on monthly salaries, and 1 geologist and 1 topographic engineer on per diem salaries.

APPROPRIATIONS AND ALLOTMENTS.

The funds available for field and office work relating to the field season of 1920 included an appropriation of $75,000 and an unexpended balance of $10,400 from the appropriation of the preceding year. The subjoined tables show the allotments of these funds geographically, by types of work, and by salaries and field expenses. A balance of $13,800 will be used for the field work of 1921. In these tables the money devoted purely to office work has not been allocated to the several projects, as in previous administrative reports. The overhead charges, including administration, amount to about 23 per cent of the total and may be properly allocated to the several projects at this ratio.

Approximate general distribution of appropriations for investigations in Alaska, field season 1920.

	1919–20	1920–21
General geologic investigation	.....	$2,700
Southeastern Alaska	.....	9,240
Prince William Sound	.....	1,400
Cook Inlet	$3,500	8,910
Southwestern Alaska	.....	1,000
Susitna region	3,750	5,610
Yukon Basin	1,600	4,420
Kuskokwim Basin	300	5,380
Seward Peninsula	1,150	3,200
Administrative	.....	4,250
Collection of mineral statistics	.....	1,900
Miscellaneous expenses, including clerical work, office supplies, etc	100	13,190
Balance to be allotted to field work, 1921	.....	13,800
	10,400	75,000

Approximate allotments to different kinds of surveys and investigations, field season 1920.

	1919–20	1920–21
Reconnaissance geologic surveys	$3,400	$13,82 0
Special geologic investigations	1,150	13,82 5
Topographic reconnaissance surveys	5,750	9,870
Investigation of water resources	.....	4,345
Administrative	.....	4,250
Collection of mineral statistics	.....	1,900
Miscellaneous expenses, including clerical work, office supplies, map compilation, etc.	100	13,190
To be allotted to field work, 1921	.....	13,800
	10,400	75,000

Allotments for salaries and field expenses, field season 1920.

	1919–20	1920–21
Scientific salaries	.....	$29,395
Field expenses	$10,300	16,115
Clerical salaries and miscellaneous expenses	100	15,690
To be allotted to field work, 1921	.....	13,800
	10,400	75,000

INVESTIGATIONS AND SURVEYS.

The following table shows the progress of investigations in Alaska and the annual grant of funds since systematic surveys were begun in 1898.[1] It should be noted that a varying amount is spent each year on special investigations that yield results which can not be expressed in terms of area. In 1917, when the United States entered the World War, the Alaska funds were nearly all allotted to the investigation of such minerals as platinum, sulphur, and antimony, which were then of special importance, and few areal surveys were made. Since then the reduction of the annual appropriation and the increased cost of all field work have not permitted extensive geologic and topographic surveys, which must be made before an adequate knowledge of the mineral resources of the Territory can be obtained.

Progress of surveys in Alaska, 1898–1920.

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[a]					Investigations of water resources.	
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500; 25, 50, or 100-foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Measurements of stream volume.
		Sq. m.	*Sq. m.*	*Sq.m.*	*Sq. m.*	*Sq. m.*	*Sq. m*	*Miles.*			
1898	$46,189	9,500	.....	.....	12,840	2,070	.....	.....	.....	.....	.....
1899	25,000	6,000	.....	.....	8,690	.....	.....	.....	.....	.....	.....
1900	60,000	3,300	6,700	.....	630	11,150	.....	.....	.....	.....	.....
1901	60,000	6,200	5,800	.....	10,200	5,450	.....	.....	.....	.....	.....
1902	60,000	6,950	10,050	.....	8,330	11,970	96	.....	.....	.....	.....
1903	60,000	5,000	8,000	96	.....	15,000	.....	.....	.....	.....	.....
1904	60,000	4,050	3,500	.....	800	6,480	480	86	19	.....	.....
1905	80,000	4,000	4,100	536	.....	4,880	787	202	28	.....	.....
1906	80,000	5,000	4,000	421	.....	13,500	40	.....	.....	14	286
1907	80,000	2,600	1,400	442	.....	6,120	501	95	16	48	457
1908	80,000	2,000	2,850	604	.....	3,980	427	76	9	53	556
1909	90,000	6,100	5,500	450	6,190	5,170	444	.....		81	703
1910	90,000	.....	8,635	321	.....	13,815	36	.....	.....	69	429
1911	100,000	8,000	10,550	496	.....	14,460	246	.....	.....	68	309
1912	90,000	.....	2,000	525	.....	.....	298	.....	.....	69	381
1913	100,000	3,500	2,950	180	3,400	2,535	287	.....	.....	.....	.....
1914	100,000	1,000	7,700	325	600	10,300	10	.....	.....	.....	.....
1915	100,000	.....	10,700	200	.....	10,400	12	3	2	9	.....
1916	100,000	.....	5,100	636	.....	9,700	67	.....	.....	20	.....
1917	100,000	.....	1,750	275	.....	1,050	.....	.....	.....	19	.....
1918	77,000	.....	3,500	.....	.....	1,200	.....	.....	.....	.....	.....
1919	75,000	.....	2,700	.....	.....	2,300	.....	.....	.....	19	.....
1920	75,000	.....	1,480	.....	.....	770	.....	.....	.....	19	.....
	1,788,189	73,200	108,965	5,507	51,680	152,300	3,731	462	74	.....	.....
Percentage of total area of Alaska	.....	12.48	18.58	0.94	8.81	25.97	0.64	.....	.....	.....	.....

[a] The Coast and Geodetic and International Boundary surveys have also made topographic surveys in Alaska. The areas covered by these surveys are of course not included in these totals.

General work.—Alfred H. Brooks, geologist in charge, was engaged in office work until July 4, when he accompanied John Barton Payne, Secretary of the Interior, and Josephus Daniels, Secretary

[1] The Geological Survey made some investigations of the gold and coal deposits of the Pacific seaboard region in 1895 and of the Yukon region in 1896.

of the Navy, to Alaska. In the course of this journey a part of the Matanuska coal field and the Government railroad were examined. Through the courtesy of Admiral Hugh Rodman, a visit to Cold Bay, on the Alaska Peninsula, was also made. Later a visit was made to the Bering River coal and Katalla oil fields. From August 24 to September 13 the time was spent in examining the copper and gold lodes of Prince William Sound and in studying the local geology. A part of the work was done in company with O. C. Ralston, metallurgist, of the Bureau of Mines. Later, also in company with Mr. Ralston, 10 days was devoted to examination of some of the copper deposits of the Ketchikan district. Returning, Mr. Brooks reached Washington October 4. Of the nine months devoted to office work for the fiscal year 1920, 44 days was devoted to the annual progress report, 8 days to the annual press bulletin, 12 days to field plans, 5 days to reading manuscript, 8 days to military geology, 36 days to geologic studies, and the remainder to routine matters.

R. H. Sargent was on furlough for about three-fourths of the year. While on duty he was occupied chiefly in administration of the Alaska topographic surveys and map compilation.

S. R. Capps was on furlough until February 21, 1921. While on duty he was engaged chiefly in continuing the preparation of his report on the geology and mineral resources of the region tributary to the Government railroad.

G. L. Harrington was on furlough all but about one week in the year and while on duty devoted his time chiefly to the report on the Ruby-Iditarod district.

J. B. Mertie, jr., was on furlough until March 31 and gave the rest of the fiscal year to the continuation of his report on the Ruby-Iditarod district.

C. P. McKinley, in addition to compiling his field data, devoted about two months to compiling a topographic map of the Katmai region from photographs furnished by the National Geographic Society.

Miss Lucy M. Graves, chief clerk, has continued to carry much of the burden of the administration of the Alaska division and has acted as chief during the absence of the geologist in charge and the senior geologist, G. C. Martin. The details of collecting the statistics of the mineral production of Alaska have been in the hands of T. R. Burch.

Field parties.—G. H. Canfield continued water-power investigations in southeastern Alaska up to April 1, when the work was suspended on account of lack of funds. A record of five years of stream flow has now been obtained for about 19 of the best of the water-power sites in southeastern Alaska. In view of the demands for other investigations in Alaska, the continuation of the stream gaging does not appear to be justified under the present reduced appropriation. This work could not have been done without the cordial cooperation of the Forest Service, which has rendered much valuable assistance in providing gage readers, local transportation, and office space. The great importance of this water-power investigation to the pulp-wood and mining industries is generally recognized, and it is hoped that funds will be available for its continuation at an early date.

Lewis G. Westgate completed a geologic reconnaissance survey of the Portland Canal region of the Ketchikan district between July 19 and September 24.

F. H. Moffit, with Herbert Insley, geologic assistant, and C. P. McKinley, topographer, made a geologic and topographic reconnaissance survey covering 380 square miles in the Tuxedni Bay region of Cook Inlet between June 10 and September 10. The original plan had been to extend the survey southward to include the Iliamna Bay oil field. This proved impossible on account of the almost unprecedented rainfall of the summer, which both retarded the field work and made a part of the region impassable for a pack train, owing to swollen rivers and swamps.

J. R. Eakin made topographic reconnaissance surveys of an area of 390 square miles on the southern slope of the Alaska Range in the headwater region of the Susitna basin. The field work, which was carried on from June 27 to August 28, was greatly retarded by rainy weather, which made it impossible to carry the survey across the range, as had been planned.

Philip S. Smith devoted the time from July 17 to September 22 to a continuation and revision of the geologic reconnaissance mapping of the Salcha-Goodpaster region. His survey, which included the investigation of mineral resources, covered a total area of 1,200 square miles, of which about 500 had been previously unmapped.

G. C. Martin continued the study of the geology and mineral resources of the Ruby, Iditarod, and Innoko districts. He also made a special investigation of the auriferous lodes of the Nixon Fork basin of the Mount McKinley district, in the upper Kuskokwim basin. The field work was carried on from July 1 to August 29.

S. H. Cathcart devoted the time from July 3 to September 19 to a geologic study of the mineral deposits of parts of Seward Peninsula. This was a part of a project for an intensive investigation of the mineral-bearing lodes of the peninsula, which unfortunately, because of lack of funds, could not be continued in 1921.

Field parties, 1921.—A. F. Buddington is engaged in making a geologic reconnaissance survey and study of the mineral resources of the Wrangell district, in southeastern Alaska.

S. R. Capps, assisted by W. R. Smith, is making a geologic reconnaissance survey of the Cold Bay oil field. R. K. Lynt is making a topographic survey of the same area.

F. H. Moffit, with A. A. Baker, geologic assistant, and C. P. McKinley, topographer, is making a detailed survey of the Iliamna Bay oil field.

George C. Martin is studying the geology and mineral resources of the Koyukuk and lower Yukon districts.

J. B. Mertie, jr., is extending the geologic reconnaissance surveys and investigations of mineral resources in the Fairbanks region.

DIVISION OF MINERAL RESOURCES.

The increase of $15,000 in the appropriation for preparation of reports on mineral resources was devoted mainly to necessary increases in the personnel of the section of mineral fuels and to much needed increases in salaries. The division now consists of 29 scientific mem-

bers and 56 clerks, of whom 16 scientists and 49 clerks devote all their time to the division. The division is still undermanned, as 11 subjects have to be cared for without the supervision of specialists, though for the time being they are being creditably handled by experienced clerks under the direction of a section or division chief. The only change in administration was the appointment of B. L. Johnson as chief of the section of foreign mineral reserves, to succeed Eugene Stebinger, resigned.

The scope of the work should be enlarged in all sections, especially in those of mineral fuels and foreign mineral reserves, to meet present demands, but the space allotted to the division is very inadequate for even the present personnel. The chiefs of the sections of mineral fuels, other nonmetals, and foreign mineral reserves occupy rooms with two or three others, mostly clerks, and their frequent conferences with visitors or others are necessarily held to great disadvantage and with repeated interruption to all in the room. As many as four or five clerks working on different subjects and doing different kinds of work have to be assigned to a single small room, and the work necessarily suffers. The present average space of 73 square feet for each individual is grossly inadequate when the amount of necessary furniture and the space necessary to handle large tabulation sheets are considered. The esprit of the division is excellent despite these trying conditions, but the nervous and mental strain due to them is bound to injure the work in the long run.

The sections of metals and nonmetals continued to supply the usual information. Cordial cooperation with industrial associations and Government organizations has increased during the year to mutual advantage and has demonstrated a growing appreciation of mineral statistics and closely related economic studies and their interpretation by qualified specialists.

The work in the section of mineral fuels has been more conspicuous because of the general public interest in coal and petroleum. Twelve permanent members devoted all their time to coal, and the force was augmented in April and May by 10 temporary employees. The weekly report on coal production and the spring report on consumers' and dealers' stocks, both of which were made possible in former years by cooperation with the National Coal Association and the Bituminous Coal Commission, were financed by the division. Numerous special reports or data for reports and for congressional hearings were also prepared. The work on oil and gas was performed by 13 employees. The scope of the monthly report on production of petroleum was enlarged, and the portion relating to stocks was improved by a detailed statement of gross and net stocks. The preparation of a series of maps showing oil and gas fields of different States was begun, and the maps of Louisiana and Kansas were finished. Special reports and papers of timely interest to the oil and gas industries were also prepared.

Demands on the three western offices were heavier than ever, and a conspicuous feature of the year was the preponderance of inquiries for nonmetallic minerals, and especially for oil. Although these offices were established principally for the adequate study of the metal-mining industry they have met this new demand and have rearranged their equipment so as best to meet the new situation. The personnel

of these offices has done admirable work, but it is not large enough to meet all demands. As a partial remedy for this defect, J. M. Hill, geologist, was transferred to the San Francisco office to study local economic problems and to furnish more strictly geologic and mineralogic information to visitors. He began his duties September 1. A special distribution office similar to those at San Francisco and Denver was established at Salt Lake City and has considerably lightened the demand on the two statisticians there for general information; but the need of a resident geologist in Salt Lake City to keep informed and to give information on new developments, especially of nonmetallic minerals, is urgent. The Denver office force also needs to be enlarged for the same purpose.

The section of foreign mineral reserves, owing to the loss of two geologists, has been concentrating its efforts on furnishing timely information on mineral commodities, especially oil, by the publication of papers in the technical press, and on building up the files of specially prepared abstracts, clippings from current periodicals, consular reports, mining-company reports, data on mineral reserves, bibliographies, maps, and statistics of foreign production. Part I of the World Atlas of Commercial Geology was published in February, but progress on the mineral-reserve atlases of Europe and Latin America has been negligible because of the shortage of geologists adapted for this particular work. The manuscripts for these atlases are available, however, for those who wish to consult them at the office of the Geological Survey. While the present shortage of personnel continues the publication of a current bibliography of economic geology, monthly or less frequently, would fill a much-felt want. Expansion in all the lines above cited is necessary if the section is properly to keep pace with the demands of the interested public. With more funds qualified clerical help can doubtless be procured, but it is less easy to find economic geologists adequately qualified and willing to pursue the more scientific problems of foreign mineral reserves.

Progress of the regular reports of the division, after delays due to the war period and to cooperation with the Bureau of the Census, is once more nearly back to normal. During the year the last six chapters of Mineral Resources for the year 1918 were transmitted. Forty-one chapters for 1919 have been transmitted and twenty-one remain, for some of which not all the schedules had been received from the Bureau of the Census at the end of the fiscal year. Seventeen reports for 1920 have thus far been transmitted.

The second preliminary summary of mineral resources of the United States (for 1919) was delayed through the difficulty in procuring data and was not published until September 8, 1920. The corresponding summary for 1920, though affected by some delays, made much better progress and was issued July 7, 1921. The work of collecting and compiling satisfactory data on all the different mineral industries is so complicated that it is impossible to publish a satisfactory summary earlier than June.

Cooperation with State surveys and bureaus, which was only nominal during the collection of the census data, was resumed January 1, 1921, on its former basis.

DIVISION OF CHEMICAL AND PHYSICAL RESEARCH.

ORGANIZATION AND FUNDS.

The division of chemical and physical research was on June 30, 1921, composed of seven chemists, two physicists, two laboratory aids, one clerk, one laboratory assistant, and one laborer. The reinstatement of one chemist in August was balanced by the resignation in September of another who had been temporarily employed to assist in reducing the congestion of analytical routine work.

Of the $40,000 appropriated for the work of this division $7,500 was allotted to the search for deposits of natural potash salts and nitrates. These investigations, being largely in the nature of field exploration and examination, were administered under the division of geology.

The high cost of chemical supplies and equipment has imposed a relatively heavy lien on the total funds for the year.

WORK IN CHEMISTRY.

The chemical work of the division, in charge of the chief chemist, comprised researches in physical chemistry, chemical geology, and mineralogical chemistry and routine qualitative and quantitative analyses of rocks, minerals, ores, and waters. During the year 2,548 chemical analyses were reported, of which 135 were of commercial interest and 1,267 of scientific interest; the remaining 1,146 were qualitative tests.

The classification and description of the qualities of the surface waters of the United States, carried on in cooperation with the water-resources branch, by F. W. Clarke, is nearing completion. In collaboration with Dr. H. S. Washington, of the Carnegie Geophysical Laboratory, Mr. Clarke completed a manuscript on the composition of the earth's crust. A paper on the evolution of the earth's crust was read before the National Academy of Sciences in April by Mr. Clarke, who also prepared for publication in the Memoirs of the Academy "A recalculation of atomic weights," the most complete treatise ever published on this subject.

Physical and chemical investigations of sediments, natural brines, and the solubility of sodium and potassium carbonates were made by R. C. Wells. He prepared a report on physical and chemical investigations of sediments for the division of geology of the National Research Council, published a paper on the salt error of cresol red in the Journal of the American Chemical Society, and prepared another on the alkalinity of Searles Lake brine for publication in the Journal of Industrial and Engineering Chemistry. Two papers—"Changes in natural waters" and "Physicochemical studies relating to the growth of corals"—were presented by Mr. Wells at the Pan-Pacific Scientific Congress, at which he represented the Geological Survey. Mr. Wells also prepared a report on "Sodium sulphate, its sources and uses," to be issued as a bulletin of the Geological Survey, and the chapter on "Sodium compounds" for Mineral Resources, 1919. Specifications for the use of lime in causticizing were prepared by Mr. Wells for the interdepartmental committee on chemical lime, 1921.

A series of native vanadium compounds collected by D. F. Hewett was investigated by W. T. Schaller, who, in the course of his work in descriptive mineralogy and mineralogic chemistry, also studied a new mineral collected by P. S. Smith in Alaska.

The fossil organic compounds found in oil shale were studied by E. T. Erickson, in collaboration with David White, the object being to determine the composition and original nature of the resin and waxlike bodies preserved in the shale, and their distinction in composition and character from the groundmass. A paper by Mr. Erickson describing tschermigite (ammonium alum) from Wyoming was prepared for publication in the American Mineralogist, and another entitled "Tests to detect the presence of small quantities of petroleum, other true bitumens, and pyrobitumen" will appear at an early date in the Engineering and Mining Journal.

Studies and experiments on the action of nitric acid on certain rocks and on the effect of carbonic acid on limestone were continued during the entire year by George Steiger in cooperation with G. F. Loughlin. In cooperation with E. S. Larsen, jr., Mr. Steiger also conducted a series of experiments on the dehydration of gypsum. A paper by Messrs. Steiger, Larsen, and J. T. Pardee on bementite and neotocite from western Washington, with conclusions as to the identity of bementite and caryopilite, was printed by the Washington Academy of Sciences in January. A manuscript is in preparation by Messrs. Steiger and Larsen on griffithite, nontronite, and alunogen.

A paper entitled "Notes on analysis of mineral sulphide water," by J. G. Fairchild, was printed by the Washington Academy of Sciences in December.

The salinity of a large number of water samples collected by the Bureau of Fisheries from different parts of Chesapeake Bay was determined by E. P. Henderson.

In addition to the contributions mentioned above, minor communications were offered to the National Research Council and other scientific bodies by different members of the scientific staff.

The work in search for potash, including the demonstration of the presence of potash-rich salts associated with the rock salt and anhydrite deposits of western Texas, is described in the report of the division of geology (pp. 42–43). Orby C. Wheeler, the geologist maintained in the field jointly by the Bureau of Economic Geology and Technology of the University of Texas and the United States Geological Survey, was in August succeeded by D. D. Christner. In the spring R. S. Sternbergh was detailed to record the progress and roughly test the cuttings as boring proceeded at one of the wells now being drilled in the region known to contain potash.

WORK IN PHYSICS.

In addition to administering the work of the physical laboratory, C. E. Van Orstrand made field observations of temperatures in deep wells in New Jersey, West Virginia, Wyoming, Texas, and California. Reductions of observations of temperatures in more than 3,000 overflowing wells are being made for the purpose of comparing the temperature gradients in oil-bearing and nonoil-bearing areas. Several short papers and progress reports based upon these investi-

gations have been prepared by Mr. Van Orstrand for outside publication, and a comprehensive memoir on the deep earth temperatures of the globe is in preparation. Meanwhile the preparation of tables of the probability integral has gone forward. A memoir embracing "Tables of the exponential function and of the circular sine and cosine to radian argument" has been published in the memoirs of the National Academy of Sciences.

Field and laboratory investigations of the size of grain and the porosity, permeability, and productivity of oil, gas, and water sands have been continued by A. F. Melcher, a part of this work being carried on in cooperation with the Bureau of Mines. Field examinations and studies of oil sands from outcrops and from well cuttings were made by Mr. Melcher in Pennsylvania, Wyoming, and Oklahoma. Progress reports embodying some of the results of this work, for which new apparatus has been constructed by Mr. Melcher, are being prepared for outside publication.

Experiments on the diffusion of solids were conducted by M. A. Shoultes under the direction of Mr. Van Orstrand. Mr. Shoultes has also made interpolations of the exponential function and assisted in reducing the observations of deep earth temperatures and in making porosity tests.

TOPOGRAPHIC BRANCH.

ORGANIZATION.

The organization of the topographic branch during the year was as follows:

Chief topographic engineer, C. H. Birdseye.
Atlantic division, topographic engineer in charge, Frank Sutton.
Central division, topographic engineer in charge, W. H. Herron.
Rocky Mountain division,[1] topographic engineer in charge, T. G. Gerdine.
Pacific division,[1] topographic engineer in charge, G. R. Davis.
Division of West Indian surveys, topographic engineer in charge, Glenn S. Smith. (In the absence of Mr. Birdseye Mr. Smith acted as chief topographic engineer.)
Computing section, geographer in charge, E. M. Douglas.
Section of inspection and editing, topographic engineer in charge, W. M. Beaman.
Section of cartography, draftsman in charge, A. F. Hassan.
Map information office, topographic engineer in charge, J. H. Wheat.
Section of relief maps, geographer in charge, J. H. Renshawe.
Section of photographic mapping, topographic engineer in charge, T. P. Pendleton.

PERSONNEL.

During the fiscal year two members of the topographic branch who had held commissions in the Engineer Officers' Reserve Corps (one topographic engineer and one junior topograhper) were reinstated in their former positions. The technical force was increased by the appointment of 20 junior topographers and the rein-

[1] During the year the Rocky Mountain and Northwestern divisions were consolidated into the Rocky Mountain division and certain changes in organization were made in the States formerly included in the Rocky Mountain and Pacific divisions.

statement and transfer of 1 map reviser, 2 topographic engineers, 1 junior topographer, and 3 draftsmen. During this period the force was reduced by 6 resignations and 2 transfers, and 1 assistant topographer and 5 junior topographers who had not requested reinstatement from the Army were dropped from the rolls. With these changes the corps now includes 1 chief topographic engineer, 5 topographic engineers in charge of divisions, 5 geographers, 67 topographic engineers, 3 topographers, 36 assistant topographic engineers, 41 junior topographers, 1 map editor, 2 map revisers, 1 computer, and 10 draftsmen, a total of 172. During the year 9 topographic engineers, 1 assistant topographic engineer, and 5 junior topographers were on furlough. One topographic engineer in charge of a division and 16 members of the permanent force were on furlough during the year for work in Haiti and the Dominican Republic. (See pp. 6–7.) In addition, 27 technical field assistants were employed during the whole or a part of the year. The clerical force comprises 13 clerks of various grades.

PUBLICATIONS.

The published work of the topographic branch for the fiscal year consists of 64 maps and 9 advance chapters of a bulletin giving the results of triangulation and primary traverse work in 28 States (parts C to K of Bulletin 709; see p. 11).

A notable publication of the year was a new relief map of the United States printed in shades of brown and blue to show the relative heights of the land and depths of the sea.

APPROPRIATIONS.

The Federal appropriations for topographic surveys for the fiscal year 1921 were as follows:

Topographic surveys	$330,000.00
Statutory salaries	9,200.00
Special funds for military mapping (contributed by War Department)	50,000.00
Total	389,200.00

Practically all of these appropriations were expended during the fiscal year.

COOPERATION.

Cooperation has been maintained in 20 States and 1 Territory, which contributed the following amounts:

Arizona	$8,559.20
California	22,254.92
Colorado	725.39
Hawaii	24,753.15
Idaho	66.70
Illinois	11,771.53
Iowa	2,193.04
Kentucky	12,343.82
Maine	7,496.14
Michigan	14,476.53

Mississippi	$30,784.08
Missouri	4,687.12
New York	14,999.29
North Dakota	1,514.51
Pennsylvania	45,059.58
Texas	16,313.45
Vermont	2,937.20
Virginia	5,330.76
Washington	10,170.19
West Virginia	22,081.73
Wisconsin	15,273.72
	273,792.05

In addition, the Illinois State Department of Public Works and Buildings expended $2,918.54 for work on the Illinois State road map by direct payment of the salaries of draftsmen furloughed for that purpose. The Bureau of Soils expended $15,750 for base-map traverses of counties in Georgia, Mississippi, and Texas. This was not met by Survey funds. Work executed for the land-classification board on base maps needed in the classification of lands and power sites entailed the expenditure of $32,400, which was paid for from the appropriation for the classification of lands, 1921. The amount of $1,284.21 was expended by the Survey in compiling road maps for the Bureau of Public Roads. For the completion of the office work on the topographic map of Camp A. A. Humphreys, Va., the War Department contributed $1,880.24, which was not met by Survey funds. The total amount expended from these sources was $54,232.99.

The total amount expended from all sources for the work of the topographic branch was $717,225.04.

SUMMARY OF RESULTS.

The condition of topographic surveys to June 30, 1921, distinguished as to scale, etc., is shown on Plate I.

As shown in the following table, the new area mapped was 12,311 square miles, making the total area surveyed to date in the United States 1,313,447 square miles, or 43.3 per cent of the entire country. In addition, 1,669 square miles of resurvey was completed, making the total area of surveys during the year 13,980 square miles.

In connection with these surveys, 4,796 linear miles of primary and precise levels were run, making 287,746 miles of primary and precise levels run since the authorization of this work by Congress in 1896. In the course of this work 1,123 permanent bench marks were established. In addition, 576 linear miles of river surveys and 5,715 linear miles of road traverse were run.

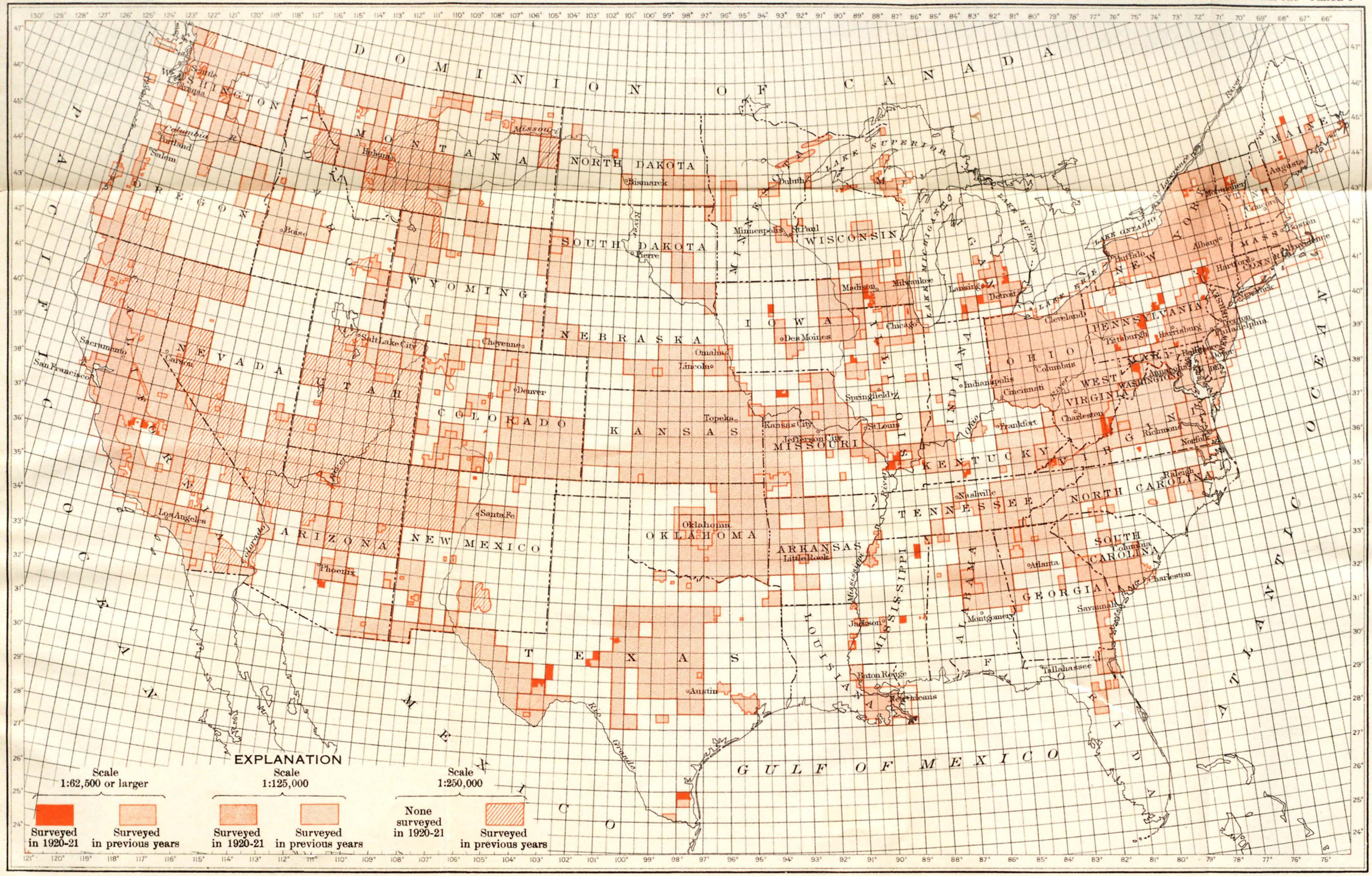
Triangulation stations to the number of 122 were occupied and 78 were permanently marked. Primary-traverse lines aggregating 1,775 miles were run, in connection with which 394 permanent marks were set.

Present condition of topographic surveys of the United States and new area surveyed July 1, 1920, to June 30, 1921.

State.	New area mapped July 1, 1920, to June 30, 1921.	Total area mapped to June 30, 1921.	Percentage of total area of State mapped to June 30, 1921.
	Sq. miles.	*Sq. miles.*	
Alabama	.....	19,192	37.0
Arizona	382	70,618	62.0
Arkansas	.....	21,494	40.3
California	714	125,594	79.3
Colorado	883	51,930	49.9
Connecticut	.....	4,965	100.0
Delaware	.....	2,370	100.0
District of Columbia	.....	70	100.0
Florida	.....	4,716	8.0
Georgia	.....	24,835	41.9
Idaho	38	28,490	33.7
Illinois	815	18,416	32.4
Indiana	.....	3,609	10.0
Iowa	225	12,270	21.8
Kansas	.....	64,159	78.0
Kentucky	395	18,778	46.2
Louisiana	.....	8,366	17.2
Maine	182	10,479	31.7
Maryland	.....	12,327	100.0
Massachusetts	.....	8,266	100.0
Michigan	934	11,153	19.2
Minnesota	.....	7,354	9.0
Mississippi	940	3,140	6.7
Missouri	481	37,394	53.8
Montana	.....	58,558	40.0
Nebraska	.....	27,117	35.0
Nevada	.....	51,141	46.2
New Hampshire	.....	4,235	45.3
New Jersey	.....	8,224	100.0
New Mexico	60	42,648	34.7
New York	660	46,001	93.4
North Carolina	.....	18,876	36.0
North Dakota	116	10,017	14.1
Ohio	.....	41,040	100.0
Oklahoma	.....	39,908	57.0
Oregon	20	25,588	26.4
Pennsylvania	1,888	27,896	61.8
Rhode Island	.....	1,248	100.0
South Carolina	.....	13,675	44.1
South Dakota	.....	19,032	25.0
Tennessee	.....	21,283	50.6
Texas	1,865	76,864	28.9
Utah	124	69,155	82.0
Vermont	85	4,929	51.5
Virginia	239	36,058	84.5
Washington	563	31,590	45.6
West Virginia	.....	24,170	100.0
Wisconsin	702	14,121	25.1
Wyoming	.....	30,088	31.0
Total United States (exclusive of Alaska)	12,311	1,313,447	43.3
Hawaii	368	1,761	27.3

GENERAL OFFICE WORK.

Computations for vertical and horizontal control were made and the results were copied and catalogued by the computing section. Relief maps of the Black Hills, the Mississippi Valley, central California, Kentucky, Ohio, and Wyoming were prepared by the section of relief maps. The section of photographic mapping was engaged in transforming airplane photographs to base maps for use by the Bureau of Soils and in miscellaneous work in connection with the utilization of airplane photographs in topographic mapping. The map informa-



A. HOEN & CO. LITH. BALTIMORE.

AREAS COVERED BY TOPOGRAPHIC SURVEYS MADE BY UNITED STATES GEOLOGICAL SURVEY PRIOR TO JULY 1, 1921

AND THE SCALE EMPLOYED FOR EACH AREA

Scale $\frac{1}{14000000}$

100 0 100 200 300 400 500 Miles

tion office was engaged in indexing and cataloging the map data available in the several Federal departments and in furnishing miscellaneous map information to the public.

SECTION OF INSPECTION AND EDITING OF TOPOGRAPHIC MAPS.

The section of inspection and editing of topographic maps has the general supervision of the office preparation of all field topographic maps and direct charge of their inspection and editing prior to approval and reproduction; it also supervises the preparation of an increasing number of maps referred to the Survey by other Government bureaus for photolithography or engraving.

The number of topographic maps in progress in the office (exclusive of those being engraved and printed) ranged from 75 in July to 110 in February; the monthly average was 97. During the year 78 topographic maps were sent to the engraving division for advance-sheet photolithography. An average of 16 employees were engaged in this section for the year. James McCormick devoted nearly one-half of his time to special investigations pertaining to geographic names and service as the Survey representative on the United States Geographic Board.

The work of this section is described further under "Publication branch" (p. 98).

SECTION OF CARTOGRAPHY.

The compilation of the base of the United States portion of the international map of the world was continued during the year. The North Dakota, South Dakota, and Nebraska portions of this map, begun in the preceding year, were completed, and the compilation of maps of other States was carried to the following percentages: California, 45 per cent; Colorado, 65 per cent; Kansas, 10 per cent; Maine, 40 per cent. Maps of this series have been completed for 38 States.

The cartographic force completed numerous other map projects, the most important of which were a map for the determination of the Turkish-Armenian boundary for the Department of State; a map of the northeastern United States for the superpower survey; a base for a relief map of Ohio; a road map of Illinois, in cooperation with that State; and road maps for 28 States, in cooperation with the Bureau of Public Roads.

ATLANTIC DIVISION.

FIELD WORK.

Summary.—During the season topographic mapping was carried on in Maine, Maryland, Mississippi, New York, Pennsylvania, Vermont, Virginia, and West Virginia. This work comprised the completion of the survey of 14 quadrangles and the resurvey of 5 quadrangles, in addition to which 13 quadrangles were partly surveyed, 6 were partly resurveyed, and 2 were revised. Primary triangulation and primary traverse were carried on by six parties in Mississippi, Pennsylvania, Tennessee, Virginia, and West Virginia.

Topographic surveys in Atlantic division from July 1, 1920, to June 30, 1921.

State.	Contour interval.	For publication on the scale of 1:62,500.		Total area surveyed.	Levels.			Primary traverse.		Triangulation.	
		New.	Resurvey.		Primary.	Precise.	Bench marks.	Distance run.	Permanent marks.	Stations occupied.	Stations marked.
	Feet.	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Miles.*	*Miles.*		*Miles.*			
Maine	20	182	.....	182	116	.....	19	.....	.....	.....	.....
Mississippi	20	940	.....	940	815	41	183	582	138	.....	.....
New York	20	660	.....	660	61	.....	12	.....	.....	.....	.....
Pennsylvania	20	1,888	.....	1,888	398	6	72	88	2	.....	.....
Tennessee	.....	.....	.....	.....	.....	.....	.....	100	25	.....	.....
Vermont	20	85	.....	85	.....	.....	.....	.....	.....	.....	.....
Virginia	20,50	79	160	239	94	.....	29	37	12	.....	.....
West Virginia	50	.....	1,286	1,286	666	.....	183	.....	.....	19	21
	.....	3,834	1,446	5,280	2,150	47	498	807	177	19	21

Georgia.—For the Bureau of Soils 335 linear miles of road traverse in Jenkins County and 410 linear miles in Wilkinson County, Ga., covering in all 814 square miles, were executed, thereby completing the area in these counties which had been partly covered by topographic maps. This work was done at the expense of the Survey. In addition, a road map of Bibb County was prepared from airplane photographs taken by the Army Air Service, the only field work by the Survey being the running of 36 miles of primary traverse. The data for these three maps were adjusted and delivered to the Bureau of Soils for use as base maps in plotting the classification of the soils.

Maine.—In cooperation with the State Water Power Commission the survey of the Moosehead Lake quadrangle, in Piscataquis and Somerset counties, Me., was completed, and that of the Farmington quadrangle, in Franklin and Somerset counties, was begun, the total area mapped being 182 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Brassua Lake and Farmington quadrangles 116 miles of primary levels were run and 19 bench marks established.

Mississippi.—In cooperation with the State of Mississippi, the survey of the Booneville and Forest quadrangles, in Newton, Prentiss, Scott, Tippah, and Union counties, was completed, and that of the Meridian and Tupelo quadrangles, in Itawamba, Lauderdale, and Lee counties, was begun, the total area mapped being 851 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Booneville, Cato, Chunky, Decatur, Edwards, Forest, Meridian, Morton, Nettleton, Pelahatchee, and Tupelo quadrangles 815 miles of primary levels and 41 miles of precise levels were run and 183 permanent bench marks were established. For the control of the Booneville, Cato, Chunky, Forest, Meridian, Morton, Newton, Pelahatchee, and Tupelo quadrangles 582 miles of primary traverse were run and 138 permanent marks set. Hersey Munroe, topographic engineer, was in immediate charge of the field work.

In addition, 1,083 linear miles of road traverse in Scott County and 1,192 linear miles in Rankin County, covering in all 1,388 square

miles, were executed for the Bureau of Soils to serve as data for base maps on which to plot the soil classification. This work was done in such a manner as to be available for future incorporation in regular topographic maps.

Mississippi-Louisiana.—In addition to the cooperative work, the survey of the Natchez quadrangle, in Adams and Jefferson counties, Miss., and Catahoula County, La., was completed, the total area mapped being 89 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. All the area mapped was in Mississippi.

New York.—In cooperation with the State engineer and surveyor, the survey of the Childwold and White Lake quadrangles, in Franklin, St. Lawrence, and Sullivan counties, N. Y., was completed, and that of the Livingston Manor and Stark quadrangles, in Delaware, St. Lawrence, and Sullivan counties, was begun, the total area mapped being 462 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Livingston Manor and Stark quadrangles 61 miles of primary levels were run and 12 permanent bench marks established. (See also Pennsylvania-New York.)

Pennsylvania.—In cooperation with the State Topographic and Geologic Survey, the survey of the Altoona, Hanover, New Florence, Philipsburg, Stahlstown, and Trout Run quadrangles, in Adams, Blair, Cambria, Center, Clearfield, Fayette, Indiana, Lycoming, Somerset, Westmoreland, and York counties, Pa., was completed, and that of the Howard, Lock Haven, Pocono, Shippensburg, Tyrone, and Williamsport quadrangles, in Blair, Center, Clinton, Cumberland, Franklin, Huntingdon, Lycoming, Monroe, and Union counties, was begun, the total area mapped being 1,667 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Carlisle, Chambersburg, Hanover, Lock Haven, Mattawana, New Florence, Newville, Shippensburg, Stahlstown, and Tyrone quadrangles 298 miles of primary levels and 6 miles of precise levels were run and 55 permanent bench marks were established. For the control of the Lock Haven, Williamsport, and Mauch Chunk quadrangles 88 miles of primary traverse were run and 2 permanent marks set.

Pennsylvania-New York.—The survey of the Damascus and Long Eddy quadrangles, in Pike and Wayne counties, Pa., and Delaware and Sullivan counties, N. Y., was completed, the total area mapped being 419 square miles (221 square miles in Pennsylvania and 198 square miles in New York), for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of these quadrangles 100 miles of primary levels were run and 17 permanent bench marks established.

Tennessee.—In cooperation with the State geologist, for the control of the Portageville and Reelfoot Lake quadrangles 100 miles of primary traverse were run and 25 permanent marks set.

Vermont.—In cooperation with the State geologist, the survey of the Bolton quadrangle, in Addison, Chittenden, Lamoille, and Washington counties was begun, the total area mapped being 85 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet.

Virginia.—In cooperation with the State geologist, the survey of the Chatham quadrangle, in Pittsylvania County, was begun, the total area mapped being 79 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Callands and Chatham quadrangles, 94 miles of primary levels were run, 29 permanent bench marks established, 37 miles of primary traverse run, and 12 permanent marks set.

Virginia-Kentucky.—In cooperation with the State of Virginia, the resurvey of the Big Stone Gap quadrangle in Lee, Scott, and Wise counties, Va., and Harlan County, Ky., was continued, the total area mapped being 160 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. The area mapped was all in Virginia, the portion which lies in that State being completed.

West Virginia.—In cooperation with the State geologist, the resurvey of the Alderson, Clintonville, and Moorefield quadrangles, in Greenbrier, Hampshire, Hardy, Monroe, and Summers counties, W. Va., was completed, and that of the Richwood and White Sulphur Springs quadrangles, in Greenbrier and Nicholas counties, was begun, the total area mapped being 759 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of the Alderson, Circleville, Clintonville, Hanging Rock, Lobelia, Richwood, and White Sulphur Springs quadrangles 389 miles of primary levels were run and 108 permanent bench marks established. For the control of the Durbin, Hanging Rock, Marlinton, and Mingo quadrangles 11 triangulation stations were occupied and 11 marked. E. I. Ireland, topographic engineer, was in immediate charge of the field work.

West Virginia-Maryland.—In cooperation with the State of West Virginia, the resurvey of the Keyser quadrangle, in Hampshire and Mineral counties, W. Va., and Garrett County, Md., was completed, the total area mapped being 80 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. The area mapped was all in West Virginia. For the control of this quadrangle 10 miles of primary levels were run.

In addition, the culture for 25 square miles in the Davis and Elk Garden quadrangles, in Garrett County, Md., was revised in order to bring the Maryland portion of the map up to the standard of the work done in West Virginia.

West Virginia-Virginia.—In cooperation with the State of West Virginia, the resurvey of the Ronceverte quadrangle, in Greenbrier and Monroe counties, W. Va., and Alleghany and Craig counties, Va., was completed, and that of the Callaghan, Pearisburg, and Simmonsville quadrangles, in Greenbrier and Monroe counties, W. Va., and Alleghany, Craig, Giles, and Montgomery counties, Va., was begun, the total area mapped being 447 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. The area mapped was all in West Virginia. For the control of the Callaghan, Capon Bridge, Edinburg, Orkney Springs, Ronceverte, and Wardensville quadrangles 267 miles of primary levels were run and 75 permanent bench marks established. For the control of the Callaghan, Cass, Hightown, Warm Springs, and Winterburn quadrangles 8 triangulation stations were occupied and 10 marked.

OFFICE WORK.

The drafting of 26 sheets was completed and that of 7 sheets partly completed. Primary-level circuits were adjusted for 47 quadrangles. Geographic positions were computed for 27 quadrangles.

CENTRAL DIVISION.

FIELD WORK.

Summary.—During the season topographic mapping was carried on in Illinois, Iowa, Kentucky, Michigan, Missouri, and Wisconsin. This work comprised the completion of the survey of 14 quadrangles and the resurvey of 1 quadrangle, in addition to which 11 quadrangles and one special area were partly surveyed. Primary traverse was carried on by five parties in Kentucky, Michigan, Missouri, Ohio, and Wisconsin.

Topographic surveys in Central division from July 1, 1920, to June 30, 1921.

State.	Contour interval.	For publication on the scale of—			Total area surveyed.	Levels.			Primary traverse.	
		1:62,500		1:24,000 (new).		Primary.	Precise.	Bench marks.	Distance run.	Permanent marks.
		New.	Resurvey.							
	Feet.	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Miles.*	*Miles.*		*Miles.*	
Illinois	10, 20	592	223	.....	815	344	.....	89	.....	.....
Iowa	10	225	.....	.....	225	64	.....	14	.....	.....
Kentucky	20	395	.....	.....	395	.....	.....	.....	166	36
Michigan	10	934	.....	.....	934	213	134	46	100	22
Missouri	20	481	.....	.....	481	450	.....	130	368	77
Ohio	.....	.....	.....	.....	.....	.....	.....	.....	23	.....
Wisconsin	20	637	.....	65	702	38	.....	9	131	36
	.....	3,264	223	65	3,552	1,109	134	288	788	171

Illinois.—In cooperation with the Illinois Department of Registration and Education the survey of the Carbondale and Dongola quadrangles, in Jackson, Johnson, Pulaski, Union, and Williamson counties, and the resurvey of the Joliet quadrangle, in Cook, Du Page, and Will counties, were completed, and the survey of the Buda and Monmouth quadrangles, in Bureau and Warren counties, was begun, the total area mapped being 760 square miles, for publication on the scale of 1:62,500, with contour intervals of 10 and 20 feet. For the control of the Alexis, Buda, Carbondale, Joliet, Keithsburg, Milan, Monmouth, Orion, and Woodhull quadrangles 344 miles of primary levels were run and 89 permanent bench marks established.

Illinois-Wisconsin.—In cooperation with the State of Illinois the survey of the Grays Lake quadrangle, in Lake and McHenry counties, Ill., and Kenosha County, Wis., was completed, the total area mapped being 55 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. The area mapped was all in Illinois.

Iowa.—In cooperation with the Iowa State Geological Survey, the survey of the Dakota quadrangle, in Humboldt and Webster coun-

ties, was completed, the total area mapped being 225 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. For the control of the Dakota and Lehigh quadrangles 64 miles of primary levels were run and 14 permanent bench marks established.

Kentucky.—In cooperation with the State geologist, the survey of the Brownsville quadrangle, in Butler, Edmonson, and Warren counties, Ky., was completed, and that of the Bowling Green, in Allen, Simpson, and Warren counties, was continued, the total area mapped being 314 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Frankfort, Georgetown, Lockport, Lucas, and Mammoth Cave quadrangles 144 miles of primary traverse were run and 31 permanent marks set.

Kentucky-Illinois.—The survey of the Fords Ferry quadrangle, in Caldwell, Crittenden, and Livingston counties, Ky., and Hardin County, Ill., was begun, the total area mapped being 81 square miles (all in Kentucky), for publication on the scale of 1:62,500, with a contour interval of 20 feet.

Kentucky-Tennessee.—For the control of the Adolphus quadrangle 22 miles of primary traverse were run and 5 permanent marks set (all in Kentucky).

Michigan.—In cooperation with the State geologist, the survey of the Durand, Flint, Holly, Marshall, and Schoolcraft quadrangles, in Calhoun, Eaton, Genesee, Kalamazoo, Livingston, Oakland, Saginaw, St. Joseph, Shiawassee, and Tuscola counties, Mich., was completed, and that of the Clinton, De Witt, and Laingsburg quadrangles, in Eaton, Ingham, and Shiawassee counties, was begun, the total area mapped being 934 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. For the control of the De Witt, Flint, Holly, Laingsburg, Marshall, and Schoolcraft quadrangles 213 miles of primary levels and 134 miles of precise levels were run and 46 permanent bench marks were established. For the control of the Corunna, De Witt, and Laingsburg quadrangles 100 miles of primary traverse were run and 22 permanent marks set.

Missouri.—In cooperation with the State geologist, the survey of the Cape Girardeau, Chillicothe, Gallatin, and Jonesboro quadrangles, in Caldwell, Cape Girardeau, Daviess, Grundy, and Livingston counties, Mo., was begun, the total area mapped being 481 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Bucklin, Cape Girardeau, Chillicothe, Chula, College Mound, Dawn, Elmer, Gallatin, Hale, Jonesboro, Linneus, and Winston quadrangles 450 miles of primary levels were run and 130 permanent bench marks established, and for the control of the Altenburg, Cape Girardeau, Chula, Condray, Hale, Jonesboro, Morley, and Perryville quadrangles 368 miles of primary traverse were run and 77 permanent marks set.

Ohio.—At the request of the Chief of Engineers, 23 miles of primary traverse were run in the East Cincinnati, Hamilton, Mason, and West Cincinnati quadrangles, Ohio, to assist in the development of experiments in airplane photography.

Wisconsin.—In cooperation with the Wisconsin State geologist, the survey of the Blanchardville, Mazomanie, Monroe, and New Glarus quadrangles, in Dane, Green, Iowa, Lafayette, and Sauk counties,

was completed, and that of the Browntown quadrangle, in Green and Lafayette counties, was begun, the total area mapped being 637 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Galesville, Hillsboro, La Crosse, La Forge, Stoddard, and Viroqua quadrangles 131 miles of primary traverse were run and 36 permanent marks set.

In addition, the survey of the Gogebic range area, in Ashland and Iron counties, was begun, the area mapped being 65 square miles, for publication on the scale of 1:24,000, with a contour interval of 10 feet. For the control of this area 38 miles of primary levels were run and 9 permanent bench marks established.

OFFICE WORK.

The drafting of 15 sheets was completed and that of 5 sheets partly completed. Primary-level circuits were adjusted for 18 quadrangles. Geographic positions were computed for 19 quadrangles.

ROCKY MOUNTAIN DIVISION.

FIELD WORK.

Summary.—During the season topographic mapping was carried on in Colorado, Idaho, New Mexico, North Dakota, Oregon, Texas, and Washington. This work comprised the completion of the survey of 12 quadrangles and 3 special areas and the partial survey of 3 quadrangles and 1 special area. In addition, a profile survey was made of a portion of one river. Primary triangulation and primary traverse were carried on by two parties in Texas.

Topographic surveys in Rocky Mountain division from July 1, 1920, to June 30, 1921.

State.	Contour interval.	For publication on the scale of—					Total area surveyed.
		1:12,000	1:24,000	1:31,680	1:62,500	1:125,000	
	Feet.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Colorado	20, 100	5	.....	.....	.....	878	883
Idaho	5, 25, 50, 100	.....	.....	26	12	.....	38
New Mexico	50	.....	.....	.....	60	.....	60
North Dakota	20	.....	.....	.....	116	.....	116
Oregon	50	.....	.....	.....	20	.....	20
Texas	5, 25, 50	.....	28	2	1,835	.....	1,865
Washington	50, 100	.....	.....	.....	.....	563	563
	.....	5	28	28	2,043	1,441	3,545

State.	Primary levels.		Primary traverse.		Triangulation.	
	Distance run.	Bench marks.	Distance run.	Permanent marks.	Stations occupied.	Stations marked.
	Miles.		*Miles.*			
Colorado	116	34	.....	.....	.....	.....
North Dakota	68	8	.....	.....	.....	.....
Texas	265	72	86	17	37	24
	449	114	86	17	37	24

Colorado.—The mapping of the Kerber Creek mining district, in Saguache County, Colo., was completed, the total area mapped being 5 square miles, for publication on the scale of 1:12,000, with a contour interval of 20 feet. This work was done in cooperation with the State geologist, the United States Geological Survey furnishing the services of an experienced topographic engineer and the necessary instruments.

In addition to this cooperative mapping the survey of the Conejos quadrangle, in Archuleta, Conejos, and Rio Grande counties, was completed, the total area mapped being 878 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. For the control of the Conejos and Summitville quadrangles 88 miles of primary levels were run and 27 permanent bench marks established.

Idaho.—In cooperation with the Idaho Bureau of Mines and Geology the survey of the Seven Devils quadrangle, in Adams County, was continued, the total area mapped being 12 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet.

In addition to the cooperative topographic mapping in Idaho, a plan and profile survey of Snake River between Huntington, Oreg., and Lewiston, Idaho, was completed; also, for power investigation, an area of 26 square miles lying between Snake and Salmon rivers was mapped, and a distance of 187 linear miles was traversed, for publication on the scale of 1:31,680, with contour intervals of 5, 25, and 100 feet. This work was done for the land-classification board, the topographic branch furnishing the services of an experienced topographic engineer and the necessary instruments.

New Mexico.—The survey of the Rio Brazos quadrangle, in Rio Arriba County, N. Mex., was completed, the total area mapped being 60 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of the Monero quadrangle 28 miles of primary levels were run and 7 permanent bench marks established.

North Dakota.—In cooperation with the State Geological Survey the survey of the Garrison quadrangle, in McLean County, N. Dak., was completed, the total area mapped being 116 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of this area 68 miles of primary levels were run and 8 permanent bench marks established.

Oregon.—In cooperation with the War Department the survey of the Reedsport quadrangle, in Coos and Lane counties, Oreg., was continued, the total area mapped being 20 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet.

Texas.—In cooperation with the War Department the survey of the Hess Canyon, Katherine Nos. 1 and 2, Marathon No. 1, and Padre Island No. 2 quadrangles, in Brewster, Cameron, Hidalgo, Pecos, and Willacy counties, Tex., was completed, the total area mapped being 956 square miles, for publication on the scale of 1:62,500, with contour intervals of 5 and 50 feet. For the control of the Katherine Nos. 1 and 2 quadrangles 109 miles of primary levels were run, 30 permanent bench marks established, 86 miles of primary traverse run, and 17 permanent marks set. For the control of the Alice, Hebronville,

Loma Chata, Pato, and San Ignacio quadrangles 37 triangulation stations were occupied and 24 marked.

In cooperation with the Texas Bureau of Economic Geology and Technology the survey of the Fort Stockton, Ketchum Mountain, Sawyer No. 3, and Sierra Madera quadrangles, in Irion, Crockett, Pecos, and Reagan counties, was completed, the total area mapped being 879 square miles, for publication on the scale of 1:62,500, with a contour interval of 25 feet. For the control of the Ketchum Mountain quadrangle 36 miles of primary levels were run and 10 permanent bench marks established. The United States Geological Survey gave credit to the State for cooperation on the Katherine Nos. 1 and 2 quadrangles, which were mapped in cooperation with the War Department.

In cooperation with the State Board of Water Engineers the survey of the Bronte irrigation project, in Coke County, was begun, the total area mapped being 30 square miles, for publication on the scales of 1:24,000 and 1:31,680, with a contour interval of 5 feet. For the control of this area 120 miles of primary levels were run and 32 permanent bench marks established.

In addition, 1,854 linear miles of road traverse in Henderson County and 841 linear miles in Hopkins County, covering in all 1,230 square miles, were executed for the Bureau of Soils to serve as data for base maps on which to plot the soil classification. This work was done in such a manner as to be available for future incorporation in regular topographic maps.

Washington.—In cooperation with the Washington Board of Geological Survey the survey of the Colockum Pass quadrangle, in Douglas and Kittitas counties, was completed, and that of the Sultan quadrangle, in King and Snohomish counties, was continued, the total area mapped being 563 square miles, for publication on the scale of 1:125,000, with contour intervals of 50 and 100 feet.

OFFICE WORK.

The drafting of 18 sheets was completed and that of 2 sheets partly completed. Primary-level circuits were adjusted for 24 quadrangles. Geographic positions were computed for 20 quadrangles.

PACIFIC DIVISION.

FIELD WORK.

Summary.—During the season topographic mapping was carried on in Arizona, California, Hawaii, and Utah. This work included the completion of the survey of 19 quadrangles and 1 special area and the partial survey of 14 quadrangles and 1 special area. In addition, profile surveys of a number of streams were made. Primary triangulation and primary traverse were carried on by three parties in Arizona, California, and Hawaii.

Topographic surveys in Pacific division from July 1, 1920, to June 30, 1921.

State.	Contour interval.	For publication on the scale of—			Total area surveyed.
		1:2,400	1:31,680	1:62,500	
	Feet.	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*
Arizona	10, 25, 50	1	32	349	382
California	5	.....	714	.....	714
Hawaii	10, 50	.....	368	.....	368
Utah	5, 25, 100	.....	124	.....	124
	.....	1	1,238	349	1,588

State.	Levels.			Primary traverse.		Triangulation.	
	Primary.	Precise.	Bench marks.	Distance run.	Permanent marks.	Stations occupied.	Stations marked.
	Miles.	*Miles.*		*Miles.*			
Arizona	509	38	102	.....	.....	19	11
California	10	.....	2	94	29	29	12
Hawaii	350	.....	119	.....	.....	18	10
	869	38	223	94	29	66	33

Arizona.—The survey of the Casa Grande Valley, in Pinal County, Ariz., was begun, the total area mapped being 263 square miles, for publication on the scale of 1:62,500, with a contour interval of 25 feet. For the control of this area 32 miles of primary levels and 38 miles of precise levels were run, 18 permanent bench marks established, and 19 triangulation stations were occupied, 11 of which were marked. This work was done for the land-classification board, the topographic branch furnishing the services of experienced topographic engineers and the necessary instruments.

In cooperation with the National Park Service for work in the Grand Canyon the survey of the Anita NW. ¼, Grandview, Red Butte, and Supai quadrangles, in Coconino County, was begun, the total area mapped being 86 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of the Chino and Supai quadrangles 108 miles of primary levels were run and 31 permanent bench marks established.

Arizona-Nevada.—In cooperation with the State of Arizona and the United States Reclamation Service the United States Geological Survey continued special surveys and investigations in Arizona and Nevada to ascertain the feasibility of the storage and diversion of the waters of Colorado River. This was known as the Imperial Valley investigation. Surveys were carried on near the Boulder and Black Canyon dam sites and reservoir sites. For this purpose 33 square miles of topographic mapping and 106 miles of river traverse were completed, for publication on the scales of 1:2,400 and 1:31,680, with contour intervals of 10 and 50 feet. For the control of this project 369 miles of primary levels were run and 53 permanent bench marks established.

California.—In cooperation with the California Department of Engineering for work in San Joaquin Valley the survey of the Chaney Ranch, Firebaugh, Kearney Park, Kerman, Kings River, Laguna Seca, No. 20, No. 23, No. 24, Round Mountain, Sanger, and Sultana quadrangles, in Fresno, Madera, and Tulare counties, was completed, and that of the Fresno, Herndon, Mendota, Monocline Ridge, No. 25, and Tumey Hills quadrangles, in Fresno and Madera counties, was begun, the total area mapped being 714 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. For the control of the Tumey Hills quadrangle 10 miles of primary levels were run and 2 permanent bench marks established; for the control of the Caruthers, Conejo, Fresno, No. 30, Riverdale, and Selina quadrangles 94 miles of primary traverse were run and 29 permanent marks set; and for the control of the Kerman, Fresno, Helm, Herndon, Jamison, Kearney Park, Malaga, No. 20, No. 25, No. 26, No. 31, No. 32, Oil City, Raisin, Tranquillity, and Wheatville quadrangles 29 triangulation stations were occupied and 12 marked.

Hawaii.—In cooperation with the governor of Hawaii the survey of the Honuapo NE. ¼, Honuapo SE. ¼, Kalae NE. ¼, Kilauea SW. ¼, Kilauea SE. ¼, Pahala NE. ¼, and Pahala NW. ¼ quadrangles, in Hawaii County, was completed, and that of the Honuapo NW. ¼, Honuapo SW. ¼, Kahului NW. ¼, and Mauna Loa SE. ¼ quadrangles, in Hawaii and Maui counties, was begun, the total area mapped being 368 square miles, for publication on the scale of 1:31,680, with contour intervals of 10 and 50 feet. For the control of the Honuapo NW. ¼, Honuapo SW. ¼, Honuapo SE. ¼, Hoopuloa NE. ¼, Kahului, Kailua NW. ¼, Kailua SW. ¼, Kalae NW. ¼, Kalapana NW. ¼, Kauhako NE. ¼, Kauhako NW. ¼, Kauhako SE. ¼, Kilauea SE. ¼, Lahaina, Makuu SW. ¼, Mauna Loa SE. ¼, Pahala NE. ¼, Pahala NW. ¼, Puako SW. ¼, Puako SE. ¼, Puna SW. ¼, Puna SE. ¼, and Waiki NW. ¼ quadrangles 350 miles of primary levels were run and 119 permanent bench marks established. For the control of the Kilauea NW. ¼, Kilauea SW. ¼, Kilauea SE. ¼, Mauna Loa SE. ¼, and Puna SW. ¼ quadrangles 18 triangulation stations were occupied and 10 marked. A. O. Burkland, topographic engineer, was in immediate charge of the field work.

Utah.—Profile surveys of a number of streams in the Utah Lake basin, in Summit, Wasatch, Morgan, Utah, and Juab counties, Utah, were made, 124 square miles of topographic mapping and 283 miles of river traverse being completed, for publication on the scale of 1:31,680, with contour intervals of 5, 25, and 100 feet. This work was done for the land-classification board, the topographic branch furnishing the services of experienced topographic engineers and the necessary instruments.

OFFICE WORK.

The drafting of 19 sheets was completed and that of 14 sheets partly completed. Primary-level circuits were adjusted for 56 quadrangles. Geographic positions were computed for 16 quadrangles.

WATER-RESOURCES BRANCH.

ORGANIZATION.

The work of the water-resources branch is conducted under the supervision of N. C. Grover, chief hydraulic engineer, and is organized in six divisions.

Division of surface water, John C. Hoyt, hydraulic engineer, in charge.
Division of ground water, O. E. Meinzer, geologist, in charge.
Division of quality of water, W. D. Collins, chemist, in charge.
Division of power resources, A. H. Horton, hydraulic engineer, in charge.
Superpower survey, W. S. Murray, chairman of engineering staff.
Division of enlarged and stock-raising homesteads, H. C. Cloudman, classifier, in charge.

PERSONNEL.

During the year the technical force was reduced 61 and was increased 55—a net reduction of 6. At the end of the year the force consisted of 1 chief hydraulic engineer, 31 hydraulic engineers, 6 engineers, 32 assistant engineers, 13 junior engineers, 4 geologists, 1 associate geologist, 1 assistant geologist, 1 chemist, 1 associate chemist, 2 junior chemists, 14 classifiers, and 3 assistant classifiers, a total of 110. Of this number 1 assistant engineer is on furlough, and 1 hydraulic engineer, 5 assistant engineers, and 3 junior engineers are employed occasionally.

In the clerical force there were 31 separations and 29 accessions, and at the end of the year the force numbered 36.

ALLOTMENTS.

The appropriation for gaging streams was $180,000. The cooperative funds made available by State allotments, amounting to $185,415, have been increased in some States and decreased in others, making necessary corresponding adjustments of this work. The appropriation for power surveys was $125,000.

Allotments of appropriations, water-resources branch, 1920–21.

For gaging streams:			
Administration, general		$17,494.51	
Branch administration		11,100.00	
Computations		19,000.00	
Inspection		1,400.00	
			$48,994.51
Surface water—			
New England—			
Connecticut	$1,000.00		
Maine	1,000.00		
New Hampshire	1,500.00		
Vermont	1,000.00		
Massachusetts	2,500.00		
		7,000.00	
New York		6,000.00	
Pennsylvania		200.00	
Middle Atlantic States		1,500.00	
South Atlantic States		5,000.00	
Tennessee		2,500.00	
Texas		5,500.00	

For gaging streams—Continued.			
Surface water—Continued.			
Upper Mississippi River—			
Wisconsin	$3,500.00		
Minnesota	300.00		
Iowa	2,000.00		
Illinois	1,700.00		
		$7,500.00	
Kansas		4,000.00	
Colorado, Wyoming, and New Mexico		8,000.00	
Montana		5,500.00	
North Dakota		300.00	
Great Basin—			
Utah	5,000.00		
Nevada	3,000.00		
		8,000.00	
Idaho—			
Outside of Snake River basin	4,300.00		
Snake River basin	1,200.00		
		5,500.00	
Oregon		5,500.00	
Washington		5,500.00	
California		6,000.00	
Arizona		3,000.00	
Hawaii—			
At Honolulu	4,000.00		
At Washington	500.00		
		4,500.00	
			$91,000.00
Ground water			22,000.00
Quality of water			13,000.00
General supplies			600.00
Contingent			4,405.49
			180,000.00
For power survey:			
Superpower survey		100,000.00	
Power production		25,000.00	
			125,000.00
For classification of lands, field			100,000.00

Of the total appropriations 58 per cent was allotted for work in public-land States. Exclusive of the superpower survey 77 per cent was allotted for work in public-land States.

COOPERATION.

States.—The following amounts were expended by States from cooperative allotments:

Alabama		$110
Arizona		3,015
California:		
State engineer	$7,635	
State Water Commission	4,775	
City and County of San Francisco	2,430	
Los Angeles County	3,160	
San Bernardino, Riverside, and Orange counties	2,970	
		20,970
Colorado		500
Connecticut		365
Georgia		1,300

Hawaii:		
Commissioner of Public Lands	$19,580	
City and County of Honolulu (estimated)	2,000	
Governor of Hawaii (estimated)	7,500	
		$29,080
Idaho:		
Outside of Snake River basin	10,340	
Snake River basin	2,165	
		12,505
Illinois		4,000
Iowa:		
State Highway Commission	2,415	
State Geological Survey	705	
		3,120
Kansas		5,910
Kentucky		270
Maine		4,435
Massachusetts		2,970
Minnesota		465
Montana		5,530
Nevada		2,395
New Hampshire		1,400
New York:		
State engineer	3,995	
Conservation Commission	12,345	
		16,340
North Carolina		2,315
North Dakota		270
Oregon		7,225
Pennsylvania		19,420
South Dakota		45
Tennessee		1,305
Texas		12,895
Utah		6,780
Vermont		1,270
Washington		8,390
West Virginia		590
Wisconsin		4,725
Wyoming		5,505
		185,415

The work done under cooperative agreements with the States has been restricted to studies of stream flow, except in California, Idaho, and Connecticut.

Reclamation Service.—The measurement of streams that are to furnish water to reclamation projects under construction has been continued in cooperation with the United States Reclamation Service. The field work is done by Survey engineers who are employed in the locality, and the cost is repaid by the Reclamation Service through transfer of funds.

The Survey also continued to assist the Reclamation Service in an investigation undertaken to obtain a basis for the equitable distribution of the waters of Milk and St. Mary rivers—a work carried on under cooperative agreement with the Canadian Department of the Interior.

Office of Indian Affairs.—In accordance with authorization by the Office of Indian Affairs, stream gaging was continued on the Crow, Fort Hall, Yakima, Colville, Klamath, Gila River, Shoshone, Western Shoshone, Walker River, and Uinta Indian reservations.

National Park Service.—Streams in the Yosemite, Yellowstone, and Glacier national parks were measured during the year at stations maintained in cooperation with the National Park Service.

Forest Service.—A study of stream flow in the Angeles National Forest, in southern California, was continued in cooperation with the Forest Service. Stream gaging in the Uncompahgre National Forest was done by the Forest Service, which was reimbursed by the Geological Survey.

City of San Francisco.—In connection with the proposed storage of the water of Tuolumne River in Hetch Hetchy Valley as a water supply for the city of San Francisco, measurement of that stream was continued in cooperation with the city government.

Federal Power Commission.—Projects of the Federal Power Commission in Alaska, Oregon, California, Idaho, Wyoming, and Arizona were examined, and one of the district engineers of the branch acted as the Survey's representative on the commission's Deschutes River board.

GENERAL SUMMARY.

Investigations of surface streams have been continued by maintaining gaging stations in 38 States, Hawaii, and Alaska. Cooperation with States and other Federal organizations has made possible the large amount of work in progress. Thirty-two cooperating States (including Hawaii) have contributed $166,230 for work in these States, and the Indian Office, National Park Service, Forest Service, and Reclamation Service have also contributed largely to the study of the flow of particular streams.

Ground-water investigations have been in progress in 10 States and in Hawaii. The funds for carrying on the investigations in Hawaii were supplied by the Territorial Government and the city of Honolulu.

Many investigations of the present and probable future use of both surface and ground waters have been made in connection with the classification of public lands, with special reference to their use for power, under permit, or for agriculture, under the enlarged-homestead, desert-land, or Carey acts. The results of such investigations are generally incorporated in unpublished special reports to the Commissioner of the General Land Office and to the Secretary of the Interior.

A report on the water powers of the world was compiled and sent to the printers for publication as Part II of the World Atlas of Commercial Geology.

Statistical reports of the production of electricity and consumption of fuel by public-utility power plants have been prepared, and the mapping of the transmission lines and power stations has been continued. A compilation of the amount of developed water power in the United States is about 70 per cent completed.

A notable feature of the work of the year was the administration of the "superpower survey," an investigation directed to the preparation of an exhaustive report on the generation and distribution of electric power to railroads and other industries in the region between Boston and Washington. The work was completed within the fiscal year, and the report will be published as the Geological Survey's Professional Paper 123. (See p. 6.)

PUBLICATIONS.

The publications of the year prepared by the water-resources branch comprised 17 reports and 2 separate chapters. Titles and brief summaries of these publications are given on pages 14–16. At the end of the year 9 other reports were in press and 17 manuscripts were awaiting editorial work.

DIVISION OF SURFACE WATER.

ORGANIZATION.

The work of the division of surface water consists primarily of the measurement of the flow of rivers, but it includes also special investigations of conditions affecting stream flow and the utilization of the streams.

In carrying on the work the United States is divided into 19 districts, including Hawaii. The location of the districts and district offices and the names of the engineers in charge are given in the following list:

New England: C. H. Pierce, Customhouse, Boston, Mass.
New York: C. C. Covert, Journal Building, Albany, N. Y.
Pennsylvania: O. W. Hartwell, Telegraph Building, Harrisburg, Pa.
Middle Atlantic and Ohio River: G. C. Stevens, Washington, D. C.
South Atlantic and eastern Gulf: W. E. Hall, 33–35 Broadway, Asheville, N. C.
Tennessee: W. R. King, Temple Court Building, Chattanooga, Tenn.
Upper Mississippi River: S. B. Soulé, Capitol Building, Madison, Wis.; suboffices, Kimball Building, Chicago, Ill., and Ames, Iowa.
Missouri-Kansas: E. L. Williams, Rolla, Mo.; suboffice, Federal Building, Topeka, Kans.
Upper Missouri River: W. A. Lamb, Montana National Bank Building, Helena, Mont.
Rocky Mountain: Robert Follansbee, New Post Office Building, Denver, Colo.
Great Basin: A. B. Purton, Federal Building, Salt Lake City, Utah.
Idaho: C. G. Paulsen, Idaho Building, Boise, Idaho.
Snake River basin: G. C. Baldwin, Federal Building, Idaho Falls, Idaho.
Washington: G. L. Parker, Federal Building, Tacoma, Wash.
Oregon: F. F. Henshaw, Post Office Building, Portland, Oreg.
California: H. D. McGlashan, Customhouse, San Francisco, Calif.; suboffice, Federal Building, Los Angeles, Calif.
Arizona: R. C. Rice, care of University of Arizona, Tucson, Ariz.
Texas: C. E. Ellsworth, Capitol Building, Austin, Tex.
Hawaii: James E. Stewart, Capitol Building, Honolulu, Hawaii.

CHARACTER AND METHODS OF WORK.

Field investigations necessary to the work are made from the district offices, where the results are sufficiently analyzed to insure accuracy and completeness. At selected places, known as gaging stations, the volume of water carried by the streams is measured and records of stage and other data are collected from which the daily flow of the streams is computed. Data collected from the district offices are transmitted to Washington, where they are reviewed in the computing section and prepared for publication. By this review the records obtained in different parts of the country are brought to a uniform standard, and standardization is further effected through annual conferences of the engineers.

At the end of the year 1,354 gaging stations were being maintained, including 64 in Hawaii; 315 stations were discontinued and 320 new stations established during the year. Records for about 190 additional stations were received, ready for publication, from other Government bureaus and private persons, and a number of Government and State organizations and individuals also cooperated in the maintenance of the regular gaging stations.

Gaging stations and cooperating parties for the year ending June 30, 1921.

State.	Geological Survey alone.	Reclamation Service.	Forest Service.	Indian Office.	Army engineers.	Weather Bureau.	Other Federal bureaus.	State cooperation.	Municipal cooperation.	Private persons.	Counted more than once.	Maintained at end of year.	Established during year.	Discontinued during year.	Regular gagings during year.	Miscellaneous gagings during year.
Alabama	....	....	....	....	1	1	....	2	....	1	1	4	.....	.....	.....	.....
Arizona	....	1	....	4	....	....	....	30	....	1	2	34	16	5	286	40
California	....	....	24	1	....	1	6	153	43	35	110	153	10	5	1,496	432
Colorado	6	2	12	....	....	1	....	15	1	3	1	39	3	1	147	4
Connecticut	....	....	....	....	....	....	....	5	....	3	2	6	.....	.....	24	.....
Georgia	....	....	....	....	2	2	....	5	....	9	3	15	7	14	38	12
Idaho	....	4	4	14	....	2	....	95	1	191	75	236	140	108	1,389	223
Illinois	....	....	....	....	1	2	9	29	1	1	14	29	6	.....	58	.....
Indiana	....	....	....	....	....	....	....	....	....	1	....	1	.....	.....	1	.....
Iowa	....	....	....	....	....	5	....	23	....	5	6	27	1	.....	120	2
Kansas	....	....	....	....	....	1	....	17	1	....	2	17	1	.....	119	8
Kentucky	....	....	....	....	....	1	....	4	....	....	....	5	.....	.....	5	.....
Maine	....	....	....	....	....	....	....	17	....	4	4	17	2	1	104	11
Maryland	3	....	....	....	....	....	....	....	....	....	....	3	.....	.....	5	.....
Massachusetts	....	....	....	....	....	....	....	17	....	....	....	17	.....	.....	71	.....
Michigan	....	....	....	....	....	....	....	....	....	1	....	1	.....	.....	.....	.....
Minnesota	....	....	....	....	2	2	....	6	....	....	....	10	.....	.....	36	.....
Missouri	....	....	....	....	....	....	....	5	....	....	....	5	5	.....	7	10
Montana	8	51	4	11	....	....	....	48	....	3	....	125	30	3	567	103
Nevada	....	....	....	3	....	....	....	24	....	5	8	24	3	1	127	18
New Hampshire	....	....	....	....	....	....	....	13	....	9	9	13	3	2	53	.....
New Jersey	1	....	....	....	....	....	....	....	....	....	....	1	.....	.....	.....	.....
New York	....	....	....	....	1	3	....	55	2	14	20	55	10	15	433	16
North Carolina	....	....	....	....	18	1	....	....	....	3	1	21	13	1	87	4
North Dakota	....	....	....	....	....	....	....	5	....	....	....	5	.....	7	17	.....
Ohio	....	....	....	....	2	....	....	....	....	....	....	2	.....	.....	4	.....
Oregon	....	2	1	10	....	3	....	18	11	29	....	74	11	29	462	62
Pennsylvania	....	....	....	....	....	....	....	....	....	....	....	.....	3	90	178	3
South Dakota	....	....	....	....	....	....	....	....	....	....	....	....	.....	1	.....	.....
Tennessee	....	....	....	....	27	10	....	4	....	7	12	36	13	.....	157	3
Texas	....	1	....	....	....	3	....	40	8	4	16	40	3	2	301	156
Utah	....	1	....	4	....	....	....	58	1	18	24	58	5	5	130	65
Vermont	....	....	....	....	....	....	....	12	....	6	6	12	4	1	64	2
Virginia	3	....	....	....	7	1	....	....	....	2	....	13	8	.....	34	1
Washington	3	1	3	10	....	....	1	4	21	34	....	77	10	6	501	75
West Virginia	....	....	....	....	6	....	....	11	....	3	6	14	2	.....	36	4
Wisconsin	....	....	....	....	3	....	....	44	....	8	11	44	.....	1	137	3
Wyoming	....	8	3	5	....	1	2	42	....	8	12	57	10	4	211	2
Hawaii	....	....	....	....	....	....	....	64	1	23	24	64	1	13	529	87
	24	71	51	62	70	40	18	865	91	431	369	1,354	320	315	7,934	1,346

PUBLICATIONS.

For convenience and uniformity in publication the United States has been divided into 12 primary drainage basins, and the results of stream measurements are published annually in a series of progress reports that correspond to these 12 divisions. Prior to 1914 the records for each division were contained in a single water-supply paper; since 1914 the records for the twelfth division have been published in three papers. In addition to the progress reports, special reports on hydraulic subjects have been completed for publication during the year.

DIVISION OF GROUND WATER.

GENERAL FEATURES.

The division of ground water investigates the waters that lie below the surface—their occurrence, quantity, quality, and head; their recovery through wells and springs; and their utilization for domestic, industrial, irrigation, and public supplies and at watering places for live stock and desert travelers. Each year ground-water surveys are made of selected areas where the problems of water supply are most urgent, and the results are published in water-supply papers or other reports. These papers generally include maps showing the ground-water conditions in the areas surveyed. The work is planned with a view eventually to cover the entire country. The investigations relating to quality of water are made in cooperation with the division of quality of water; the surveys in the Atlantic Coastal Plain and in the West Indies are under the supervision of the chief of the section of Coastal Plain investigations of the geologic branch.

Many projects involving large expenditures for drilling wells to develop water supplies are considered each year by the United States Government, especially by the War and Navy departments. The ground-water division is called upon to furnish information and advice on a large number of these projects.

A comprehensive paper on ground water in the United States, with a discussion of principles, is being prepared by O. E. Meinzer. Part I of this paper, which relates to the occurrence of ground water, has been completed, and Part II, which relates to the origin, circulation, and quantity of ground water, is in preparation. An artesian-water map of the United States is being prepared for Part II by Norah E. Dowell. Each part is to be published as a water-supply paper.

A report on the relation of ocean water to ground water along the seacoasts, with special reference to Connecticut, is being prepared by J. S. Brown.

Cooperation with the committee on physiography was continued through Mr. Meinzer, who serves on that committee.

The division suffered a severe loss in the untimely death of Arthur J. Ellis, which occurred July 22, 1920. Mr. Ellis had been continuously engaged in ground-water investigations since his appointment in the Geological Survey in 1911.

WORK BY STATES.

Arizona.—A survey of the geology and water resources of San Pedro Valley was begun in cooperation with the Arizona Agricultural Experiment Station. The geologic investigations are being made by Kirk Bryan, of the Geological Survey, and the hydraulic and irrigation engineering investigations by G. E. P. Smith, of the experiment station. Field work was in progress during nearly the entire year.

California.—A manuscript report on the quantity of ground water available in Santa Clara Valley, Calif., by W. O. Clark, was filed in the office of the United States Geological Survey in San Francisco, where it is accessible to the public. It is based chiefly on measurements of percolation losses from Coyote River during a period of

eight years and about 10,000 measurements of water levels in wells. The report is accompanied by several detailed hydrologic maps.

Some progress was made by D. G. Thompson in the preparation of a comprehensive paper on the geography, geology, and hydrology of the Mohave Desert region. Mr. Thompson also completed a report on recent developments and ground-water prospects in Antelope Valley, primarily for the information of the Federal land bank at Berkeley. A manuscript copy of this report was filed in the office of the United States Geological Survey in Los Angeles, where it is accessible to the public.

Water-level measurements were made in selected wells in southern California that have been under observation for a period of years. Many additional observation wells were selected, and seepage measurements were made with a view to obtaining precise data on the intake and discharge of the ground-water reservoirs on which the citrus-fruit industry largely depends. This work is under the direction of F. C. Ebert, hydraulic engineer in the surface-water division, and D. G. Thompson, geologist in the ground-water division.

The large amount of ground-water work in California is made possible through financial cooperation of the State Department of Engineering.

Connecticut.—A report on the New Haven area, Conn., comprising 18 towns, is being prepared by J. S. Brown.

A report on the Pomperaug Valley area, comprising a description of three towns and a detailed quantitative study of ground water, begun by A. J. Ellis, is being completed by Norah E. Dowell.

All ground-water work in Connecticut is done in cooperation with the State Geological and Natural History Survey.

Hawaii.—Two ground-water investigations are in progress in the Hawaiian Islands, one in the vicinity of Honolulu, by H. S. Palmer, and one in the Kau district, on the Island of Hawaii, by W. O. Clark. The investigation in the vicinity of Honolulu relates to the availability of high-level supplies that could be recovered by gravity flow from infiltration tunnels. This report has been transmitted to the mayor of Honolulu. The investigation in the Kau district relates to the discovery of additional high-level supplies for fluming sugar cane. The funds for carrying on these investigations are supplied by the Territorial Government and the city of Honolulu.

Idaho.—Near the end of the fiscal year cooperative arrangements were made with the Idaho State Commissioner of Reclamation and the State Bureau of Mines and Geology for an investigation of the source and quantity of water available for irrigation in the Mud Lake region and an investigation of the artesian-water conditions in several other areas. Mr. Meinzer went to Idaho to organize the field work. The Mud Lake investigation is being carried on jointly with C. G. Paulsen, district engineer. L. L. Bryan has been assigned to do the engineering work involved in this project.

Mississippi.—The investigation of ground water in Mississippi was continued in cooperation with the section of Coastal Plain investigations and the division of quality of water. (See pp. 34, 80.)

Montana.—The investigations of ground water in eastern Montana, which had been carried on for several years by A. J. Ellis, were left incomplete at his death. A report on Musselshell and Golden Valley counties was compiled by Mr. Meinzer, and manuscript copies were

filed at the offices of the United States Geological Survey and the State engineer, in Helena, and the Montana State College, in Bozeman. Near the end of the fiscal year field work was begun on ground water in Yellowstone County by G. M. Hall. The ground-water investigations in Montana are made in cooperation with the State engineer, who has assisted in collecting well records, and with the chemical laboratory maintained jointly by the State Board of Health and the Montana State College, at which water analyses are made under the direction of Prof. W. M. Cobleigh.

North Dakota.—For several years H. E. Simpson has been engaged on a comprehensive investigation of ground water in North Dakota for the State Geological Survey. During this fiscal year the Federal Survey furnished financial assistance so that this investigation could be continued and a report thereon completed for publication. About 200 samples of ground water were collected for analysis.

South Carolina.—Investigations in South Carolina were continued, in cooperation with the section of Coastal Plain investigations, by C. W. Cooke, under the direction of T. W. Vaughan. (See p. 41.)

Texas.—The work in Texas was carried on in cooperation with the section of Coastal Plain investigations and the division of quality of water. (See p. 43.) A report on ground water in the Coastal Plain southwest of Brazos River was submitted by Alexander Deussen, but work on the quality of the water in this region is still in progress.

Virginia.—A study of the quality of water in the Coastal Plain of Virginia is in progress in cooperation with the section of Coastal Plain investigations and the division of quality of water. (See the following paragraph.)

DIVISION OF QUALITY OF WATER.

The division of quality of water makes analyses of surface and ground waters and interprets such analyses to determine the suitability of the waters, as far as mineral content is concerned, for domestic and industrial uses. During the year 341 samples of water were analyzed and classified. For the report on Mississippi ground waters prepared in the Coastal Plain section a discussion of the chemical character of the waters was prepared, based on 215 analyses made in the water laboratory and 254 made elsewhere but classified and many of them recalculated in this division. Sections on the quality of water were prepared or revised for manuscripts of eight reports of the ground-water division, which contained 146 analyses made in the water laboratory and 91 made elsewhere. The discussion of quality of water in 11 manuscripts of geologic folios was reviewed or written; six analyses were made for one area. The year's work included analyses of 60 samples from the Coastal Plain of Virginia collected by members of the Coastal Plain section. These analyses, with 32 made the previous year, form the basis for a report on the chemical character of ground water in the area.

DIVISION OF POWER RESOURCES.

The work of the division of power resources during the year consisted of the preparation of monthly reports of the production of electricity and consumption of fuel by public-utility power plants,

the preparation of State maps showing the location of the power stations and transmission lines used in public service, and information in tabular form in regard to the equipment of the power stations and chief characteristics of the transmission lines, the supervision of a compilation of developed water power in the United States, and the compilation of certain data for the superpower survey.

The monthly reports of power production are based on reports submitted by public-utility companies showing their monthly output of electricity and the fuel consumed in generating it, if fuel is used. Companies operating about 3,900 power plants, each having a monthly output of 10,000 kilowatt-hours or more, are requested to submit reports of their production of electricity and consumption of fuel, and reports are received from companies representing approximately 95 per cent of these plants. The output and fuel consumption of plants that are not reported are estimated from the best information available. It requires about two months to prepare the data of any month for publication. Annual summaries of the monthly reports for 1919 and 1920 were prepared. The following tables show the power and fuel statistics for the calendar years 1919 and 1920:

Electricity produced at public-utility power plants in the United States, 1919–20.

Year.	Total.		Water power.			Fuel power.		
	Kilowatt-hours.	Increase (per cent).	Kilowatt-hours.	Per cent of total.	Increase (per cent).	Kilowatt-hours.	Per cent of total.	Increase (per cent).
1919	38,921,000,000	.....	14,606,000,000	37.5	.....	24,315,000,000	62.5	.....
1920	44,004,000,000	13.1	16,545,000,000	37.6	13.3	27,459,000,000	62.4	12.9

Fuel consumed in the production of power at public-utility plants in the United States, 1919–20.

Year.	Coal.		Fuel oil.		Gas.	
	Short tons.	Increase (per cent).	Barrels.	Increase (per cent).	M cubic feet.	Increase (per cent).
1919	35,100,000	.....	11,050,000	.....	21,406,000	.....
1920	37,244,000	6.1	13,123,000	18.2	24,702,000	15.4

The preparation of State maps showing the location of power stations and transmission lines used in public service has been continued through the year. In order to avoid the delay which would be caused by publishing the maps as illustrations in water-supply papers, the maps alone will be published for sale. Maps of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Pennsylvania, New Jersey, Maryland, and Delaware are now ready for printing. Revised maps of West Virginia, Virginia, and

Indiana are ready for final tracings. Data are available for the preparation of maps of Ohio, Illinois, Kentucky, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Michigan, and Wisconsin.

The compilation of the amount of developed water power in the United States and the preparation of maps showing the location of each power plant of 100 horsepower or more have been carried on under the direction of the district engineers of the surface-water division. This work is about 70 per cent completed.

DIVISION OF ENLARGED AND STOCK-RAISING HOMESTEADS.

In the season of 1920 field work in the examination of lands applied for under the enlarged and stock-raising homestead laws was started during the preceding fiscal year and was therefore in full progress at the beginning of July. The work was carried on until the end of November, when it had to be discontinued because of bad weather and snow cover. There were 20 classifiers of various grades, including 4 assigned from the land-classification board, engaged in active field work. Most of these men worked singly, although there were a few parties of two and three men.

Field examination under the stock-raising homestead law was confined generally to lands for which applications had already been made, though in some areas block examinations were made of large tracts, including lands for which no applications were on file. The lands included in pending applications in the following States were examined:

Montana: Lewistown, Havre, Great Falls, Helena, Missoula, and Bozeman districts, most of the Glasgow district, and about three-fourths of the Miles City district.

Wyoming: Buffalo, Douglas, Newcastle, and Evanston districts, and about two-thirds of the Laramie Peaks area of the Cheyenne district.

Colorado: Sterling district and one-fifth of the Denver district.

Utah: About one-third of the Salt Lake City district.

Idaho: One-half of the Boise district.

Oregon: All districts except a small part of the La Grande district.

California: Practically all districts.

In the season of 1921 examination of lands applied for under the stock-raising homestead law was begun early in May, mostly in areas in which no work had been done or in which work was not finished the previous season. By the end of the fiscal year examination of pending applications was completed in western Kansas; western Oklahoma; the Leadville and Hugo districts, Colorado; the Coeur d'Alene district, Idaho; the La Grande district, Oregon; and the Vancouver and Walla Walla districts, Washington; and work was in progress in North Dakota; the Rapid City district, South Dakota; western Nebraska; the Miles City, Havre, and Glasgow districts, Montana; the Cheyenne and Evanston districts, Wyoming; the Denver and Glenwood Springs districts, Colorado; New Mexico; Utah; Nevada; the Boise district, Idaho; and the Spokane district, Washington.

Field examinations of entries under the enlarged-homestead acts have been made during the year or were in progress at the end of the year in North Dakota, South Dakota, Montana, Wyoming, Colorado, New Mexico, Utah, Idaho, Oregon, and Nevada.

A reconnaissance investigation of the surface and ground-water resources of Nevada is being made for the purpose of classifying lands under the ground-water reclamation act approved October 22, 1919.

For the purpose of classifying lands with relation to their value in connection with the development of water power, surveys have been made of the water-power possibilities of John Day and Grand Ronde River basins, Oreg., of Green River and tributaries above the town of Green River, Wyo., of Snake River from Huntington, Oreg., to Lewiston, Idaho, and of various short stretches of river in Montana, Idaho, and Utah. Surveys were also begun along Siuslaw River and tributaries, Oreg., Snake River from Weiser to Milner, Idaho, and Arkansas River and tributaries in Colorado.

Investigations in the Klamath River basin, Oregon and California, and in the Great Salt Lake basin, Utah, which were undertaken primarily to determine the possibility of using streams for power and irrigation, have been completed. The results of these investigations are being embodied in reports that will be published as water-supply papers.

A report on the water powers of New Mexico, prepared from data collected for use in the designation of lands with respect to their value for water power, has been completed and will be issued as a water-supply paper.

LAND-CLASSIFICATION BOARD.

ORGANIZATION AND PERSONNEL.

The work of the land-classification board consists of classification based on mineral character and classification based on water supply, and the corresponding units of organization are the division of mineral classification and the division of hydrographic classification. The latter division includes three more or less distinct sections, each dealing with a type of classification work in which water supply is an essential element. At the end of the fiscal year the organization and the technical personnel were as follows:

Chief of branch, W. C. Mendenhall, geologist.
Chief engineer and assistant chief of branch, Herman Stabler.
Secretary of branch, Elsie Patterson.
Division of mineral classification: C. D. Avery, mining engineer; N. W. Bass, classifier; W. W. Boyer, associate geologist.
Division of hydrographic classification: Power section: B. E. Jones and W. G. Hoyt, hydraulic engineers; N. J. Tubbs, engineer; E. E. Jones, classifier; Warren Oakey, assistant engineer. Irrigation section: J. F. Deeds, hydraulic engineer; C. E. Nordeen, topographic engineer; W. N. White and A. D. Ryan, classifiers. Grazing section: J. G. Mathers, engineer; A. E. Aldous, G. W. Holland, W. L. Hopper, and R. O. Helland, classifiers.

In addition two engineers, R. W. Davenport and D. J. Guy, have been detailed from the board for duty with the Federal Power Commission.

During the year there were 10 additions to the force and 12 separations. At its end the total number of persons on the regular staff, including the clerical force, was 54. In addition to this regular force 14 classifiers on the rolls of the water-resources branch were amalgamated with the land-classification board staff during the office season in connection with the stock-raising homestead classifications.

SCOPE AND CHARACTER OF THE WORK.

The land-classification board is charged with the task of applying the results of field studies to the administration of the laws affecting the use and disposition of lands and mineral resources, public and reserved. In the fulfillment of this task it utilizes the results that have been accumulated by the Survey during the 42 years of its existence, calls for special field examinations by the geologic, topographic, and water-resources branches when needed, and prepares from the data thus obtained reports applicable to the particular purpose in view. Thus it supplies to the other offices and bureaus of the Department of the Interior and to a minor extent to other departments the facts and the interpretation of the facts necessary to the administration of numerous complex laws dealing with natural resources. It has prepared and recommended the withdrawal of land from entry by orders temporarily suspending the operation of the coal-land laws until the lands could be examined, classified, appraised, and restored to entry and purchase at appraised prices. It has recommended the creation of oil, phosphate, and potash reserves until Congress could enact appropriate laws for the disposition of these minerals. It has initiated the placing of public lands that are valuable for the development of water power in reserves to prevent their acquisition under the homestead and selection laws in such manner as to interfere with the development of power and has had important duties in facilitating the use of such lands under the laws providing for water-power development. With the aid of the geologists of the geologic branch it has selected the lands set aside as oil and oil-shale reserves for the use of the Navy in the future, and it has drafted the orders for their withdrawal from entry.

Since the passage of the mineral-leasing act of February 25, 1920 (41 Stat., 437), making available for lease the mineral reserves previously created primarily to enable Congress to make fitting legal provision for their development, the board has been required to define the "known geologic structures of producing oil fields," to advise the department as to what is leasing and what prospecting ground, to create coal-leasing units, and to suggest appropriate royalties and minimum annual tonnages, and generally to make the classifications and advise as to the geologic and economic problems which must be solved to render the leasing act effective.

By means of information already available or obtained through field examinations by the water-resources branch the board has made the classifications required by the enlarged and stock-raising homestead laws. It furnishes to the General Land Office reports on the character of lands sought under the public-land laws and on irrigation projects, to the Indian Office reports on the character of land sought under the laws providing for the disposition of Indian lands, and to the Federal Power Commission reports on the power value of lands and on proposed power developments.

FUNDS.

For the first time since the organization of the board an appropriation specifically available for all the types of classification of public lands which devolve upon the Survey was made in the sundry civil act approved June 5, 1920. This act provided $300,000 for those

examinations and classifications of lands which are required in the administration of the public-land laws.

The work of land classification, which was developed as a by-product of the general field work of the Survey, was supported in its early stages by allotments from appropriations made primarily for the other work of the field branches. Under these conditions it was practically impossible to arrange an orderly program of land classification and to have the necessary special field work done in accordance with the urgent demands for data for classification because such a program would have involved the expenditure of funds greatly needed for other purposes. This disability was relieved in part in 1917 by an appropriation for the classification required under the enlarged and stock-raising homestead laws, but the work in water power and mineral classification remained without satisfactory financial provision until 1920.

The provision of separate funds for land classification in the sundry civil act of June 5, 1920, has not only relieved the other branches of the Survey of the burden of allotments for the support of the work of the board but has made it possible to allot parts of these funds to those branches to enable them to carry on field studies for land classification.

The appropriation of $300,000 for 1921 has been expended on administration and classification work by the branches and divisions of the Survey organization approximately as follows:

Land-classification board	$102,000
Water-resources branch	106,000
Division of Alaskan mineral resources	12,000
Division of geology	25,000
Topographic branch	32,000
Administrative branch	23,000
	300,000

SUMMARY OF WORK OF CLASSIFICATION.

With the passage of the mineral leasing act prior to the beginning of the fiscal year withdrawals of mineral lands practically ceased. Some lands that had been classified as mineral were reclassified as nonmineral during the year, but the principal work done in classification was that required in the administration of the leasing acts. The coal-land reserves were reduced during the year by 215,494 acres. Reports were made on 249 applications for coal prospecting permits and on 78 applications for coal leases.

The oil and gas reserves were reduced by 60,524 acres during the year. Twenty-four oil and gas producing "structures," containing 233,217 acres, were defined as leasing territory in accordance with the requirements of the oil and gas sections of the leasing act. Reports were made on 6,994 applications for oil and gas prospecting permits and on 6 applications for oil and gas leases.

The oil-shale reserves and classifications and the potash and phosphate reserves remained practically unchanged through the year, but reports were prepared upon 159 applications for permits to prospect for potash, 2 applications to lease potash lands, and 12 applications for patent under the patent provisions of the potash-leasing law. A few reports were rendered under the phosphate, oil

shale, and sodium sections of the mineral leasing act. In all, 7,530 reports were made during the year upon applications under the mineral leasing laws.

The area in power-site reserves was increased from 2,591,019 acres on July 1, 1920, to 3,723,716 acres on June 30, 1921. This increase involved minor changes required by new information as to existing reserves but is due mainly to action taken on applications made under the Federal water power act for lands mostly in forest or other reservations but not previously included in power-site reserves, and to the inclusion within the reserves of certain lands that are designated as valuable for power under special acts of Congress but not withdrawn for power. An area of 11,546 acres in the former Coos Bay wagon-road grant was designated as power-site lands under the terms of the revestment act of February 26, 1919.

The area in outstanding reservoir withdrawals was increased to 83,773 acres as the result of the withdrawal of 80 acres of land in Utah needed for control of water supply.

Under the stock-raising homestead law 32,318,822 acres were designated as stock-raising lands, and 850,894 acres previously designated were reclassified as not stock-raising lands and the designation thereof canceled. The total area so designated was increased from 74,492,336 to 105,960,264 acres.

Additional areas of 26,186,597 acres were designated as nonirrigable under the enlarged-homestead acts, and 2,616,940 acres found to have been improperly classified were eliminated from designations previously made. The total area remaining so designated at the end of the year is 316,529,138 acres. Of this area, 548,554 acres in Idaho, an increase of 3,520 acres, and 1,552,854 acres in Utah, an increase of 49,840 acres, are classified under the nonresidence provisions of the act as being without domestic water supply sufficient to make continuous residence possible.

The area in public water reserves was increased to 244,918 acres as the result of the addition of 7,220 acres to the area previously so classified and the elimination of 1,585 acres.

The area designated under the Nevada ground-water reclamation act was increased from 57,600 to 726,680 acres during the year.

CORRESPONDENCE.

During the year 28,832 letters and petitions were received by the land-classification board. This is a decrease of about 16 per cent from the number for the preceding fiscal year. In addition, about 4,400 copies of miscellaneous correspondence were sent to the board for its information and filing; this correspondence is made up largely of General Land Office letters to its local officers and of reports on the character of lands by its inspectors and examiners, copies of decisions rendered by the Department of the Interior, and withdrawals and restorations by the Reclamation Service. Within the same period 18,191 letters—largely technical reports—were prepared in the board. This is an increase of 14 per cent above the output for the preceding fiscal year. For the working days of the year these figures show a daily average of 95 for the incoming and of 60 for the outgoing.

CASES CONSIDERED.

The number and the character of the cases referred to the Survey for the preparation of reports thereon to be used as a basis for administrative action under the laws governing the disposal of public lands are shown in the following table:

General summary of cases, fiscal year 1920–21.

Class.	Pending June 30, 1920.	Received during year.	Disposed of during year.	Pending June 30, 1921.	Gain or loss.
Mineral character only:					
Requests for information	929	797	562	1,164	− 235
Field service reports	757	1,057	872	942	− 185
Applications for classification as to mineral	52	449	316	185	− 133
Applications for mineral permits	64	8,289	7,419	934	− 870
Applications for mineral patents	.....	12	12	.....	.....
Applications for mineral leases	2	127	99	30	− 28
	1,804	10,731	9,280	3,255	−1,451
Water resources only:					
Requests for information	6	5	8	3	+ 3
Field service reports	10	3	8	5	+ 5
Cases in national forests	.....	14	14	.....	.....
Applications for reclassification as to water resources	29	18	35	12	+ 17
Applications for rights of way	31	149	169	11	+ 20
Federal Power Commission cooperative cases	.....	73	19	54	− 54
Lists under Carey Act	.....	2	2	.....	.....
Irrigation project reports	18	28	32	14	+ 4
Petitions under enlarged-homestead acts	3,131	1,616	3,781	966	+2,165
Applications under stock-raising homestead act	14,455	11,612	17,624	8,443	+6,012
Applications under ground-water reclamation act	102	317	308	111	− 9
	17,782	13,837	22,000	9,619	+8,163
Mineral character and water resources:					
Requests for information	2,020	1,721	2,170	1,571	+ 449
Field service reports	314	520	351	483	− 169
Requests for information as to water resources, accompanied by field service reports as to mineral character	106	30	63	73	+ 33
Indian Office requests for information	14	22	18	18	− 4
	2,454	2,293	2,602	2,145	+ 309
Grand total	22,040	26,861	33,882	15,019	+7,021

DIVISION OF MINERAL CLASSIFICATION.

The character of the mineral classification work of the board has been fundamentally altered by the adoption by Congress of the policy of leasing the more important publicly owned nonmetalliferous mineral deposits. The principal laws which put this policy into effect are the Alaska coal-leasing act of October 20, 1914 (38 Stat., 741), the potash-leasing act of October 2, 1917 (40 Stat., 297), and the mineral-lands leasing act of February 25, 1920 (41 Stat., 437). The first two laws cited may be regarded as in a measure experimental, the final adoption of the leasing policy as to coal, phosphate, oil, oil shale, gas, and sodium in the United States being expressed in the latest and most general of these laws, that of February 25, 1920. Before these measures became law the greater part of the oil and gas, phosphate, and potash lands were reserved and could not be acquired. Coal lands could be purchased, but first they must be examined and appraised. Oil-shale lands, except a small acreage

held for future naval use, could be acquired under the placer act. All these lands except the naval reserves are now available for lease, and during the year there have been many applications for the rights provided for in the new measures, especially under the sections relating to oil and gas.

The sections of the act that relate to coal require among other things the determination whether a prospecting permit or a lease should be issued, and if a lease then a leasing unit must be established, an appropriate royalty must be fixed, and a minimum tonnage to be mined annually must be determined before the lands are offered for lease. The sections of the act that relate to oil distinguish between leasing and prospecting territory by defining leasing territory as lands "within the known geologic structure of a producing oil or gas field." The board determines what is leasing territory under this definition and advises the Department through the General Land Office as to the structural relations of all lands involved in applications for oil-prospecting permits.

Similar functions are performed in the administration of the potash-leasing law and the phosphate, oil shale, and sodium sections of the general mineral lands leasing act.

The gross areas remaining withdrawn at the end of the fiscal year for certain minerals under the act of June 25, 1910, are shown in the following table. Any of these lands that are still in public ownership, except the special naval reserves, and any other deposits of these minerals owned by the United States are now subject to the leasing acts.

Summary of outstanding withdrawals, June 30, 1921, in acres.

State.	Coal.	Oil.	Oil shale.	Phosphate.	Potash.
Arizona	141,945	230,400			
California	17,643	1,257,229			90,513
Colorado	4,278,422	222,977	41,560		
Florida				119,723	
Louisiana		467,030			
Idaho	4,761			1,015,717	
Montana	10,612,923	1,350,937		287,883	
Nevada	83,833		123		39,422
New Mexico	5,585,208				
North Dakota	10,386,439	84,894			
Oregon	4,361				
Utah	5,313,836	1,962,787	86,584	302,465	
Washington	823,025				
Wyoming	2,437,723	1,121,102		998,552	
	39,690,119	6,697,356	128,267	2,724,340	129,940

Twenty-four areas, containing 233,217 acres, were defined during the year as within the "known geologic structure of a producing oil or gas field"—that is, they were defined as leasing rather than prospecting territory under the oil and gas sections of the act of February 25, 1920. The area included in one field, the Cat Creek field, Mont., was reduced during the year on the basis of information supplied by developments and detailed structural studies carried out since the field was originally defined. The reduction amounted to 22,276 acres. The net addition during the year to the officially defined producing areas is therefore 210,941 acres, and the total area included at the end

of the year in the 33 producing "structures" defined since the passage of the act is 331,474 acres. Known producing fields which contain no public lands are not officially defined, because the leasing act does not apply to them.

A list of the producing fields defined between the passage of the act and June 30, 1921, with the date of the definition and the area, follows:

Producing oil and gas fields defined in accordance with the act of February 25, 1920.

Field.	Date defined.	Area (acres).	Field.	Date defined.	Area (acres).
CALIFORNIA.			WYOMING—continued.		
Kern River	July 15, 1920	34,866	Dry Piney	Apr. 2, 1920	2,559
Coalinga West Side	July 20, 1920	15,002	Mule Creek	Apr. 5, 1920	1,527
Coalinga East Side	do	9,760	Thornton	do	1,274
Lost Hills	do	4,206	Hamilton dome	do	11,087
McKittrick Front	Aug. 11, 1920	4,882	Elk Butte	July 15, 1920	2,002
McKittrick	do	5,935	Garland	July 20, 1920	587.94
Elk Hills	do	46,640	Byron	do	224.35
Buena Vista Hills	do	23,772	Wiley anticline	do	879
Sunset	do	12,183	Grass Creek	Aug. 18, 1920	3,067
Midway	Aug. 17, 1920	26,341	Buffalo Basin	do	7,922
MONTANA.			Big Muddy	Aug. 20, 1920	6,427
			Osage	Aug. 25, 1920	[a] 14,151
Cat Creek	Apr. 2, 1920	[a] 47,205	Do. (revised)	Oct. 5, 1920	15,224
Do. (revised)	Apr. 4, 1921	24,929	Iron Creek	Sept. 17, 1920	920
WYOMING.			Poison Spider	do	5,359
			Torchlight dome	Oct. 30, 1920	1,004
Lance Creek	Apr. 2, 1920	10,736	Mahoney dome	Dec. 15, 1920	5,232
Rock Creek	do	4,354	Wertz dome	do	686
Salt Creek	do	34,398	Greybull	Apr. 26, 1921	95.93
Big Sand Draw	do	7,393			331,474

[a] Not included in total.

The applications for permits, leases, and patents (patents for a portion of the area included in a prospecting permit are provided for in the potash leasing law only, 40 Stat., 297), received and reported upon during the year are indicated in the subjoined table:

Applications under the mineral leasing acts for the fiscal year 1920–21.

Mineral.	Permits.			Leases.			Patents.		
	Received.	Acted on.	Pending.	Received.	Acted on.	Pending.	Received.	Acted on.	Pending.
Potassium	104	159	.....	2	2	.....	12	12	.....
Coal	313	249	64	105	78	28	.....	.....	.....
Phosphate	.....	.....	.....	9	9	.....	.....	.....	.....
Oil and gas	7 851	6 994	866	5	6	.....	.....	.....	.....
Oil shale	.....	.....	.....	4	3	1	.....	.....	.....
Sodium	21	17	4	2	1	1	.....	.....	.....

DIVISION OF HYDROGRAPHIC CLASSIFICATION.

WATER POWER.

Power-site reserves.—The classification of the public lands with relation to their value in connection with water-power development was continued during the year, the classifications and withdrawals being made under the acts of March 3, 1879 (20 Stat., 394); June 25, 1910 (36 Stat., 847, 855, 858); and August 24, 1912 (37 Stat., 47). On July 1, 1920, the area included in power-site reserves was

2,591,019 acres. During the year 6,644 acres were withdrawn or classified as valuable for power sites, and the total area withdrawn was decreased 130 acres by interpretations of previous withdrawals in the light of recent surveys.

Under the terms of the Federal water-power act of June 10, 1920 (41 Stat., 1063), lands of the United States reserved or classified as power sites or included in projects applied for under that act are reserved from entry, location, or other disposal. The reservation thus provided is more definite and complete than any theretofore made for power-site purposes. Under this provision of law 686,747 acres that had been included in water-power designations under special acts of Congress but not otherwise reserved or withdrawn for power purposes are now regarded as power-site reserves. Furthermore, applications for projects under the Federal water-power act have resulted in the reservation of 439,009 acres not otherwise reserved or withdrawn for power purposes. On June 30, 1921, the total area reserved for power-site purposes by withdrawal, classification, designation, or application under the Federal water-power act was 3,723,716 acres.

Power-site reserves, fiscal year 1920–21, in acres.

State.	Reserves outstanding June 30, 1920.	New withdrawals, 1920–21.	Classifications, 1920–21.	Designations not previously recorded as reserved.	Reserved by application under Federal water-power act.	Restorations, 1920–21.	Reserves outstanding June 30, 1921.
Alabama	120				302		422
Alaska	91,015	2,400			37,652		131,067
Arizona	302,208			528,245	8,722		839,175
Arkansas	22,354				3,727		26,081
California	[a]293,907	3,456			288,179		585,542
Colorado	266,454				6,296		272,750
Florida					486		486
Idaho	[a]261,201				2,209		263,410
Michigan	1,240						1,240
Minnesota	12,309						12,309
Montana	[a]156,280	361			17,506	28	174,119
Nebraska	761						761
Nevada	27,543				52		27,595
New Mexico	65,572			142,611			208,183
Oregon	[a]432,770		267	15,891	6,730	102	455,556
South Dakota					12		12
Utah	[a]455,143		160		18,152		473,455
Washington	[a]113,766	427			8,057		122,250
Wisconsin					1,096		1,096
Wyoming	88,376				39,831		128,207
	2,591,019	6,644	427	686,747	439,009	130	3,723,716

[a] Revised.

Water-power designations.—The act of June 9, 1916 (39 Stat., 218), revesting in the United States title to lands in Oregon held by the Oregon-California Railroad Co., provides for classification as "power-site lands" of such of the revested lands as are found to be chiefly valuable for water-power sites. On June 30, 1921, the total area classified as power-site lands under the provisions of the act was 141,653 acres, no change in the area so classified having been made during the year.

The act of February 26, 1919 (40 Stat., 1179), revests in the United States title to certain lands in Oregon known as the Coos Bay wagon-road grant, which had been held by the Southern Oregon Co., and provides for the classification of these lands in the manner described

in the act of June 9, 1916, above referred to. During the year 11,546 acres were designated as power-site lands under this act, this being the total area of lands so designated.

On June 30, 1920, 758,083 acres were included in outstanding designations of land valuable for water power in Arizona and 196,400 acres were included in such designations in New Mexico, under the provisions of the enabling acts of those States. The area designated in these two States remained unchanged during the year.

All the designated lands are power-site reserves, having been withdrawn under appropriate acts of Congress or reserved by the terms of the Federal water-power act.

Operations under the Federal water-power act.—The Federal water-power act of June 10, 1920 (41 Stat., 1063), provides that the work in connection with the administration of the act shall be performed by the departments of War, Agriculture, and the Interior. In accordance with this provision 27 applications for preliminary permit and 7 applications for license were referred to the Geological Survey for investigation and report. One application for a preliminary permit and 4 applications for license were acted on, leaving 26 applications for preliminary permit and 3 applications for license pending on June 30.

Under the Federal water-power act lands classified as valuable for power sites may be opened to entry subject to the right of the United States or its permittees to use the land for power-site purposes, upon a determination by the Federal Power Commission that this power-site value will not be injured or destroyed by opening them to selection and entry. During the year 39 applications to the Federal Power Commission for such determination were referred to the Survey for an examination and report. Of these applications 14 were acted on and 25 were pending at the end of the fiscal year.

At the request of the Office of Indian Affairs, field investigations were made of certain power-site lands on Indian reservations with a view to their allotment to Indians subject to a water-power reservation such as is included in the provisions of section 24 of the Federal water-power act.

Applications for reclassification.—On July 1, 1920, 29 applications for reclassification of lands as to water resources were awaiting action, and during the fiscal year 18 were received. Action was taken on 35 of these cases, leaving 12 pending on June 30, 1921.

Right of way applications.—Departmental regulations of January 6, 1913, under the act of Congress approved March 4, 1911 (36 Stat., 1235, 1253), and of March 1, 1913, under the act of Congress approved February 15, 1901 (31 Stat., 790), charge the Geological Survey with certain administrative duties in connection with applications for rights of way over the public lands for purposes relating to the development, transmission, and use of power. The act of Congress approved June 10, 1920 (41 Stat., 1063), known as the Federal water-power act, expressly repeals "all acts or parts of acts inconsistent with this act." It appeared, in view of the general scope and purpose of this water-power act, that no further action on applications under the earlier acts, in so far as they cover the same subject matter, should be initiated. On July 1, 1920, there were 20 such applications pending in the Geological Survey, and 18 of these were returned to the General Land Office for reference to the

Federal Power Commission. It has been ruled that the Federal water-power act does not apply to allotted Indian lands or to permits for transmission lines where the power is generated wholly by steam. Accordingly, one such case which was pending July 1, 1920, and two others which were referred to the Geological Survey by the General Land Office during the year were acted on, leaving one case pending.

Pursuant to the instructions of the Secretary, dated August 24, 1916 (45 L. D., 326), permittees under the act of February 15, 1901 (31 Stat., 790), and grantees under the act of March 4, 1911 (36 Stat., 1253), to whom rights have been granted by the Secretary of the Interior since January 1, 1913, were called upon for detailed reports of the operations or developments of their power systems during the calendar year 1920. Of the 56 permittees and grantees reporting, eight reported that they did not operate during the year. The remaining 48 generated or transmitted over their systems 4,201,000,000 kilowatt-hours of electrical energy. Of this amount 3,788,000,000 kilowatt-hours, or over 90 per cent, was generated by water power. The operating expenses for companies generating 100,000,000 kilowatt-hours or more per year, of which 91.6 per cent was hydroelectric, including taxes and allowances for depreciation, average 5.2 mills per kilowatt-hour generated, a decrease of 13 per cent under the unit cost shown by reports received for 1919. The energy reported by them as delivered was 23 per cent less than the energy reported as generated or purchased, indicating a loss of 872,000,000 kilowatt-hours. The average price of current sold, based on gross income from electrical operations, by the same companies was 13.8 mills per kilowatt-hour.

Power output of permittees and grantees, 1916–1920.

Year.	Number reporting.	Kilowatt-hours.	Increase.	
			Kilowatt-hours.	Per cent.
1916	26	1,200,000,000	.....	.....
1917	32	2,000,000,000	800,000,000	67
1918	51	3,200,000,000	1,200,000,000	60
1919	57	3,100,000,000	−100,000,000	−3
1920	56	4,201,000,000	1,100,000,000	35

A large number of right-of-way applications of other types are referred to the Geological Survey for consideration and report. These embrace applications for rights of ways for railroads under the acts of March 3, 1875 (18 Stat., 482), and March 2, 1899 (30 Stat., 990), affecting public lands and Indian reservations, respectively, on which report is made as to whether or not allowance of the application will adversely affect possible or existing power or irrigation development; applications for rights of way for irrigation purposes under the acts of March 3, 1891 (26 Stat., 1101), and May 11, 1898 (30 Stat., 404), on which report is made as to interference with power development, the feasibility of the project, and other features; applications for rights of way across national forests for mining, milling and municipal purposes under the act of February 1, 1905 (33 Stat., 628); and a variety of miscellaneous applications for domestic, municipal, mining, and railroad water supply.

Applications for rights of way, 1920–1921.

Class.	Pending June 30, 1920.	Received.	Acted on.	Pending June 30, 1921.
Railroad	5	19	22	2
Irrigation	6	68	70	4
Power	20	2	21	1
Miscellaneous	.....	60	56	4
Total number of applications for original consideration	31	149	169	11
Additional applications for reconsideration	11	23	29	5

During the year two Carey Act segregation lists were received, and a report on each was forwarded to the General Land Office.

At the beginning of the year 18 cases were pending, either awaiting reports to the General Land Office under the instructions of March 15, 1913, from the Secretary of the Interior relative to irrigation projects whose water rights or shares of stock are presented as evidence of compliance with the requirements of the desert-land act, or awaiting reports as to the engineering and economic feasibility of applications under the irrigation-district law of August 11, 1916 (39 Stat., 506). During the year 28 new cases were received and reports were submitted to the General Land Office in 32 cases, leaving 14 cases pending June 30, 1921. Seven cases of these types submitted for reconsideration were pending at the beginning of the year, and seven additional cases were received during the year. Twelve of these cases were acted upon, leaving two pending at the end of the fiscal year.

RESERVOIR WITHDRAWALS.

One withdrawal in connection with water-storage reservoir-site investigations has been made during the year. This withdrawal embraces the public land in a reservoir site in Utah said to be valuable in connection with a proposed irrigation development.

Reservoir withdrawals outstanding June 30, 1921.

	Acres.		Acres.
Arizona	23,040	Utah	80
Colorado	1,728	Washington	35,943
Montana	9,080	Wyoming	1,714
North Dakota	1,569		
Oregon	10,619		83,773

ENLARGED HOMESTEADS.

Classification of lands under the enlarged-homestead acts of February 19, 1909 (35 Stat., 639), June 17, 1910 (36 Stat., 531), June 13, 1912 (37 Stat., 132), March 3, 1915 (38 Stat., 953), March 4, 1915 (38 Stat., 1162), July 3, 1916 (39 Stat., 344), September 5, 1916, (39 Stat., 724), and February 20, 1917 (39 Stat., 925), was continued during the year. As a result of the investigations of surface and ground-water conditions made during the fiscal year in conjunction with data obtained previously, the number of pending cases at the end of the fiscal year has been reduced to a point considerably below the number pending at any time since the enactment of the preference right act of March 4, 1915 (38 Stat., 1162).

Action on petitions under enlarged-homestead acts, 1920–21.

State.	Pending June 30, 1920.	Received.	Total.	Action taken.					Pending June 30, 1921.	Cases reconsidered.
				All designated.	Part designated.	Refused.	Recalled.	Total.		
Arizona	156	144	300	154	3	45	38	240	60	13
Arkansas	1		1				1	1		
California	170	81	251	121	1	38	17	177	74	3
Colorado	660	358	1,018	846	5	18	44	913	105	41
Idaho	188	109	297	177	2	25	17	222	75	25
Kansas	50	52	102	54			5	59	43	4
Montana	515	258	773	670	16	16	15	717	56	52
Nebraska	1		1				1	1		
Nevada	14	4	18						18	
New Mexico	347	140	487	390	9	8	22	429	58	15
North Dakota	110	43	153	101	2	2	7	112	41	13
Oklahoma		2	2		1	1		2		
Oregon	45	72	117	18	2	7	6	34	83	2
South Dakota	161	5	166	76	2		57	135	31	9
Utah	290	133	423	180	1	33	36	250	173	54
Washington	57	25	82	4	8	22	9	43	39	1
Wyoming	366	190	556	401	10	9	26	446	110	35
	3,131	1,616	4,747	3,192	62	224	301	3,781	966	267

The general provisions of the acts, which apply in 14 States, permit the entry by one person of 320 acres of "nonmineral, nonirrigable, unreserved, and unappropriated surveyed public lands which do not contain merchantable timber." As a prerequisite to the allowance of an entry under these acts the lands must have been designated by the Secretary of the Interior as not being, in his opinion, "susceptible of successful irrigation at a reasonable cost from any known source of water supply." Under the provisions of section 6 of the acts of February 19, 1909, and June 17, 1910, applicable in Utah and Idaho only, the Secretary may further designate lands which do not have upon them "such a sufficient supply of water suitable for domestic purposes as would make continuous residence upon the lands possible," and entrymen upon such lands are relieved of the necessity of residence.

Enlarged-homestead designations, 1920–21, in acres.

State.	Outstanding July 1, 1920.	Designations.	Cancellations.	Outstanding June 30, 1921.
Arizona	25,496,323	2,185,675	2,387,380	25,294,618
California	8,825,736	2,980,660	226,480	11,579,916
Colorado	29,192,274	2,780,990		31,973,264
Idaho:				
Sections 1–5 and 7	10,501,132	1,763,778	1,560	12,263,350
Section 6	545,034	3,520		548,554
	11,046,166	1,767,298	1,560	12,811,904
Kansas	572,474	33,260		605,734
Montana	51,157,431	1,218,008		52,375,439
Nevada	46,383,498			46,383,498
New Mexico	32,159,763	10,593,286		42,753,049
North Dakota	11,942,842	285,270		12,228,112
Oregon	19,577,735	492,540		20,070,275
South Dakota	15,728,385	183,620		15,912,005
Utah:				
Sections 1–5 and 7	7,867,095	813,610		8,680,705
Section 6	1,503,014	49,840		1,552,854
	9,370,109	863,450		10,233,559
Washington	6,032,703	217,380	200	6,249,883
Wyoming	25,474,042	2,585,160	1,320	28,057,882
	292,959,481	26,186,597	2,616,940	316,529,138

STOCK-RAISING HOMESTEADS.

The stock-raising homestead law, approved December 29, 1916 (39 Stat., 862), authorizes the Secretary of the Interior to designate unreserved public lands in any of the public-land States, but not in Alaska, as "stock-raising lands." The lands to be designated are those whose surface is chiefly valuable for grazing and raising forage crops and which do not contain merchantable timber, are not susceptible of irrigation from any known source of water supply, and are of such character that 640 acres is reasonably required to support a family.

A total of 17,624 petitions for designation were acted on during the year, and the number of pending cases was reduced from 14,445 to 8,443. The details of action taken are shown in the accompanying table. Since the law became effective 93,325 applications have been received, of which 84,882 have been acted on. The area designated as stock-raising lands during the year was 32,318,822 acres, and 850,894 acres previously designated were reclassified as not being of the character defined by the stock-raising homestead law. The net increase in the area of stock-raising lands was therefore 31,467,928 acres, the total area so classified on June 30, 1921, being 105,960,264 acres.

Action on petitions under the stock-raising homestead act, 1920–21.

State.	Pending July 1, 1920.	Received.	Total.	Action taken 1920–21.					Pending June 30, 1921.	Cases reconsidered.
				All designated.	Part designated.	Refused.	Recalled.	Total.		
Arizona	534	256	790	617	5	11	23	656	134	43
Arkansas	2	.....	2	.....	.....	.....	.....	.....	2	.....
California	1,173	383	1,556	1,325	20	19	63	1,427	129	185
Colorado	1,449	2,041	3,490	1,327	29	22	117	1,495	1,995	84
Idaho	737	784	1,521	441	23	42	116	622	899	114
Kansas	41	19	60	15	4	.....	2	21	39	1
Michigan	3	1	4	3	.....	.....	.....	3	1	.....
Montana	3,397	2,342	5,739	4,041	63	172	268	4,544	1,195	196
Nebraska	51	92	143	88	2	.....	4	94	49	4
Nevada	61	103	164	112	7	8	3	130	34	4
New Mexico	2,202	856	3,058	2,437	51	22	100	2,610	448	228
North Dakota	92	67	159	18	23	3	11	55	104	13
Oklahoma	90	58	148	112	.....	1	8	121	27	6
Oregon	576	774	1,350	202	11	29	85	327	1,023	50
South Dakota	444	375	819	378	40	2	43	463	356	59
Utah	648	310	958	295	24	1	88	408	550	38
Washington	357	195	552	62	4	51	40	157	395	19
Wyoming	2,598	2,956	5,554	4,208	53	46	184	4,491	1,063	83
	14,455	11,612	26,067	15,681	359	429	1,155	17,624	8,443	1,127

Stock-raising homestead designations, 1920–21, in acres.

State.	Outstanding July 1, 1920.	Designations.	Cancellations.	Outstanding June 30, 1921.
Arizona	2,443,070	11,166,860	832,040	12,777,890
Arkansas	240	.....	.....	240
California	4,261,966	3,092,166	.....	7,354,132
Colorado	5,475,681	631,520	.....	6,107,201
Idaho	2,863,814	1,587,990	574	4,451,230
Kansas	88,674	4,440	.....	93,114
Michigan	320	591	.....	911
Montana	8,379,227	5,356,040	16,000	13,719,267
Nebraska	95,408	29,370	.....	124,778
Nevada	131,019	68,830	.....	199,849
New Mexico	22,753,153	7,143,530	.....	29,896,683
North Dakota	301,859	8,395	.....	310,254
Oklahoma	22,481	27,390	.....	49,871
Oregon	5,323,721	81,140	400	5,404,461
South Dakota	6,198,107	69,370	320	6,267,157
Utah	564,360	152,700	240	716,820
Washington	331,294	28,926	.....	360,220
Wyoming	15,257,942	2,869,564	1,320	18,126,186
	74,492,336	32,318,822	850,894	105,960,264

PUBLIC WATER RESERVES.

Withdrawals of tracts containing watering places located in regions largely devoid of sources of water supply for stock grazing on surrounding open public range were continued during the year, and restorations of such tracts were also made. These reserves are created under the act of June 25, 1910 (36 Stat., 847), as amended by section 10 of the act of December 29, 1916 (39 Stat., 862), in order that control of the water on the land withdrawn may be retained in the Government. Efforts of private individuals to develop and protect the water supply on such lands from damage and pollution, however, may be encouraged by granting special privileges to such individuals through the issuance of permits under the act of February 15, 1901 (31 Stat., 790).

Areas amounting to 7,220 acres were included in public water reserves during the year, and 1,585 acres were eliminated from such reserves by means of information obtained through field examinations by the General Land Office and the Survey.

Public water reserves withdrawn, restored to entry, and outstanding, 1920–21, in acres.

State.	Withdrawals outstanding July 1, 1920.	New withdrawals.	Restorations.	Withdrawals outstanding June 30, 1921.
Arizona	14,001	390	140	14,251
California	59,761	115	280	59,596
Colorado	1,900	40	120	1,820
Idaho	10,640	1,240	.....	11,880
Montana	7,724	200	[a]485	7,439
Nevada	6,853	2,520	.....	9,375
New Mexico	6,041	360	.....	6,401
Oregon	12,384	400	.....	12,784
South Dakota	240	.....	.....	240
Utah	35,587	240	.....	35,827
Washington	920	.....	.....	920
Wyoming	83,232	1,715	560	84,387
	239,283	7,220	1,585	244,918

[a] Includes 85 acres restored previous to fiscal year but not reported.

GROUND-WATER RECLAMATION IN NEVADA.

The ground-water reclamation act of October 22, 1919 (41 Stat., 293), authorizes the issuance of permits to citizens of the United States or associations of such citizens, giving the exclusive right to make explorations within the limit of 2,560-acre tracts of a certain type of land in Nevada for the purpose of obtaining water from wells for irrigation. The act provides that land covered by these permits shall have been designated by the Secretary of the Interior as nonmineral, nontimbered, and not known to be susceptible of successful irrigation at a reasonable cost from any known source of water supply. Under instructions issued March 19, 1920, orders of designation are prepared in the Geological Survey and appropriate advice is given to the Commissioner of the General Land Office concerning all applications for permits under this act. Extensive field investigations were begun during the year in connection with the classification work required under this act, and much valuable information has been assembled. With the aid of this information an area of 669,080 acres was designated under the terms of the act during the year, increasing the total area so designated from 57,600 to 726,680 acres.

PUBLICATION BRANCH.

DIVISION OF BOOK PUBLICATION.

SECTION OF TEXTS.

During the year 18,331 pages of manuscript were edited and prepared for printing, and proof sheets comprising 2,186 galley proofs and 15,431 page proofs were read and corrected. Indexes were prepared for 28 publications, covering 5,227 pages. The publications of the year are listed and abstracted on pages 8–23.

At the end of the fiscal year six persons were employed in this section. The water-resources branch has continued to render special assistance in preparing copy and reading proof.

SECTION OF ILLUSTRATIONS.

The number of illustrations prepared was 3,547, including 211 miscellaneous maps, 451 photographs, 900 sections and diagrams, 1,808 paleontologic drawings, and 177 miscellaneous illustrations. The illustrations transmitted to accompany manuscripts numbered 990, to be reproduced by chromolithography, photolithography, halftone, zinc etching, four-color process, wax engraving, and cuts already engraved. The number of proofs received and examined was 809. At the end of the year material for illustrating 57 reports is on hand, of which material for 26 reports is 10 to 95 per cent completed. One additional draftsman was recently added to the force, which now comprises 12 persons.

DIVISION OF MAP EDITING.

SECTION OF GEOLOGIC MAPS.

Two geologic folios (Nos. 211 and 212) were completed and published during the year. No. 211 describes the Elkton and Wilmington quadrangles (Del.-Md.-Pa.-N. J.), and No. 212 the Syracuse and Lakin

quadrangles (Kans.). The maps of Folio 213 (New Athens-Okawville, Ill.) were completed and printed and the text was set up. The maps of the Brilliant-Raton-Koehler (N. Mex.-Colo.) and Black Hills (S. Dak.) folios were engraved. The maps of the Ray (Ariz.) and Hot Springs (Ark.) folios were engraved and approved for transfer to stone. The maps of the Carlyle-Centralia and West Frankford-Galatia (Ill.) folios were prepared for engraving. During the year illustrations of 38 other reports were examined and criticized by the geologist in charge of the section. Part I of the World Atlas of Commercial Geology was completed and published, and work on the base maps for Part II was begun.

SECTION OF INSPECTION AND EDITING OF TOPOGRAPHIC MAPS.

During the year 97 topographic maps were edited and transmitted for engraving, 219 published topographic maps were edited for reprint, and 181 maps were edited as illustrations for 25 Survey reports, a total of 497 maps edited. Engraved proof was read in first and second plate and in combined proof for 65 new topographic maps, and plate proof was read for corrections to 129 reprinted topographic maps. Proofs were corrected for 81 maps reproduced by photolithography. At the end of the year 115 maps were in process of engraving and printing. Index maps for 9 State circulars were revised and proofs corrected, and 19 maps of the series 9–323 were also revised for a new edition of the United States index map showing progress of topographic and geologic surveying. During the year 64 new topographic maps were published (60 engraved on copper and 4 printed by photolithography). (See also "Topographic branch," p. 61.)

DIVISION OF DISTRIBUTION.

A total of 483 publications, comprising 130 new books and pamphlets, 34 reprinted books and pamphlets, 2 new geologic folios, 4 new geologic maps, 1 part of the World Atlas of Commercial Geology, 67 new or revised topographic maps, and 245 reprinted topographic maps were received by the division of distribution during the year. A number of special pamphlets and forms prepared for administrative use were also delivered and distributed. The total units of all publications received numbered 549,103 books and pamphlets, 7,628 geologic folios, 4,883 copies of the World Atlas, 370 geologic maps, and 908,196 topographic and other maps, a grand total of 1,470,180.

The division distributed 619,117 books, 15,141 folios, 3,110 copies of the World Atlas, and 740,042 maps, a total of 1,377,410, of which 10,902 folios, 1,347 copies of the World Atlas, and 553,820 maps were sold. The sum received and deposited in the Treasury as the result of sales of publications was $43,654.91, including $39,790.31 for topographic and geologic maps, $1,294.60 for geologic folios, and $2,570 for the World Atlas. The division received and answered 106,430 letters.

DIVISION OF ENGRAVING AND PRINTING.

TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS.

During the fiscal year 60 new topographic maps were engraved and printed, including the map of the Bone Spring quadrangle (Tex.), which had been previously published in photolithographed form. In

addition to these, 10 new topographic maps were engraved, but the printing was not completed by June 30. The engraving on approximately 20 more new topographic maps was nearly completed, there remaining only to be done some minor correction work. Four new maps were photolithographed and printed, and new editions of three topographic maps were issued, making a total of 67 new or revised maps printed and delivered.

Corrections were engraved on the plates of 224 maps. Reprint editions of 216 topographic maps showing corrections and of 29 corrected State and other photolithographed maps were also printed and delivered.

Of new and reprinted maps 312 different editions, amounting to 908,196 copies, were delivered to the map room. This is an increase of 129 editions and 196,324 copies over the preceding year.

Two new geologic folios were published during the year. The editions of these folios amounted to 7,628 copies, an increase of 420 copies over the preceding year. Extra geologic maps of these folios amounting to 370 copies were also delivered.

OTHER GOVERNMENT MAP PRINTING.

A large amount of work was also done for the Government Printing Office, Office of the Chief of Staff, Office of the Chief of Engineers, Coast Artillery (Fort Monroe, Va.), Federal Board for Vocational Education, Bureau of War Risk Insurance, United States Shipping Board, Department of State, Panama Canal, Coast and Geodetic Survey, Department of Labor, Post Office Department, Department of Justice, International Boundary Commission, Women's Bureau, Department of the Interior, Reclamation Service, General Land Office, Bureau of Mines, Office of Indian Affairs, National Park Service, Bureau of Standards, Forest Service, Federal Power Commission, Interstate Commerce Commission, Alaskan Engineering Commission, Bureau of Lighthouses, Bureau of Markets, Bureau of Plant Industry, Department of Commerce, Weather Bureau, General Service Schools (Fort Leavenworth, Kans.), Government of Santo Domingo, United States Grain Corporation, Engineer Map-Reproduction Plant, and United States Railroad Administration. This work for other branches of the Government included many reprint editions and amounted to about $110,000, for which the appropriation for engraving and printing geologic maps was reimbursed by transfer of credit on the books of the United States Treasury.

Work was also done for the Tennessee Charcoal & Iron Co., Collinwood, Tenn.; J. B. Lyon Co., Albany, N. Y.; A. Hoen & Co., Baltimore, Md.; W. E. Wrather, Dallas, Tex.; and Ansel F. Hall, in charge of information, Yosemite National Park; and the money received in payment for the work was turned into the Treasury of the United States to be credited to miscellaneous receipts. On requisition of the Government Printing Office, 67 transfer impressions were made and shipped to contracting printers. Under cooperative agreements, transfer impressions were furnished without charge to the State geological surveys of Maryland, Ohio, New York, Virginia, North Carolina, and Illinois.

During the year Part I of the World Atlas of Commercial Geology was completed, and Part II was begun. A large amount of miscellaneous work relating to the map publications was also done, including index circulars and lists of geologic folios, topographic maps, and State maps.

Of contract and miscellaneous printing of all kinds, 2,839,648 copies were printed. Including topographic maps and geologic folios, a grand total of 3,755,842 copies were printed and delivered during the year.

PHOTOGRAPHIC LABORATORY.

The output of the photographic laboratory consisted of 13,974 negatives, of which 1,255 were wet, 1,878 dry, 417 paper, 6,486 field negatives developed, and 3,938 photolithographic negatives; 674 lantern slides; 46,647 prints, of which 25,719 were maps and diagrams, 18,191 photographs for illustrations, and 2,737 rectigraphs; 3,786 zinc plates; 218 zinc etchings, 74 celluloid prints; 30 lantern slides colored; 803 prints mounted; and 216 prints bleached.

ADMINISTRATIVE BRANCH.

After October 16, in addition to performing technical work as one of the specialists in the division of mineral resources and as geologist, Philip S. Smith served as administrative geologist and, during the absence of the Director, as acting Director. Up to that date Mr. Smith was engaged in geologic investigations in Alaska, and the duties of the administrative geologist and acting Director were performed by Marius R. Campbell. Henry C. Rizer served throughout the year as chief clerk.

EXECUTIVE DIVISION.

The work of the executive division was of the same general character as during the fiscal year 1920.

Mails, files, and records.—During the year 185,695 pieces of mail received, of which 2,391 were registered, were opened and referred. In addition, 164,306 letters were received direct by the other divisions, making a total of 350,001, an increase of 9 per cent compared with 1920.

Of the letters opened in this division, 24,591 contained $44,219.40 remitted for Survey publications, an increase of 8 per cent in number of letters and an increase of $4,831.59 in amount compared with 1920.

The recording, referring, reviewing, filing, and mailing of correspondence required the services of nine clerks. The number of ordinary letters mailed through the division was 125,726, of registered letters and packages 23,160, and of form letters and cards, etc., 770,000. In addition, 264,700 pieces of mail were sent out direct from other divisions. The total number of outgoing pieces of mail from the Geological Survey was 1,183,586.

Personnel.—The roll of Secretary's appointees numbered 999 at the end of the fiscal year, 33 more than at the end of 1920. The total number of changes in the personnel was 1,419, which included 313 appointments, 280 separations (7 deaths), and 826 promotions and miscellaneous changes.

During the year 19,136 days of annual leave and 4,253 days of sick leave were granted, being 77 per cent of the amount of the annual leave which could have been taken and 17 per cent of the amount of sick leave which it would have been possible to grant to an average of 826 employees; 14,133 days of leave without pay and furlough were also granted.

Freight and express.—During the year 3,284 pieces of freight and express were handled, 1,120 outgoing and 2,164 incoming.

DIVISION OF SCIENTIFIC AND TECHNICAL EQUIPMENT.

The requisitions on the division of scientific and technical equipment during the year numbered 1,534, of which 1,445 were completed. Registration of instruments was checked and errors were corrected. Several new devices were produced, including a deep-well gaging machine, a device for removing burette cocks without breakage, a stirring machine, a dividing machine for accurate scaling in both ordinary and metric measurements, a machine for setting cross hairs, and a machine that will cut disks from metal of any kind without loss of metal. All these devices save labor or increase efficiency, or both. As all jobs are done at actual cost the charges are about 40 per cent less than those that would be made for the same work in an outside shop.

DIVISION OF ACCOUNTS.

Condensed statements covering the expenditures from Federal funds during the year are given on pages 102–103. The amounts contributed by States for cooperative work are set forth in detail on pages 58–59, 73–74.

Amounts appropriated for and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1921.[a]

Appropriation.	Funds available.				Expenditures.			Balance.
	Appropriation.	Repayments.		Total.	Disbursements.	Outstanding liabilities.	Total.	
		Made.	To be made.					
Salaries, office of Director	$28,520.00			$28,520.00	$24,548.61		$24,548.61	$3,971.39
Salaries, scientific assistants	29,900.00			29,900.00	29,900.00		29,900.00	
Gaging streams, etc	180,000.00	$29,396.66	$12,033.54	221,430.20	216,347.49	$3,500.00	219,847.49	1,582.71
Chemical and physical researches	40,000.00	107.30		40,107.30	35,957.42	1,537.75	37,495.17	2,612.13
Preparation of illustrations	18,280.00	61.10		18,341.10	18,240.67	1.69	18,242.36	98.74
Mineral resources of the United States	125,000.00	69.67		125,069.67	123,909.51	804.48	124,713.99	355.68
Geologic maps of the United States	125,000.00	99,679.78	16,887.84	241,567.62	225,228.84	14,386.00	239,614.84	1,952.78
Books for the library	2,000.00			2,000.00	1,432.36	567.64	2,000.00	
Topographic surveys	330,000.00	69,892.56	27,899.52	427,792.08	421,012.90	6,227.36	427,240.26	551.82
Geologic surveys	352,000.00	2,619.10	2,944.24	357,563.34	341,346.59	9,378.64	350,725.23	6,838.11
Mineral resources of Alaska	75,000.00	337.75		75,337.75	62,833.90	9,970.00	72,803.90	2,533.85
Classification of lands	300,000.00	732.67	1,108.79	301,841.46	291,714.14	8,953.22	300,667.36	1,174.10
Power surveys	125,000.00	25,500.00	204.19	150,704.19	149,184.04	562.38	149,746.42	957.77
	1,730,700.00	228,396.59	61,078.12	2,020,174.71	1,941,656.47	55,889.16	1,997,545.63	22,629.08

a In addition to these appropriations, $140,000 for Survey publications was contained in the appropriation for printing and binding but not disbursed by Survey officials.

Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1921.

Appropriation.	Total.	Salaries and wages.	Transportation of persons and things.	Provisions; subsistence and support of persons.	Forage; subsistence and support of animals.	Printing, engraving, lithographing, etc.	Special and miscellaneous service.	Materials; miscellaneous supplies, etc.	Stationery, drafting, etc., supplies.	Equipment (including live stock).	Maintenance, operation, and repair of passenger-carrying vehicles.	Hire of motor-propelled and horse-drawn passenger carrying vehicles.	Purchase of motor-propelled passenger-carrying vehicles.
Salaries, office of Director	$24,548.61	$24,548.61											
Salaries, scientific assistants	29,900.00	29,900.00											
Gaging streams, etc	216,347.49	156,782.36	$13,784.86	$11,464.24	$32.50	$688.83	$9,732.50	$3,047.90	$416.32	$15,271.23	$468.84	$945.23	$3,712.68
Chemical and physical researches	35,957.42	27,032.08	825.42	1,980.26	10.85		1,501.10	975.90	356.21	1,467.22	1,251.00	70.00	487.38
Preparation of illustrations	18,240.67	17,753.29	2.33			29.30	305.10	59.64	67.94	23.07			
Mineral resources of the United States	123,909.51	115,271.21	3,118.54	1,733.91		412.05	2,688.39	21.20	337.00	327.21			
Geologic maps of the United States	225,228.84	163,906.43	154.79	77.25		102.52	10,689.82	10,543.29	34,905.87	4,848.87			
Books for the library	1,432.36									1,432.36			
Topographic surveys	421,012.90	295,853.21	24,361.63	45,233.20	7,321.00	2,374.66	17,114.75	2,765.36	786.17	17,817.26	4,175.37	3,210.29	
Geologic surveys	341,346.59	265,266.80	12,173.68	18,650.03	489.75	1,226.04	9,804.30	1,379.80	1,036.21	26,729.71	1,588.79	2,303.03	698.45
Mineral resources of Alaska	62,833.90	48,107.69	7,795.70	3,062.88	53.00		2,095.63	409.08	190.27	1,119.65			
Classification of lands	291,714.14	201,491.25	12,968.85	29,375.62	1,549.66	397.20	7,330.23	1,073.70	671.98	35,087.50	702.02	406.13	660.00
Power surveys	149,184.04	122,752.57	4,758.85	6,408.70		269.94	13,145.57	632.92	421.68	793.81			
	1,941,656.47	1,468,665.50	79,944.65	117,986.09	9,456.76	5,500.54	74,407.39	20,908.79	39,189.65	104,917.89	8,186.02	6,934.68	5,558.51

LIBRARY.

In the library the receipts of books, pamphlets, periodicals, and maps numbered 15,269. The loans recorded were 6,774, and 12,930 readers consulted the library in person. The catalog was increased by the addition of 6,240 cards, and 361 titles were sent to the Library of Congress for printing, the proof reading for which amounted to 99 galleys. The books collated and sent to the bindery numbered 350. Translations were made for other divisions of the Survey to the number of 221. The manuscript of the cumulated bibliography of North American geology, 1785–1918, was completed and submitted for publication.

INDEX.

O