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FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

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OF THE

DIRECTOR OF THE UNITED STATES  
GEOLOGICAL SURVEY

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SECRETARY OF THE INTERIOR

FOR THE FISCAL YEAR

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# THIRTY-SEVENTH ANNUAL REPORT OF THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY.

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GEORGE OTIS SMITH, *Director.*

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The appropriations for the work of the United States Geological Survey for the fiscal year 1915-16 comprised items amounting to \$1,570,520. The plan of operations was approved by the Secretary of the Interior, and detailed statements of the work performed are given in this report.

## SPECIAL FEATURES.

### ECONOMY IN SCIENCE.

The increased extent to which the large industrial corporations of the country now support their own departments of scientific research is a gratifying development of the times. Science is regarded as a necessity rather than a luxury. And this coming of science into its own as a large factor in the industrial life of the Nation is necessarily followed by a certain reaction of business upon science. Never before, perhaps, has the demand been so keen for research that is no less than ever scientific in spirit and in method but that has a definite purpose and yields definite results. The idea of making science useful is not new, but the utility of science has become more universally the test of its value.

In the scientific work done under the Federal Government this demand for results is abundantly justified by the public need. If the strongest corporations are making large use of chemists, physicists, and geologists, the general public has similar need in its service for applied science.

The business policy of organizing scientific investigation for effective work, however, is far from novel, for in 1878, in the report to Congress advocating the creation of the United States Geological Survey, the National Academy of Sciences described the ideal plan for a scientific bureau as that which would yield the "best results at the least possible cost." Since that day, moreover, economy in science has become a more pressing issue.

At the centennial exercises of the United States Coast and Geodetic Survey, in April, 1916, the Director of the Geological Survey called attention to the gratifying fact that for nearly four decades the two Surveys had worked side by side in the cause of American science coordinately rather than competitively. The result has been economy instead of waste. With this record in mind the appeal was then made for the application to the business of the two score Federal scientific bureaus of the same rules that the legislatures and courts now enforce for the control of corporations. Unrestrained competition in the public service is no less wasteful than unregulated competition in private business. The ideal of the best service at the lowest cost leads to the recognition of the idea of natural monopolies in the Government scientific service, for this recognition will insure the same real saving to society that has come with the recent growth of public-utility monopolies. It does not follow that because the scientific bureau offers a special service to the public without direct price the public official is any less vitally interested in actual costs.

If the scientific work of the Government is to be organized on the basis of specialization rather than of competition the correlative idea of adequate regulation must be adopted. A large share of this duty of insuring a proper coordination of the public scientific work must be accepted directly by the bureau chiefs and their immediate advisers in the work of administration. Moreover, to this group of Government scientists the obligation is double—they are constrained as public servants to avoid wasteful use of public money and as scientists to conserve scientific effort by preventing duplication in research and in publication. Faith in the effectiveness of highly specialized science must carry with it the belief that some one bureau, by reason of its organization, personnel, and experience, can conduct scientific investigations of a certain kind better than any other bureau. This is practical logic of the type that is recognized in private business, for under the public regulation of natural monopoly the public-utility company that first enters the local field is recognized and even protected by the public-service commission as long as the service it renders is at all adequate. The attempt of an overzealous bureau chief to seek preferment for his bureau on other grounds is not in harmony with the public-service idea that the Federal scientific bureau is only an agency to get results that are of largest value to the public it serves.

#### STATISTICS THAT HAVE VALUE AS NEWS.

A leading trade journal in a recent editorial commented upon the United States Geological Survey's "enviable reputation for accuracy and preciseness throughout all its different branches" but added that



in maintaining this accuracy the Survey had "in the past shown a tendency to ignore the necessity for promptness in placing its vast store of statistical data before the public." This editorial, which was headed "Geological Survey speeding up on statistics," was prompted by the innovation in publishing statistics of coal production referred to below.

The obvious difficulty of giving to the public statistical data that are accurate and yet not somewhat out of date has been met since 1910 by supplementing the complete detailed reports with the publication in the first week of January of preliminary estimates of mineral production for the year just ended. These new-year statements have now attained a degree of accuracy that not only meets the practical needs of most users of this information but also robs the later complete reports of their news value. Thus the Survey's estimate of the gold output of Alaska for 1915, published January 1, 1916, was less than 1.2 per cent in excess of the final figures made public about four months later, and Alaska's exceptionally large yield of copper was estimated within 3 per cent. For the last two years the preliminary estimates of the coal output of the United States were only four-tenths of 1 per cent and 2.6 per cent in error; for the more erratic petroleum industry the estimates of marketed output published January 1 have been within one-half of 1 per cent and 5 per cent of the final figures; the preliminary estimates of cement were within three-tenths of 1 per cent and four-tenths of 1 per cent of the actual output. The Survey geologist who made an estimate of the output of iron ore for 1914, in a statement issued January 1, 1915, "approximated" the final figures with an error of only 239 tons, and his preliminary figures for the output in 1915, published January 1, 1916, were within nine-tenths of 1 per cent of the complete final figures.

It is, of course, through the collection of detailed statistics from individual producers that the specialist is able to keep so closely in touch with his subject that his preliminary estimates have high value for approximate accuracy. Some advances have been made in the date of publication of the final statistical reports, but here the compiler encounters the difficulty of obtaining full and prompt co-operation from a very small minority of the producers, so that it is the last 1 or 2 per cent of the returns that cost the most time and effort. A gain of weeks in the date of publication of the statistics of some products might be made, but only at a sacrifice in the quality of the results. The standard of accuracy maintained by the man of scientific training shows itself in his aversion to round figures. The Survey will continue to seek improvement in the promptness of issue of the final reports, but the public need for authoritative mineral statistics possessing full news value will be met by estimates pub-

lished January 1 and at other times in the year. The Survey's new-year and mid-year statements have already won a place in the public press because they furnish the business interests with impartial estimates of the rate of production of the raw materials and fuels that are so essential to the Nation's industry and commerce.

As information to be valuable must be timely, the Geological Survey regards the preparation and issue of its quarterly and monthly statements as representing the ideal plan for statistics of all the principal metals and mineral fuels. Already a further step in the same direction has been planned: commencing August 15, the Survey will issue every month a comparative statement of railroad movement of coal and coke for the preceding month. It is believed that these authoritative figures will furnish the public a valuable index of the general industrial conditions as well as of the current rate of utilization of the country's mineral reserves.

#### THE GEOLOGY OF PETROLEUM.

The far-reaching importance to the United States of an adequate supply of petroleum and gasoline has long been recognized by the Survey, which during the last two years has made greater efforts than ever before to assist in discovering and in developing new oil reserves. Brief accounts of the work accomplished, with titles of reports published or in preparation this year, describing the structure and oil prospects in many new and undeveloped areas, especially in the Western States, in the Southwest, and in the Midcontinent region, will be found in the record of the geologic work carried on in the several States (pp. 51-91). Even with all the funds which, with justice to other mineral interests, could be devoted to investigations of oil and gas, it has not been found possible to extend these researches at all in proportion to the increase in public demand for information both as to old and to new fields. A recent editorial in the *Standard Oil Bulletin* states: "Time was when oil operators were strongly inclined to give little or no heed to the opinions of geologists, but that time is past." The value of the studies of geologic structure in the search for oil is not only thus recognized by the great oil companies, but most of these corporations are now recruiting corps of geologists, if they had not already had trained geologists in their employ. Naturally, the information thus acquired by these corporations for their guidance in leasing lands and in locating exploratory drill holes is not available to the public—a fact which makes more pressing the need of the landowner and of the small independent driller for all the information which the Federal or State surveys can give.

One function that is especially appropriate for the national service is the prosecution of field studies seeking a better understanding

of the principles and conditions governing the origin, movement, and segregation of oil and gas, thus extending direct aid in the discovery of new pools and new fields. With this object in view, attention is given not only to the geologic structure in the pools already developed and to the mutual relations of the oil, gas, and water as revealed by the drill, but to the problems of discontinuity, tightness, cementation by chemical reaction, porosity, and the more difficult questions of capillarity. In the investigations of such subjects, concerning which some misinformation seems to exist, the physicists of the division of chemistry and physics are cooperating with the geologists.

Estimates of the reserves of petroleum remaining in the ground in the different States were compiled in February by the Survey geologists for the use of the Secretary of the Interior in reply (Senate Doc. 310) to Senate resolution No. 40, Sixty-fourth Congress. Further, in anticipation of the day when, on account of the advancing cost of gasoline and other products obtained from petroleum, it might be found commercially profitable to utilize some of the enormous supply of petroleum to be derived from the distillation of the vast deposits of so-called hydrocarbon shales of the Green River formation of northwestern Colorado and northeastern Utah, the Survey has for three years been making field investigations of these deposits. The examinations have been accompanied by mapping of the areas of hydrocarbon shales and by such field measurements of the thickness of the shales in workable beds and such rude field distillation tests as will afford primary information concerning the amount and richness of the shales in different parts of the region.

Very rough but cautious calculations of the contents of the shale in parts of the area examined indicate that the distillation of shale from beds over 3 feet thick in Colorado alone will yield more than 20,000,000,000 barrels of crude oil, from which more than 2,000,000,000 barrels of gasoline can be extracted by ordinary methods. A report giving the results of these explorations and tests and an account of experiments as to possible gasoline production, both by the ordinary commercial processes and by the Rittman process, is now in press.

#### THE SEARCH FOR POTASH.

The search for potash has continued with unabated zeal. The project of drilling in Smoke Creek Desert, Nev., outlined in last year's annual report, was completed, four deep wells having been put down at selected points in that locality. No potash of commercial importance was found. However, the fact has from the first been clearly recognized that the chances of success in this search must necessarily be small at most places, for the area in the western

United States to be explored is large and the funds available for tests by deep drilling must limit these tests to a few places each year. The surface indications that may help in determining places for drilling are only of the most general nature, yet these have been utilized with skill and judgment in the location of the tests made, and it is not questioned that the possibilities fully justified those tests.

In view of the character of the deposits encountered in the tests of the Quaternary lake beds of the Great Basin region it was concluded that probably there were better prospects of discovering deposits of potash and other salts in the Permo-Triassic "Red Beds" of the Southwest and of the Rocky Mountain region. The field examinations of the "Red Beds," to which reference was made in the last report, clearly indicated the occurrence of several periods of dry climate while this series of beds was being laid down, with consequent evaporation of continental water bodies, and these field studies have also disclosed interesting evidence of the deposition by evaporation of enormous deposits of rock salt, gypsum, and anhydrite in parts of the "Red Beds" country, especially in eastern New Mexico, northwestern Texas, and western Oklahoma.

Most of the drilling for water or for oil in this region has been confined to a few localities, so that in large areas the drill has never penetrated the deeper strata and the interbedded saline deposits. However, the drilling already done shows the presence of as much as 600 or 700 feet of buried rock salt in parts of the great "Red Beds" region. Potash, if present in stratified precipitate, should be associated with some of these saline deposits. Furthermore, the strata of this region, which consist largely of red sandstones and shales, thin dolomites, and gypsum, are similar in composition and general character to those that contain the great potash deposits of Germany, where also large deposits of gypsum and rock salt lie between the rock beds. It should also be noted that the periods of aridity and of saline deposition in the southwestern part of this country were essentially contemporaneous with the periods of evaporation and precipitation in the Stassfurt district. Finally, crystals of potash salts were found in the waste from a bore hole near Boden, not far from Amarillo, Tex., by Dr. J. A. Udden, of the Bureau of Economic Geology and Technology of the University of Texas, and he also found traces of potash in muds or brines from several other wells, the earliest discovery—that in the brines of the well at Spurr, in Dickens County—having been made by Dr. Udden while he was examining drill samples and studying drill logs from western Texas under the auspices of the Federal Survey.

The facts cited justify the hope that beds of potash salts, possibly of commercial importance, may lie buried somewhere in the great "Red Beds" region of the Southwest. Such deposits were perhaps



precipitated only in very small areas in much reduced remnants of the shallow seas of the period. If they exist, they are likely to be lenticular, and, though their areal extent is problematic, they are doubtless of very slight extent in comparison with the great area of the "Red Beds." It therefore follows that if lenses of commercial importance exist in these beds a large number of holes may be drilled in different areas, even under the best geologic guidance, before such a lens is penetrated by the drill. On the other hand, it is possible that drillers may already have penetrated such lenses in their search for oil or water without recognizing the fact, for generally no analyses of the "brines" or the "salt beds" so encountered are made by owners or drillers. At the present rate of the Geological Survey's drilling tests in this region, it must be expected that many years may pass before the drill shall penetrate a single lens. Nevertheless, the need of getting adequate supplies of cheap potash in this country—and none are likely to be so cheap or so adequate as those that lie buried in the earth—is obviously so great and so imperative as to leave little doubt of the wisdom or, possibly, the necessity of incurring the expense of discovering them or proving that they do not exist.

There are indications that a great basin of salt water was evaporated in the Panhandle region of northern Texas, and as potash-bearing crystals of salt were found near Boden, and traces of potash are said to have been found in brines or muds from wells at two or three other localities in this general region, a place at Cliffside, 7 miles northwest of Amarillo, was chosen for the first test to be made by the Survey in the "Red Beds" country. Accordingly, after the tests in the Smoke Creek Desert, Nev., were completed, the drill was shipped to Cliffside, where the owners of certain lands generously permitted the Survey to use them for like tests under terms of option by the Government. Work was begun in the autumn, and, in spite of such accidents as are usually incidental to boring in the "Red Beds," the hole was carried to a depth of 361 feet before the balance of the funds available for potash exploration was exhausted.

It is hoped that with the funds provided in the appropriation for the fiscal year 1917 it will be possible to continue this well to a depth of at least 1,800 feet, which should be sufficient to determine the stratigraphic position and the character of the deposits that furnish the red potash-salt crystals near Boden, if not to carry it to the base of the lowest salt bed, which is probably at a depth of nearly 2,300 feet. This drill hole, which should afford a thorough test of the questions raised by the indications found near Boden, will, however, be conclusive only for this area and, if unsuccessful,

can not be regarded as condemning other areas in the "Red Beds" region.

Meanwhile, efforts are being made to enlist the cooperation of drillers for oil and water at all points in the "Red Beds" country at which beds of rock salt are known or suspected to lie buried, in order that samples of brines and salt and of the rocks adjacent to the salt beds may be sent to the Survey for rough tests as to their possible content of potash salts in commercial amounts. In passing, it may be noted that the studies in this region point to the presence in western Texas, eastern New Mexico, western Oklahoma, and southern Kansas of one of the greatest rock-salt reserves of this continent, if not of the world.

In this year, as in previous years, field examinations were made of all reported deposits of potash salts or nitrates that the samples or other information showed were worthy of field investigation and tests. The alunite deposits near Marysvale, Utah, were reexamined, and a report was published giving rough quantitative estimates of the quantity of potash they contain. Further, to supply a growing demand by chemical engineers for information as to the possibility of extracting potash and other products from various potash silicate rocks, field examinations, with adequate sampling for chemical analysis in the Survey laboratory, have been made of the greensands of New Jersey, Delaware, Maryland, and western Tennessee and of the sericite deposits in North Carolina and Georgia. During the year a paper calling attention to the potash content of tailings of certain copper and gold ores was published.

#### THE MINING-DÉBRIS PROBLEM.

A notable contribution to geologic literature in its broadest relations has during this year been completed for publication. The report, which will be issued during the coming year, is entitled "Hydraulic mining débris in the Sierra Nevada" and represents an extremely thorough investigation by Grove Karl Gilbert. To illustrate the scope of the investigation and of the report now completed, the circumstances under which this work was begun should be mentioned. In a memorial presented to the President of the United States in 1905, the California Miners' Association, after emphasizing the contribution of placer and hydraulic mining to California and to the Nation, expressed the conviction that a rational application of the natural laws governing the deposition of sediment from torrential streams would permit both hydraulic mining and agriculture to be carried on in this region, not only without prejudice to each other, but to their mutual advantage. In the belief that the question was primarily geologic, as it involves the study of erosion and of sedimentation in the mining districts as well as in the lower

valley regions, the association requested that the Director of the United States Geological Survey should be instructed "to undertake a particular study of those portions of the Sacramento and San Joaquin valleys affected by the detritus from torrential streams."

The investigation then begun by Mr. Gilbert was planned to include a field study of the natural phenomena connected with the problem and a laboratory study of the laws of transportation of detritus by running water. The results of this laboratory study have already been published in the Survey's Professional Paper 86—"The transportation of *débris* by running water"—and the report just prepared, which deals with the geologic and physiographic phases of the problem, presents the results of the completed investigation and contains conclusions much broader than the answers to the specific questions raised by the California Miners' Association.

This report, which will be published as Professional Paper 105, will rank as one of the largest contributions of the United States Geological Survey to geologic and engineering science and will also assist materially in solving this problem, which involves mining, agriculture, and navigation. To make such an investigation eminently successful, it has been necessary that the investigator should unite an aptitude for close observation and for logical interpretation with a habit of determining quantitatively as many as possible of the factors of the problem in hand. To his task Mr. Gilbert has brought these qualities in a marked degree, with the result that his report is a masterpiece wherein geology and engineering both contribute to the solution of a practical problem of the first rank. Especially important has it been that this subject should be viewed with the broad outlook of the geologist who appreciates the time factor that enters to so large a degree into any reaction of crustal change, erosion, and sedimentation. The studies cover every phase of the subject, from the original source of the detritus in the Sierra Nevada to the possibility of its transportation through the Golden Gate to the Golden Gate Bar, and in his broad treatment Mr. Gilbert has not only estimated the waste due to agriculture, grazing, roads and trails, and mining and studied its movement seaward, but he has supplemented his observations and estimates with instrumental surveys of impounded detritus as well as with measurements of tidal currents in the Golden Gate. This investigation utilizes the results of the earlier work by the Army engineers and has also had the benefit of generous cooperation by the officials of the United States Coast and Geodetic Survey, the United States Weather Bureau, the Lighthouse Service, and the United States Board of Engineers for Rivers and Harbors.

The investigator appreciated the fact that the problem intrusted to him was complex, involving many factors other than those directly

connected with mining, and recognized that the beneficial use of these rivers, now overburdened with *débris*, must be effected by co-operative endeavor on the part of several interests. The public interest in agricultural reclamation, as well as in placer mining, must now be harmonized with the public interest in navigation. In its conclusions, therefore, this scientific study, which had its origin in the antagonism of mining and agriculture, is found to involve a question of relative values between commerce and agriculture, as well as between mining and irrigation and power development. Mr. Gilbert therefore concludes that the great users of the Sierra's water must cooperate in the control of these rivers, to the end that the largest possible benefits may be gained without too great injury to navigation. This report, in which scientific conclusions based on highly technical data are presented in plain and simple terms, serves to illustrate how high a public service can be rendered by the geologist in connection with economic questions of large civic importance.

#### DISTRIBUTION OF MAPS.

The project of covering the 3,000,000 square miles of the United States with accurate topographic surveys was definitely adopted by the Federal Government in 1882, and the work is even now less than half completed. The standards of accuracy and refinement in topographic surveying have been constantly raised by the topographic engineers, with the view of meeting adequately every use to which the resulting maps can be put. The law provides for the sale of the United States Geological Survey maps at the cost of printing, a charge that must be considered merely nominal when it is realized that the cost of an edition of the printed map may be only a small percentage of the cost of surveying the area it represents. The Government itself is making a large and increasing use of these topographic maps, but the expenditure of public funds for these surveys is otherwise fully warranted only as the public uses the maps. To promote this use, the Survey has recently given more attention to the wider distribution of the maps.

The distribution of a Government map is largely a problem of publicity, though the necessity of adopting commercial business methods in handling orders for the maps when once a demand is created must not be overlooked. In informing the public of the existence of authoritative maps published by the Federal Government a special effort is now made to reach the communities in each area covered by a map, and to this end every map as issued is brought to the attention of the local and State press, as well as of postmasters and school-teachers. Other methods of promoting wider distribution involve the cooperation of boy-scout masters, schoolboys, and hotel managers, as well as of a large number of bookstores as local agents.



Within the last year the most helpful publicity has been gained through the voluntary cooperation of several press services and magazines of large circulation, in connection with their policy of bringing the people into closer touch with the work and publications of the Federal Government. The publication in one magazine

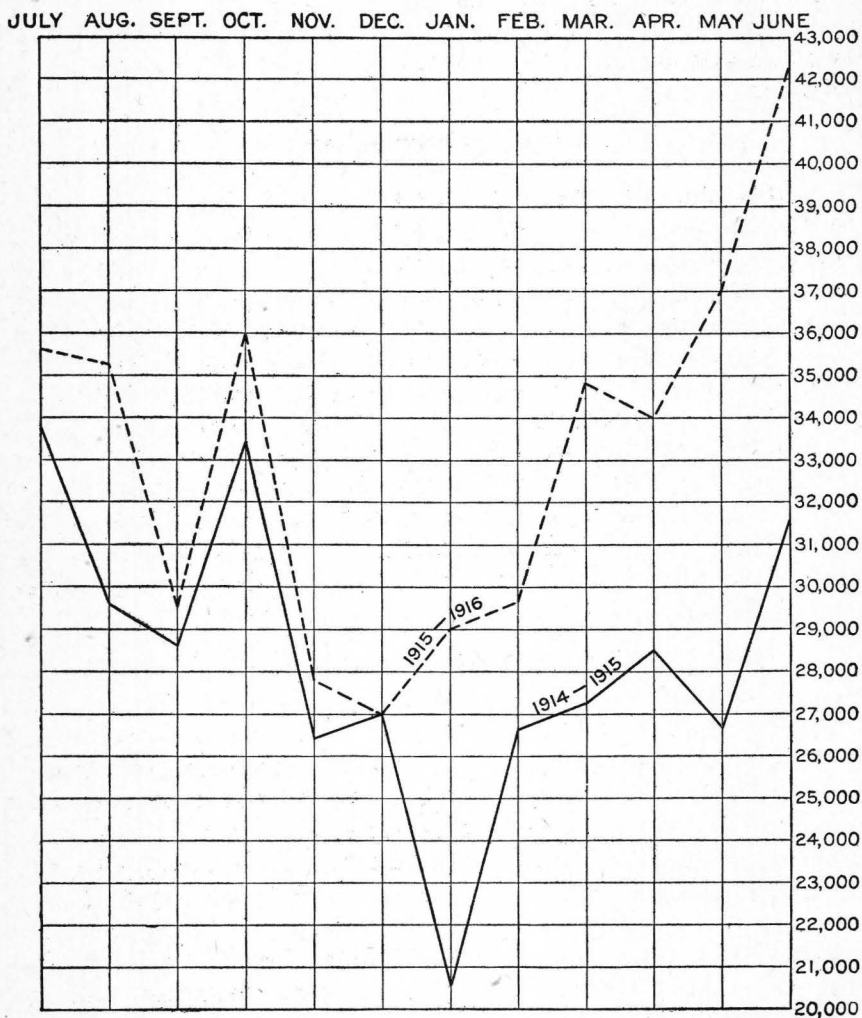


FIGURE 1.—Diagram showing maps sold during the fiscal years 1915 and 1916.

of a brief statement regarding the Geological Survey's maps resulted within a month in orders for 550 maps and thousands of inquiries for the State indexes that show the areas already mapped.

Figure 1 shows a large increase in the number of maps sold in 1915-16 over the number sold in 1914-15. This increase amounted to about 17 per cent. The two curves also bring out the fact that the

periods of maximum demand for these Government maps are the beginning of the vacation period and the beginning of the school year. The larger use of topographic maps in 1915-16, both in the open and in the classroom, is a gratifying index of the popular benefit already resulting from the increase in the work of publicity.

It may be noted here that the sales of Survey publications by the Superintendent of Documents have increased from 10,841 books, amounting to \$3,689.55, in 1914-15, to 16,348 books, amounting to \$8,620.35, in 1915-16.

#### SCOPE OF THE WORK.

In this administrative report the activities of each branch of the Survey are set forth in detail; the following paragraph is a brief summary of the whole. Geologic investigations were made in 47 States, Alaska, the Canal Zone, and the West Indies; topographic surveys were made in 29 States, Alaska, and Hawaii; and stream measurements were made in 39 States, Alaska, and Hawaii. The total area covered by the geologists in reconnaissance and detailed surveys was more than 54,000 square miles, and the area topographically mapped by the topographers was more than 33,000 square miles. The land-classification work of the Geological Survey last year resulted in the classification of about 32,000,000 acres in the public-land States. In the collection of statistics of mineral production the Geological Survey cooperated with the State geologists of 14 States and carried on correspondence with 92,000 producers.

#### WORK OF THE YEAR.

##### PUBLICATIONS.

The publications of the year consisted of 1 annual report, 1 monograph, 2 professional papers, 15 separate chapters from 2 professional papers, 35 bulletins, 45 separate chapters from six bulletins, 24 water-supply papers, 9 separate chapters from 5 water-supply papers, 1 annual report on mineral resources for 1914 (published also in 61 advance chapters, 5 delivered in 1914-15 and 56 in 1915-16), 13 advance chapters from the annual report on mineral resources for 1915, 6 geologic folios, 1 list of publications, pamphlets entitled "Service Bulletin, 1915," and "Extracts from the Style Book of the Government Printing Office," leaflets entitled "The production of copper in 1915," "The production of lead in 1915," and "The production of spelter in 1915," text for back of map entitled "Origin of Delaware Water Gap and of the surrounding features," 3 circulars concerning maps and folios, 33 index map circulars, 81 press bulletins, and 13 circular lists of new publications. The total number of pages in these publications was 19,722.

Brief notes on the publications of the year are given below :

**THIRTY-SIXTH ANNUAL REPORT OF THE DIRECTOR** of the United States Geological Survey to the Secretary of the Interior, for the fiscal year ended June 30, 1915. 1915. 186 pages, 2 plates.

A detailed account of the work of the Geological Survey during the fiscal year 1915, with a statement of the total appropriation made by Congress for the Survey and the allotments for each kind of work. Under the heading "Special features" the Director discusses the larger public service that is every year being rendered by the Survey and the increasing demand for such service and describes briefly the Survey's exhibit at the Panama-Pacific Exposition, San Francisco. The book also includes abstracts of the publications of the year and maps of the United States showing areas covered by topographic and geologic surveys.

**MONOGRAPH 54.** The Mesozoic and Cenozoic Echinodermata of the United States, by W. B. Clark and M. W. Twitchell. 1915. 341 pages, 108 plates.

This contribution to American paleontology contains descriptions and half-tone illustrations of many species and varieties of echinoderms found in the United States. The senior author of the work was the first American to attempt a general systematic study of the Mesozoic and Cenozoic representatives of this group, his first important paper on this subject being "The Mesozoic Echinodermata of the United States," published in 1893 as Bulletin 97 of the United States Geological Survey. Some of the forms of the Echinodermata are very numerous and because of their wide geographic and restricted geologic range are valuable in determining questions of correlation. The revision presented in this contribution should therefore be of some value in stratigraphic geology. Monograph 54 also contains tables showing the stratigraphic positions of the more important American Mesozoic formations, the geologic distribution of the Mesozoic Echinodermata of the United States, and the stratigraphic distribution of the Cretaceous Echinodermata of Texas.

**PROFESSIONAL PAPER 89.** The fauna of the Chapman sandstone of Maine, including descriptions of some related species from the Moose River sandstone, by H. S. Williams, assisted by C. L. Breger. 1916. 347 pages, 27 plates, 2 text figures.

A study of the fossils of the Chapman sandstone of Maine with a view to correlating this formation with certain others of New York, New England, and Europe, which appear to be of the same horizon. The species are discussed and illustrated in detail.

**PROFESSIONAL PAPER 95.** Shorter contributions to general geology, 1915; David White, chief geologist. 1916. 120 pages, 7 plates, 35 text figures.

A consolidation of nine short papers issued first as parts A to I, inclusive, forming the third annual volume bearing this title. The papers of this series relate to any phase of geology that possesses general interest, and only their brevity prevents the separate publication of each as a bulletin or professional paper. Professional Paper 95 contains the following contributions: The composition of muds from Columbus Marsh, Nev., by W. B. Hicks; Eocene glacial deposits in southwestern Colorado, by W. W. Atwood; Relation of the Cretaceous formations to the Rocky Mountains in Colorado and New Mexico, by W. T. Lee; An ancient volcanic eruption in the upper Yukon basin, by S. R. Capps; Evaporation of potash brines, by W. B. Hicks; Erosion intervals in the Eocene of the Mississippi embayment, by E. W. Berry; Preliminary report on the diffusion of solids, by C. E. Van Orstrand and F. P. Dewey; Notes on the geology of Gravina Island, Alaska, by P. S. Smith; The age of the Ocala limestone, by C. W. Cooke.

PROFESSIONAL PAPER 98-A. Evaporation of brine from Searles Lake, Cal., by W. B. Hicks. 1916. Pp. 1-8, figs. 1-2.

Part of Professional Paper 98, "Shorter contributions to general geology, 1916." Discusses the effect of evaporation on the brine from a bed of crystalline salts in southeastern California known as Searles Lake. This is the most valuable potash-bearing brine known in the United States, so that economical methods for extracting potash and other commercial salts from it are now eagerly sought. The experiments described in this paper were made in continuation of those on artificial brines described in Professional Paper 95-E, "Evaporation of potash brines," by the same author.

PROFESSIONAL PAPER 98-B. Relation of the Wissahickon mica gneiss to the Shenandoah limestone and Octoraro schist of the Doe Run and Avondale region, Chester County, Pa., by E. F. Bliss and A. I. Jonas. 1916. Pp. 9-34, Pls. I-III, figs. 3-5.

Describes briefly the geology of a part of the Coatesville quadrangle, in Chester County, Pa., giving special attention to the age of the different rocks. The authors conclude that the Wissahickon mica gneiss, one of the formations occurring in this area, is of pre-Cambrian age and that it is separated from the Shenandoah limestone and Octoraro schist, which are of Cambrian and Ordovician age, by a thrust fault that has been obscured by post-Ordovician metamorphism.

PROFESSIONAL PAPER 98-C. Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914, by B. L. Johnson. 1916. Pp. 35-36, Pls. IV-V, figs. 6-7.

A brief account of the recession of an Alaskan glacier which in 1899 nearly closed Doran Strait, the connecting waterway between Harriman Fiord and Port Wells. The total retreat of Barry Glacier in the four years between 1910 and 1914 was about 8,200 feet along its eastern edge and 2,500 feet along its western edge.

PROFESSIONAL PAPER 98-D. Experiments on the extraction of potash from wyomingite, by R. C. Wells. 1916. Pp. 37-40.

Describes laboratory experiments with the rock wyomingite, made to determine its value as a source of potash. Wyomingite is a lava which occurs extensively in the Leucite Hills, in Sweetwater County, Wyo. It is composed largely of the mineral leucite, a silicate of alumina and potash which is richer in potash than feldspar, long regarded as one of the most promising prospective sources of potash.

PROFESSIONAL PAPER 98-E. The physical conditions and age indicated by the flora of the Alum Bluff formation, by E. W. Berry. 1916. Pp. 41-59, Pls. VII-X, fig. 8.

This paper describes a small flora collected from the Alum Bluff formation, which occurs at a horizon hitherto unrepresented paleobotanically in southeastern North America, and discusses the bearing of this flora on the physical conditions of deposition and the probable age of the deposits.

PROFESSIONAL PAPER 98-F. The physical conditions indicated by the flora of the Calvert formation, by E. W. Berry. 1916. Pp. 61-73, Pls. XI-XII.

Gives a summary of the small flora preserved in the Miocene diatomaceous beds of the Calvert formation in the District of Columbia and Virginia and discusses its bearing on the physical conditions of the Calvert epoch.

PROFESSIONAL PAPER 98-G. Revision of the Beckwith and Bear River formations of southeastern Idaho, by G. R. Mansfield and P. V. Roundy. 1916. pp. 75-84, Pls. XIII-XIV.

Gives a statement of the stratigraphic problems involved in attempting to correlate certain strata of the Wayan and Montpelier quadrangles, Idaho,



with the Beckwith and Bear River formations as now defined. The lack of agreement, both lithologically and faunally, between these formations as exposed in the quadrangles named and in the region of their type localities has caused doubt as to whether they have been properly classified.

PROFESSIONAL PAPER 98-H. The flora of the Fox Hills sandstone, by F. H. Knowlton. 1916. Pp. 85-93, Pls. XV-XVIII.

Brief descriptions of the known fossil flora of the Fox Hills sandstone in the Rocky Mountain region. Although only 13 forms have thus far been recognized, a discussion of the affinities and relations of this flora should arouse considerable interest, because the Fox Hills sandstone lies between formations that have furnished abundant plant remains, and knowledge of its flora has long been desired.

BULLETIN 565. Results of spirit leveling in Colorado, 1896 to 1914, inclusive; R. B. Marshall, chief geographer. 1915. 192 pages, 1 plate.

BULLETIN 568. Results of spirit leveling in Missouri, 1896 to 1914, inclusive; R. B. Marshall, chief geographer. 1915. 219 pages, 1 plate.

BULLETIN 573. Results of spirit leveling in Arizona, 1899 to 1915, inclusive; R. B. Marshall, chief geographer. 1915. 123 pages, 1 plate.

Reports on precise and primary leveling in the States mentioned, showing the exact altitude above sea level of a great number of places. The work in Missouri since 1906 was done in cooperation with the State. Some of these elevations have been adjusted by the United States Coast and Geodetic Survey from precise leveling. Others (in Missouri) are elevations of stone-line bench marks established by the Mississippi River Commission and by the Missouri River Commission from primary leveling. Each book contains a plate showing Geological Survey designs for bench marks.

BULLETIN 587. Geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. 1915. 243 pages, 38 plates, 43 text figures.

A concise summary of what is known of the geography, geology, and mineral resources of Kenai Peninsula, Alaska, based on investigations made at different times by many observers. Kenai Peninsula contains auriferous lodes of some promise, though deep mining has so far been done on only a small scale. The future of placer mining in this part of Alaska depends on the exploitation of many large bodies of gravel carrying too little gold to permit development by the simple methods thus far chiefly used. The book contains numerous illustrations, which include a map of central Alaska, topographic and geologic reconnaissance maps of Kenai Peninsula, a map showing distribution of timber, and sketches and photographs showing features of geologic interest.

BULLETIN 591. Analyses of rocks and minerals from the laboratory of the United States Geological Survey, 1880 to 1914, tabulated by F. W. Clarke, chief chemist. 1915. 376 pages.

A compilation of chemical analyses of rocks, clays, and soils, arranged by States, and of meteorites and minerals.

BULLETIN 593. The fauna of the Batesville sandstone of northern Arkansas, by G. H. Girty. 1915. 170 pages, 11 plates.

Descriptions of invertebrate fossils of a section of upper Mississippian rocks in northern Arkansas, lying just above the Moorefield shale, whose fauna has been described in Bulletin 439 by the same author.

BULLETIN 595. Fauna of the so-called Boone chert near Batesville, Ark., by G. H. Girty. 1915. 45 pages, 2 plates.

The fossils that form the subject of this account are poorly preserved and as a fauna comprise little that is new. They occur in rocks of Missis-

sippian age whose outcrops were studied in the vicinity of Batesville, Ark. The noteworthy thing about this fauna is that practically all the species occur also in the Moorefield shale, which lies just above the chert, and practically none of them occur in the typical Boone limestone. This would indicate that the cherty limestone is younger than the true Boone and should really be classed as a distinct formation.

BULLETIN 598. Faunas of the Boone limestone at St. Joe, Ark., by G. H. Girty. 1915. 50 pages, 3 plates.

This bulletin consists of two distinct parts—one describing the fauna of the St. Joe limestone member of the Boone limestone, the other describing a small fauna obtained in the Boone not far above the St. Joe. These rocks are of lower Mississippian age. The collections of fossils described in both papers were obtained near the town of St. Joe, in northern Arkansas. Many of the forms are illustrated in the halftone plates which accompany the report.

BULLETIN 601. Geology and mineral deposits of the National mining district, Nev., by Waldemar Lindgren. 1915. 58 pages, 8 plates, 8 text figures.

Discusses briefly the geology of the Santa Rosa Range, a narrow desert mountain range of northwestern Nevada, in general, and of the National mining district, on the western slope of this range, in particular. Gives detailed descriptions of developments in the district. Special interest attaches to the description of the extraordinary shoot of rich gold ore which brought the district into prominence in 1909 and to the conclusion that the high-grade ores of National, like those of Goldfield, were deposited within a comparatively short distance from the surface. The illustrations include a geologic map of the National district, a map of the National mine, diagrams and sections of the National vein, and photomicrographs of gold quartz.

BULLETIN 602. Anticlinal structure in parts of Cotton and Jefferson counties, Okla., by C. H. Wegemann. 1915. 108 pages, 5 plates.

A reconnaissance report whose object is to offer first aid to the prospector for oil in the region discussed. The anticlines and domes pointed out are believed to be the most promising areas of the region for testing, for nearly everywhere in Oklahoma accumulations of oil and gas are associated with such features of structure, though their exact relations to these features vary from area to area and even from pool to pool. Incomplete as the results necessarily are, on account of the difficulties encountered, the work of the State and Federal surveys will have been many times repaid if the use of this report will prevent a large part of the fruitless drilling that usually attends the geologically unaided search for oil and gas in undeveloped areas. The illustrations of the bulletin include a geologic sketch map of Oklahoma and northern Texas, showing the location of oil and gas fields, and a geologic map of parts of Cotton and Jefferson counties, Okla., showing structure. The report was prepared in cooperation with the Oklahoma Geological Survey.

BULLETIN 603. Geology and oil resources of the west border of the San Joaquin Valley north of Coalinga, Cal., by Robert Anderson and R. W. Pack. 1915. 219 pages, 14 plates, 5 text figures.

The main purpose of this report is to present the geologic evidences of the existence of petroleum in the rocks along the foothills that form the western border of San Joaquin Valley, Cal., between the Coalinga oil district and Livermore Pass, and to discuss the chances of finding oil in commercial quantity in this region. With this end in view, a general description of the physical features of the region is given, with special ref-

erence to the geologic features which have a bearing on the presence or absence of petroleum in the several areas considered. The writers take this opportunity of presenting also some additional geologic information, which may be of interest to the geologist if not to the oil prospector. The illustrations show many interesting geologic features and include a geologic map, with sections, of the valley between the Coalinga oil field and Livermore Pass.

BULLETIN 604. The phosphate deposits of Florida, by G. C. Matson. 1915. 101 pages, 17 plates, 2 text figures.

A brief summary of the geology of the northern part of the Florida Peninsula, followed by a discussion of the mode of occurrence, geologic relations, and origin of the phosphates which occur there and methods of mining them. Numerous halftone plates give views of the deposits and of fossils found in them.

BULLETIN 605. The Ellamar district, Alaska, by S. R. Capps and B. L. Johnson. 1915. 125 pages, 10 plates, 10 text figures.

This report gives the results of a detailed study of the geology and ores of the Ellamar district, which lies at the northeast border of Prince William Sound and includes part of the mainland, about half of Bligh Island, and a number of smaller islands. The Prince William Sound region is now one of the larger copper producers of Alaska and promises to hold that position, so that any information as to its very complex geology is of considerable importance. Bulletin 605 discusses the mines and prospects of the Ellamar district and contains detailed topographic and geologic maps of the area.

BULLETIN 606. Origin of the zinc and lead deposits of the Joplin region, Missouri, Kansas, and Oklahoma, by C. E. Siebenthal. 1915. 283 pages, 11 plates.

A valuable contribution to the study of the lead and zinc deposits of the Mississippi Valley, which are not only of great economic importance but have long been intensely interesting to students of ore deposits because they constitute a conspicuous example of the occurrence of sulphide ores in a region where plutonic or volcanic activities can have had no part in their genesis. The author holds that the Joplin ores were segregated from disseminated zinc and lead minerals in the Cambrian and Ordovician rocks of the Ozark uplift by circulating artesian alkaline-saline sulphureted waters, and his careful observations and cogent reasoning have gone far to establish the general conclusion that ordinary cold artesian water may under some circumstances be a very efficient agent in the solution, transportation, and deposition of the constituents of certain sulphide ores. The illustrations include topographic and geologic maps and cross sections of the Ozark uplift, diagrams showing early and late stages in Ozark artesian circulation, and halftone plates showing the manner of occurrence of the ores in certain of the mines.

BULLETIN 607. The Willow Creek district, Alaska, by S. R. Capps. 1915. 86 pages, 15 plates, 5 text figures.

Describes the geography and geology of the Willow Creek district, which lies in south-central Alaska, about 10 miles north of the head of Knik Arm, and includes not only the basin of Willow Creek, but all the mountainous portion of the Little Susitna River basin. The author points out that the geology of this area is favorable to the occurrence of gold deposits, so that the outlook for a permanent lode district here is hopeful. Each mine and prospect is treated in detail, and the book contains many halftone plates, as well as topographic and geologic maps, showing features of interest to the miner and geologist.

**BULLETIN 608.** The Broad Pass region, Alaska, by F. H. Moffit, with sections on Quaternary deposits, igneous rocks, and glaciation by J. E. Pogue. 1915. 80 pages, 8 plates, 3 text figures.

Describes briefly the geography and geology of the Broad Pass region, Alaska, which includes the headwater tributaries of Chulitna and Nenana rivers and the heads of some streams flowing into Susitna River. Broad Pass, a wide glaciated valley between the head of Chulitna River and Jack River, a tributary of the Nenana, was discovered in 1898 by members of the United States Geological Survey and has recently been chosen as the route of the proposed Government railroad from Seward to Fairbanks. Although no commercial mineral deposits have yet been found in this region, what is known of the geology gives hope that such deposits may be found. The book is illustrated by topographic and geologic reconnaissance maps and views showing geologic conditions in the area described.

**BULLETIN 609.** The fractional precipitation of some ore-forming compounds at moderate temperatures, by R. C. Wells. 1915. 46 pages, 2 text figures.

The experiments described in this bulletin were made to aid in elucidating the chemistry of ore deposition. As the solubility of a compound in water is the factor that most affects the separation and deposition of its ore-forming constituents, these experiments were confined to aqueous solutions at moderate temperatures, and they have shown the order of solubility of the compounds of each of the classes investigated—sulphides, hydroxides, carbonates, and silicates. For the sake of comparison the results obtained are assembled in tabular form at the end of the book.

**BULLETIN 610.** Mineralogic notes, series 3, by W. T. Schaller. 1916. 164 pp., 5 plates, 99 text figures.

Gives results of the author's mineralogic research work in the chemical laboratory of the United States Geological Survey from July, 1911, to December, 1913. Describes and shows the crystal forms of several new minerals, the most interesting of which is probably koechlinite, a bismuth molybdate found first at Schneeberg, Germany. Series 1 and 2 of these notes were published as Bulletins 490 and 509.

**BULLETIN 611.** Guidebook of the western United States, Part A, The Northern Pacific Route, with a side trip to Yellowstone Park, by M. R. Campbell and others. 1915. 212 pages, 27 route maps, 27 plates, 39 text figures.

The first of a series of handbooks for railway travelers in the Western States, describing the geography, geology, history, and natural resources of the region traversed by the principal transcontinental routes. The present volume deals with the country along the Northern Pacific Railway from St. Paul to Seattle and along the branch line to Yellowstone Park.

He is a very unobservant traveler who can cross the Great Plains, the Rocky Mountains, the lava plateau of the Columbia, and the Cascade Range without noting some of the diversities in the color and character of the rocks and the striking differences in the landscape. It is the purpose of this volume to answer some of the questions which these views from the car windows evoke, to tell what the rocks are and how they got there, to explain the effects of earth movements upon them, to show how that conspicuous element in scenery which we call topography is the result of a long succession of geologic events—in brief, to tell the story of the mountains, valleys, and plains. It does not stop there, however. It connects this record of the prehistoric past with the present march of western progress and development by showing the relation of geologic processes to natural resources of various kinds; it describes the utilization of these resources



and tells how man has turned them to account since Lewis and Clark toiled over the route that is now so quickly traversed in luxurious comfort.

Every effort has been made to make the volume interesting as well as accurate. Matter slightly more detailed or technical than that in the body of the text has been separated as footnotes, and a glossary has been provided for such geologic terms as it was necessary to use. The more important sources of geologic information on the region are listed in the back of the book, and a table showing the principal divisions of geologic time appears on the back of the title-page. Each map unfolds so that it can be consulted conveniently without turning the page which the traveler may be reading. The halftone views and text figures have been chosen with care to convey definite information.

**BULLETIN 613.** Guidebook of the western United States, Part C, The Santa Fe Route, with a side trip to the Grand Canyon of the Colorado, by N. H. Darton and others. 1915. 194 pages, 25 route maps, 42 plates, 40 text figures.

This guide describes the country along the Atchison, Topeka & Santa Fe Railway from Kansas City to Los Angeles. It presents the facts in an itinerary from station to station, and although the description of the rocks and their relations and of the scenic features forms a large proportion of the matter, nearly every page gives information as to notable historic events, industrial resources, plants, and animals. The story of the Indians, past and present, especially the characteristic Pueblo tribes, is told in some detail. The treatment is popular, and many interesting facts are presented, making the book easy reading. Some of the more technical data are given in footnotes and diagrams. The 25 maps covering the route not only show the main features of mountains and valleys, plains and rivers within sight from the railway, but give figures of elevation and distance, and the distribution of the rocks is indicated by a separate color. Many of the facts regarding the rocks are here presented for the first time. The book contains numerous views of prominent scenic features and pictures of restorations of some of the very remarkable animals whose bones are found in the clays. A glossary of geologic terms and a table of the larger divisions of geologic time are included. A list of recent geologic literature relating to the region serves as a guide to more detailed reading.

**BULLETIN 614.** Guidebook of the western United States, Part D, The Shasta Route and Coast Line, by J. S. Diller and others. 1915. 142 pages, 19 route maps, 33 plates, 15 text figures.

A manual for the traveler between Seattle or Los Angeles and San Francisco, which describes in clear, simple language the geography, geology, history, and natural resources of the region visible from the car windows. Geology is made interesting to the reader by an avoidance of details and by the selection for treatment of the features that are likely to attract the eye. Care is taken also to point out the connection between the story of the earth and the present human activity in the region.

The book is divided into two parts, one dealing with the route from Seattle to San Francisco and one with the route from Los Angeles to San Francisco. Both routes go through regions that present great diversity in geology, scenery, climate, and resources. For the northern route the history of civilized settlement goes back to the early fur traders and trappers, and for the southern route to the Spanish padres and their Indian converts. As in the other guidebooks in this series the route is covered by convenient maps and the text is well illustrated by views and diagrams.

BULLETIN 615. Rhode Island coal, by G. H. Ashley. 1915. 62 pages, 5 plates, 3 text figures.

A brief discussion of the character and attempted utilization of Rhode Island coal, which has always had a certain interest to the people of that State as a source of local supply in competition with Pennsylvania coal. The author concludes that, as this coal is a high-ash, high-moisture, graphitic anthracite which requires peculiar handling, the best prospect for its present use is in producing electric power at the mines, either in steam engines or by means of specially devised producer-gas or water-gas plants. He adds that this can probably not be done until Rhode Island coal can be mined and delivered at the furnace for less than one-half the wholesale price of competing coals in Providence and Boston. The illustrations consist of a sketch map of the Rhode Island coal field, views at several of the mines, and charts showing the composition and theoretical heating power of Rhode Island coal as compared to its competitors and the relation of its carbon content to its fuel value.

BULLETIN 616. The data of geochemistry (third edition), by F. W. Clarke. 1915. 821 pages.

A manual of geologic chemistry, including chapters on the nature, distribution, and relative abundance of the chemical elements, the composition of the atmosphere and of volcanic gases and sublimates, the mineral content of surface and underground waters, the nature of saline residues, the molten magma of the earth's interior, the rock-forming minerals, the composition of igneous, sedimentary, and metamorphic rocks, the decomposition of rocks, the metallic ores, the natural hydrocarbons, and coal.

BULLETIN 617. Bibliography of North American geology for 1914, with subject index, by J. M. Nickles. 1915. 167 pages.

A list, arranged alphabetically by authors' names, of publications on the geology of the continent of North America and adjacent islands, also Panama and the Hawaiian Islands, issued in 1914. The work is indexed and contains lists of chemical analyses reported and minerals, rocks, and formations described.

BULLETIN 618. Geology and underground waters of Luna County, N. Mex., by N. H. Darton. 1916. 188 pages, 13 plates, 15 text figures.

Describes the geologic structure of Luna County, in southwestern New Mexico, with the especial purpose of showing the extent of the area underlain by water-bearing deposits, the depth of these deposits, and the amount of water available. This information was much needed because of the arrival in the desert valleys of this region of new settlers who had come with the expectation of using underground water for irrigation. A list of the wells in each township is given and some of them are briefly described. The illustrations include a geologic map of Luna County, geologic sections across certain of the mountains, and halftone plates showing methods of irrigation.

BULLETIN 619. The Caddo oil and gas field, La. and Tex., by G. C. Matson. 1916. 62 pages, 8 plates, 5 text figures.

Describes the stratigraphic and structural geology of the Caddo oil and gas field, which lies mainly in Caddo Parish, northwestern Louisiana, with especial reference to the occurrence, accumulation, and source of the oil and gas. The illustrations include a map of the Caddo field, sections showing simple types of structure in this district, and logs of the wells.

**BULLETIN 620.** Contributions to economic geology (short papers and preliminary reports), 1915, Part I, Metals and nonmetals except fuels; F. L. Ransome and H. S. Gale, geologists in charge. 1915. 361 pages, 12 plates, 22 text figures.

This bulletin includes sixteen brief reports of two classes—(1) short papers giving comparatively detailed descriptions of occurrences that have economic interest but are not of sufficient importance to warrant a more extended description; (2) preliminary reports on economic investigations the results of which are to be published later in more detailed form. These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded. Each paper has been issued as an advance chapter as soon as it was ready. A list of the papers, arranged according to subjects, is given below.

*Gold and silver.*

A gold-platinum-palladium lode in southern Nevada, by Adolph Knopf.  
Gold deposits near Quartzsite, Ariz., by E. L. Jones, jr.

A reconnaissance in the Kofa Mountains, Ariz., by E. L. Jones, jr.

A reconnaissance of the Cottonwood-American Fork mining region, Utah, by B. S. Butler and G. F. Loughlin.

Notes on the fine gold of Snake River, Idaho, by J. M. Hill.

Preliminary report on the economic geology of Gilpin County, Colo., by E. S. Bastin and J. M. Hill.

The Aztec gold mine, Baldy, N. Mex., by W. T. Lee.

*Iron.*

Iron ore in Cass, Marion, Morris, and Cherokee counties, Tex., by E. F. Burchard.

Iron-bearing deposits in Bossier, Caddo, and Webster parishes, La., by E. F. Burchard.

*Quicksilver.*

Some cinnabar deposits in western Nevada, by Adolph Knopf.

Quicksilver deposits of the Mazatzal Range, Ariz., by F. L. Ransome.

*Potash.*

Potash in certain copper and gold ores, compiled by B. S. Butler.

Recent alunite developments near Marysvale and Beaver, Utah, by G. F. Loughlin.

*Miscellaneous.*

Nitrate deposits in southern Idaho and eastern Oregon, by G. R. Mansfield.

A reconnaissance for phosphate in the Salt River Range, Wyo., by G. R. Mansfield.

Cassiterite in San Diego County, Cal., by W. T. Schaller.

**BULLETIN 621.** Contributions to economic geology, 1915, Part II; advance chapters as follows:

**BULLETIN 621-A.** Field apparatus for determining ash in coal, by C. E. Leshner. 1915. Pp. i-ii, 1-12, Pls. I-II, figs. 1-2.

**BULLETIN 621-B.** The Healdton oil field, Carter County, Okla., by C. H. Wegemann and K. C. Heald. 1915. Pp. i-ii, 13-30, Pls. III-V, fig. 3.

- BULLETIN 621-C. The Loco gas field, Stephens and Jefferson counties, Okla., by C. H. Wegemann. 1915. Pp. i-iv, 31-42, Pls. VI-VII, fig. 3.
- BULLETIN 621-D. The Duncan gas field, Stephens County, Okla., by C. H. Wegemann. 1915. Pp. i-iv, 43-50, Pls. VIII-IX, fig. 3.
- BULLETIN 621-E. A reconnaissance in Palo Pinto County, Tex., with special reference to oil and gas, by C. H. Wegemann. 1916. Pp. i-ii, 51-59, figs. 4-5.
- BULLETIN 621-F. Possibilities of oil in the Porcupine dome, Rosebud County, Mont., by C. F. Bowen. 1915. Pp. i-ii, 61-70, Pl. X, fig. 6.
- BULLETIN 621-G. The Lawton oil and gas field, Okla., by C. H. Wegemann and R. W. Howell. 1915. Pp. i-iv, 71-85, Pls. XI-XII, fig. 3.
- BULLETIN 621-H. Anticlines in the Clinton sand near Wooster, Wayne County, Ohio, by C. A. Bonine. 1915. Pp. i-ii, 87-98, Pl. XIII.
- BULLETIN 621-I. The Orofino coal field, Clearwater, Lewis, and Idaho counties, Idaho, by C. T. Lupton. 1915. Pp. i-ii, 99-108, figs. 7-8.
- BULLETIN 621-J. A reconnaissance for oil near Quanah, Hardeman County, Tex., by C. H. Wegemann. 1915. Pp. i-ii, 109-115, Pl. XIV, fig. 9.
- BULLETIN 621-K. Geology and coal resources of northern Teton County, Mont., by Eugene Stebinger. 1916. Pp. i-iii, 117-156, Pls. XV-XVI, fig. 10.
- BULLETIN 621-L. Oil and gas near Basin, Big Horn County, Wyo., by C. T. Lupton. 1916. Pp. i-ii, 157-190, Pls. XVII-XVIII, fig. 11.
- BULLETIN 621-M. Geology and oil prospects of Cuyama Valley, Cal., by W. A. English. 1916. Pp. i-iii, 191-215, Pls. XIX-XXI, fig. 12.
- BULLETIN 621-N. Structure of the Berea oil sand in the Summerfield quadrangle, Guernsey, Noble, and Monroe counties, Ohio, by D. D. Condit. 1916. Pp. i-ii, 217-231, Pls. XXII-XXIII, figs. 13-15.
- BULLETIN 621-O. Structure of the Berea oil sand in the Woodsfield quadrangle, Belmont, Monroe, Noble, and Guernsey counties, Ohio, by D. D. Condit. 1916. Pp. i-iv, 233-249, Pls. XXIV-XXV, figs. 13, 16-17.
- BULLETIN 621-P. Analyses of coal samples from various parts of the United States, by M. R. Campbell and F. R. Clark. 1916. Pp. i-iv, 251-370.
- BULLETIN 622. Mineral resources of Alaska—report on progress of investigations in 1914, by A. H. Brooks and others. 1915. 380+xi pages, 11 plates, 8 text figures.

This volume contains a condensed summary both of the results of the investigations of Alaskan mineral resources during 1914 and of the status of the mining industry of the Territory. It is the eleventh of a series of annual bulletins devoted to this subject and is made up of eighteen papers by eight authors. These papers were published separately, but the editions were small.

The arrangement and manner of treatment in this volume are the same as in those previously issued. First, papers of a general character are presented, followed by those treating of special districts, arranged geographically from south to north. One of these papers deals with administrative matters, one is a general summary of the mining industry, one treats of the future of the placer-mining industry, and the remainder deal more specifically with the mineral resources of certain districts. In the geologic papers emphasis is laid on the conclusions having immediate interest to the miner. The titles of the papers are given below:

Preface, by A. H. Brooks.

Administrative report, by A. H. Brooks.

The Alaskan mining industry in 1914, by A. H. Brooks.

The future of gold placer mining in Alaska, by A. H. Brooks.

Tin mining in Alaska, by H. M. Eakin.



Mining in the Juneau region, by H. M. Eakin.

Mineral deposits of the Kotsina-Kuskulana district, with notes on mining in Chitina Valley, by F. H. Moffit.

Auriferous gravels of the Nelchina-Susitna region, by Theodore Chapin.

Mining on Prince William Sound, by B. L. Johnson.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson.

Mineral resources of the Chisana-White River district, by S. R. Capps.

Mining in the Fairbanks district, by H. M. Eakin.

Mining in the Hot Springs district, by H. M. Eakin.

Mineral resources of the Lake Clark-Iditarod region, by P. S. Smith.

Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren.

Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains, by A. G. Maddren.

Iron-ore deposits near Nome, by H. M. Eakin.

Placer mining in Seward Peninsula, by H. M. Eakin.

**BULLETIN 623.** Petroleum withdrawals and restorations affecting the public domain, by M. W. Ball; compilation by L. W. Stockbridge. 1916. 427 pages, 9 plates.

This bulletin gives true and accurate copies of orders of withdrawal, restoration, modification, and classification of public lands supposed to contain oil. It includes also a short statement of the purpose of the withdrawal policy, a brief review of the history of oil withdrawals, and a chapter on oil-land law, giving the statutes and judicial decisions of interest to the oil operator on the public domain. Maps which accompany the bulletin show the areas withdrawn in each State where oil withdrawals were outstanding January 15, 1916.

**BULLETIN 626.** The Atlantic gold district and the North Laramie Mountains, Fremont, Converse, and Albany counties, Wyo., papers by A. C. Spencer. 1916. 85 pages, 5 plates, 6 text figures.

These papers describe the geology and ore deposits of two areas in Wyoming lying about 125 miles apart. Although no large mine has been developed in the Atlantic district, gold to the value of \$1,500,000 has been produced there, and the district gives promise of further profitable development. Mining in the North Laramie Mountains is still in the prospecting stage, but this district also is worthy of development. Most of the prospecting has been done in the search for copper, but at one locality lead ores have been found, at another chromic iron ore, and at another magnetic iron ore. The illustrations include geologic maps of the districts described and sketch maps showing the location of claims and principal mineral prospects.

**BULLETIN 628.** Geology and coal resources of Castle Valley, in Carbon, Emery, and Sevier counties, Utah, by C. T. Lupton. 1915. 88 pages, 12 plates, 1 text figure.

Describes briefly the geography and geology of Castle Valley, in east-central Utah, studied in connection with an investigation made to determine the quality and quantity of the coal resources of the valley. The age and thickness of the coal-bearing formations and their relations to the underlying and overlying rocks are discussed, as well as the character of the coal and the development of the valley with respect to mines, prospects, and transportation routes. The illustrations include a geologic map of Castle Valley, sections of several of the coal beds, and half-tone plates showing geologic features of the coal-bearing formations.

BULLETIN 629. Natural gas resources of parts of north Texas—Gas in the area north and west of Fort Worth, by E. W. Shaw; Gas prospects south and southeast of Dallas, by G. C. Matson—with notes on the gas fields of central and southern Oklahoma, by C. H. Wegemann. 1916. 126 pages, 7 plates, 13 text figures.

The investigations resulting in this report were made in order to determine the extent of the gas reserve within reach of the cities of Dallas and Fort Worth. The Survey's examination was purely geologic, dealing exclusively with the structure of the areas, the amount of gas already produced, the probable amounts still remaining in the old fields, and the probabilities of discovering new pools sufficient to maintain an adequate supply of gas for these cities for the next decade or more. The bulletin is illustrated by maps of the two principal gas fields in this part of Texas—the Petrolia and the Mexia-Groesbeck—maps showing the geologic structure of the area, and diagrams showing features of the wells of importance to the driller and prospector.

BULLETIN 632. Spirit leveling in West Virginia, 1896 to 1915, inclusive; R. B. Marshall, chief geographer. 1916. 168 pages, 1 plate.

BULLETIN 633. Spirit leveling in Maine, 1899–1915; R. B. Marshall, chief geographer. 1916. 64 pages, 1 plate.

BULLETIN 636. Spirit leveling in Louisiana, 1903 to 1915, inclusive; R. B. Marshall, chief geographer. 1916. 101 pages, 1 plate.

Reports on precise and primary leveling in the States named, showing the exact altitude above sea level of a great many places. Some of these elevations have been adjusted by the United States Coast and Geodetic Survey from precise leveling. The work in Louisiana during 1900 and 1909 was done in cooperation with the State. Each bulletin contains a halftone plate showing Geological Survey designs for bench marks.

BULLETIN 640–A. Notes on the Promontory district, Utah, by B. S. Butler and V. C. Heikes. 1916. Pp. 1–10, figs. 1–2.

Part of Bulletin 640, "Contributions to economic geology, 1916, Part I." A brief sketch of the geography and geology of the Promontory mining district, in Boxelder County, Utah, with a discussion of the ore deposits, chiefly lead and zinc.

BULLETIN 640–C. Some manganese mines in Virginia and Maryland, by D. F. Hewett. 1916. Pp. 37–71, figs. 4–10.

Discusses the manganese deposits of Virginia and Maryland, which have become important since the introduction of the Bessemer process of making steel, because they are accessible to the iron and steel producing centers of the East. Describes half a dozen of the mines in detail and gives sketch maps of their workings.

BULLETIN 641–A. Ozokerite in central Utah, by H. M. Robinson. 1916. Pp. 1–16, Pl. I.

Part of Bulletin 641, "Contributions to economic geology, 1916, Part II." Gives results of an examination of the ozokerite field of Utah, the largest district in the United States in which ozokerite has been mined and prospected. The European war has seriously affected the importation of this material from Austria, so that at present the domestic product can compete favorably with the foreign in American markets. Ozokerite, or mineral wax, is a nonconductor of electricity and is extensively used for insulating. Much of it is converted into ceresin, a highly purified product used to replace or adulterate beeswax, as well as for a variety of other purposes.

BULLETIN 644–A. Primary traverse in Alabama and North Carolina, 1913–1915; R. B. Marshall, chief geographer. 1916. Pp. i–vii, 1–12, Pl. II.

BULLETIN 644-B. Triangulation in Arizona and New Mexico, 1913-1915; R. B. Marshall, chief geographer. 1916. Pp. i-vii, 13-24, Pl. II.

Parts of Bulletin 644, "Triangulation and primary traverse, 1913-1915."  
WATER-SUPPLY PAPER 332. Surface water supply of the United States, 1912, Part VII, North Pacific drainage basins; N. C. Grover, chief hydraulic engineer; F. F. Henshaw, G. C. Baldwin, and W. A. Lamb, district engineers. 1916. 748 pages, 2 plates.

Presents briefly the results of measurements of stream flow made in the North Pacific drainage basins during the year ending September 30, 1912. Data for each gaging station are given under the following heads: Location, Records available, Drainage area, Gage, Channel, Discharge measurements, Artificial control, Winter flow, Accuracy, and Cooperation. Contains also tables giving gage heights and daily and monthly discharges at each station and halftone plates representing typical gaging stations and current meters. The report was prepared in cooperation with the States of Montana, Idaho, Washington, and Oregon and was issued first in three separate chapters, each covering the drainage basins mentioned in its title, namely:

A. Pacific drainage basins in Washington and upper Columbia River basin, by F. F. Henshaw and W. A. Lamb.

B. Snake River basin, by G. C. Baldwin and F. F. Henshaw.

C. Lower Columbia River and Rogue, Umpqua, and Siletz rivers, by F. F. Henshaw and E. S. Fuller.

WATER-SUPPLY PAPER 340. Stream-gaging stations and publications relating to water resources, 1885-1913, compiled by B. D. Wood. 1916. 195 pages.

A directory of Survey stream-gaging stations and publications relating to water resources of the United States. This report was published in twelve separate parts, each of which contains a list of all gaging stations maintained in the section named in its title and an annotated list of publications issued by the United States Geological Survey relating specifically to that section, as well as a similar list of reports that are of general interest, covering a wide range of hydrologic subjects, and brief references to reports published by State and other organizations. The section of the country covered by each part of Water-Supply Paper 340 is shown below.

I. North Atlantic coast drainage basins

II. South Atlantic coast and eastern Gulf of Mexico drainage basins.

III. Ohio River basin.

IV. St. Lawrence River basin.

V. Hudson Bay and upper Mississippi River drainage basins.

VI. Missouri River basin.

VII. Lower Mississippi River basin.

VIII. Western Gulf of Mexico drainage basins.

IX. Colorado River basin.

X. The Great Basin.

XI. Pacific coast basins in California.

XII. North Pacific slope drainage basins.

WATER-SUPPLY PAPER 345. Contributions to the hydrology of the United States, 1914; N. C. Grover, chief hydraulic engineer. 1915. 225 pages, 17 plates, 24 text figures.

Made up of nine short papers and preliminary reports on the water supply of various sections of the country. Issued first, as received, in the form of separate chapters, in order that the interested public may have early information of the results of investigations made by the hydraulic engineers

and geologists of the Geological Survey. A list of the papers included in the volume follows:

Preliminary report on ground water for irrigation in the vicinity of Wichita, Kans., by O. E. Meinzer.

Ground water for irrigation in the vicinity of Enid, Okla., by A. T. Schwennesen, with a note on ground water for irrigation on the Great Plains, by O. E. Meinzer.

Underground water of Luna County, N. Mex., by N. H. Darton, with results of pumping tests, by A. T. Schwennesen.

Ground water for irrigation in the valley of North Fork of Canadian River near Oklahoma City, Okla., by A. T. Schwennesen.

A method of determining the daily discharge of rivers of variable slope, by M. R. Hall, W. E. Hall, and C. H. Pierce.

The discharge of Yukon River at Eagle, Alaska, by E. A. Porter and R. W. Davenport.

The water resources of Butte, Mont., by O. E. Meinzer.

Ground-water resources of the Niles cone and adjacent areas, Cal., by W. O. Clark.

Gazetteer of surface waters of Iowa, by W. G. Hoyt and H. J. Ryan.

WATER-SUPPLY PAPER 351. Surface water supply of the United States, 1913, Part I, North Atlantic coast basins; N. C. Grover, chief hydraulic engineer; C. C. Covert and G. C. Stevens, district engineers. 1915. 189 pages, 2 plates.

WATER-SUPPLY PAPER 352. Surface water supply of the United States, 1913, Part II, South Atlantic and eastern Gulf of Mexico basins; N. C. Grover, chief hydraulic engineer; G. C. Stevens and W. E. Hall, district engineers. 1915. 84 pages, 3 plates.

WATER-SUPPLY PAPER 355. Surface water supply of the United States for the year ending September 30, 1913, Part V, Hudson Bay basins and upper Mississippi River; N. C. Grover, chief hydraulic engineer; W. A. Lamb and W. G. Hoyt, district engineers. 1915. 181 pages, 2 plates.

WATER-SUPPLY PAPER 359. Surface water supply of the United States, 1913, Part IX, Colorado River basin; N. C. Grover, chief hydraulic engineer; Robert Follansbee, E. A. Porter, and G. A. Gray, district engineers. 1915. 260 pages, 2 plates.

WATER-SUPPLY PAPER 362-C. Surface water supply of lower Columbia River and Rogue, Umpqua, Wilson, and Nehalem rivers, 1913; N. C. Grover, chief hydraulic engineer; F. F. Henshaw, district engineer. 1915. 246 pages.

These papers present briefly the results of measurements of stream flow made in the drainage basins in the titles. Data for each gaging station are given under the following heads: Location, Records available, Drainage area, Gage, Channel, Discharge measurements, Artificial control, Winter flow, Accuracy, and Cooperation. The books contain also tables giving gage heights and daily and monthly discharges at each station.

WATER-SUPPLY PAPER 369. Water powers of the Cascade Range, Part III, Yakima River basin, by G. L. Parker and F. B. Storey. 1916. 169 pages, 20 plates, 12 text figures.

The third of a series of reports dealing with the water powers on rivers flowing from the Cascade Range in Washington and Oregon. Descriptions of the geologic history, physical characteristics, economic conditions, and industrial development of the region are given, together with a map of the basin, plans and profiles of the streams, stream-flow records, and short discussions of the developed water powers and undeveloped possible sites. The report was prepared in cooperation with the Washington State Board of Geological Survey.



**WATER-SUPPLY PAPER 370.** Surface water supply of Oregon, 1878-1910, by F. F. Henshaw and H. J. Dean. 1915. 829 pages, 1 plate.

Presents briefly the results of measurements of stream flow made in Oregon from 1878 to 1910, inclusive. As an introduction to the report the natural features of Oregon are discussed. Then follow data for each gaging station under the following heads: Location, Records presented, Drainage area, Gage, Channel, Discharge measurements, Winter flow, Diversions, Rating curves, Extreme stages, Accuracy, and Cooperation. Contains also tables giving gage heights and daily and monthly discharges at each station and a map of Oregon showing the principal rivers.

**WATER-SUPPLY PAPER 371.** Equipment for current-meter gaging stations, by G. J. Lyon. 1915. 64 pages, 37 plates, 10 text figures.

A technical description, accompanied by numerous precisely drawn plans, of the types of equipment for current-meter gaging stations that have been found most effective in facilitating observations and insuring accurate results. Includes many tables giving bills of material for certain parts of the equipment. The book is designed especially for the use of hydraulic engineers and others interested in stream-flow measurement.

**WATER-SUPPLY PAPER 372.** A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport, with a section on south-eastern Alaska, by J. C. Hoyt. 173 pages, 22 plates, 6 text figures.

This paper presents the results of the first systematic study of the water powers of south-central Alaska, which includes the region tributary to Copper River, Prince William Sound, and the lower Susitna. This general province contains valuable mineral deposits, chiefly gold, copper, and coal, as well as good farming lands, and its rapid development led to the search for water powers, which had been supposed to exist in abundance in this region. Water-Supply Paper 372 shows, however, that water powers available throughout the year are not so abundant in this part of Alaska as had been assumed. Appended to the main report is a reprint of an article on the water powers of southeastern Alaska which appeared in 1910 as part of Bulletin 442, "Mineral resources of Alaska, 1909." The illustrations include maps of parts of the region discussed, showing the location of rainfall stations, gaging stations, and measuring points, diagrams showing monthly and annual precipitation, and halftone plates showing hydrographic features.

**WATER-SUPPLY PAPER 373.** Water resources of Hawaii, 1913, by G. K. Larrison. 1915. 190 pages.

Contains results of measurements of the flow of certain streams and ditches and rainfall records in the Territory of Hawaii made during the calendar year 1913. Data for each gaging station are given under the following heads: Location, Records available, Drainage area, Gage, Control, Discharge measurements, Diversion, Accuracy, and Cooperation. Tables giving gage heights and daily and monthly discharges at each station are included in the report.

**WATER-SUPPLY PAPER 374.** Ground water in the Hartford, Stamford, Salisbury, Willimantic, and Saybrook areas, Conn., by H. E. Gregory and A. J. Ellis. 1916. 150 pages, 13 plates, 10 text figures.

Gives the results of a study of the ground-water supply of certain areas in Connecticut—a study which is so planned as to cover eventually all the towns of the State and to include investigations of stream flow as well as ground water. The work on which this paper is based consisted in gathering information concerning municipal water supplies, measuring the

dug wells used in rural districts, obtaining data concerning drilled wells, driven wells, and springs, collecting and analyzing samples of water from wells, springs, and brooks, and studying the character and relations of bedrock and of surficial deposits with reference to their influence upon the ground-water supply. An individual description of each town is given, accompanied by a map of the area in which it is situated.

**WATER-SUPPLY PAPER 375.** Contributions to the hydrology of the United States, 1915; Nathan C. Grover, chief hydraulic engineer. 1916. 181 pages, 9 plates, 31 text figures.

This report is made up of seven short papers on ground water in certain arid sections of the United States and on methods of gaging river discharge. Issued first in the form of separate chapters, so as to furnish promptly information of the results of investigations made by the hydraulic engineers of the Geological Survey. A list of the papers included in the volume follows:

Ground water for irrigation in the Sacramento Valley, Cal., by Kirk Bryan.

Ground water in Paradise Valley, Ariz., by O. E. Meinzer and A. J. Ellis.

The relation of stream gaging to the science of hydraulics, by C. H. Pierce and R. W. Davenport.

Ground water in Big Smoky Valley, Nev., by O. E. Meinzer.

A method of correcting river discharge for a changing stage, by B. E. Jones.

Conditions requiring the use of automatic gages in obtaining records of stream flow, by C. H. Pierce.

Ground water in Lasalle and McMullen counties, Tex., by Alexander Deussen and R. B. Dole.

**WATER-SUPPLY PAPER 376.** Profile surveys in Chelan and Methow river basins, Wash., prepared under the direction of R. B. Marshall, chief geographer. 1915. 8 pages, 5 plates.

**WATER-SUPPLY PAPER 377.** Profile surveys in Spokane River basin, Wash., and John Day River basin, Oreg., prepared under the direction of R. B. Marshall, chief geographer. 1915. 7 pages, 9 plates.

**WATER-SUPPLY PAPER 378.** Profile surveys in 1914 on Middle Fork of Willamette River and White River, Oreg., prepared under the direction of R. B. Marshall, chief geographer. 1915. 8 pages, 6 plates.

**WATER-SUPPLY PAPER 379.** Profile surveys in 1914 in Umpqua River basin, Oreg., prepared under the direction of R. B. Marshall, chief geographer. 1915. 7 pages, 13 plates.

These reports describe briefly the general features of the river basins mentioned in their titles and give a list of the gaging stations maintained by the Geological Survey on the main streams and their tributaries. The illustrations consist of plans and profiles of certain of the streams described or parts of them.

**WATER-SUPPLY PAPER 383.** Surface water supply of the United States, 1914, Part III, Ohio River basin; N. C. Grover, chief hydraulic engineer; A. H. Horton and W. E. Hall, district engineers. 1916. 121+xxxii pages, 2 plates.

**WATER-SUPPLY PAPER 385.** Surface water supply of the United States, 1914, Part V, Hudson Bay and upper Mississippi River basins; N. C. Grover, chief hydraulic engineer; W. G. Hoyt and A. H. Horton, district engineers. 1915. 246+xxix pages, 2 plates.

**WATER-SUPPLY PAPER 388.** Surface water supply of the United States, 1914, Part VIII, Western Gulf of Mexico basins; N. C. Grover, chief hydraulic engineer; G. A. Gray, district engineer. 1915. 124+xxi pages, 2 plates.

These papers present briefly the results of measurements of stream flow in the basins named in the titles during the calendar year 1914. Data for each gaging station are given under the following heads: Location, Records available, Drainage area, Gage, Channel, Discharge measurements, Artificial control, Winter flow, Accuracy, and Cooperation. Contain also tables giving gage heights and daily and monthly discharges at each station and halftone plates representing typical gaging stations and current meters. At the end of each book is a list of all gaging stations maintained in the region covered and an annotated list of publications issued by the United States Geological Survey relating specifically to the region, as well as a similar list of reports that are of general interest, covering a wide range of hydrologic subjects, and brief references to reports published by State and other organizations.

**WATER-SUPPLY PAPER 397.** Ground water in the Waterbury area, Conn., by A. J. Ellis, under the direction of H. E. Gregory. 1916. 73 pages, 4 plates, 10 text figures.

Discusses the source, occurrence, use, and methods of developing the ground-water supplies of an area of about 171 square miles in Connecticut, including Waterbury and several other manufacturing towns, whose industries are largely dependent upon water power. An individual description of each town in the area is given, and especial stress is laid on its water supply. The illustrations include a map of the area discussed, and diagrams, sections, and halftone plates showing hydrographic features.

**WATER-SUPPLY PAPER 398.** Ground water in San Joaquin Valley, Cal., by W. C. Mendenhall, R. B. Dole, and Herman Stabler. 1916. 310 pages, 5 plates, 4 text figures.

Discusses the occurrence, quality, accessibility, character, and proper use of the ground waters of San Joaquin Valley, an area destined to become one of the chief agricultural districts of the West. The development of this valley is controlled by the distribution of rainfall, the character of the soils, and the possibility of applying other water than that which reaches the valley as a direct result of precipitation upon its surface, so that it behooves the inhabitants to avail themselves of every opportunity to increase the acreage of the lands under irrigation. An individual discussion of the water supply of each county in the valley is given, accompanied by tables of field assays and mineral analyses of its ground waters. The illustrations include maps of the valley showing artesian areas, ground-water levels, pumping plants, and location and depth of wells in relation to sulphate content of ground waters and cross sections and diagrams showing content of sulphate and total mineral matter of ground waters in certain parts of the valley.

**WATER-SUPPLY PAPER 399.** Geology and ground waters of northeastern Arkansas, by L. W. Stephenson and A. F. Crider, with a discussion of the chemical character of the waters, by R. B. Dole. 1916. 315 pages, 11 plates, 4 text figures.

Discusses the physiography, geology, and ground waters of the region mentioned in its title, embracing about 13,250 square miles and forming part of that great arm of the Gulf Coastal Plain known as the Mississippi embayment. Although this region is abundantly supplied with surface streams the water from them is unfit for domestic use without filtration, but the

underground supplies require no purification and are therefore less expensive. The paper gives a detailed description of the water resources of each county in the region discussed and includes a chapter on the chemical character of these waters and methods of purification of water in general. The illustrations include a geologic map and a map of the ground-water resources of eastern and northeastern Arkansas, geologic sections, and halftone plates showing some of the water-bearing formations:

WATER-SUPPLY PAPER 400-A. The people's interest in water-power resources, by G. O. Smith. 1916. Pp. 1-8.

Part of Water-Supply Paper 400, "Contributions to the hydrology of the United States, 1916." This paper was read before the Second Pan-American Scientific Congress, Washington, December, 1915. It shows that in the vast potential hydroelectric energy available in the United States, estimated now at over 60,000,000 horsepower, lies this country's largest asset in the future industrial rivalry among nations, and advocates such Government regulation—Federal, State, and municipal—of the development of water power that both the public and the private owner and operator may participate in the benefits.

MINERAL RESOURCES OF THE UNITED STATES, 1914. 1916. Part I; Metals; H. D. McCaskey, geologist in charge; iv+\*73+995 pages, 1 plate, 8 text figures. Part II, Nonmetals; E. F. Burchard, geologist in charge; iv+1,122 pages, 5 plates, 11 text figures.

Statistics of the production, importation, and exportation of mineral substances in the United States, including accounts of the chief features of mining progress, comparisons of past and present production and conditions, and the application of the products in the useful arts. Contains inserts showing mineral products of the United States, 1905-1914, and production of coal in the United States, 1807-1914. Issued first, as received, in 61 advance chapters, each covering a single mineral product or group of allied products.

MINERAL RESOURCES OF THE UNITED STATES, 1915. Thirteen advance chapters, as follows:

The public interest in mineral resources, by G. O. Smith. 1915. Pp. 1a-9a. Part I: A.

Chromic iron ore in 1915, by J. S. Diller. 1916. Pp. 1-6. Part I: 1.

Gold, silver, copper, lead, and zinc in the Eastern States in 1915 (mines report), by J. M. Hill. 1916. Pp. i-v, 7-20. Part I: 2.

Fuel briquetting in 1915, by C. E. Leshner. 1916. Pp. i-ii, 1-6, figs. 1-4. Part II: 1.

Sand-lime brick in 1915, by Jefferson Middleton. 1916. Pp. 7-8. Part II: 2.

Fuller's earth in 1915, by Jefferson Middleton. 1916. Pp. 9-12. Part II: 3.

Asbestos in 1915, by J. S. Diller. 1916. Pp. i-ii, 13-18, fig. 5. Part II: 4.

Slate in 1915, by G. F. Loughlin. 1916. Pp. 19-31. Part II: 5.

Fluorspar in 1915, with a note on cryolite, by E. F. Burchard. 1916. Pp. i-ii, 33-41, fig. 6. Part II: 6.

Feldspar in 1915, by F. J. Katz. 1916. Pp. 43-53. Part II: 7.

Silica in 1915, by F. J. Katz. 1916. Pp. 55-60. Part II: 8.

Abrasive materials in 1915, by F. J. Katz. 1916. Pp. 65-80. Part II: 10.

Graphite in 1915, by E. S. Bastin. 1916. Pp. 81-93. Part II: 11.

GEOLOGIC FOLIO 196. Philipsburg (Mont.) folio, by F. C. Calkins and W. H. Emmons. 1915. 25 folio pages of text, 3 maps, 1 columnar-section sheet, 12 plates, 9 text figures.



Description and maps of the Philipsburg quadrangle, comprising about 827 square miles in Deer Lodge, Granite, and Powell counties, Mont.

GEOLOGIC FOLIO 197. Columbus (Ohio) folio, by G. D. Hubbard, C. R. Stauffer, J. A. Bownocker, C. S. Prosser, and E. R. Cumings. 1915. 15 folio pages of text, 3 maps, 2 sheets of half-tone illustrations, 10 text figures. Published also in octavo form, 111 pp.

Description and maps of the Columbus quadrangle, comprising about 915 square miles in Delaware, Fairfield, Franklin, Licking, Madison, Pickaway, and Union counties, Ohio.

GEOLOGIC FOLIO 198. Castle Rock (Colo.) folio, by G. B. Richardson. 1915. 13 folio pages of text, 3 maps, 1 columnar-section sheet, 20 plates, 6 text figures.

Description and maps of the Castle Rock quadrangle, comprising about 925 square miles in Douglas, El Paso, and Elbert counties, Colo.

GEOLOGIC FOLIO 199. Silver City (N. Mex.) folio, by Sidney Paige. 1916. 19 folio pages of text, 2 maps, 1 structure-section sheet, 13 plates, 17 text figures.

Description and maps of the Silver City quadrangle, comprising about 1,003 square miles in Grant and Luna counties, N. Mex.

GEOLOGIC FOLIO 200. Galena-Elizabeth (Ill.-Iowa) folio, by E. W. Shaw and A. C. Trowbridge. 1916. 13 folio pages of text, 4 maps, 13 plates, 9 text figures.

Description and maps of the Galena and Elizabeth quadrangles, comprising about 442 square miles in Jo Daviess County, Ill., and Dubuque and Jackson counties, Iowa.

GEOLOGIC FOLIO 201. Minneapolis-St. Paul folio, by F. W. Sardeson. 1916. 14 folio pages of text, 8 maps, 22 plates, 14 text figures.

Description and maps of the Anoka, Minneapolis, St. Paul, and White Bear quadrangles, comprising about 846 square miles in Anoka, South Dakota, Hennepin, Ramsey, Scott, and Washington counties, Minn.

Topographic and other maps as follows:

Aitkin, Minn.	Buffalo Creek, Cal. <sup>3</sup>	Falls City, Nebr.
Alabama (State). <sup>1</sup>	Byron, Cal.	Foraker, Okla.-Kans.
Alaska (1:12,000,000).	Byron Hot Springs, Cal. <sup>3</sup>	Frazer, Mont.
Albany, Oreg.	Cache Slough, Cal.	Freedom, Idaho-Wyo.
Alger, Ohio.	Casco Bay, Me. <sup>4</sup>	Gastonia, N. C.
Arlington, Oreg.-Wash.	Chateaugay, N. Y.	Georgia (State). <sup>1</sup>
Avon, Ill.	Concord, Cal. <sup>5</sup>	Gouverneur, N. Y.
Babel Slough, Cal.	Cooperstown, Cal.	Grass Creek Basin, Wyo.
Bachelor Valley, Cal.	Cornettsville, Ky.	Grays Bend, Cal.
Belhaven, N. C.	Craig, Colo.	Greenup, Ohio-Ky. <sup>3</sup>
Bellefontaine, Ohio.	Crestline, Ohio.	Hacker Valley, W. Va.
Bering River coal field,	Cuyuna, Minn.	Hamakua, Hawaii.
Alaska. <sup>2</sup>	Deming, N. Mex. <sup>5</sup>	Harold, Ky.
Big Bar and vicinity, Cal.	Dixon, Cal.	Harrington, Cal. <sup>3</sup>
Bluefield, W. Va. <sup>3</sup>	Eagle Rock, Va.	Haywards, Cal. <sup>5</sup>
Blue Mesa, Wyo.	East Liberty, Ohio.	Hershey, Cal.
Boone, Iowa.	Edgington, Ill.-Iowa.	Honomu, Hawaii.
Brilliant, N. Mex.-Colo.	Ely, Nev. <sup>5</sup>	Howe, Nebr.
Brinkhaven, Ohio.	Esparto, Cal. <sup>3</sup>	Iaeger, W. Va.-Ky. <sup>6</sup>
Bucu, Va.	Estacada, Oreg.	Illinois (State). <sup>1</sup>
Bucyrus, Ohio.	Fairfax, Va.	Kenton, Ohio.

<sup>1</sup> Photolithograph, 1:1,000,000.

<sup>2</sup> Plate V, Bull. 335, issued separately.

<sup>3</sup> Preliminary edition showing part of quadrangle.

<sup>4</sup> Resurveyed and reengraved.

<sup>5</sup> New edition, revised in field.

<sup>6</sup> Sheet completed; part engraved in 1912.

Kentucky (State). <sup>1</sup>	Ohio (State). <sup>1</sup>	Spenceville, Cal. <sup>2</sup>
Kinston, N. C.	Oregon (State). <sup>1</sup>	Sturgis, S. Dak. <sup>6</sup>
Kohala, Hawaii.	Oswego, Mont.	Summersville, W. Va.
Lake Bonaparte, N. Y.	Patterson, Cal. <sup>2</sup>	Summitville, Colo.-N. Mex.
Larue, Ohio.	Paulsell, Cal.	Tennessee (State). <sup>1</sup>
Lone Tree Valley, Cal. <sup>2</sup>	Pearce, Ariz.	Thalheim, Cal.
Lovdal, Cal.	Pennsylvania and New Jersey (States). <sup>1</sup>	Three Tree Flat, Cal.
Maine Prairie, Cal.	Peterstown, W. Va.-Va. <sup>2</sup>	Tracy, Cal. <sup>2</sup>
Manhattan and vicinity, Nev.	Pickins, W. Va.	Trigo, Cal.
Mare Island, Cal.	Point Conception (sheet I-10 of world map).	Tualatin, Oreg.
Maricopa, Ariz.	Portland, Me. <sup>3</sup>	United States contour map, 18 by 28 inches. <sup>5</sup>
Marseilles, Ill. <sup>3</sup>	Regina, Va.-Ky. <sup>2</sup>	Virginia (State). <sup>1</sup>
Martinsburg, W. Va.-Va.-Md.	Richwood, Ohio.	Vorden, Cal.
Maryland and Delaware (States). <sup>1</sup>	Ripon, Cal.	Waipio, Hawaii.
Maryland and Delaware (States). <sup>4</sup>	Romain, Cal. <sup>2</sup>	Waldoboro, Me.
Massachusetts and Rhode Island contour map. <sup>5</sup>	St. Albans, Vt.	Washington (State). <sup>1</sup>
Michigan (State). <sup>1</sup>	St. Paris, Ohio.	Waynesville, Ohio.
Midway, Cal. <sup>2</sup>	Salida, Cal.	Wealthwood, Minn.
Millersburg, Ohio.	San Francisco, Cal. <sup>6</sup>	Wellington, Utah.
Mission, Tex.	San Juan, Tex.	Wenatchee, Wash.
Mojave, Cal.	San Mateo, Cal. <sup>6</sup>	Westley, Cal.
Montpellier, Cal.	Saxon, Cal.	Westport, Cal.
Mount Gilead, Ohio.	Searles Lake, Cal.	West Virginia (State). <sup>1</sup>
Murfreesboro, Tenn.	Shauck, Ohio.	Whitesburg, Ky.-Va.
Neosho, Mo.	Shawneetown, Ill.-Ky.	Windber, Pa.
New York (State). <sup>1</sup>	Siam, Ohio.	Winona, W. Va.
Northeast, Pa.-N. Y.	Soledad, Cal.	Winters, Cal.
Norwalk, Ohio.	Stryker, Mont.	Wolf Point, Mont.
Oakdale, Cal.	Somerset, Pa.	Yosemite National Park, Cal. <sup>6</sup>
Ocosta, Wash.	South Carolina (State). <sup>1</sup>	Zamora, Cal. <sup>2</sup>
	Spearfish, S. Dak. <sup>6</sup>	

## GEOLOGIC BRANCH.

## SCOPE OF WORK.

The geologic branch is responsible for the strictly geologic work of the Survey, which was originally established for "the classification of the public lands and the examination of the geological structure, mineral resources, and products of the national domain" and was later authorized "to continue the preparation of a geological map of the United States." In pursuance of these objects the Survey has been obliged to extend its operations to every part of the country and to nearly every field of geology. Its growth, however, has not kept pace with the growth of the mineral development which it has promoted. The calls for service made on it by the public were never before so numerous nor so varied.

The Survey has not only performed this fundamental and principal work but has gradually come to be regarded, in effect, as a national bureau of public information on geologic matters, touching

<sup>1</sup> Photolithograph, 1 : 1,000,000.

<sup>2</sup> Preliminary edition showing part of quadrangle.

<sup>3</sup> Resurveyed and reengraved.

<sup>4</sup> Photolithograph, 1 : 500,000.

<sup>5</sup> New edition, office revision.

<sup>6</sup> New edition, revised in field.

not only all parts of the United States and Alaska but other countries as well. The marked increase in the number of inquiries received by the Survey is due not merely to the present abnormal activity in the mineral industries, but largely also to the growing tendency of the American people to apply to the Federal Survey for geologic information of every sort, whether this information is to be gained by new field work or by examination of the Survey's accumulated records and its great library. The geologic branch therefore has a double task, embracing on the one hand geologic surveying—including the investigation, description, and mapping of the geology and mineral deposits of all parts of the country and the classification of the public lands—and the publication of the results of its work, and on the other hand the furnishing to the public of miscellaneous geologic information derived from all available sources.

#### ORGANIZATION.

For the systematic and efficient accomplishment of its work the geologic branch is organized in four divisions—geology, David White, chief geologist, in charge; Alaskan mineral resources, Alfred H. Brooks, geologist, in charge; mineral resources, H. D. McCaskey, geologist, in charge; chemical and physical researches, G. F. Becker, geologist, in charge. These divisions, though largely autonomous, are conducted in the closest cooperation, with resultant effectiveness as well as economy. Most of the statistical reports of the division of mineral resources are prepared by members of the division of geology who are specialists in the geology of the respective mineral deposits and whose field investigations give opportunities for close contact with and observation of the mineral industries. Between the division of Alaskan mineral resources and the division of geology there is free exchange of assistance in paleontologic and other laboratory investigations. The division of chemistry and physics cooperates with the members of the scientific staffs of all the other divisions in the solution of the chemical problems under investigation and performs the chemical determinations necessary to the routine work of the Survey. In the distribution and use of field equipment the geologic branch cooperates with the topographic and water-resources branches.

The geologic investigations to be carried on by the Survey in the United States are planned by the chiefs of sections in the division of geology in council with the chief geologist, who has general supervision of the work. The chief geologist has given particular attention to cooperation in geology with State surveys and devotes such time as is available to him for field work to field inspections and conferences with chiefs of sections and geologists and to the direction and inspection of the work of the section of eastern fuels.

## PUBLICATIONS.

The publications of the fiscal year 1916 prepared wholly or partly in the geologic branch embrace 1 monograph, 31 professional papers, bulletins, etc., 127 chapters of reports later published as annual volumes, and 6 geologic folios. Titles and brief abstracts of these publications are given on pages 19-37. Besides the official publications, 61 papers were, with the permission of the Director, published in scientific journals and in the publications of scientific societies. Nine reports based on work done in cooperation with State geological surveys have, in accordance with the cooperative agreements, been transmitted to the States for publication. On the other hand, two somewhat extensive geologic reports, prepared by the State organizations under the same agreements, have been submitted for publication by the Federal Survey, and others are in preparation by the States. In the preparation of the reports of mineral production considerable material relating to certain of the industries in the different States is compiled by the State geologists.

## PROGRESS OF GEOLOGIC MAPPING.

The areas in the United States covered by geologic maps published by the Survey and the general nature of the work in each area are shown on Plate I. This map does not, however, indicate areas for which reports, prepared by this Survey, have been submitted for publication to cooperating State organizations or to other bureaus and departments of the Federal Government.

The progress of geologic surveying in Alaska is described in the section on the division of Alaskan mineral resources (pp. 91-99).

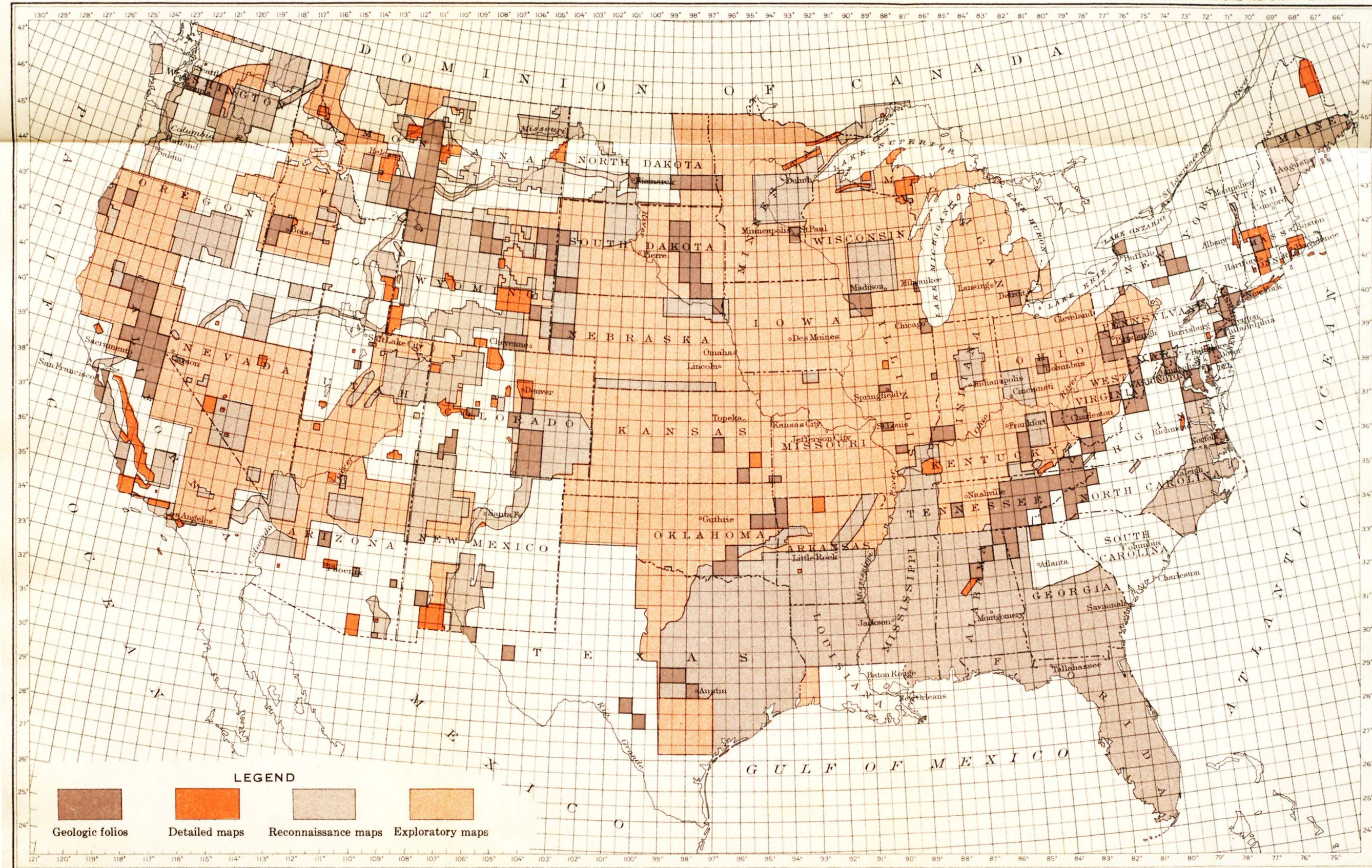
## DIVISION OF GEOLOGY.

## ORGANIZATION.

The scientific force of the division of geology at the beginning of the year consisted of 70 geologists, 28 associate geologists, 33 assistant geologists, 9 junior geologists, and 24 geologic aids. During the year 10 members of the scientific staff resigned to take positions in private life at higher salaries, one new member was appointed, and one was transferred from another division. The total number of geologists of various grades on the staff at the end of the year was 156. Of this number, 80 were employed continuously, 33 gave only part of their time to Survey work, and 43 were not employed.

The division of geology was organized in nine sections, the scope of whose work is outlined on pages 44-48. Near the end of the year the division was reorganized, and beginning July 1, 1916, its work will be distributed among ten sections, as stated on pages 48-49.





MAP OF THE UNITED STATES, SHOWING AREAS COVERED BY GEOLOGIC MAPS PUBLISHED PRIOR TO JULY 1, 1916



The geologic work of the division, both in the field and in the office, is under the immediate supervision of the chiefs of the respective sections, who are directly responsible for maintaining efficiency and a high scientific standard. Exceptions are made of the studies of detrital deposition in California, just completed by G. K. Gilbert, the general descriptions by Mr. Gilbert of the structure in the Great Basin region, and the general monographic treatment of the geology of the Yellowstone National Park, in preparation by Arnold Hague. The work of these distinguished senior geologists of the Survey is reported directly to the chief geologist.

## ALLOTMENTS.

The total funds available for the geologic work of the Survey in the United States for the year 1915-16 were as follows:

Geologic surveys .....	\$350, 000
Statutory salaries .....	13, 700
Search for potash deposits (part of the appropriation for chemical and physical researches) .....	16, 150
	<hr/> 379, 850

The allotments of the appropriations were as follows:

Section of eastern areal geology .....	\$20, 025
Section of western areal geology .....	28, 520
Section of Coastal Plain investigations .....	13, 525
Section of stratigraphy and paleontology .....	20, 040
Section of metalliferous deposits .....	42, 245
Section of nonmetalliferous deposits (including potash) ..	36, 640
Section of glacial geology .....	6, 015
Section of eastern fuels .....	29, 175
Section of western fuels .....	50, 000
Geologic-map editing .....	7, 020
Débris investigation and inspection .....	3, 900
Supervision, administration, salaries of clerical, technical, and skilled-labor forces, instruments, supplies, and contingent fund .....	93, 025
	<hr/> 350, 130
Land-classification board .....	29, 720
	<hr/> 379, 850

Of the amounts allotted to this division, approximately \$263,700 was expended directly for geologic work, including the search for potash. Of this amount, about \$165,800, or 62.8 per cent, was expended west of the one hundredth meridian, and \$97,900, or 37.2 per cent, east of the one hundredth meridian. If, however, the \$29,720 for the operations of the land-classification board is included, 66.6 per cent of a total approximating \$293,420 was spent for investiga-

tions west of the one hundredth meridian—that is, essentially in the public-land States. The allotment for supervision, etc., is divisible in very nearly the same proportion between the eastern and western work.

#### COOPERATION WITH FEDERAL BUREAUS AND STATE SURVEYS.

In strictly geologic field investigations or paleontologic studies the Survey cooperated through the division of geology with 19 States—Alabama, Georgia, Illinois, Iowa, Kentucky, Maryland, Michigan, Minnesota, Mississippi, Missouri, New Jersey, North Carolina, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Virginia, and Wisconsin. Informal cooperation, without specific financial obligations, exists between most of the other States having geological surveys.

The Survey cooperated with the Bureau of Mines in the metallographic study of ores, in the investigation of the invasion of California oil wells by salt water, in studies of the application of geology to engineering problems of mining and construction, and in the examination of placers and placer mining in the United States. Technologic papers prepared by Survey geologists in the course of their detailed investigations of mineral deposits have been submitted to the Bureau of Mines for publication. The Survey is also engaged with the Bureau of Standards, the Bureau of Mines, and the Office of Public Roads in a thorough and systematic study of the building stones of the United States. Through the division of geology it cooperated informally with the Smithsonian Institution, the Bureau of Fisheries, the Forest Service, the Navy Department, the War Department, and the Lighthouse Service, as well as with a number of institutions of learning, including, in particular, the Geophysical Laboratory and Marine Biological Station of the Carnegie Institution. Services varying in extent have been rendered during the year to the Department of Agriculture in the examination of lands in the national forests and monuments; to the Department of Justice in connection with its suits regarding public lands; to the Navy Department in regard to oil and water supplies; to the Office of Indian Affairs in the classification of Indian lands; to the War Department with reference to nitrate deposits and to water supplies in its reservations; and, most important of all, to the General Land Office in the classification of withdrawn coal, oil, and phosphate lands.

#### GENERAL FEATURES OF THE WORK OF THE YEAR.

The highly diverse services rendered by the geologic branch were fully outlined in the reports for the last two years.<sup>1</sup> All phases of

<sup>1</sup> U. S. Geol. Survey Thirty-fifth Ann. Rept., pp. 34–36, 71–74, 1914; Thirty-sixth Ann. Rept., pp. 42–50, 1915.

the work have been continued, though on account of a reduction of \$50,000 in the appropriation it has been necessary to refuse requests for field examinations in greater number than ever before. To some extent, however, the lack of money for the expenses of field investigations and for pay of young assistants has been compensated by the greater capacity and scientific productivity developed in the staff with growing experience, knowledge, and maturity. Nevertheless, an increase in the funds sufficient to provide salaries and field expenses of geologic aids to serve under the direction of the older geologists would yield more than proportionate benefits in the extension of the work, the fuller response to the public demands, and the more economical utilization of the directive knowledge and experience of the older and higher-salaried men.

As usual, greater attention has been given to the geologic examination and classification of the lands and to special study of the mineral deposits in the public-land States than to any other investigation or region. Accounts of this work are given under the respective State headings (pp. 51-91).

In the last annual report reference was made to studies by the Survey of the chemical character of the waters at different depths in the California oil fields, and of the change in these waters near accumulations of oil. The results of these studies, a preliminary report on which will soon be issued as Bulletin 653, give reason for the expectation that, in this region at least, great assistance in the search for oil may be derived from observations of the chemical characteristics of the waters. These observations will be checked by field work and tests in areas that present different climatic and other physical conditions.

A large map showing the coal fields of the United States and indicating the general rank of the coals, prepared to accompany a general summary description of the coals of the country and their qualities, is now in press for publication as the first part of Professional Paper 100, "The coal fields of the United States." More detailed reports covering the coal fields of several States are now prepared, and others are in preparation or planned, to be in due time issued as parts of this professional paper.

Some results of the studies of the ores from certain of the western metal-mining districts by use of the metallographic microscope, to which reference was made last year, are now being prepared for publication in a paper entitled "Studies of the genesis of some ores at Tonopah, Nev." The joint geologic and chemical studies of silver enrichment are continuing, with promise of still more results of high value.

The economic geologic investigations of broad geographic scope now in progress include examinations of the marbles in the Appa-



lachian States and the limestones in the Central States, the accumulation of data for a descriptive catalogue of the building stones of the United States, and studies of the phosphate resources of Kentucky and Tennessee and of the tungsten, mica, graphite, and gypsum deposits of the United States. Papers on the conservation of the phosphate deposits, giving new estimates of the phosphate resources of the country, have been published through unofficial channels.

The deciphering of the later chapters in the geologic history of the Gulf region of the United States, and in particular an understanding of the mutual relations of the Antillean region of the Gulf coast of Central America and South America, have been very much furthered by a number of contributions made by members and associates of the section of Coastal Plain investigations in several publications, both official and unofficial, which are noted in the detailed account of the work of the division by States. A general report by Mr. MacDonald on the geology of the Canal Zone region is near completion.

Among the reports completed that should be of unusual interest to the mining public may be mentioned the comprehensive description of the Tintic district, Utah, with maps, by Messrs. Lindgren and Loughlin, and a general report on the mining districts of Utah, by Mr. Butler.

So great was the demand for the first edition of the bulletin on the useful minerals of the United States that a revised and much enlarged edition has been prepared. This is now in press as Bulletin 624.

Three guidebooks to the western United States, Bulletins 611, 613, and 614, prepared mainly during the preceding year, were published. Another one, descriptive of the country along the Denver & Rio Grande Route from Denver to Salt Lake, is now in preparation. These books, which are designed for the use of travelers and are written in popular and educational style, deal not only with the geology but with the natural resources, history, and development of the country traversed.

#### SCOPE OF THE WORK OF THE SECTIONS.

The work of the several sections of the division of geology is briefly outlined in the following synopsis:

1. The section of eastern areal geology—Arthur Keith, geologist, in charge—conducts reconnaissance and detailed work in areal or general geology in regions east of the one hundredth meridian, the primary object of which is to make known, mainly through folios of the Geologic Atlas, the general geology of the regions studied, or to prepare scientific and educational descriptions of them. Papers de-

scribing the more important of the mineral deposits of the areas thus examined may be prepared for publication in advance in the economic bulletins. The work of this section is carried on in close cooperation with several State surveys and university departments of geology, an effort being made to coordinate the work of all participants. During the year the operations of the section have covered areas in Alabama, Arkansas, Delaware, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Vermont, and Virginia.

2. The work of the section of western areal geology (west of the one-hundredth meridian)—F. L. Ransome, geologist, in charge—corresponds to that of the section of eastern areal geology and is similar in scope, these sections being especially charged with the preparation of the folios of the Geologic Atlas of the United States. The work of this section has included areal mapping and descriptions of areal geology in Arizona, Colorado, Idaho, Montana, Nebraska, New Mexico, Oregon, South Dakota, Washington, and Wyoming.

3. The section of Coastal Plain investigations—T. W. Vaughan, geologist, in charge—is occupied with the study of the geology of the Atlantic and Gulf Coastal Plain of the United States in the broadest practicable way. Special attention is given to studies that will aid in understanding the geologic history of the province, including investigations of the physiology, stratigraphy, geologic structure, paleontology, and origin of the different kinds of sediments. Knowledge thus acquired furnishes a scientific foundation for the investigation of geologic resources of many kinds. In the study of economic resources particular consideration is given to ground waters, which are of inestimable value in the conservation of public health, and a preliminary survey of this resource has now been almost completed for the entire province.

The paleontologic work of the section is of fundamental importance, as only by detailed and accurate knowledge of the organisms occurring in and characterizing the geologic formations and their subordinate members can the time equivalents of beds in one area be recognized in another. This knowledge also aids in recognizing beds that are penetrated by well borings if fossils should occur in the material brought up by the drill.

During the year a preliminary geologic map of the Coastal Plain was drawn on a scale of 1:1,000,000, embracing an area of 450,000 square miles. The reconnaissance mapping of the area, except the State of South Carolina and about 13,000 square miles adjacent to the Rio Grande in Texas, has been completed. The two deficiencies

mentioned will be filled as soon as possible—it is hoped within the coming fiscal year.

Much attention has been paid by members of the section to sediments now being laid down in the sea, because of their bearing on the interpretation of the conditions under which sediments exposed on the land surface and encountered in well borings were deposited.

The National Museum, the Bureau of Fisheries, the Carnegie Institution, the Bureau of Soils, the Bureau of Lighthouses, the Bureau of Plant Industry, and a number of specialists in biology or paleontology, as well as the division of underground waters of the water-resources branch, have cooperated with or contributed to the work of this section.

Investigations have been carried on by this section during the year in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, North Carolina, Rhode Island, South Carolina, Tennessee, Texas, and Virginia.

4. The section of glacial geology—W. C. Alden, geologist, in charge—is engaged in the study of the work of glaciers, the glacial and interglacial deposits and the contemporary deposits of the bordering regions, and the geologic history of the continent during the Quaternary period. The geologists occupied with these varied and specialized problems are charged with the classification and mapping of the Quaternary deposits of the glaciated regions. The work of this section during the year has comprised field studies and mapping and the preparation of reports covering areas in California, Illinois, Iowa, Maine, Massachusetts, Michigan, Minnesota, Montana, New York, New Jersey, North Dakota, Pennsylvania, Vermont, and Wisconsin.

5. The section of paleontology and stratigraphy—T. W. Stanton, geologist, in charge—is responsible for the determination of the relative age and equivalence of the strata in different areas and for the reference of the formations to a geologic time scale. The collections of fossils sent in by field geologists for examination and those obtained by the paleontologists themselves in the course of special field investigations have equaled those of previous years in size and importance. Their identification and the preparation of preliminary reports on them form a considerable part of the paleontologists' work, the results of which are embodied in many of the economic and stratigraphic reports of the Survey and add greatly to their accuracy and value. Reports on current collections of vertebrate fossils have been furnished by the United States National Museum.

The work of this section is practically coextensive with that of the divisions of geology and of Alaskan mineral resources and is indispensable to the geologic mapping of the areas surveyed and the satisfactory determination of the structure. It touches nearly all the States.

6. The section of the geology of metalliferous deposits—F. L. Ransome, geologist, in charge—not only studies metalliferous deposits and mines and investigates the conditions and modes of ore deposition but also carries on reconnaissance geologic examinations of many new districts and makes complete detailed areal surveys, for folio publication, of quadrangles in which metalliferous deposits are of especial importance, the folios being subject to the inspection and approval of the geologists in charge of areal geology. Several geologists in this section have prepared, for publication in Mineral Resources of the United States, statistical reports on the production of metals or minerals with which they are specially conversant and statements on the industrial conditions relating to them. The work of the section has embraced the investigation of metalliferous deposits in Alabama, Arizona, California, Colorado, Georgia, Idaho, Kansas, Louisiana, Maryland, Minnesota, Missouri, Montana, Nevada, New Mexico, Oklahoma, Oregon, Tennessee, Texas, Utah, Virginia, Washington, and Wyoming.

7. The section of the geology of nonmetalliferous deposits—H. S. Gale, geologist, in charge—is concerned with the study of the deposits of nonmetallic ores and minerals, exclusive of fuels, and with the geologic investigation and mapping of regions in which such minerals or deposits are of paramount importance. During the year the greater part of the work of the section has consisted in large part of the search for potash in commercial quantities in the salts of old evaporation basins or dried-up ancient lakes of the Great Basin region and in the Permo-Triassic "Red Beds" of New Mexico and Texas. These investigations are more fully described on pages 11-14. With them has been combined a diligent search for nitrates.

The classification of the phosphate-bearing lands in Idaho, Montana, and Wyoming withdrawn from entry has also been carried forward. Special investigations relating to clays, building stones, and the eastern phosphate fields have been made, and field and office work in the preparation of general bulletins on the graphite, mica, and gypsum deposits of the United States have been in progress. The work in the section has involved field investigations or laboratory studies relating to nearly every State.

8. The section of eastern fuels—David White, chief geologist, in charge—conducts examinations of areas east of the one-hundredth meridian that contain coal, oil, or gas. It not only investigates and describes the economic geology but in some regions also works out the detailed areal geology for folio publication, the folios being subject to the inspection and approval of the geologist in charge of the section of eastern areal geology. In this section special attention has been given to the discovery and mapping of structure favorable to the occurrence of oil and gas in undeveloped regions which may later produce oil.



The work of the section during the year has been done in cooperation with the State surveys of Illinois, Kentucky, Missouri, Oklahoma, Pennsylvania, Tennessee, and Virginia. Noncooperative work has been done in Kansas, Louisiana, Mississippi, Ohio, Texas, and West Virginia.

9. The section of western fuels—M. R. Campbell, geologist, in charge—conducts examinations and surveys in the fuel-bearing regions west of the one-hundredth meridian, similar to those made by the section of eastern fuels. The greater part of the work of the western section has consisted in classifying and mapping coal or **oil bearing lands of the public domain in California, Colorado, Montana, New Mexico, Utah, and Wyoming**, but the section has also carried on detailed mapping of the geology in quadrangle units for folio publication, subject to the approval of the geologist in charge of the section of western areal geology. Several members, including the chief of this section, serve as members of the coal and oil committees in the land-classification board.

Broad researches of general interest in progress in this section include studies of the mutual chemical relations of water and oil in oil fields and of the utilization of the hydrocarbon shales of Colorado and Utah as sources of petroleum and other distillation products, also the preparation of a general report on the coal fields of the United States.

The section of geologic-map editing—G. W. Stose, geologist, in charge—is a part of the publication branch, but its work is so intimately associated with the work of the individual geologists in the division of geology that it is administered as a part of the geologic branch, in which the chief of the section is an active geologist. The geologic field investigations made by Mr. Stose are reported in the sections to which they pertain. The office work of this section is described on pages 166–167.

To lessen the administrative work of the geologist in charge of western areal geology and the geology of metalliferous deposits and of the geologist in charge of western fuels, and thereby to increase their opportunities for scientific work, the sections of the division of geology were, in June, 1916, reorganized as follows, to take effect July 1:

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 the geology of metalliferous deposits. F. L. Ransome, geologist, in charge.
4. Section of the geology of nonmetalliferous deposits. H. S. Gale, geologist, in charge.
5. Section of Coastal Plain investigations. T. W. Vaughan, geologist, in charge.
6. Section of glacial geology. W. C. Alden, geologist, in charge.

7. Section of paleontology and stratigraphy. T. W. Stanton, geologist, in charge.

8. Section of the geology of western coal fields. M. R. Campbell, geologist, in charge.

9. Section of the geology of eastern coal fields. G. H. Ashley, geologist, in charge.

10. Section of the geology of oil and gas fields. David White, chief geologist, in charge.

The subsection of investigations in petrology, in charge of E. S. Larsen, jr., is to be attached to the section of the geology of metal-liferous deposits.

#### ASSISTANCE TO OTHER DIVISIONS.

In addition to performing work in their respective sections, a considerable number of the geologists in the sections of metalliferous and nonmetalliferous deposits and several geologists in the sections of eastern and western areal geology have prepared for publication, in the annual volumes of Mineral Resources, reports on the production and statements of the industrial conditions relating to a large number of mineral resources with which they are especially familiar. Parts of the salaries of some of these geologists are paid from the funds of the division of mineral resources, and the traveling and field expenses incurred by others in the collection of data are also paid from the funds of that division.

A number of economic geologists of this division serve as members of the special committees of the land-classification board. The paleontologists of the division report on fossils collected for the division of Alaskan mineral resources and are called upon to classify fossils for the National Museum and, through courtesy, occasionally for foreign Governments and other scientific institutions.

Close cooperation, with constant interchange of information, exists between the geologic branch and the water-resources branch in the investigation of underground-water movements and supplies and of sedimentary deposition. Members of the land-classification board serve in the geologic field parties.

#### COMMITTEE ON GEOLOGIC NAMES.

The committee on geologic names, a standing committee of the geologic branch, was reorganized on December 1, 1915, and now consists of T. W. Stanton (chairman), G. W. Stose, W. T. Lee, Sidney Paige, and L. W. Stephenson. The chiefs of section in the division of geology and the chief of the division of Alaskan mineral resources also serve as associate members, each of whom is invited to attend meetings at which matters pertaining to his section or division are under consideration. Authors of manuscripts

under discussion are expected to be present or to select someone to submit their views. On each question the individual opinions of the persons present are recorded and forwarded to the chief geologist, who makes the decision, subject to appeal to the Director. The records are kept by the secretary, Miss M. G. Wilmarth, who also examines all manuscripts submitted for publication and compares the geologic nomenclature and classification used in them with the standards in current use by the Geological Survey. During the year 153 manuscripts, comprising 15,200 pages and involving about 3,150 geologic names, have been examined. Good progress has been made in preparing the manuscript of a stratigraphic lexicon of geologic formations, mentioned in the report for last year, and some preliminary work has been done toward compiling general correlation charts.

#### COMMITTEE ON PHYSIOGRAPHY.

The committee on physiography was, on March 1, 1916, reorganized, with changes both in the scope of its work and in its personnel. The reorganized committee consisted of M. R. Campbell (chairman), Laurence LaForge, F. E. Matthes, E. W. Shaw, and P. S. Smith. At his request Mr. LaForge was relieved from service with the committee, and in June, by arrangement with the chief hydraulic engineer, O. E. Meinzer, of the water-resources branch, was appointed in his place.

The duties of this committee are as follows:

1. To read critically and give advice as to physiographic papers or physiographic chapters or sections in other papers submitted for publication by the Survey.
2. To consider the classification and nomenclature of physiographic provinces.
3. To prepare or make recommendations as to the preparation of physiographic descriptions in popular language, to be printed on the backs of topographic sheets.
4. To consult with geologists regarding the solution of physiographic problems.
5. To formulate the usage of physiographic terms, in continuance of the work of the old committee.
6. To confer with the chiefs of sections and with the chief geologist regarding physiographic work to be undertaken by the Geological Survey.

After considering for some time certain general principles of physiography, the committee entered upon a joint consideration, with a committee appointed by the Association of American Geographers, of a standard scheme of physiographic divisions in the United States. The work previously in progress in the committee

of the association was completed in cooperative conferences, and the joint findings were approved and arranged for publication.

The committee has taken up the question of more exact definition of physiographic terms and, through conferential discussion with the leading physiographers of the country, it aims at greater uniformity and cooperation among American physiographers, both in the use of terms and in physiographic classification.

#### GENERAL SUMMARY OF GEOLOGIC WORK.

Geologic investigations were continued in 47 States, the Canal Zone, and the West Indies. Systematic detailed surveys in metal-mining districts were carried on in California, Minnesota, Nevada, New Mexico, and Utah, and reconnaissance studies of metal-mining districts were made in Alabama, Idaho, Maryland, Montana, Nevada, New Mexico, Utah, and Virginia. Potash and nitrate prospects were investigated in the States containing semiarid regions, in the "Red Beds" region of the Southwest, and through the analytical testing of brines coming from many oil, water, and salt wells in other portions of the country. Other nonmetalliferous deposits of one kind or another were examined in nearly every State. Coal fields were investigated in Colorado, Idaho, Kentucky, Montana, New Mexico, Ohio, Pennsylvania, Tennessee, Utah, Virginia, and Wyoming; and studies with mapping of oil and gas structures were made in California, Colorado, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Montana, New Mexico, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and Wyoming. Reports describing mineral deposits previously examined in other States and not mentioned above are now in preparation. General and detailed geologic and paleontologic work was continued in all parts of the country, including a large amount of geologic work in connection with the examination of the economic resources just mentioned. Work in classifying lands of the public domain and of Indian reservations was carried on in Arizona, California, Colorado, Idaho, Montana, New Mexico, North Dakota, Oregon, Utah, Washington, and Wyoming.

#### WORK OF THE DIVISION BY STATES.

##### ALABAMA.

The important graphite deposits in Clay County, Ala., were examined by E. S. Bastin in June, and a brief description was immediately given to the press. The detailed description of the deposits will appear in Mr. Bastin's general report on the graphite deposits of the country.

A report on the red iron-ore beds in northeastern Alabama has been completed by Mr. Burchard and will be included in a bulletin



on the red iron ores of northeastern Alabama, eastern Tennessee, and northwestern Georgia.

The texts for the Bessemer-Vandiver and Montevallo-Columbiana folios, by Charles Butts, have been completed and are in preparation for publication.

Collections of Tertiary fossils from the State were identified and the preparation of a report on the stratigraphy and correlation of the Jackson and Vicksburg groups was begun by C. W. Cooke. Reports on the fossil floras of the Jackson and Claiborne groups, by E. W. Berry, and on the orbitoid and nummulitid Foraminifera, by J. A. Cushman, have been almost completed. Brief examinations of the terraces near Tuscaloosa and Mobile were made by E. W. Shaw and G. C. Matson. The age of the Ocala limestone is discussed in Professional Paper 95-I by C. W. Cooke; and the geologic history of a part of the Coastal Plain of the State is considered by E. W. Berry in Professional Paper 95-F. The older Tertiary Bryozoa are described in a paper by F. Canu and R. S. Bassler, almost completed.

Two reports by G. C. Matson and E. W. Berry, entitled "The Pliocene Citronelle formation of the Gulf Coastal Plain and its flora" (Professional Paper 98-L) and "The Catahoula sandstone and its flora" (Professional Paper 98-M), are in press.

#### ARIZONA.

The preparation of a professional paper on the copper deposits of the Ray and Miami districts has been continued, when other duties permitted, by F. L. Ransome. The work done contributes to some extent toward the preparation of the Ray folio, which Mr. Ransome also has in hand.

The geology and geography of the Navajo country are described by H. E. Gregory in a paper to be published as Professional Paper 93. This paper is based on an extended reconnaissance of parts of Arizona, New Mexico, and Utah.

Some Paleozoic sections in Arizona and their correlation are discussed in a paper by F. L. Ransome for publication as Professional Paper 98-K.

A report entitled "A reconnaissance of the Archean complex of the Grand Canyon," by L. F. Noble and J. F. Hunter, jr., is in press as Professional Paper 98-I. The field work on which this report was based was done in 1914 by Mr. Noble, partly at his own expense; the petrographic studies were made in 1915 by Mr. Hunter.

Progress was made by C. H. Clapp during the summer of 1915 in the mapping of the Winkelman quadrangle, although no funds could be allotted to him.

Reports on the production of asbestos, talc and soapstone, and chromic iron ore in the United States during 1915 have been prepared by J. S. Diller. Arizona now stands first in the production of high-grade asbestos.

## ARKANSAS.

The coal fields of Arkansas are described in summary form, with analyses, by A. J. Collier in a manuscript which will appear as a chapter in Professional Paper 100, "The coal fields of the United States."

The geology of the Hot Springs quadrangle was briefly reviewed by H. D. Miser, in connection with the examination of the area covering Hot Springs and vicinity, for which a folio will soon be submitted for publication.

The geology and mineral deposits of the Caddo Gap quadrangle were further examined by Mr. Miser. The folio covering the Caddo Gap and De Queen quadrangles is near completion. A collection of plants from the Bingen sand in this region proved to be the first identifiable fossil plant material procured from the Upper Cretaceous of Arkansas.

A detailed geologic and topographic map of the principal area of diamond-bearing peridotite in Arkansas was also made by Mr. Miser.

In the northeastern part of the State additional investigations of the sunken lands were made for the Department of Justice by E. W. Shaw, and some valuable geologic results were obtained in the course of the work. A report on the floras of the Jackson and Claiborne groups has been nearly completed by E. W. Berry.

A report on the geology and ground waters of northeastern Arkansas, by L. W. Stephenson and A. F. Crider, has been published as Water-Supply Paper 399. Eocene erosion intervals are described by E. W. Berry in Professional Paper 95-F, and descriptive reports on the Chester and Pottsville faunas of Arkansas and Oklahoma are in preparation by G. H. Girty.

Papers by Mr. Girty on the invertebrate faunas of the Batesville sandstone, of the so-called Boone chert at Batesville, and of the Boone limestone at St. Joe have been printed as Bulletins 593, 595, and 598, respectively.

The greensands of Hempstead County were examined by G. H. Ashley and sampled for chemical analysis and study with special reference to their potash content. A report of the results of the analyses will soon be published.

## CALIFORNIA.

The studies of hydraulic mining debris in the Sierra Nevada, Cal., carried on by G. K. Gilbert under the joint auspices of the geologic and water-resources branches, were continued and practically com-

pleted. Additional field work in the measurement of tidal currents in the summer and autumn of 1914 was supplemented by research in the archives of the Coast and Geodetic Survey, and information gained from these and from various other sources led not only to revision but to expansion, so that the report is now much more voluminous than it was originally, and three-fifths of it embodies either new material or old material with new treatment.

The investigation of the petroleum resources of California was continued by R. W. Pack, assisted by W. A. English. Mr. Pack, on account of the necessity for completing a report at an early date, was unable to take the field; but Mr. English, under Mr. Pack's direction, spent  $3\frac{1}{2}$  months in an examination of certain withdrawn lands in the Cholame and San Miguel quadrangles, for the purpose of classifying them as oil or nonoil lands and also of obtaining data for a report on the possibilities of finding oil. The area examined contains 970 square miles, 490 square miles of which was examined in detail and 480 square miles in a fairly detailed reconnaissance. The land has been classified, and Mr. English has submitted a report on the oil possibilities of the region.

Mr. Pack, in addition to supervising the work of Mr. English, has prepared a detailed report on the Sunset-Midway oil field, for the use of the experts of the Bureau of Mines, and has nearly completed a report on the same field for publication. Mr. Pack spent the last half of May and all of June in the field, gathering data for the completion of this report.

The study of the water problem in the Sunset-Midway and Coal-inga oil fields, begun by G. S. Rogers in 1914, was continued by him in the summer of 1915. Mr. Rogers spent  $3\frac{1}{2}$  months in collecting well logs and in gathering data for a general study of the encroachment of water upon the productive territory in each of the fields and in a study of the effect of petroleum upon water and conversely of different waters upon petroleum. The results of the chemical studies are given in a manuscript submitted by Mr. Rogers for publication as Bulletin 653 of the Survey. The chemical examination of the water promises to be of great value in "wild-cat" operations, at least in regions of dry climate, as it seems to enable the driller to judge of the proximity of oil by the change in composition of the water, or of the probable absence of oil by the uniformity of composition of the water encountered in drilling.

A report on the geology and oil resources of the west border of the San Joaquin Valley, by Robert Anderson and R. W. Pack, has been published as Bulletin 603, and a short paper by W. A. English on the geology and oil prospects of Cuyama Valley as Bulletin 621-M.

A special survey of the work of the recent volcanic eruptions in the Lassen Peak region, embracing about 200 square miles, was

made in 1915 by J. S. Diller, who is preparing an educational bulletin on this interesting field. During the last two years two papers by Mr. Diller, "Lassen Peak, our most active volcano," and "The geological history of Lassen Peak," have been published unofficially.

Brief examinations of a nickel prospect and a molybdenum prospect, both in San Diego County, were made by F. C. Calkins, and notes on them have been issued as Bulletin 640-D. A paper describing the occurrence of tin in this county was prepared by W. T. Schaller and issued as Bulletin 620-P. Progress has been made by Mr. Schaller in a study of the pegmatite intrusions of the county, which, in addition to containing gem minerals, present features of exceptional petrologic interest.

Field work in the Yosemite National Park was continued during the summer of 1915 by F. C. Calkins. Mr. Calkins and F. E. Matthes, who has been engaged in studying and mapping the glacial deposits, have nearly completed the writing of a geologic guidebook to the Yosemite, which is to be followed by the presentation of their scientific results in more complete and detailed form.

A detailed study of the mining geology of the northern portion of the Mother Lode district was made by Adolph Knopf, with the assistance of J. F. Hunter, jr., during a part of the field season.

A report, based on field work of previous seasons, entitled "A geologic reconnaissance of the southern Sierra escarpment," by Mr. Knopf, with a section on the stratigraphy of the Inyo Range by Edwin Kirk, has been transmitted for publication.

Notes on the petrology and economic geology of the Weaverville quadrangle are in preparation by H. G. Ferguson as contributions to the detailed study of the geology of the quadrangle, made by J. S. Diller, for folio publication.

With a view to revision of portions of the long-delayed report on the copper deposits of Shasta County, two weeks were spent in the summer of 1915 by L. C. Graton and B. S. Butler in that county. The report is awaiting final revision by Prof. Graton.

Some recently opened deposits of tungsten ore near Bishop were examined late in June, 1916, by Adolph Knopf.

The Rock Creek quadrangle is gradually being mapped in detail for folio publication by L. F. Noble, mainly at his own expense.

A large area in southern California has been covered by a reconnaissance examination, with mapping, by R. T. Hill, and a rough manuscript draft of the important results has been submitted for examination.

A traverse on the Duck Lake and Surprise Valley basin, in Nevada and California, was made by H. S. Gale in the course of his investigations of saline deposits that may contain potash salts or nitrates.



The results of experiments by W. B. Hicks in the evaporation of the brines from Searles Lake, with special reference to the recovery of the potash, have been printed in Professional Paper 98-A.

A remarkable Pliocene reef-coral fauna from Carrizo Creek, Imperial County, has been described in a report by T. W. Vaughan. All the species in this fauna are closely related to species at present living in the Gulf of Mexico and the Caribbean Sea, and most of them have near relatives in the Pliocene Caloosahatchee marl of Florida, strongly suggesting if not actually proving marine connection of the Gulf of California with the Gulf of Mexico in Pliocene time.

Progress has been made on a report describing the late Tertiary invertebrate faunas of California and other Pacific Coast States, by W. H. Dall.

A brief paper entitled "Faunal correlation of the Pacific coast Cretaceous," by T. W. Stanton, was read at the Berkeley meeting of the Paleontological Society, and two papers entitled "Notes on two conifers from the Pleistocene Rancho La Brea asphalt deposits, near Los Angeles, Cal.," and "The present status of knowledge concerning the Jurassic and Lower Cretaceous floras of the Pacific coast" have been prepared by F. H. Knowlton for unofficial publication.

Sections of Mesozoic and later rocks near Oroville, along Cache Creek near Rumsey, in the neighborhood of San Francisco, along the west side of San Joaquin Valley from El Puerto Creek to Little Panoche Creek, in the Ventura quadrangle, and at La Jolla were examined by T. W. Stanton for purposes of correlation.

#### COLORADO.

The survey of the eastern part of the San Juan Mountains, Colo., was continued by Whitman Cross, E. S. Larsen, jr., and J. F. Hunter, jr. The work comprised detailed reconnaissance mapping of parts of the Creede, Summitville, and Del Norte quadrangles. The geologic mapping of the Creede quadrangle was completed, the part covered during the season being about 600 square miles, as also was that part of the Summitville quadrangle in which the volcanic formations are present, embracing about 700 square miles. Messrs. Larsen and Hunter continued work in the Summitville quadrangle and also made a rapid reconnaissance of a small part of the Conejos quadrangle, on the east, for which no adequate topographic base is yet available. Preparation of material for the final general report on the geology of the San Juan area and the assembling of data resulting from the season's field work occupied Mr. Cross during a part of the winter. The collections from the Creede and Summitville quadrangles have been under study by Mr. Hunter. Field work in the Del Norte quadrangle was resumed by Mr. Larsen in June. Progress in the preparation of the San Cristobal folio has been made by Mr. Larsen.

The report on the geology and ore deposits of the Creede district, by W. H. Emmons and E. S. Larsen, jr., has been completed but has been sent to Mr. Emmons for final revision. The occurrence of unusual minerals at Wagon Wheel Gap, including the new mineral creedite, has been described by Mr. Larsen and R. C. Wells in unofficial publications.

The Pleistocene deposits in the southern portion of the Uncompahgre quadrangle and in the Needle Mountains quadrangle, in the San Juan Mountain region, were mapped in detail by W. W. Atwood, assisted by Kirtley Mather. The area thus surveyed included 700 square miles. Similar deposits in the Silverton, Telluride, and Engineer Mountain quadrangles, which A. D. Hole mapped some years ago, were studied and the necessary revision accomplished to make the work in this region conform with the more recent studies. This semidetailed mapping covered 650 square miles. In connection with the mapping of the Pleistocene deposits, Mr. Atwood and Mr. Mather have continued their study of the physiographic history of the San Juan Mountains. During the later part of the season special attention was given to the study of geologic conditions in the vicinity of reservoirs and reservoir sites in the San Juan Mountains, with a view to the preparation of a report that will be of service to engineers. To this report Mr. Hunter has contributed an account of the Mosca reservoir, in Beaver Creek Park, in the drainage basin of the South Fork of the Rio Grande, Rio Grande County.

A summary report on the economic geology of Gilpin County and adjacent portions of Clear Creek and Boulder counties, embracing the Central City district, by E. S. Bastin and J. M. Hill, was issued as Bulletin 620-M. The detailed report is in press as Professional Paper 94.

The oxidized zinc ores of Leadville are described by G. F. Loughlin in a chapter transmitted for inclusion in the monograph on the Leadville district, in preparation by J. D. Irving.

The field investigations of the deposits of oil shale in northwestern Colorado were vigorously continued by the party in charge of D. E. Winchester. Dry distillations and rough determinations of ammonium sulphate were made on the spot, in connection with measurements of the beds and mapping of the extent of the deposits. The report of tests and geologic examinations of these shales made in the summer of 1914 was revised and enlarged to include the results of the work of 1915. This report, which is now in press as Bulletin 641-F, will be a valuable addition to the knowledge of this oil shale as a future source of oil, fertilizer, and other distillation products. The large importance of these deposits, their petroleum content, and their gasoline possibilities have been noted in advance statements.

How near the country may be to the successful commercial development of these vast reserves no one can tell.

The preparation of a guidebook for the Mesa Verde National Park, by A. J. Collier, is in progress but has been interrupted by other more pressing matters.

On account of the great public demand for additional guides to the mineral resources, geology, and scenery in the Western States the preparation of a guidebook for the Denver & Rio Grande Railroad, from Denver, Colo., to Salt Lake City, Utah, was begun, and in August, 1915, M. R. Campbell, who was assigned to the task, visited all the points of interest to tourists along the main line of this road, examining the route from Florence to Grand Junction on foot and in great detail. The manuscript for this part has been prepared and will be ready for publication as soon as the work through to Salt Lake City is completed in 1916.

The detailed geology of the Castle Rock quadrangle, situated north of the Colorado Springs quadrangle, is described and mapped by G. B. Richardson in Folio 198 of the *Geologic Atlas*.

The stratigraphy of the rocks including the Scranton coal bed was examined in detail by W. T. Lee, whose correlations of these beds have been incorporated by Mr. Richardson in a short paper for unofficial publication.

Detailed examination of the coal resources of the Yampa field was continued in the summer of 1915 by the survey of the Pagoda quadrangle, by E. T. Hancock. This quadrangle embraces an area of 228 square miles, mainly southwest of the town of Hayden. During the winter Mr. Hancock has practically completed the preparation of the Meeker folio and the Axial and Monument Butte folio and has nearly finished an economic report on the Pagoda quadrangle.

The Grand Mesa and Book Cliffs coal fields will be treated by W. T. Lee in Professional Paper 100, "The coal fields of the United States."

In the South Platte Valley above Greeley the exposures of the Fox Hills sandstone were reviewed by T. W. Stanton, and the additional land plants obtained from this marine formation, with those previously collected by T. E. Williard from the same neighborhood, furnished the material for F. H. Knowlton's paper "Flora of the Fox Hills sandstone" (Professional Paper 98-H).

A report on the flora of the Tertiary lake beds at Florissant, Colo., was submitted for publication by F. H. Knowlton, and his paper on the flora of the Laramie of the Denver Basin is practically finished.

Phosphate beds in Colorado, Wyoming, and Utah were examined by A. R. Schultz, who also made a preliminary examination of the geology and structure of the Uinta Range.

## DELAWARE.

The folio for the Elkton and Wilmington quadrangles, Del., including parts of Pennsylvania and Maryland, has been revised by Florence Bascom and B. L. Miller and is ready for publication.

The greensands of the State were examined by W. C. Phalen and G. H. Ashley, who collected samples for chemical analysis and study with special reference to their possible utilization for their potash and phosphate contents.

## DISTRICT OF COLUMBIA.

Incidentally and largely as by-products of unofficial activities data have been gathered by E. W. Shaw, Arthur Keith, and others for use in mapping the geology of the area including the city of Washington on the new topographic map for the District, now nearly completed.

The Miocene flora from the Benning Road near the District line is described by E. W. Berry in Professional Paper 98-F.

## FLORIDA.

The geologic work of the Survey in Florida was directed mainly toward the differentiation and definition of the Tertiary formations and the unraveling of the geologic history of the region, which is closely bound in its later history to the Central American province. Investigations of the stratigraphy and paleontology of the Eocene and lower Oligocene formations were continued by C. W. Cooke. Miss J. A. Gardner devoted most of the year to monographing the fossil Mollusca of the Chipola, Oak Grove, and Shoal River members of the upper Oligocene Alum Bluff formation. J. A. Cushman is describing the orbitoid and nummulitid Foraminifera. The molluscan faunas of the Choctawhatchee marl of Red Bay and the Pliocene Mollusca of Deland were studied and reports on them prepared by W. C. Mansfield. The older Tertiary Bryozoa of the State are described in a manuscript by F. Canu and R. S. Bassler. In cooperation with the Carnegie Institution of Washington, investigations of the Florida living corals, the coral reefs, and the keys were continued by T. W. Vaughan and E. W. Shaw. Special attention was paid to the physiography, including detailed investigations of the agencies determining the shapes of the keys, and to bottom deposits that are now being formed off the south coast of Florida.

Papers on the geology of the State or on geologic processes operative there were published or submitted for publication during the year as follows: The phosphate deposits of Florida are described in Bulletin 604, by G. C. Matson; the age of the Ocala limestone is the subject of a paper by C. W. Cooke (Professional Paper 95-I); the



physical conditions and age indicated by the flora of the Alum Bluff formation are discussed in Professional Paper 98-E by E. W. Berry; the extension of the Citronelle formation into western Florida is considered by Mr. Matson in Professional Paper 98-L (in press); several papers on the living corals and coral reefs and geology of southern Florida were published outside of the Survey by T. W. Vaughan and E. W. Shaw; a report on the salinity of the ocean water at Fowey Rocks was written by R. B. Dole and A. A. Chambers; and a paper on the temperature of the Florida coral-reef tract was prepared by Mr. Vaughan.

#### GEORGIA.

In order to procure data for the use of chemical engineers as to the practicability of utilizing the sericite deposits of Georgia for the production of potash the principal sericite districts in the State were investigated by P. S. Smith with reference both to the quantities of the material at certain points and to the potash contents of the veins that are of workable thickness. Samples were collected at many places in the vicinity of Jasper and Blue Ridge for chemical analysis, the results of which will be published at an early date.

The water supply of Savannah was investigated by R. B. Dole and L. W. Stephenson, and the municipal authorities were advised as to the best means of remedying the defects that were causing pollution and of increasing and maintaining the supply to meet future demands.

Progress was made in the preparation of a report on the upper Eocene and lower Oligocene formations of the State, and field work on the Claiborne and Jackson groups in a number of counties was done by C. W. Cooke.

Collections of Cretaceous and Tertiary plants were studied by E. W. Berry, who has nearly completed a report on the fossil floras of Claiborne and Jackson age. The orbitoid and nummulitid Foraminifera of the State are being studied by J. A. Cushman, and the upper Oligocene Mollusca from Bainbridge have been described by W. H. Dall. The older Tertiary Bryozoa of the State are described in a manuscript by F. Canu and R. S. Bassler. Notes on the upper Eocene and lower Oligocene formations of the State are contained in C. W. Cooke's paper on the age of the Ocala limestone (Professional Paper 95-I).

A molluscan fauna of Oligocene age collected on Flint River has been described by W. H. Dall in a paper to be published by the United States National Museum.

A bulletin on the red iron ores of northwestern Georgia, northeastern Alabama, and eastern Tennessee, by E. F. Burchard, based on field work done in previous seasons, is near completion.

## IDAHO.

Field work for a comprehensive summary report on the geology and ore deposits of Idaho was continued during the year by J. B. Umpleby and E. L. Jones, jr. The deposits of Washington, Adams, and Canyon counties were examined by Mr. Umpleby; those of Boise, Elmore, Ada, Owyhee, and Gem counties by Mr. Jones, whose reconnaissance covered approximately 850 square miles. A short report on lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, was prepared by Mr. Jones and submitted for publication as Bulletin 640-E. In May, 1916, Mr. Umpleby, with Mr. Jones, began the study of the deposits in the Coeur d'Alene district as opened by mining operations since the detailed examination by F. L. Ransome and F. C. Calkins in 1904. In connection with this work a reconnaissance examination was made of the Pine Creek district, south of Kellogg.

The economic section of the Hailey folio was completed by Mr. Umpleby and is now awaiting the completion of the part on general geology by L. G. Westgate, to whom no allotment could be made but who has continued office work on his manuscript.

Bulletin 620-L, "Notes on the fine gold of Snake River, Idaho," by J. M. Hill, based on field work done in a previous season, was issued during the year.

Investigations of the fuel resources of the State are reported in Bulletin 621-I, "The Orofino coal field, Clearwater, Lewis, and Idaho counties, Idaho," by C. T. Lupton.

Data for a report on the building stones of the State are being gathered by G. F. Loughlin.

A detailed report on the ore deposits of the Mackay region, by J. B. Umpleby, is now in press as Professional Paper 97.

Detailed geologic mapping of the Slug Creek, Lanes Creek, and Freedom quadrangles, done in previous seasons by G. R. Mansfield and assistants, was reviewed by Mr. Mansfield during two weeks in July, 1915, the scattered areas reexamined aggregating about 100 square miles. A paper entitled "A revision of the Beckwith and Bear River formations of southeastern Idaho," written incidentally to the preparation of the folios covering the quadrangles mentioned, was published as Professional Paper 98-G.

## ILLINOIS.

The geologic investigations in and about the Illinois coal field were, as in preceding years, continued in cooperation with the State Geological Survey. The work of the year was characterized not so much by its extension into new areas as by the completion of manuscripts and maps for areas that had been already investigated or were under examination.

In the Shawneetown and Equality quadrangles the stratigraphy and structure were studied by Wallace Lee, who mapped the Mississippian portion of the Shawneetown quadrangle, in which the determination of the structure is complicated by the mantle of loess and by faults. To unravel the stratigraphy in this area it was found necessary to make reconnaissance studies in company with Stuart Weller in the Golconda quadrangle and in the Elizabethtown region. Field work in the Shawneetown quadrangle, about one-third of which lies in Kentucky, was nearly completed, and the report by Mr. Lee on the Kentucky area, mapped in cooperation with the Kentucky Geological Survey, was transmitted to that State for publication. A reconnaissance was made of the coal measures in portions of the Pennsylvanian area in the Equality quadrangle.

The manuscript and maps for a folio to cover the Gillespie and Mount Olive quadrangles, examined by Mr. Lee in 1914, were finished and submitted for critical review. The folds in these quadrangles, contoured in the report earlier submitted to the State for publication, have in part been tested with favorable results. The geologic examination and mapping of the Birds quadrangle, in which the State Survey had previously investigated the structure and oil and gas resources, was completed by T. E. Savage, under agreement, and the folio, to include the descriptions and maps of the Birds and Hardinville quadrangles, was nearly finished by Mr. Savage, who has also, under agreement, concluded the field investigations necessary for the preparation of a report on the Vincennes quadrangle, a portion of which lies in Indiana.

Manuscripts and maps for two folios covering the Canton and Avon quadrangles, by Mr. Savage, and the La Salle and Hennepin quadrangles, by U. S. Grant and H. D. Cady, have been transmitted by the State Survey to the Federal Survey for publication. These folios represent State work exclusively and were transmitted as a part of its cooperation.

Several problems of the Pleistocene in this State received considerable attention. An account of the extinct lakes in southern and western Illinois, based on field examinations made by E. W. Shaw, were transmitted to the State Geological Survey for publication. Mr. Shaw's study of the surficial geology of the Gulf embayment in the southernmost counties of Illinois was continued.

Critical comparison and differentiation of the Illinoian drift and associated deposits from the post-Kansan drift of northeastern Iowa were made by W. C. Alden in the Edgington and Milan quadrangles and in Henry County.

The upper Mississippian rocks in southern Illinois, western Kentucky, and eastern Missouri were examined in conference by G. H.

Girty, Stuart Weller, and Charles Butts with the object of bettering the classification and determining the equivalents of the strata in different regions of the Mississippi Valley. This is a part of a general investigation in which the State geological surveys of Illinois, Missouri, Kentucky, Tennessee, Iowa, and Oklahoma are cooperating with the Federal Survey. The correlation of the Chester formations in Illinois and adjacent States was discussed by E. O. Ulrich in a paper read before the Paleontological Society.

## IOWA.

The cooperative investigation of the evidence of an Iowan stage of glaciation was continued by W. C. Alden for the Federal Survey, assisted by M. M. Leighton, of the Iowa Geological Survey. Considerable progress has been made on the report of this work, some preliminary results of which have already been made public by Mr. Alden.

## KANSAS.

A comprehensive report on the origin of the zinc and lead deposits of the Joplin region, by C. E. Siebenthal, field studies in connection with which extended into southeastern Kansas, was issued during the year as Bulletin 606.

The stratigraphy and structure of small areas in southeastern Cawley and southwestern Chautauqua counties, bordering the Foraker quadrangle (Oklahoma), were examined by K. C. Heald in connection with the study of the structure and oil prospects in the quadrangle.

The Syracuse-Lakin folio, by N. H. Darton, has been submitted for publication.

## KENTUCKY.

Nearly all the geologic work done by this Survey in Kentucky was carried on in efficient cooperation with the State Geological Survey.

The Kentucky portion (about one-third) of the Shawneetown quadrangle was examined and mapped in detail by Wallace Lee, and a report by Mr. Lee on the economic geology of the quadrangle was transmitted for publication by the Kentucky Geological Survey, in cooperation with which the work was done.

A report on the general geology and mineral resources of Jefferson County was completed early in the year by Charles Butts and has been published by the Kentucky Geological Survey. This work is contributory to a geologic folio to cover the Louisville and Kosmosdale quadrangles, after more data on certain problems are procured and some small areas outside of the county are mapped.



A detailed reconnaissance of the stratigraphy for purposes of formational definition and correlation of the Mississippian formations in west-central Kentucky was begun by Mr. Butts. The results of this work, one-half of the cost of which was borne by the State, will be submitted to the State for publication.

A reconnaissance field study of formations of late Trenton age in central Kentucky was made by E. O. Ulrich.

The later Tertiary and Pleistocene history of the western part of the State is being specially studied by E. W. Shaw. The erosion intervals during Eocene time are considered by E. W. Berry in Professional Paper 95-F, and a paper on the old Eocene floras, by Mr. Berry (Professional Paper 91), is almost ready for distribution.

#### LOUISIANA.

Investigations of the oil fields and oil and gas indications in Louisiana were continued during the fiscal year, and field work was completed for a report on the oil fields of De Soto and Red River parishes. The results will be embodied in a report by G. C. Matson and O. B. Hopkins, to be published during the coming year. The report on the Caddo oil and gas field, by Mr. Matson, has been published as Bulletin 619.

Special investigations were made in Natchitoches Parish near Campti and Natchitoches, in Sabine Parish near Pelican, in Tensas Parish near Point Pleasant, and in Cameron Parish near Cameron. The results of these studies will not appear in special reports but will be incorporated in a bulletin containing descriptions of the oil and gas fields and oil and gas indications in Louisiana that is now being prepared by Messrs. Matson and Hopkins. Samples of the oil and gas in the Caddo, De Soto, Shreveport, and Pelican districts were collected and submitted to the Bureau of Mines for examination. The results of these examinations will probably be published in the report on the fields in De Soto and Red River parishes.

Two reports by G. C. Matson and E. W. Berry, "The Pliocene Citronelle formation of the Gulf Coastal Plain and its flora" (Professional Paper 98-L) and "The Catahoula sandstone and its flora" (Professional Paper 98-M), were submitted for publication, and collections of fossils, both from surface outcrops and from deep wells in Louisiana, were studied and reported on by the Survey paleontologists. A report on the flora of the Jackson and Claiborne groups has been almost completed by E. W. Berry, and a monographic account of the old Eocene floras is almost ready for distribution as Professional Paper 91. The orbitoid Foraminifera are being studied by J. A. Cushman.

A report on iron-bearing deposits in Bossier, Caddo, and Webster parishes, by E. F. Burchard, was published as Bulletin 620-G.

## MAINE.

The detailed mapping of the Portland and Casco Bay quadrangles, Maine, was reviewed by F. J. Katz, principally to adjust previous mapping to fit the new topographic base. An area of about 350 square miles in the Biddeford, Kennebunk, Buxton, and Berwick quadrangles was covered in reconnaissance by Mr. Katz.

A study of the coastal marshes and peat bogs in the quadrangles above mentioned was made by Mr. Katz, with the late Prof. C. A. Davis, special attention being given to the evidence showing very recent subsidence of the coast.

The Dover and York quadrangles were covered in reconnaissance by Mr. Katz, and the broader structural features as well as the formations to be mapped were roughly determined. About 55 square miles in the center of the district was surveyed in detail.

As a result of field examinations and conferences between Arthur Keith, Laurence LaForge, and Mr. Katz in the area embracing parts of the Kennebunk, Biddeford, Portland, Casco Bay, Dover, and York quadrangles, conclusions were reached as to the stratigraphy of the rocks in these quadrangles and their correlation with areas being geologically mapped in Massachusetts. Some of these conclusions have been incorporated in the Portland-Casco Bay folio, which is approaching completion.

A report on the fauna of the Chapman sandstone, by H. S. Williams, assisted by C. L. Breger, has been published as Professional Paper 89.

## MARYLAND.

A brief reconnaissance of the Baltimore and Parkton quadrangles, Md., and an investigation of the Baltimore gneiss were made by Eleanor F. Bliss.

The maps and descriptions of the Williamsport quadrangle, which will be covered by the Williamsport-Hagerstown folio, have been well advanced by G. W. Stose. This folio will be published in co-operation with the Maryland Geological Survey, but the area mapped includes parts of West Virginia and Pennsylvania.

The folio for the Elkton and Wilmington quadrangles, which was prepared by Miss Florence Bascom and B. L. Miller, in cooperation with the Maryland Geological Survey, has been revised and is ready for publication. These quadrangles include parts of Pennsylvania and Delaware.

The Tolchester folio, also prepared under cooperative auspices by B. L. Miller, E. B. Mathews, Arthur Bibbins, and H. P. Little, has been revised and is in course of publication.

The results of the examinations of manganese mines and deposits in Maryland and Virginia by D. F. Hewett are included in a preliminary paper published as Bulletin 640-C.

Extensive prospecting recently accomplished in the gold-quartz veins in the vicinity of Great Falls was inspected by Arthur Keith, F. L. Ransome, and J. M. Hill.

The Frostburg-Flintstone folio awaits the completion by the State Geological Survey of its part of the text and maps.

Data for use in mapping in detail the geology of the area to be covered by the new large-scale topographic map including the District of Columbia, now in preparation by the topographic branch, are being assembled by Arthur Keith, E. W. Shaw, N. H. Darton, and others.

At the request of the municipal authorities the water supply of Hyattsville was examined, and suggestions were made in regard to increasing the supply to meet the demands of the community.

The greensands on Severn River and about Marlboro were examined by G. H. Ashley, and samples were collected for analysis and study with special reference to their potash content.

#### MASSACHUSETTS.

A description of the topography of Massachusetts was prepared by Arthur Keith for publication in a paper on the surface waters of that State, to be issued as Water-Supply Paper 415.

Reconnaissance examinations in the Haverhill, Lowell, Lawrence, Newburyport, Salem, and Groton quadrangles, Mass., and in the Milford and Manchester quadrangles, N. H., and adjacent territory were made by Laurence LaForge, who, in much of this area, as well as in critical localities in the Worcester area, was accompanied by Arthur Keith. The western margin of the Lowell quadrangle and the eastern margin of the Groton quadrangle were mapped in detail by Mr. LaForge.

Detailed mapping of the Newbury Basin by Mr. LaForge was inspected by Mr. Keith, who discovered late Silurian or early Devonian fossils in one of the volcanic formations in the Rowley quadrangle, from which a collection was later made by Mr. LaForge in company with R. D. Mesler. A description of the geology of northeastern Massachusetts based on this and a previous reconnaissance was prepared by Mr. LaForge and is incorporated in the report on the geology of Massachusetts and Rhode Island by Prof. B. K. Emerson, which has been revised and is now in press as Bulletin 597.

A brief reconnaissance of the Barre quadrangle was made by Arthur Keith, who also examined the Devonian rocks in the Greenfield quadrangle.

The areal and economic survey of the Greylock quadrangle was continued by L. M. Prindle, about 65 square miles being covered in detail.

The Devonian formations in the Greenfield (Mass.), Brattleboro (Vt.), and Keene (N. H.) quadrangles were critically examined, and a brief inspection of the area south of Williamstown was made by Mr. Keith.

Geologically important points in the Sheffield, Sandisfield, and Becket quadrangles were inspected by Mr. Keith in connection with the criticism of the folios for these areas, which have been submitted for publication.

The mapping of the surface geology of the Warwick, Winchendon, Fitchburg, and Groton quadrangles was continued during the field season by Prof. B. K. Emerson. Work on the text and maps for the two folios covering these quadrangles is well advanced.

In the Boston and Boston Bay quadrangles some additional field work was done by Mr. LaForge. The descriptions and maps of these quadrangles for the Boston folio are well advanced. In the Framingham quadrangle further revisions of the geologic and topographic maps were made by Mr. LaForge for incorporation in the Boston folio.

Field work has been done on the islands south of Rhode Island and the mainland of Massachusetts and on Cape Cod by J. B. Woodworth. The office work preliminary to writing a report on the results of the investigations is well advanced. Collections of fossil plants from Marthas Vineyard have been reported on by E. W. Berry.

In connection with the study of the glacial and older deposits of this region by Mr. Woodworth, a field conference of several days in June was held with W. C. Alden.

The manuscript, maps, and illustrations for the Pleistocene portion of the folio covering the Berlin and Greylock quadrangles, in New York and Massachusetts, were submitted for publication by F. B. Taylor, who also transmitted the illustrations for the Pittsfield-Becket and Sheffield-Sandisfield folios, covering quadrangles in New York and Massachusetts.

#### MICHIGAN.

The gypsum deposits of Michigan are described in a general report on the gypsum deposits of the United States, in preparation by R. W. Stone.

The fauna of the Marshall group is in process of description by G. H. Girty, who is making this study in cooperation with the Michigan Geological Survey.

The geology of the Detroit quadrangle is described and mapped in a folio by W. H. Sherzer now in press. This folio was prepared in cooperation with the State Geological Survey.



## MINNESOTA.

The cooperative studies begun last year by this Survey and the Minnesota State Survey, leading to reports on the economic geology of the Cuyuna iron range, were continued. The rock outcrops over an area of about 30 townships in central Minnesota were mapped in detail, and detailed topographic and geologic maps of open pits were made. Numerous drill samples were examined in areas in which no outcrops occur. The cores of 265 drill holes, aggregating 53,270 feet, were examined. The resulting reports are about to be submitted by E. C. Harder. One relates to the geology of east-central Minnesota, including the Cuyuna range. The other report discusses the physiology, morphology, and activity of iron-depositing bacteria and the formation of certain iron-ore deposits; it also contains a statement of the relative importance of chemical and biologic processes in iron-ore deposition.

The mapping and study of the glacial and associated deposits of Minnesota, which has been carried on under cooperative agreement between the Federal and Minnesota geological surveys, was completed by Frank Leverett, assisted by F. W. Sardeson, of the Minnesota Survey. A report on the surface formations and agricultural conditions of northeastern Minnesota was completed and transmitted for publication by the State in December. The map and manuscript for the report on the southern half of Minnesota, describing the several classes of drift and their soils, was transmitted by Mr. Leverett for publication. A general report on the Quaternary formations of Minnesota is in preparation by Mr. Leverett for publication by the Federal Survey.

Two reports, one on the building stones of Minnesota, by Oliver Bowles, and the other on the clays of the State, by F. F. Grout, prepared under cooperative agreement, have been submitted for publication as bulletins of this Survey.

Folio 201, describing in detail the geology of the four 15-minute quadrangles of the Minneapolis and St. Paul area, by F. W. Sardeson, has been issued. This publication is of more than ordinary educational value.

## MISSISSIPPI.

Reports on the physiography and the stratigraphy of the Cretaceous and Tertiary deposits of Mississippi and on the ground waters of the State are being prepared in cooperation with the Mississippi Geological Survey and are about half completed.

The orbitoid and nummulitid Foraminifera are being investigated by J. A. Cushman. A report on the floras of the Jackson and Claiborne groups has been almost completed by E. W. Berry; and

the older Tertiary Bryozoa are described in a manuscript by F. Canu and R. S. Bassler.

The following publications relating to the Coastal Plain formations have been published or submitted for publication during the year: "Erosion intervals in the Eocene of the Mississippi embayment" (Professional Paper 95-F) and "The physical conditions and age indicated by the flora of the Alum Bluff formation" (Professional Paper 98-E), by E. W. Berry; "The Pliocene Citronelle formation and its flora" (Professional Paper 98-L) and "The Catahoula sandstone and its flora" (Professional Paper 98-M), by G. C. Matson and E. W. Berry; "The age of the Ocala limestone" (Professional Paper 95-I), by C. W. Cooke. A paper on the lower Eocene floras by Mr. Berry (Professional Paper 91) was in press at the close of the year.

In view of the importance, both to the State and to the Nation, of the discovery of petroleum in the Coastal Plain east of Mississippi River, work was begun late in 1914 in the search for areas of structure favorable for the occurrence of petroleum in that region, for while the presence of such structure is but one important factor in the occurrence of oil pools it was believed that the discovery of the structure would not only encourage oil operators to make tests, but, by leading them to more favorable localities, would tend to eliminate the losses and discouragement that would arise from necessarily fruitless drilling in places where the structure is not favorable. Structural investigations begun near Vicksburg, Warren County, during the last fiscal year, were this year continued across parts of Hinds and Rankin counties. The results of these investigations, which were in part announced in a press notice last year, are being published as Bulletin 641-D, "Structure of the Vicksburg-Jackson area, Mississippi, with special reference to oil and gas," by O. B. Hopkins. A brief examination of reported oil indications in Jackson County, near Pascagoula, was made by Mr. Hopkins.

#### MISSOURI.

In Missouri the cooperation of the State has been continued in areal and paleontologic work. In the mapping of the general geology and mineral resources of Ste. Genevieve County, which embraces portions of several quadrangles, the State Bureau of Economic Geology and Mines has performed by far the greater part of the work, and the mapping of the county for State publication is completed. Field examinations necessary to the mapping of the portions of the Farmington and Weingarten quadrangles lying outside of Ste. Genevieve County were completed under Federal auspices by Stuart St. Clair and F. C. Greene.

In connection with the joint cooperation of the surveys in the States bordering Mississippi River and containing geologic formations of Mississippian age, paleontologic studies have been systematically organized for purposes of classification and correlation, and field conferences between State and Survey geologists and paleontologists were held at a number of critical points.

The folio by F. C. Greene and Henry Hinds, covering the Leavenworth and Smithville quadrangles, including a portion of Kansas, is now in press. The text of the Green City folio is in the hands of Mr. Greene for final revision.

Bulletin 606, on the origin of the Joplin lead and zinc ores, by C. E. Siebenthal, the result of a long-continued and thorough investigation of the geology and ore deposits of the Joplin region, was issued during the year.

The formations in southeastern Missouri included in the proposed "Ozarkian" system were reviewed by E. O. Ulrich in association with State Geologist H. A. Buehler.

#### MONTANA.

The lignite field in the northeast corner of Montana, north of the Fort Peck Indian Reservation, was examined by A. J. Collier, assisted by W. T. Thom, jr., and Raymond Baker. An area of about 1,900 square miles was examined in a detailed reconnaissance, in order that the land might be classified and the coal land thrown open to purchase. The data for the classification of the land have been submitted to the land-classification board, and an account of the geology and lignite resources of the region has also been prepared by Mr. Collier, but the submission of this report has been delayed in order that it might be extended to include the description of adjacent areas, the examination of which was begun in June.

The economic report on the Ekalaka coal field of southeastern Montana was completed by C. M. Bauer and will be submitted for publication in "Contributions to economic geology."

An examination of that part of the Milk River coal field which lies north of the area already examined by L. J. Pepperberg, extending from R. 8 E. to R. 24 E. and embracing about 1,590 square miles, was made by Eugene Stebinger, assisted by W. P. Woodring and J. D. Sears. The data regarding the land in this field have been submitted to the land-classification board, and some progress has been made in the preparation of a report. A rapid reconnaissance of 250 square miles southeast of the mouth of Judith River was also made by Mr. Stebinger and his party, and the land has been classified and appraised.

Reports on the oil possibilities of north-central Montana, including an account of the large gas well near Havre (Bulletin 641-C),

and on anticlines in the Blackfeet Indian Reservation, treating mainly of the belt of disturbed rocks just east of the Rocky Mountain front (Bulletin 641-J), have been prepared and submitted by Mr. Stebinger.

Considerable progress has been made by Mr. Stebinger in the preparation of the Blackfeet-Cut Bank folio.

The report on the geology and coal resources of northern Teton County, by Mr. Stebinger, has been published as Bulletin 621-K; and Folio 196, covering the Philipsburg quadrangle, by F. C. Calkins and W. H. Emmons, has been issued.

The examination of an area in Yellowstone Valley west of Billings for the purpose of locating and mapping anticlines and procuring evidence as to whether or not they contain oil was begun in June, 1916, by E. T. Hancock, assisted by W. T. Thom, jr., and J. D. Sears. Similar investigations in the Mussellsell Valley west of Roundup were begun at the same time by C. F. Bowen, assisted by W. P. Woodring. A paper entitled "Gradation from continental to marine conditions of deposition in central Montana during the Eagle and Judith River epochs," based on studies in Montana in 1914, was offered by Mr. Bowen for Survey publication.

At the close of his work in the Bighorn Basin, Wyo., C. J. Hares made a hurried examination of the Hailstone Basin, about 40 miles northwest of Billings. This basin is eroded in an anticline, and Mr. Hares examined it for the purpose of determining whether or not the stratigraphy and structure are favorable for the occurrence of oil. His report has been prepared and submitted for publication.

In connection with an examination of certain outlying phosphate lands in Granite County and of the Pioneer gold placer district in Powell County, begun early in June, 1916, by J. T. Pardee, an area of approximately 75 square miles was geologically surveyed in semi-detail. The withdrawn phosphate lands in the vicinity of Helena were examined in May and June by A. R. Schultz.

A bulletin on the phosphate deposits of the Garrison and Philipsburg areas was completed by J. T. Pardee and transmitted for publication as Bulletin 640-K.

A paper on the Jefferson limestone was prepared by Edwin Kirk for unofficial publication. Some work was done by W. C. Alden on a paper discussing the glaciation in Glacier National Park.

#### NEVADA.

In pursuance of an investigation of the enrichment of silver ores, which has been in progress for some time, E. S. Bastin spent a week at Virginia City, Nev., in the summer of 1915. A report prepared by Mr. Bastin, in collaboration with F. B. Laney, on the genesis of the ores of Tonopah, as interpreted from detailed microscopic studies of polished surfaces of the ores, was transmitted for publication.



Four months of field work, mostly in the Manhattan district but including reconnaissance work in the Round Mountain, Jefferson, Belmont, and Golden Arrow districts, was done by H. G. Ferguson; and a report on the Golden Arrow and Clifford districts has been transmitted for publication as Bulletin 640-F. Mr. Ferguson has in preparation a report on the geology and ore deposits of the Toquima Range, including the Manhattan district.

A report on the copper deposits of the Yerington district is in preparation by Adolph Knopf. Late in June, 1916, Mr. Knopf investigated reported discoveries of tin ore in the region north of Elko.

A detailed report on the geology and ore deposits of the Ely district, by A. C. Spencer, to be issued as Professional Paper 96, is now in press.

A report on the geology and mineral deposits of the National mining district, by Waldemar Lindgren, has been issued as Bulletin 601.

A reconnaissance report by J. M. Hill on some mining districts in eastern Nevada, mostly in Elko, White Pine, Lincoln, and Clark counties, and on the Ravenswood district, in Lander County, is in press as Bulletin 648. A short report on the ore deposits at Eureka is in hand by G. F. Loughlin.

In pursuance of the plan announced in last year's report for continuing the search for potash, four wells were drilled in the Smoke Creek Desert. Well No. 1, in approximate sec. 14, T. 32 N., R. 21 E. (unsurveyed), was begun July 25, 1915, and drilled to a depth of 310 feet the first day. This well was completed to a depth of 1,200 feet on August 4. Well No. 2, in approximate sec. 8, T. 31 N., R. 21 E. (unsurveyed), was begun August 14 and drilled 145 feet the first day. This hole reached a depth of 680 feet and was then abandoned. Well No. 3, in the southeast corner of sec. 34, T. 31 N., R. 20 E., was begun September 2 and reached a depth of 233 feet the same day and 563 feet the second day. In the night of September 9, when the well was at a depth of 957 feet, an artesian flow of salty water broke out, measuring about 425 gallons a minute. On the flat mud surface, where access was made possible only by the unusual dryness of the season, this flow quickly made further work at this site impossible, and the hole was abandoned. Well No. 4, in approximate sec. 16, T. 29 N., R. 20 E. (unsurveyed), was begun September 23 and reached a depth of 173 feet the same day. This well was completed at a depth of 1,360.7 feet on October 6, the immediate cause of stoppage at this particular depth being a breakage of the hydraulic pumps. These wells give an interesting geologic record concerning these basins and serve as a practical basis for judgment, especially as regards artesian conditions, with regard to a large area of public

lands for which as yet little use has been found, although a commercial amount of potash, the principal object of the search, was not discovered. The logs and samples from these wells will be studied and made a matter of record.

A brief examination with sampling of the Washeim niter claims, near White Plains, was made by H. S. Gale, who, in the course of his investigation for potash and niter salts, visited the Desert Crystal Works, now operating at Huxley, and made traverses of the Duck Lake and Surprise Valley basin, in Nevada and California, and of the upper Quinn River valley.

A very large deposit in the Muddy River valley, near St. Thomas, which had previously been known and exploited as kaolin was recognized as magnesite by Mr. Gale. An examination was made of the deposit and a press announcement was made by the Survey, calling attention to the availability of this material as a source of magnesia, which is one of the materials urgently needed because of the war stoppage of imports.

The alunite deposits 22 miles southwest of Las Vegas were examined and sampled by Mr. Gale, and the great natural cliffs of rock salt exposed along the lower part of Virgin River, in southern Nevada, were examined and sampled by him with reference to a possible potash content.

The study of the sedimentary record in the Black Rock Basin was continued by M. I. Goldman, but this work has not yet been brought to a definite conclusion.

#### NEW HAMPSHIRE.

Mapping of the surface geology of the Keene and Monadnock quadrangles, N. H., was carried forward by Prof. B. K. Emerson, who made considerable progress on the texts and maps for these areas. A brief reconnaissance of the bedrock geology of the Keene quadrangle was made by Arthur Keith.

A paper describing the Newington moraine, in southeastern New Hampshire, and its extensions into Maine and Massachusetts (Professional Paper 108-B) was prepared for publication by F. J. Katz, in association with Arthur Keith.

Detailed geologic studies and areal mapping of the Dover and York quadrangles, which include parts of Maine, were continued by Mr. Katz. A study of the peat deposits and phenomena of the coastal subsidence in these quadrangles was made by Mr. Katz in company with the late Prof. C. A. Davis, and reconnaissance studies were made by Mr. Keith. Office work by Mr. Katz on the maps and collections for the Dover-York folio is progressing.

A general investigation of the plateaus of the northern Piedmont region was begun by Mr. Keith for the purpose of correlating the local features.

## NEW JERSEY.

A critical comparison of the morainal and extramorainal drift in the Easton quadrangle, N. J., was made the subject of a field conference between the State geologist and W. C. Alden in June.

The greensand belt was examined by W. C. Phalen and sampled for chemical analysis with special reference to the availability of the sands as a source of potash. The results of the analyses are in part cited in the report on the production of potash in 1915, published as a chapter of Mineral Resources.

A description of the origin of the salient topographic and scenic features in the Delaware Water Gap quadrangle, which includes also a part of Pennsylvania, was prepared by G. W. Stose and printed on the back of the topographic map of the area.

## NEW MEXICO.

The examination of the Raton coal field, N. Mex., which has been in progress for several field seasons, was continued during July, 1915, by W. T. Lee, who made a detailed survey of about 32 square miles of coal land in the Koehler quadrangle.

A folio covering the Raton and Brilliant quadrangles has been submitted for publication by Mr. Lee, with a section on petrography by J. B. Mertie, jr.

To procure data for the more satisfactory settlement of certain questions relating to geologic structure and the correlation of formations, as well as to the classification and valuation of land in the San Juan Basin, in northwestern New Mexico, accurate areal work in this basin was begun in June, 1915, by C. M. Bauer, assisted by J. B. Reeside, jr., and H. R. Bennett. A large area extending south of San Juan River and up Chaco River to Meyers Creek, embracing about 1,300 square miles, was examined and mapped by plane-table methods. The results of this work are in part embodied in a paper entitled "Stratigraphy of a part of the Chaco River valley." This paper, which describes the later Cretaceous formations, serves as a general geologic introduction to three paleontologic papers on the fossils collected by this party. The four papers have been submitted for publication in "Shorter contributions to general geology, 1916" (Professional Papers 98-P to 98-S) under the general title "Contributions to the geology and paleontology of San Juan County, N. Mex." The vertebrate fossils are described by C. W. Gilmore, the invertebrate fossils by T. W. Stanton, and the fossil plants by F. H. Knowlton. Another paper on the coals of the Fruitland formation was completed and submitted by Mr. Bauer prior to his resignation in May to enter the service of one of the large oil companies.

A general report on the Datil Mountain coal field, by D. E. Winchester, is now about half completed, and another on the geology of the Zuni Indian Reservation is in progress, but both papers have been set aside temporarily on account of Mr. Winchester's investigations of oil shales in Colorado and Utah.

Field examinations of the "Red Beds" and their included saline and gypsum deposits were continued by N. H. Darton. These investigations, which have for their object the interpretation of the history of the deposition of this series of beds and especially the determination of the centers of greatest saline precipitation and consequently the areas in which beds of potash salts are more likely to be present, covered a large part of New Mexico and indicated that the principal saline deposits were in the eastern part of the State.

The nitrate claims in the vicinity of Rodeo were examined and sampled by H. S. Gale.

The copper deposits of the Burro Mountains (Tyrone district), in the southern part of the State, were studied by Sidney Paige, who geologically mapped 35 square miles in detail. His report on this district will be submitted early in the coming fiscal year.

The geology and copper deposits of the Santa Rita district, which A. C. Spencer and his associates have studied for portions of two field seasons, form the subject of a report now in preparation by Mr. Spencer.

Two weeks were spent at Magdalena in the summer of 1915 by G. F. Loughlin preparatory to making a detailed survey of the district during the summer of 1916. Mr. Loughlin's work was primarily underground, though it included about 5 square miles of reconnaissance surveying.

The Silver City folio (No. 199), prepared by Sidney Paige, and Bulletin 618, "Geology and underground waters of Luna County, N. Mex.," by N. H. Darton, were published in April. The folio for the Deming quadrangle, by Mr. Darton, is now in process of engraving and printing.

A report on the Navajo country, a reconnaissance of parts of Arizona, New Mexico, and Utah, by H. E. Gregory, has been submitted for publication as Professional Paper 93.

#### NEW YORK.

The areal and economic survey of the Berlin quadrangle, N. Y., including a small area in Massachusetts, was continued by L. M. Prindle, who mapped in detail about 10 square miles. Office work on the Berlin-Greylock folio text and maps is well advanced toward completion. The manuscript, maps, and illustrations describing the Pleistocene formations were submitted by F. B. Taylor for inclusion in this folio.



The glacial phenomena of the Cambridge, Equinox, and adjacent quadrangles were reviewed by Mr. Taylor and W. C. Alden in June.

The illustrations for the Pleistocene portions of the Pittsfield-Becket and Sheffield-Sandisfield folios, covering quadrangles in New York and Massachusetts, were submitted by Mr. Taylor, who also completed the corresponding portion of the Hoosic-Bennington folio, covering quadrangles in New York, Vermont, and Massachusetts.

#### NORTH CAROLINA.

The text and maps for the Kings Mountain and Gaffney quadrangles, partly in North Carolina but mostly in South Carolina, were practically completed by D. B. Sterrett, and the folio covering them is nearly ready to be submitted for publication. The maps and descriptions of the Lincolnton quadrangle are also nearly completed by Mr. Sterrett, but it is planned that this quadrangle will be described in a folio together with the Gastonia quadrangle, in which work will be undertaken later.

A report by L. W. Stephenson on the Cretaceous Coelenterata, Vermes, and Mollusca of North Carolina has been completed and transmitted for publication. This report is cooperative and is to be published by the State as part of a monograph on the Cretaceous faunas and floras.

A report on the Tertiary invertebrates of the State is nearly ready for submission. The older Tertiary Bryozoa are described in a report, now almost completed, by F. Canu and R. S. Bassler.

The sericite rocks in the vicinity of Gold Hill and Kings Mountain were examined by P. S. Smith with the object of determining their potash content and the purity and thickness of sericite that may be available in the best localities known. Samples were collected at many places for chemical analysis in the Survey laboratory. The results will be published at an early date.

In order to gain both chemical and quantitative information as to the rocks in the Eastern States that may be used for potash extraction or potash fertilizers, the greensands on Contentnea Creek were examined by G. H. Ashley and sampled for analysis and study.

#### NORTH DAKOTA.

The lignite resources of the New Salem lignite fields are described in detail by E. T. Hancock in a paper submitted for bulletin publication.

A general description of the lignite fields of North Dakota, to be published as a part of Professional Paper 100, "The coal fields of the United States," was prepared by C. J. Hares and C. M. Bauer.

A report on the Edgeley and Lamoure quadrangles for folio publication was submitted by H. A. Hard, a local geologist, who had done the field work and prepared the report under agreement with the Survey.

## OHIO.

In the Woodsfield and Summerfield quadrangles, Ohio, final field investigations of the structure of the oil sands in the Mississippian and Devonian strata have been made. A special effort has been made to procure logs and to ascertain the locations and elevations of wells in a number of pools, as the more accurate delineation of the structure of the deeper sands, made possible thereby, is proving to be of the greatest importance. The thorough study of the structure in these lower sands by R. V. A. Mills promises to show that in this region the segregation of the oil and gas in pools is strictly in accordance with the anticlinal theory. The contrary belief among many oil operators and many geologists is found to be due to an unusual lack of parallelism between the Pennsylvanian rocks, which crop out at the surface, and the underlying Mississippian and Devonian sands, on account of which the structure of the deep sands is imperfectly or even erroneously indicated by the structure of the exposed formations. Preliminary reports on the structure of the Berea oil sand in the Summerfield quadrangle (Bulletin 621-N) and in the Woodsfield quadrangle (Bulletin 621-O), both by D. D. Condit, have been published. In this work Mr. Condit has been assisted by Mr. Mills.

The structure of the Clinton sand in the vicinity of Wooster, in Wayne County, is described in a paper by C. A. Bonine, published as Bulletin 621-H.

The geology of the Columbus quadrangle is described and mapped in detail in Folio 197, which has been published during the year. In this folio, prepared by Profs. G. D. Hubbard, C. R. Stauffer, J. A. Bownocker (State geologist), and C. S. Prosser, through the courtesy of the State Geological Survey, unusual attention is given to the educational function of the Geologic Atlas.

In June the gas and oil developments in the vicinity of Cleveland were revisited by G. S. Rogers, and a report by him on the geologic structure of that area has been submitted for publication in "Contributions to economic geology."

Revised estimates of the original coal tonnage of Ohio have been carefully compiled by F. R. Clark for inclusion in the professional paper on the coal fields of the United States, in preparation under the direction of M. R. Campbell.

A report on the geology of the Steubenville and Cadiz quadrangles, by D. D. Condit, has been submitted for publication as a folio.

The field relation of the Cleveland and Huron shales to the Chagrin formation in the vicinity of Cleveland were studied by E. O. Ulrich and H. P. Cushing. The Cleveland folio, by Mr. Cushing and F. B. Van Horn, is now in process of revision by the authors.

The Hamilton and Mason quadrangles have been mapped in detail in previous years, and R. S. Bassler has practically completed his manuscript and maps for a folio covering this area, in association with Dr. N. M. Fenneman. The folio can not be finished, however, until certain features in the Cincinnati quadrangle are worked out by E. O. Ulrich.

#### OKLAHOMA.

In continuance of the investigations of the geologic structure and oil possibilities of different areas in Oklahoma both reconnaissance and detailed studies have been conducted, though on account of the reduced appropriation made by the State to its Geological Survey the cooperation of that organization consisted in courtesies and generously given information instead of the allotment of funds as in previous years.

The Foraker 15-minute quadrangle, lying in the Osage Nation along the Kansas line west of the Pawhuska quadrangle, was examined by K. C. Heald, and a report describing the structure and oil prospects of the area that has not yet been leased is now in press as Bulletin 641-B. Inspections of the outcropping formations and surface indications of structure in portions of the Osage Nation not yet topographically mapped were made by C. H. Wegemann and Mr. Heald.

The northern half of the Bristow quadrangle, which lies a few miles to the east of the Cushing pool, was examined in detail by A. E. Fath, who, notwithstanding the great difficulty of determining the geologic structure in the area, caused by local conditions, made very successful progress. A report on the area studied is now in preparation.

In connection with the investigation of the gas resources of the region potentially tributary to Fort Worth and Dallas, Tex., inspections and preliminary examinations were made by C. H. Wegemann of recent gas discoveries and of prospects along the southern border of the Oklahoma oil field, the prospects southwest of Muskogee, near Ada, being given special attention. Notes on this work by Mr. Wegemann were published in Bulletin 629.

The study of the structure, the areal geology, and the oil and gas developments in the Hominy 30-minute quadrangle was continued by R. H. Wood. The preparation of Mr. Wood's bulletin on the oil and gas structure of the quadrangle and of his report on the general geology is unfortunately delayed on account of errors in the eleva-

tions recorded in a part of the Hominy topographic sheet, and it is therefore probable that Mr. Wood's manuscript covering this quadrangle will not be completed before October.

The Healdton oil field, the Loco gas field, the Duncan gas field, and the Lawton oil and gas field, of which all except the first were examined with the cooperation of the State Geological Survey during the previous year, have been described in papers published, respectively, as parts B, C, D, and G of Bulletin 621. A report on the area lying between Beggs, Okmulgee, and Okemah, cooperatively examined in the same year, is now in preparation.

A manuscript for a bulletin by D. W. Ohern on the geology and economic deposits of the Nowata and Vinita quadrangles has been critically reviewed and is now in the hands of the author for final revision prior to publication.

The zinc and lead developments in the vicinity of Miami and Quapaw, in the Wyandotte quadrangle, were examined by C. E. Sieben-thal, who procured data for inclusion in his reports on the Joplin district and in the folio for the Wyandotte quadrangle.

#### OREGON.

Maps and manuscripts for the geologic folio covering the Sumpter quadrangle, Oreg., the areal surveys for which were completed last year, were completed in part by J. T. Pardee. Reconnaissance examinations along the valleys of the South Fork of John Day River above Dayville and the Middle Fork of John Day River above Ritter were made by D. F. Hewett in June, 1915, and the results of these examinations will be included in the same folio. The principal routes of travel in an area 600 miles square were traversed. In July, 1915, a reconnaissance examination of deposits of volcanic ash along Umatilla River near Pendleton was made by Mr. Hewett.

About 50 square miles of the Riddles quadrangle, including the developments in copper and gold mining, were reviewed by J. S. Diller, who, with G. F. Kay, completed and submitted in January, 1916, the Riddles folio for publication.

A report on the Howard mining district, examined by G. F. Loughlin in a previous season, is in preparation.

Alkali Lake was visited and sampled by H. S. Gale with reference to the somewhat unusual potash content and the borax reported to occur in the brines which it contains.

Nitrate claims in the vicinity of Burns and near Placidia Butte and Wagontire Mountain, 40 to 60 miles southwest of Burns, were investigated by Mr. Gale and samples collected for analysis. A reported deposit near McDermitt, on the Oregon-Nevada State line, was also visited.



Abert Lake was examined and sampled by Mr. Gale with reference to the potash content of its waters, and he made a single traverse across the Malheur Lake basin and a traverse of the basins of the Mann and Alvord lakes, in the southern part of the State.

#### PENNSYLVANIA.

Some revisory study was accomplished by Miss Florence Bascom and E. T. Wherry in the Reading and Boyertown quadrangles, the text and maps for which are almost completed for transmission.

Mapping of the McCalls Ferry and Quarryville quadrangles was continued by Miss E. F. Bliss, who covered about 288 square miles in considerable detail. Some progress was made on the text and maps for the folio covering these quadrangles, which was begun by Prof. E. B. Mathews.

No further field work has been done in the Quakertown and Doylestown quadrangles. Prof. Bascom, the senior geologist on this project, has completed her field work, and some progress has been made on the text and maps for her portion of the folio covering these quadrangles.

In the Coatesville and West Chester quadrangles Prof. Bascom has been engaged in a revisory study of the gneisses. Work on the text and maps for the folio embracing these quadrangles is progressing well.

The mapping of the Paleozoic limestone formations in the New Cumberland, Harrisburg, Hummelstown, Middletown, and Lebanon quadrangles occupied G. W. Stose for a part of the field season, and the Paleozoic formations of central and southern Pennsylvania were reviewed by E. O. Ulrich and Charles Butts for the purpose of correlating the formations in several areas covered by folios recently published and in preparation.

Points in the Hollidaysburg, Huntingdon, and Bellefonte quadrangles and areas between and farther northeast were reexamined by Mr. Butts, who, in the Bellefonte quadrangle, conferred with Prof. E. S. Moore. The text and maps for the Huntingdon-Hollidaysburg folio are nearly completed by Mr. Butts.

Considerable progress on the text and maps for a folio covering the Fairfield and Gettysburg quadrangles, surveyed in previous years, was made by Mr. Stose and Prof. Bascom. The text for the historical geology and a section across the Triassic area were prepared by Mr. Stose.

The folio covering the Elkton and Wilmington quadrangles, by Prof. Bascom and B. L. Miller, has been transmitted for publication. These quadrangles include areas in Maryland and Delaware, and the folio was prepared in cooperation with the Maryland Geological Survey.

The Butler quadrangle was examined and mapped by G. B. Richardson, who covered the north half, and R. V. A. Mills, who studied the south half; and a report describing the structure and coal and oil resources is in preparation. Work was begun in June in the Zelenople quadrangle, in which Mr. Richardson was assisted by Prof. T. C. Brown.

Brief examinations in conference on the extramorphinal drift in eastern Pennsylvania were held by W. C. Alden with Prof. Bascom and E. T. Wherry in the Reading quadrangle, with B. L. Miller in the Allentown quadrangle, with H. B. Kummel in the Easton quadrangle. In western Pennsylvania Mr. Alden reviewed with G. B. Richardson Pleistocene deposits in the Zelenople and Warren quadrangles.

A paper on the relations of the Wissahickon gneiss to the Shenandoah limestone and Octoraro schist of the Doe Run and Avondale region, Chester County, by Misses E. F. Bliss and A. I. Jonas, was published as Professional Paper 98-B.

#### RHODE ISLAND.

The geology of the islands off the south coast of Rhode Island was studied by J. B. Woodworth, and a report on them is in preparation.

A bulletin on Rhode Island coal, by G. H. Ashley, was published as Bulletin 615.

#### SOUTH CAROLINA.

The maps and manuscript for the folio covering the Kings Mountain and Gaffney quadrangles, which are mainly in South Carolina but include small areas in North Carolina, have been practically completed, and the material has been submitted for publication by D. B. Sterrett.

Some of the sericite rocks in North Carolina, South Carolina, and Georgia were examined by P. S. Smith, with the object of determining their potash content, purity, thickness, and accessibility. Samples for analysis were collected at many places in the vicinity of Blacksburg, S. C. A report of the investigation is in preparation by Mr. Smith.

Several weeks were spent by C. W. Cooke in field work on the Claiborne and Jackson formations of South Carolina, for the purpose of determining the age of the deposits of fuller's earth in Georgia and of establishing their correlation with formations in South Carolina.

Descriptions of the older Tertiary Bryozoa of the State are included in a general report, now almost completed, by F. Canu and R. S. Bassler.

## SOUTH DAKOTA.

Maps and descriptions of the geology of the Deadwood, Harney Peak, Rapid, and Hermosa quadrangles, covering the greater part of the Black Hills, mapped on a scale of 1:125,000, were transmitted by N. H. Darton and Sidney Paige, Mr. Darton describing the Paleozoic and bordering younger sedimentary formations and Mr. Paige mapping and describing the pre-Cambrian geology and the mineral resources of the Black Hills. In response to a request from the Secretary of the Interior, a report was made on certain mining claims in the Harney National Forest by Mr. Paige.

Field studies of the Newell quadrangle were completed by Mr. Darton for the Newell folio, which is now in press.

Having accumulated new data regarding artesian prospects in western South Dakota, Mr. Darton prepared a report on artesian waters in the region adjoining the Black Hills, which will be published as a water-supply paper.

A report on the coal fields of northwestern South Dakota, by E. R. Lloyd, E. M. Parks, C. J. Hares, and D. E. Winchester, is in press as Bulletin 627.

## TENNESSEE.

A geologic map of the Waynesboro quadrangle, Tenn., prepared by H. D. Miser, was transmitted for use in differentiating the formations in an adjoining area by the State Survey. The results of the studies by Mr. Miser will be embodied in the Waynesboro folio.

The areal mapping and structural determinations of parts of the Crossville quadrangle were revised by Charles Butts. A paper on the geologic structure with reference to oil and gas was prepared by Mr. Butts for publication by the State Survey, and a report on the coals of a portion of the quadrangle has been submitted by Mr. Butts, who also inspected the Mississippian and Silurian sections in the vicinity of Sparta and Nashville. During a part of the field work Mr. Butts was joined for conference by G. H. Ashley. These investigations were conducted in cooperation with the State.

The stratigraphic section of the Murfreesboro quadrangle was reviewed by E. O. Ulrich, for the purpose of determining the units to be mapped, and collections of early Paleozoic invertebrates for correlation were obtained by R. D. Mesler near Chattanooga, Wauhatchie, Carthage, Friendsville, White Pine, Dandridge, Whitesburg, and Midway.

The greensands in southern McNairy County were examined by G. H. Ashley, with special reference to their possible use in the production of potash, large percentages of which had been reported in earlier analyses. The beds were sampled and studied with reference

to their extent, accessibility, and origin, as well as their potash content. A report by Mr. Ashley giving the results of the examination is now in preparation.

A report on the marble deposits of the State, based on work done in cooperation by the Bureau of Mines, the Bureau of Standards, the Office of Public Roads and Rural Engineering, the State Geological Survey, and the United States Geological Survey, is nearly complete. T. N. Dale, who for this Survey has sampled and examined the marbles mineralogically and petrologically, has finished his part of the work, which is ready to transmit for publication by the State Geological Survey. A summary of the work of Mr. Dale and of the areal geology by C. H. Gordon, assistant State geologist, will be included in a general report on the southern Appalachian marble deposits.

A report on the later Tertiary and Pleistocene history of the western part of the State is in preparation by E. W. Shaw. The erosion intervals in the Eocene of the Mississippi embayment are described in Professional Paper 95-F by E. W. Berry, and his monographic account of the old Eocene floras of the Coastal Plain is in press as Professional Paper 91.

Slight progress was made on a cooperative report describing the red iron ores of eastern Tennessee, northeastern Alabama, and northwestern Georgia, in preparation by E. F. Burchard, most of Mr. Burchard's time being demanded by other duties.

Chemical analyses made from samples collected by F. R. Clark at all the shipping coal mines of the State are published, with descriptive notes and sections, in Bulletin 621-P.

#### TEXAS.

At the request of the municipalities of Dallas and Fort Worth, Tex., that the Survey investigate the gas resources in the region tributary to these cities with special reference to the prospects for an adequate gas supply for the future, examinations were made in the autumn of 1915 of as large an area as could be studied, mapped, and described in a report to be published by January, the cost of the field work being cooperatively contributed by the two cities. The results of the work were, for the most part, issued in Bulletin 629.

In the Coastal Plain region the gas and oil fields of Limestone and Navarro counties were examined, and a report on the gas field in Limestone County by G. C. Matson was included in Bulletin 629. The oil and gas fields of this county will be more fully described in a report by Mr. Matson and O. B. Hopkins, which is now in preparation. The results of chemical examinations of the oils of Navarro County, based on samples submitted to the Bureau of Mines for



examination, will also be incorporated in this publication. The oil and gas indications near Wortham, Currie, Richland, and Angus, in northern Limestone and southern Navarro counties, and at Mabank, Kaufman County, and Cash, Hunt County, were examined by Mr. Matson and described by him in Bulletin 629.

In the Paleozoic area the Strawn and Moran pools were studied and the structure of an area in the vicinity of Weatherford, Parker County, was mapped by H. M. Robinson and C. W. Hamman under the direction of E. W. Shaw. The Petrolia-Henrietta region was examined and mapped by Mr. Shaw, assisted by Mr. Robinson. Mr. Shaw made exploratory structural examinations in a large area north and west of Fort Worth. The results of these investigations are included in Mr. Shaw's contribution to Bulletin 629.

The reported oil and gas indications at Watauga, Tarrant County, and Baileyville, Milam County, were visited by O. B. Hopkins, and the area near Wolfe City, Hunt County, was examined by Mr. Hopkins and C. W. Hamman.

After a full test of the possibilities of discovering buried deposits of potash in the Smoke Creek Desert of western Nevada, the Survey drill outfit was shipped to the Panhandle of Texas as a region offering great promise in the Permo-Triassic "Red Beds" country of the Southwest. The studies by N. H. Darton of the stratigraphy, of the history of "Red Beds" deposition, and of the evidence of massive beds of gypsum, salt, and anhydrite in these rocks in New Mexico, Colorado, and Texas indicated a region of great precipitation of saline deposits in "Red Beds" time. A site near Cliffside, 7 miles northwest of Amarillo, Tex., was chosen by Mr. Darton and H. S. Gale in order to procure fuller and exact data as to the position, thickness, and richness of the beds that furnished crystals of potash salt and potash brines. The drilling at Cliffside was started late in the autumn; and on account of the exhaustion of the balance of the very small appropriation, already largely used in the work that had been carried on in Nevada, the work was stopped February 28, 1916, when the hole had reached a depth of 362 feet and before the salt beds, which should be found at intervals between 750 and 2,300 feet, had been encountered. The work will be continued in the next fiscal year.

Supplementary field studies along the zone of an uplift, including Denison and extending eastward in northeastern Texas, were made by L. W. Stephenson to correct errors in the previous geologic mapping of the Cretaceous formations of the area and to ascertain with greater accuracy the age relations of these formations. The geologic structure in Grayson County near Sherman and Fannin County near Bonham was examined by Mr. Stephenson and will be made the subject of a bulletin. Several reports were made by Survey

paleontologists on small referred collections from Texas, and the floras of Jackson and Claiborne age have been described in a paper in preparation by E. W. Berry.

A report on the geology of the Coastal Plain of Texas west of Brazos River, by Alexander Deussen, has been completed and submitted for publication. The ground waters of Lasalle and McMullen counties have been described by Mr. Deussen and R. B. Dole in Water-Supply Paper 375-G.

The iron ores in Cass, Marion, Morris, and Cherokee counties are discussed in Bulletin 620-E by E. F. Burchard.

A report on the geography and geology of the trans-Pecos region, by R. T. Hill, is under revision by the author with special reference to recent progress in the definition of physiographic provinces in the United States.

The results of examinations of the geologic structure and oil and gas prospects in a part of Palo Pinto County and near Quanah in Hardeman County, by C. H. Wegemann, have been printed in parts E and J, respectively, of Bulletin 621.

#### UTAH.

The general summary report on the ore deposits of Utah, by B. S. Butler and G. F. Loughlin, field studies for which have been in progress for two or more seasons, was submitted for publication in May, 1916.

Newly discovered zinc deposits in the Promontory Range, examined in September, 1915, by Mr. Butler and V. C. Heikes, are described in a brief report issued as Bulletin 640-A and entitled "Notes on the Promontory district, Utah."

A reconnaissance report on the Cottonwood-American Fork mining region, by Messrs. Butler, Loughlin, and Heikes, was published late in 1915 as Bulletin 620-I. A thorough study of this region is now in progress.

The report on the geology and ore deposits of the Tintic district, revisited by Waldemar Lindgren and Mr. Loughlin in 1914, has been transmitted for publication.

A reexamination of the alunite deposits at Marysvale, made by Mr. Loughlin and H. S. Gale in response to a special request from mining men, resulted in the publication of Bulletin 620-K, "Recent alunite developments near Marysvale and Beaver, Utah," by Mr. Loughlin.

The reconnaissance report on the Navajo country, covering parts of Arizona, New Mexico, and Utah, by H. E. Gregory, has been transmitted for publication as Professional Paper 93.

The deposits of ozokerite in central Utah are described in Bulletin 641-A by H. M. Robinson.

Geologic folios and economic reports for the Sunnyside, Wellington, and Castlegate quadrangles, which embrace the most important part of the Book Cliffs coal field, are in preparation by F. R. Clark, who has also made some progress in the preparation of an economic report on the Lost Creek coal field.

Further examinations of the deposits of oil shale in northeastern Utah were made by D. E. Winchester, who made more exact as well as more numerous field tests than had been possible with the apparatus used by Messrs. Day and Woodruff. Advance notices of the richness of some of these extensive deposits and of the enormous reserve of oil, gasoline, and other hydrocarbon products which they contain were issued during the winter. A preliminary report of the results of the investigations by Mr. Winchester is in press as Bulletin 641-F.

A report on the geology and coal resources of Castle Valley, Carbon, Emery, and Sevier counties, by C. T. Lupton, has been published as Bulletin 628.

Data for a report on the building stones of Utah are being accumulated by G. F. Loughlin.

A statement concerning potash in the Salduro Marsh was prepared by H. S. Gale and submitted to the Engineering and Mining Journal for publication.

An examination of the Mississippian phosphate deposits and of the stratigraphy in the Logan quadrangle was made by E. H. Finch, and township reports were submitted to the land-classification board. Phosphate beds in northern Utah were mapped by A. R. Schultz, who also made a preliminary examination of the geology and structure of the Uinta Range.

#### VERMONT.

The areal survey of the Bennington quadrangle, Vermont, was continued by L. M. Prindle, about 40 square miles being covered, principally in the pre-Cambrian rocks. This quadrangle, together with the Hoosick quadrangle, N. Y., will be described in a folio, the text and maps for which are nearing completion.

In the field Prof. T. N. Dale continued his traverse of the area between the pre-Cambrian gneiss and the Cambrian schist and quartzite in the Londonderry, Wallingford, Ludlow, Townshend, and Rutland quadrangles, about 40 square miles being studied. The results of this work were embodied in a paper, "Notes and map of the pre-Cambrian boundary east of the Green Mountain axis," which was submitted for publication. Prof. Dale also completed his catalogue of 2,626 thin sections made in connection with his work in Vermont quadrangles during past field seasons.

The special investigation of the stratigraphy and faulted structure of the Taconic Mountains in the Castleton and Pawlet quad-

rangles was continued by Arthur Keith for the purpose of solving certain intricate problems there before the western Vermont folios can be published.

The study of the pre-Cambrian formations and structure and the detailed areal mapping in the Rutland quadrangle was continued by Mr. Keith, who made a detailed survey of the West Rutland marble district, in the Castleton quadrangle.

Detailed geologic mapping along the south border of the Rochester quadrangle was begun by Mr. Keith, and he also made reconnaissance examinations of the Devonian rocks in the Brattleboro quadrangle and of the pre-Cambrian rocks in the Ludlow, Wallingford, Woodstock, and Rochester quadrangles.

A manuscript describing the Quaternary geology of the Hoosic and Bennington quadrangles was completed by F. B. Taylor.

A brief study of the glacial phenomena in the Cambridge, Equinox, and adjacent quadrangles was made in June by W. C. Alden and Mr. Taylor.

#### VIRGINIA.

As the result of brief visits to manganese mines in Virginia and Maryland during 1913, 1914, and 1915, a report entitled "Some manganese deposits of Virginia and Maryland" was prepared by D. F. Hewett for publication as Bulletin 640-C. In this report Mr. Hewett shows a probable relation between the deposition of the ores and the physiographic history of the region.

The detailed mapping and description of the southwestern Virginia coal field, which have for two years been in progress under the immediate direction of Henry Hinds, were carried on during the season by Mr. Hinds, assisted by T. K. Harnsberger. The mapping of the quadrangles was completed, and in June, 1916, field work in Buchanan County was resumed and nearly completed. During the office season a report on the coal resources of the Clintwood and Bucu quadrangles was prepared by Mr. Hinds and transmitted to the State, and it is now in press.

A report on the salt and gypsum of southwestern Virginia, for publication by the State Survey, was prepared by G. W. Stose and submitted to the State geologist. The folio on the Abingdon quadrangle is to be prepared by Mr. Stose in association with Arthur Keith.

A paper on the gypsum deposits in southwestern Virginia by Mr. Stose was revised and transmitted for publication by the Survey.

The greensands on Potomac River at Aquia Creek were examined by G. H. Ashley and sampled for analysis and study with special reference to their potash content.



The Silurian and Devonian formations near Big Stone Gap were studied and paleontologic collections obtained from them by E. O. Ulrich, assisted by T. E. Williard. Paleozoic invertebrate fossils were collected near Wytheville and Mount Sidney by R. D. Mesler.

A report on the Tertiary invertebrates of the State is almost complete. The Miocene flora at Richmond is described by E. W. Berry in Professional Paper 98-F.

## WASHINGTON.

A reconnaissance report on the Conconully and Ruby mining districts, Wash., by E. L. Jones, jr., has been issued as Bulletin 640-B. Mr. Jones also prepared and submitted classification reports on lands in contest between homestead and mining claimants in T. 40 N., Rs. 29 and 30 E. Willamette meridian.

The manuscript for a bulletin entitled "The mineral deposits of the Colville Indian Reservation," begun in the preceding year, was completed by J. T. Pardee.

Text to accompany the map of Mount Rainier National Park was submitted by F. E. Matthes.

## WEST VIRGINIA.

Office work on the maps and description of the Williamsport quadrangle, in West Virginia, Maryland, and Pennsylvania, has been advanced by G. W. Stose for the Williamsport-Hagerstown folio. The work is being done in cooperation with the State of Maryland.

## WISCONSIN.

A folio for the Wausau and Marathon quadrangles, Wis., is now being prepared by Dr. Samuel Weidman under agreement, the field examinations of these quadrangles having been made, in cooperation, by the State Geological and Natural History Survey.

## WYOMING.

Field work in the Bighorn Basin, Wyo., which was begun in June, 1914, was continued by C. T. Lupton in 1915. Mr. Lupton was assisted, in part or all of the field work, by M. W. Ball, R. H. Wood, E. M. Parks, W. B. Emery, and C. J. Hares. The work consisted in the examination of all the anticlines in the basin, in order to determine which have most promise of containing oil or gas. The territory surveyed embraced an area of about 680 square miles. This work, together with that done by Mr. Lupton the previous year and by D. F. Hewett, covered the entire southern two-thirds of the Bighorn Basin. Upon Mr. Lupton's return to the office it was decided to combine all the reports on anticlines in the basin into one paper,

of which he is principal author. This report, in which the descriptions of the anticlines in the Oregon Basin and the Ilo and Meeteetse quadrangles are contributed by Mr. Hewett, has been submitted and is undergoing critical examination.

Areal geologic work in the Hanna coal field was continued by C. F. Bowen, who, with the assistance of H. M. Robinson and C. J. Hares, mapped in great detail the Saddleback Hills quadrangle and a part of the Hanna quadrangle, an area of about 500 square miles. In addition, Mr. Bowen made a special examination of T. 19 N., R. 77 W., to classify the land. In the office Mr. Bowen has been engaged in preparing geologic folios and economic reports on the Walcott, Hanna, and Saddleback Hills quadrangles and in preparing data for the classification and valuation of the lands.

Mr. Hares prepared a preliminary report on anticlines in central Wyoming, which is now in press as Bulletin 641-I. A general report on the same region, which will describe fully the formations and discuss their probable correlations with formations in adjacent fields, will be ready for publication early in the following year.

A report on prospects for oil and gas near Basin, Big Horn County, by Mr. Lupton, has been published as Bulletin 621-L.

The examination of the Powder River coal field, which was begun in June, 1915, was continued by C. H. Wegemann, assisted by R. W. Howell, and extended to include the Salt Creek oil field. Mr. Howell assumed general charge of the coal work, and Mr. Wegemann of the oil work. The area of the coal field examined is 1,900 square miles. The parts where coal beds were found were examined in great detail, but other parts were surveyed only in reconnaissance. Mr. Howell spent the winter in preparing data for land classification and valuation and in writing an economic report for publication. This work is well advanced. Mr. Wegemann made a very detailed reexamination of the Salt Creek oil field, and his report on it is now nearly ready for critical review.

Phosphate beds at several localities in Wyoming, Colorado, and Utah were examined by A. R. Schultz, who made a preliminary study of the geology and structure of the Uinta Range.

Fourteen township reports and a general report on the phosphate of the Owl Creek Mountains region have been completed by D. D. Condit and transmitted to the land-classification board.

A report on the flora of the Frontier formation by F. H. Knowlton has been submitted for publication, and a "Note on the discovery of fossil plants in the Morrison formation" of the Bighorn Basin, by the same paleontologist, has been published unofficially. A study of the Bighorn limestone and its fauna was continued by Edwin Kirk both in the field and in the laboratory.

The Cretaceous and Tertiary section of the Hanna and Saddleback Hills quadrangles was reviewed by T. W. Stanton under the guidance of C. F. Bowen.

Reports on reconnaissance examinations of ore deposits in the Atlantic gold district and the North Laramie Mountains, by A. C. Spencer, were published during the year as Bulletin 626. To this bulletin N. H. Darton contributed a chapter on the sedimentary formations and a geologic map of part of central Wyoming.

Some progress was made by Arnold Hague in the description of the geology of the Yellowstone National Park.

Office work was continued by G. R. Mansfield on the Montpelier, Slug Creek-Crow Creek, and Lanes Creek-Freedom folios, covering quadrangles in Wyoming and Idaho.

The results of chemical experiments by R. C. Wells relating to the extraction of potash from the wyomingite of the Leucite Hills are described in Professional Paper 98-D.

#### CANAL ZONE.

A bulletin entitled "Some engineering problems of the Panama Canal," by D. F. MacDonald, was completed and published as Bulletin 86 of the Bureau of Mines. Progress was made in the preparation of a report on the geography and geology of Panama by Mr. MacDonald, who also cooperated with the committee from the National Academy of Sciences appointed at the request of the President to study and report on the Panama Canal slide problem. Whitman Cross and G. F. Becker, geologists, were members of this committee. Mr. Becker submitted a short paper entitled "Mechanics of the Panama Canal slides," to be published as Professional Paper 98-N.

A report upon the Foraminifera of the Canal Zone, exclusive of the orbitoids and nummulitids, was completed and submitted by J. A. Cushman, who is now making a special study of the larger orbitoid species and genera from that area.

#### WEST INDIES.

A report on some Cenozoic Mollusca of the West Indies was completed by C. W. Cooke. This paper will be published by the Carnegie Institution. Other reports on Antillean paleontology completed during the year discuss the calcareous algae, by M. A. Howe; the Bryozoa, by R. S. Bassler and F. Canu; and the Crustacea, by Miss M. J. Rathbun. Reports on the geology and geologic history of Cuba, by T. W. Vaughan, O. E. Meinzer, and others, and on the geology and geologic history of the Windward Islands, by R. T. Hill and Mr. Vaughan, are almost complete. The Survey has been

at no expense for the work of Messrs. Howe, Bassler, Canu, and Hill and Miss Rathbun. Papers on the shore-line features and the corals and coral reefs by T. W. Vaughan were published unofficially during the year.

#### DIVISION OF ALASKAN MINERAL RESOURCES.

##### APPROPRIATION AND CLASSES OF WORK.

Under the appropriation of \$100,000 made for the continuation of the investigation of the mineral resources of Alaska, as in previous years, work of the following classes was carried on: Reconnaissance and detailed geologic surveys, special investigations of mineral resources, reconnaissance and detailed topographic surveys, investigations of water resources, and collection of statistics on mineral production.

##### PERSONNEL.

On July 1, 1915, the personnel of the division consisted of 1 geologist in charge, 11 geologists, 4 topographers, 1 engineer, 3 clerks, and 1 draftsman on annual salaries, 1 clerk on monthly salary, 2 geologists on per diem salary, 1 field assistant, and 28 camp hands and recorders. On June 30, 1916, the personnel included 1 geologist in charge, 11 geologists, 4 topographic engineers, 1 hydraulic engineer, 3 clerks, and 1 draftsman on annual salaries. The field force also included 1 assistant and 31 camp hands and recorders.

##### FIELD WORK DURING THE SEASON OF 1915.

*Areas covered and allotments.*—Twelve parties were engaged in surveys and investigations during 1915. The area covered by reconnaissance geologic surveys, on a scale of 1:250,000 (4 miles to the inch), amounts to 10,700 square miles; by detailed geologic surveys, on a scale of 1:62,500 (1 mile to the inch), 200 square miles. Much of the time of the geologists was devoted to the investigation of special field problems in the important mining districts, the results of which can not be presented in terms of area. About 10,400 square miles was covered by reconnaissance topographic surveys on a scale of 1:250,000, and 12.5 square miles on a scale of 1:24,000 (2.64 inches to 1 mile).

The following table shows the allotment, including both field and office expenses, of the total appropriation to the districts investigated. In addition to this, a balance of about \$11,000 from last year's appropriation was expended in equipping the parties for the season's field work. In preparing this table the general office expenses were divided among the districts in a proportion determined by the cost of the surveys in each district, allowance being made for variations in the character of the work. The results are expressed in round



numbers. The "general investigations" include the cost of special studies of geology and mineral resources which were not of an areal character. The balance has been used for equipment of field parties and expenses of the season of 1916.

*Approximate geographic distribution of appropriation for Alaska investigations, 1915-16.*

Southeastern Alaska .....	\$16,300
Copper River .....	10,400
Prince William Sound .....	5,000
Cook Inlet region .....	13,500
Yukon and Kuskokwim basins .....	40,500
General investigations .....	8,300
Allotted to field work, 1916 .....	6,000
	<hr/>
	100,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible to give the exact figures, as the same party or even the same men may have carried on different kinds of work, but this statement will serve to elucidate a later table, which will summarize the complete areal surveys.

*Approximate allotments to different kinds of surveys and investigations, 1915-16.*

Reconnaissance geologic surveys .....	\$28,000
Detailed geologic surveys .....	3,800
Special geologic investigations .....	9,600
Reconnaissance topographic surveys .....	26,000
Detailed topographic surveys .....	3,000
Investigations of water resources .....	5,000
Collection of mineral statistics .....	1,300
Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation .....	17,300
Allotted to field work, 1916 .....	6,000
	<hr/>
	100,000

*Allotments for salaries and field expenses.*

Scientific and technical salaries .....	\$35,918
Field expenses .....	42,332
Clerical and other office and miscellaneous expenses .....	15,750
Allotted to field work, 1916 .....	6,000
	<hr/>
	100,000

The following table exhibits the progress of investigations in Alaska and the annual appropriations since systematic surveys were begun in 1898. It should be noted that a varying amount is spent

each year on special investigations yielding results which can not be expressed in terms of area:

*Progress of surveys in Alaska, 1898-1915.*

Field season.	Appropriations.	Areas covered by geologic surveys.			Areas covered by topographic surveys. <sup>a</sup>					Investigations of water resources. Gaging stations maintained part of year.
		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).	Detailed (scale 1:62,500 and larger; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	
		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	6,209	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
1907.....	80,000	2,600	1,400	442	.....	6,120	501	95	16	48
1908.....	80,000	2,000	2,850	604	.....	3,980	427	76	9	53
1909.....	90,000	6,100	5,500	450	6,190	5,170	444	.....	.....	81
1910.....	90,000	.....	8,635	321	.....	13,815	36	.....	.....	69
1911.....	100,000	8,000	10,550	496	.....	14,460	246	.....	.....	81
1912.....	90,000	.....	2,000	525	.....	.....	298	.....	.....	69
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
	1,361,189	73,200	94,435	4,596	51,680	137,280	3,664	462	74	.....
Percentage of total area of Alaska.....	.....	12.48	16.10	.78	8.81	23.41	.62	.....	.....	.....

<sup>a</sup> The Coast and Geodetic and International Boundary surveys and the General Land Office have also made topographic surveys in Alaska. The areas covered by these surveys are of course not included in the totals given here.

*General work.*—Alfred H. Brooks, geologist in charge, was engaged in office work until July 9, when he started for Alaska. He visited the Canfield party in southeastern Alaska and devoted 10 days to a study of the geology and mineral resources of the Iditarod district, 5 days to the Hot Springs district, and 16 days to the Fairbanks district. In this work special attention was paid to antimony deposits. Returning, he reached Washington October 14. In Mr. Brooks's office work 54 days were devoted to geologic investigations, 24 days to reading and revising manuscripts, 17 to writing articles for the annual progress report, 7 to preparing the annual press bulletin on mining developments in Alaska, 7 to mineral statistics, and 10 to field plans. The rest of his time was devoted to routine and miscellaneous matters.

To G. A. Waring was assigned the task of making a reconnaissance of the more accessible mineral springs of Alaska. He carried on field work in southeastern Alaska from June 15 to July 2, in the Yukon basin from July 10 to August 17, and in Seward Peninsula

from August 28 to September 9. During this time he investigated 18 hot and 5 other springs and collected 27 samples of surface waters.

G. C. Martin and A. G. Maddren were engaged the entire year in office work. This respite from field work was necessary owing to the accumulation of a large amount of field data which had not been completely worked up. Mr. Martin was occupied chiefly in continuing his studies of the Mesozoic stratigraphy of Alaska; Mr. Maddren was employed in preparing reports on the lower Kuskokwim region and on the international boundary region of northwestern Alaska.

Arthur Hollick was employed for six weeks in continuing the preparation of his report on the Cretaceous and Tertiary floras of Alaska.

R. H. Sargent continued the general supervision of the Alaska topographic surveys and map compilation, in addition to carrying on his own field work.

E. M. Aten continued as office assistant to the geologist in charge and supervised the office work during Mr. Brooks's absence in the field. He also continued to assist in collecting statistics of the production of precious metals in Alaska.

*Southeastern Alaska.*—The detailed topographic survey of the region adjacent to Juneau was continued by D. C. Witherspoon. Field work was begun on May 12 and continued, so far as weather permitted, until October 7. The large scale adopted for this base map (1:24,000, or about 2.64 inches to the mile), the rugged character of the country, and the rank and prickly vegetation all combine to make the work exceedingly difficult. In spite of the adverse conditions Mr. Witherspoon completed the mapping of some 12.5 square miles. He also occupied 16 triangulation stations, ran 3 miles of levels, and set 2 permanent bench marks.

The systematic geologic survey of the Ketchikan district, begun in 1913 but interrupted in 1914, was continued in 1915 by Theodore Chapin. He began field work, using a gasoline launch for transportation, on May 16 and continued it until October 23; covered about 420 square miles, and also made special investigations of the mineral resources.

Under a cooperative agreement with the Forest Service the investigation of the water powers of southeastern Alaska was begun in 1915. G. H. Canfield, who had charge of this work, established his headquarters at Ketchikan in May and continued the water measurements to the close of the fiscal year 1916. Eight automatic gaging stations and one other were installed, in addition to which many miscellaneous measurements were made. Records of stream flow will have to be obtained through a period of years before accurate data on run-off are available. Meanwhile the records thus far obtained

are not without value, and these are summarized elsewhere in this volume. Many members of the Forest Service have aided in this work, but special acknowledgment should be made to W. G. Weigle, supervisor at Ketchikan, and to Leonard Lundgren, district engineer at Portland, Oreg.

*Copper River region.*—F. H. Moffit, assisted by R. M. Overbeck, made a geologic reconnaissance of the upper Chitina River basin. A journey was made with pack train up the north side of the Chitina Valley to a point within 10 miles of the international boundary. Field work began on June 20 and ended September 25, and a geologic reconnaissance of about 900 square miles was completed. The topographic map made by the International Boundary Commission was used as a base and was supplemented by topographic reconnaissance surveys of an adjacent area of about 360 square miles.

*Prince William Sound.*—The detailed geologic survey and study of the mineral resources of the Port Valdez district, begun in 1914, was completed in 1915 by B. L. Johnson. He began field work on June 5 and continued it until October 25, covering about 200 square miles.

*Cook Inlet-Susitna region.*—J. W. Bagley devoted the early part of the season to extending a topographic reconnaissance north of the previously mapped areas in the Talkeetna Mountains and surveyed an area of 835 square miles. In addition to this he surveyed an area of 150 square miles in the Turnagain-Knik region. Mr. Bagley, using pack-train transportation, started his field work on June 6 and continued it until September 5. In the early part of the season his surveys were much hampered by the smoke of forest fires, and later he lost nearly three weeks because of the nondelivery of supplies, which, however, was due to an accident and not to the delinquency of the contractor.

S. R. Capps, with a pack train and two men, studied the geology of the Turnagain-Knik region, investigating the geology of an area of about 1,200 square miles. The field work extended from June 14 to September 12, and about a week of this time was spent in investigating the mining developments of the Willow Creek district.

*Yukon-Kuskokwim region.*—Eliot Blackwelder devoted the months of June, July, and August to stratigraphic studies in the upper Yukon Basin. The work was done by a boat trip from Eagle to Circle and thence with pack train to the White Mountains, 100 miles to the southwest. Mr. Blackwelder returned to the Yukon by raft down Beaver and Birch creeks and made traverses of those streams, whose courses through the flats were previously unknown.

H. M. Eakin made an exploration of the Cosna-Nowitna region. He left the mouth of Cosna River—a southern tributary of the Tanana—with a pack train on June 16 and carried a geologic and



topographic exploratory survey northwestward to the Nowitna. Here the horses were shot, and the party continued the journey to the Yukon on a raft, arriving there September 3. Though he had no technical assistance, Mr. Eakin made geologic exploratory surveys of an area of 2,600 square miles and topographic surveys of an area of 3,000 square miles.

A large area was also surveyed in the region including the Ruby district on the north and Iditarod on the southwest and extending southeastward to the mouth of Takotna River, a tributary of the Kuskokwim. The northern party in this field, which included C. E. Giffin, topographic engineer in charge, with G. L. Harrington as geologist, covered some 2,400 square miles by geologic and topographic reconnaissance surveys, besides revising the old surveys of some 1,600 square miles. The traveling was done by pack train, and the field season extended from June 11 to September 11. R. H. Sargent, topographic engineer, had charge of the southern party, with J. B. Mertie, jr., as geologist, and worked from June 13 to September 7. This party made topographic and geologic reconnaissance surveys of 3,520 square miles, besides revising the previous surveys of 490 square miles.

#### FIELD WORK FOR THE SEASON OF 1916.

Field parties began work before the end of the fiscal year with the following plans: Theodore Chapin during part of May and the whole of June continued the geologic mapping and study of mineral resources of the Ketchikan district, in southeastern Alaska. D. C. Witherspoon during the later part of May and the whole of June was completing the preparation of a detailed base map of the vicinity of Juneau, and the study of the geology and mineral resources of the same area is to be undertaken later by A. C. Spencer and H. M. Eakin. Mr. Eakin spent a part of the month of June in a study of the Porcupine placer district. G. H. Canfield from January throughout the year has continued the investigation of the water powers of southeastern Alaska in cooperation with the Forest Service. F. H. Moffit during part of June was engaged in some supplementary investigations of the Kotsina-Chitina copper belt. The geology and mineral resources of the southwestern part of the Prince William Sound copper-bearing region were investigated during part of June by B. L. Johnson. During June J. W. Bagley was making a topographic base map (scale 1:250,000) of the northern part of Prince William Sound. J. B. Mertie, jr., was detailed to investigate the Tolovana placer district in June and later to make some supplementary studies of the lodes of the Fairbanks and Nome districts. A detailed geologic survey of the western part of the Nenana coal

field is being carried on by G. C. Martin, A. G. Maddren, and R. M. Overbeck. This work was started in June. S. R. Capps and C. E. Giffin in June made geologic and topographic reconnaissance surveys of the Kantishna district and adjacent region. A topographic and geologic reconnaissance survey of the lower Yukon, including the Marshall placer district, was begun in June by R. H. Sargent and G. L. Harrington. All the above-mentioned pieces of work will continue into the fiscal year 1916-17.

#### COLLECTION OF STATISTICS.

The work of collecting statistics of the annual production of gold, silver, and copper, begun in 1905, was continued during the year. Preliminary estimates of mineral production were published on January 1, 1916. The progress report for 1915 (Bulletin 642), containing figures on mineral production, was transmitted in April.

#### PUBLICATIONS.

During the year three separates of professional papers (95-D, 95-H, and 98-C), five bulletins (Nos. 587, 605, 607, 608, and 622), and one water-supply paper (No. 372) relating to Alaska were issued. One general map of Alaska (No. C, scale 1:12,000,000) was issued for sale.

Four bulletins (Nos. 630, 631, 642, and 649) were in press at the end of the year. Manuscripts of the following reports have been completed: "Mineral springs of Alaska" (Water-Supply Paper 418), by G. A. Waring; "The Nelchina-Susitna region," by Theodore Chapin; "The upper Chitina Valley," by F. H. Moffit; "The Cosna-Nowitna region," by H. M. Eakin; "The panoramic camera in topographic surveying," by J. W. Bagley; "The Lake Clark-central Kuskokwim region," by P. S. Smith; and "The Canning River region of northern Alaska," by E. de K. Leffingwell.

The following reports are in hand:

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. and C. W. Wright.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren.

The upper Matanuska basin, by G. C. Martin.

The Kotsina-Kuskulana district, by F. H. Moffit.

The lower Kuskokwim region, by A. G. Maddren.

The Yakataga district, by A. G. Maddren.

The Mesozoic stratigraphy of Alaska, by G. C. Martin.

The Valdez district, by B. L. Johnson.

The Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington.

The Cretaceous and Tertiary floras of Alaska, by Arthur Hollick.

A Lower Jurassic flora from the upper Matanuska Valley, Alaska, by F. H. Knowlton.

Office work on the three maps listed below, besides the general map of Alaska noted above, has been completed:

Lower Kuskokwim region, by A. G. Maddren; scale, 1:500,000; contour interval, 500 feet.

Lake Clark-Kuskokwim region, by R. H. Sargent; scale, 1:250,000; contour interval, 200 feet.

Mineral resources of Alaska (new edition), by A. H. Brooks; scale, 1:5,000,000.

The following topographic maps are on hand:

Kotsina-Kuskulana district, by D. C. Witherspoon; scale, 1:62,500; interval, 100 feet.

Nelchina-Susitna region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet.

Juneau mining district, by D. C. Witherspoon; scale, 1:24,000; contour interval, 50 feet.

Yukon-Tanana region (compiled); scale, 1:500,000; contour interval, 500 feet.

Ruby-Kuskokwim region, by R. H. Sargent; scale, 1:250,000; contour interval, 200 feet.

Cosna-Nowitna region, by H. M. Eakin; scale, 1:250,000; contour interval, 200 feet.

Matanuska region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet.

Turnagain-Knik region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet.

#### SCIENTIFIC RESULTS.

Many important scientific results relating to problems of stratigraphy, structure, physiography, etc., are achieved each year incidentally to the areal mapping, but these need no special mention. Mr. Blackwelder's stratigraphic studies in the White Mountains of the Yukon-Tanana region show that the oldest fossiliferous rocks are probably Upper Cambrian, and these are succeeded by argillites and quartzites overlain conformably by Ordovician volcanic rocks. The next higher formation is made up of limestones and volcanic rocks (Ordovician or Silurian), and this is conformably overlain by 1,200 to 2,000 feet of massive dolomite, with some quartzite and conglomerate. The most important feature of this work is the determination that the massive dolomite and limestones are of Silurian age and not Ordovician-Devonian, as previously supposed; also that the sequence of lower Paleozoic rocks, ranging from Cambrian to Silurian in age, measures from 6,500 to 7,500 feet in thickness. In the upper Chitina Valley Mr. Moffit found an extensive development of Carboniferous or older rocks overlain by Triassic limestones and shales, succeeded by Upper Jurassic sandstones. The top of the bedrock section consists of over 5,000 feet of conglomerates, sandstones, and shales, of which at least the lower 3,000 feet can be definitely assigned to the Cretaceous. The fossils indicate that these rocks belong either in the upper part of the Lower Cretaceous or in the lower part of the Upper Cretaceous.

Messrs. Mertie and Harrington's investigations of the gold deposits of the Ruby-Iditarod region indicate that there were two epochs of mineralization in this province. The younger was definitely connected with monzonitic intrusions, probably Eocene, which invaded sediments of Upper Cretaceous age. The older is probably genetically related to Mesozoic intrusions. Mr. Brooks in his study of the Alaska stibnite deposits found considerable evidence that the antimony mineralization is connected with intrusions of Eocene age. These conclusions are subject to revision; but the evidence in hand indicates that in Alaska there were two epochs of important metallization. One of these is Mesozoic (Upper Jurassic or Lower Cretaceous) and the other Eocene. Both are genetically related to igneous intrusions. The irregularity in distribution of the Tertiary mineralization may be accounted for by the irregularity in distribution of the Eocene intrusive rocks, which in turn is the result of the localized character of the Eocene deformation, the Eocene intrusives being abundant only where the rocks have been much deformed and absent where they are little disturbed.

#### DIVISION OF CHEMICAL AND PHYSICAL RESEARCH.

In the chemical laboratory 339 quantitative analyses and 1,446 qualitative determinations of rocks and minerals were reported during the year, the samples tested consisting chiefly of minerals sent for inspection by citizens.

F. W. Clarke, in cooperation with W. C. Wheeler, continued his research on the inorganic constituents of marine invertebrates, and the manuscript reporting the results of the investigation is now ready for publication as Professional Paper 102. Some work was done on the revision of fundamental atomic weights. In February Mr. Clarke, at the request of the Treasury Department, served as a member of the annual Assay Committee.

George Steiger, in cooperation with E. S. Larsen, analyzed a new mineral, which was named sulphatic cancrinite, and wrote a description of it that was published unofficially. He also prepared a note on the action of ammonium chloride and of hydrochloric acid on muscovite for Bulletin 620-J. During the summer and fall Mr. Steiger devoted considerable time to the exhibit of the United States Geological Survey for the National Exposition of Chemical Industries. He has also had charge of the administrative work of the section of chemistry since February.

W. T. Schaller devoted practically all his time to routine work, consisting of miscellaneous chemical and mineralogic determinations. His "Mineralogic notes, series 3" (Bulletin 610), was published during the year. He has continued work on Professional Paper 92, "The gem tourmaline fields of southern California," and



on two other reports, "Mineralogic notes, series 4," and "The molds of the zeolite region of New Jersey." In March Mr. Schaller was assigned to the preparation of the annual reports on the production of gems and precious stones, mica, monazite, thorium, and zircon.

In the course of his routine analytical work, R. C. Wells, physical chemist, made analyses of the rare minerals plumbojarosite, bismutite, and greaksutite, from new localities, and of two new minerals—a bismuth arsenate, which has been named arseno-bismite, from Tintic, Utah, and a fluorine mineral, which has been named creedite, from Colorado. Mr. Wells prepared the following papers during the year: "The solubility of magnesium carbonate in natural waters," published in the *Journal of the American Chemical Society*; "The solubility of calcite in water in contact with the atmosphere, and its variation with temperature," published in the *Journal of the Washington Academy of Sciences*; "The fractional precipitation of some ore-forming compounds at moderate temperatures" (*Bulletin* 609); and "Experiments on the extraction of potash from wyomingite" (*Professional Paper* 98-D). During February, March, and April Mr. Wells was absent on leave without pay making chemical investigations connected with certain reported potash deposits near the west coast of South America.

Most of R. K. Bailey's time was taken up with routine work, consisting of both quantitative and qualitative analyses, but he was employed one hour a day in assisting Survey geologists in making laboratory experiments. Mr. Bailey was engaged for four months drilling test holes at Cliffside, Tex., in search of potash. His work consisted in taking samples and making field tests.

A. A. Chambers was assigned from the water-resources branch to the division of chemical and physical research for half time on January 16 and for full time on April 16, 1916. His time was taken up entirely with routine work in both qualitative and quantitative analyses.

W. B. Hicks attended to the drilling, sampling, and chemical work of the test holes sunk in Smoke Creek Desert, Nev., in search of potash, from July to October. He prepared for publication "Evaporation of brines from Searles Lake, Cal." (*Professional Paper* 98-A); "Some simple tests for potash," for the annual potash report; and "Some simple tests for phosphate," for the annual phosphate report.

Chase Palmer has been occupied largely with analyses of rocks, minerals, and natural waters. He has investigated the reactions between galena and iron arsenides and solutions of soluble silver salts, as a contribution to the study of the enrichment of silver ores, referred to on page 71. He has also begun experimental studies of the

reactions that take place between water, petroleum, and adjacent mineral substances. The purpose of this investigation, which is supplementary to the geologic study mentioned on page 54, is to determine the cause of the peculiar composition of the waters in oil fields and of the chemical variations in the petroleum itself.

The investigations made in the physical laboratory are directed to the twofold object of ascertaining the possibilities of conducting researches along certain lines suggested by the geologists in the prosecution of their work and of providing for systematic research in a given field when the preliminary investigations show that the results expected will justify the work. The investigations outlined for the laboratory relate to the diffusion of solids, the construction of mathematical tables, measurements of temperature of deep wells, and determinations of porosity of gas and oil sands. The first two of these investigations are now permanent, but the last two have not yet passed through the preliminary stages.

Preliminary determinations of the porosity of gas and oil sands by A. F. Melcher indicate an increased degree of accuracy in the determinations. This work is being continued, with the expectation that the results will justify an extended study of porosity and related problems dependent on size and distribution of sand grains.

A report on measurements of earth temperatures and temperature in deep wells, by C. E. Van Orstrand and A. F. Melcher, is withheld from publication pending further observations in the field. Preliminary observations leave not much doubt in regard to the efficiency of the electric method, but further tests must be made in the field before the task of making a geothermal survey can be included in the systematic work of the laboratory.

Computations on mathematical tables have been made by A. T. Harris when he was not engaged in routine experimental work. Explanatory text to accompany the tables, consisting in part of a mathematical discussion of geophysical problems dependent upon diffusion of heat and substances in the crust of the earth, has been prepared by Mr. Van Orstrand.

Experiments on the diffusion of gold and silver into lead and tin in the solid state were made by Mr. Van Orstrand and Mr. Melcher in cooperation with Dr. F. P. Dewey, of the Treasury Department. A preliminary report on the diffusion of gold into lead was published as Professional Paper 95-G. A pressure pump has been added to the laboratory equipment for the prosecution of these and other experiments.

In addition to his administrative work as chief of the division, G. F. Becker has been occupied mainly in studies of capillarity and heat conduction from the geologist's point of view, but other subjects have claimed a part of his time. In November he read before

the National Academy of Sciences a paper entitled "A possible origin for some spiral nebulae." This investigation bears on the origin of the earth, and the gist of it is that nebulae of the type discussed are vast diagrams illustrating Kepler's third law. In November Mr. Becker was also made a member of a committee of the National Academy of Sciences, appointed at the request of the President of the United States, to report on the slides in the Panama Canal, which Mr. Becker had studied in 1913, before water was admitted. As a result of this field work he was able to formulate a theory of the slides, which will doubtless appear in the final report of the committee, but as that report is not likely to be published for some time he has prepared his discussion for publication by the Survey as Professional Paper 98-N, "Mechanics of the Panama Canal slides." In this paper it is shown that the mechanics of the slides are reducible to identity with a soluble problem in capillarity, and that there is a sharp limit to the distance to which slides can extend. Mr. Becker has also printed in *Science* a short note of the history of the concept now known as energy. Contrary to current opinions, it was familiar to mathematicians of the first half of the eighteenth century.

With A. L. Day, Director of the Geophysical Laboratory, Mr. Becker also completed for publication a paper on the linear force of growing crystals. This is an experimental and theoretical refutation of attacks by certain foreign scientists on the deductions drawn from the results of an investigation made by the same authors some 10 years ago, when they pointed out the geologic importance of this force. In this country this linear force is now recognized as explaining the partial failure of many dams and as indicating how such failure may be avoided. The geologists of the State of Virginia also find it useful in explaining the phenomena of ore deposits. The new paper is in the hands of the printer.

In consultation and cooperation with Prof. P. W. Bridgman, of Harvard University, Mr. Becker has furnished some hollow cylinders of rock-forming minerals for use in pressure tests. The series is now nearly complete. Prof. Bridgman expects to compile and discuss the extremely interesting results this summer.

A number of analyses of phosphate rock and other miscellaneous analyses were made by W. C. Wheeler, whose work in conjunction with Mr. Clarke has already been mentioned. In February Mr. Wheeler resigned from the Survey and accepted an appointment in the Patent Office.

#### DIVISION OF MINERAL RESOURCES.

The Survey has continued its policy of making the annual report "Mineral Resources of the United States" more than a statistical compilation by recording and interpreting industrial progress and

by treating in full the sources from which the mineral products of the country are obtained. This report is an annual inventory of the Nation's mineral resources.

During the last 13 years the separate chapters have been prepared in large part by geologists of the Survey who have specialized in the subjects treated by them, with a view to carrying out the provision of the organic act of the Survey which directs the examination of the mineral resources and products of the national domain.

Cooperation between the Geological Survey and the State surveys in collecting most of the mineral statistics continued in force in the preparation of the report for 1915. The 14 States that cooperated were Alabama, Florida, Illinois, Iowa, Maryland, Michigan, Minnesota, Missouri, New Jersey, North Carolina, Oregon, Virginia, Washington, and Wisconsin. The plan of cooperation has been modified somewhat for 1915, and results have been expedited. By cooperation duplication of a considerable amount of work is obviated, and so far as it is applied the producers are saved the annoyance of preparing two sets of statistical returns.

During the fiscal year the work of the division consisted in large part in the preparation of the reports on the mineral production of the United States in 1914 and 1915. The report for 1914 was published in two parts, as usual. On June 30, 1916, the manuscripts of 25 chapters for the report for 1915 had been completed and transmitted to the printer. On June 30, 1915, the manuscripts of 20 chapters for the report for 1914 had been completed and transmitted to the printer.

The conditions mentioned in the last administrative report in regard to the public interest in our mineral resources aroused by the European war continued to exist. In fact, the prolongation of the war has materially increased that interest, and in consequence a chapter for Mineral Resources of the United States, 1915, entitled "The public interest in mineral resources," was prepared by the Director of the Survey and issued December 31, 1915. A greatly increased number of inquiries for information concerning domestic supplies of minerals have been received by the division during the year, and the answers to the inquiries have involved an increased amount of research by the geologists and others. The number of recorded letters referred to the division for reply increased from 4,034 in 1915 to 6,434 in 1916, an increase of 59 per cent. The Geological Survey is becoming more and more a repository of information concerning the mineral resources of the country, much of which it furnishes through correspondence, giving detailed information which can not be covered by publications, such as the location of deposits of minerals, both those that are developed and those that



are undeveloped, and names of those who can supply the different minerals.

Preliminary estimates of the output of antimony, arsenic, benzol, cement, coal, copper, gold and silver, iron ores, lead, manganese, petroleum, quicksilver, radium ores, sulphuric acid, titanium, tungsten ores, uranium ores, vanadium ores, metals in the Western States, and zinc in 1915, with reviews of the conditions that prevailed during the year, were issued in the form of special press bulletins during the later part of December, 1915, and in January, 1916. Advance statements giving the final figures covering the production of copper, lead, and zinc in 1915 have also been published.

For the first time in 1915 specialists of the division compiled mid-year reviews on most of the principal mineral industries, indicating the trend and volume of changes during the first six months of the year, and these were given to the press of the country about July 1 and widely published. In addition members of this division prepared for the use of the Secretary of the Interior a summary of the mineral resources which was published in his annual report and was also widely republished. Several members of the division also devoted considerable time to the preparation of papers for the Pan American Scientific Congress held in Washington in December and January.

The number of members of the Survey (geologists, statisticians, and clerks) in Washington who devote their entire time to the work of the division of mineral resources is 32; and 8 are stationed in the offices of the division at Salt Lake City, Denver, and San Francisco. In addition to these, 22 members, chiefly geologists, who give part of their time to other divisions of the Survey, are also specialists in the work of the division of mineral resources, making a total of 62 persons engaged in the work.

During the year 210,042 pieces of first-class mail matter, comprising chiefly inquiries for information needed for the reports but also, in increasing quantity, replies to inquiries made to the Survey for information, were sent out by the division, an increase of 9 per cent over 1915, and 72,691 pieces were received, an increase of 11 per cent over 1915.

H. D. McCaskey became geologist in charge of the division at the beginning of the fiscal year, on the retirement of E. W. Parker. Mr. McCaskey also continued in charge of the metals section and has general supervision of the offices of the division in the Western States. E. F. Burchard, a geologist of much experience in economic work and a large contributor to Mineral Resources, has been placed in charge of the nonmetals section of the division. D. B. Sterrett, geologist, who for a number of years has had charge of the preparation of reports on gems and precious stones, mica, monazite, and

zircon, was at his own request relieved of this work during the year. W. T. Schaller, who has made a special study of gems and rare minerals, has been assigned to the work of the preparation of reports on these subjects. Mr. Schaller has been referred to as the foremost mineralogist of the country and is therefore particularly well fitted for his new work.

The reports on the several mineral products were in charge of the following persons:

*Authors of chapters in Mineral Resources.*

Author.	Subject.
E. S. Bastin.....	Graphite.
A. H. Brooks.....	Gold, silver, and copper in Alaska.
E. F. Burchard.....	Cement; fluorspar and cryolite; iron ore, pig iron, and steel.
B. S. Butler.....	Copper (general report); copper and silver in Michigan (mines report).
C. A. Davis (of the Bureau of Mines).	Peat (1914).
J. S. Diller.....	Asbestos; chromic iron ore; talc and soapstone.
R. B. Dole.....	Mineral waters.
J. P. Dunlop.....	Silver, copper, lead, and zinc in the Central States, except Michigan (mines report); secondary metals; metals and ores (summary report).
H. S. Gale.....	Borax; magnesite (with C. G. Yale); nitrates.
C. N. Gerry.....	Gold, silver, copper, lead, and zinc in Idaho and Washington (mines report).
V. C. Heikes.....	Gold, silver, copper, lead, and zinc in Arizona, Montana, Nevada, and Utah (mines report).
C. W. Henderson.....	Gold, silver, copper, lead, and zinc in Colorado, New Mexico, South Dakota, Texas, and Wyoming (mines report).
F. L. Hess.....	Antimony, arsenic, bismuth, cobalt, molybdenum, nickel, selenium, tantalum, tungsten, titanium, vanadium, uranium, tin.
D. F. Hewett.....	Manganese and manganiferous ores.
J. M. Hill.....	Barytes and strontium; mineral paints; platinum and allied metals; gold, silver, copper, lead, and zinc in the Eastern States (mines report).
F. J. Katz.....	Abrasives; feldspar; silica (quartz).
C. E. Leshner.....	Coal; fuel briquetting; coke.
G. F. Loughlin.....	Building stone; lime; slate.
H. D. McCaskey.....	Gold and silver (general report); mineral products of the United States (summary report); quicksilver.
Jefferson Middleton.....	Clay, clay-working industries; fuller's earth; sand-lime brick.
J. D. Northrop.....	Petroleum; asphalt and bituminous rock; natural gas.
W. C. Phalen.....	Bauxite and aluminum; phosphate rock; potash salts; salt and bromine; sodium salts; sulphur and pyrite.
C. E. Siebenthal.....	Lead; zinc and cadmium (general reports).
W. T. Schaller.....	Gems and precious stones; mica.
R. W. Stone.....	Gypsum; sand and gravel.
C. G. Yale.....	Borax; magnesite (with H. S. Gale); gold, silver, copper, lead, and zinc in California and Oregon (mines report).

The offices of the division at Denver, Salt Lake City, and San Francisco are under direct charge of C. W. Henderson, V. C. Heikes, and C. G. Yale, respectively, who prepare the mine reports on gold, silver, copper, lead, and zinc in the Western States. They also act in cooperation with other members of the Survey where necessary, both in the field and in the office, and by keeping in close touch with the mining regions of the West they procure and disseminate much valuable information not readily obtained otherwise. These offices are therefore general Survey headquarters and bureaus of information in their respective regions. The Denver office, at 409 New Post Office Building, prepares the metal-mine reports for South Dakota, Wyoming, Colorado, and New Mexico; the Salt Lake City office, at 312 Post Office Building, covers in the same way the States of Montana, Idaho, Washington, Utah, Nevada, and Arizona; and the San

Francisco office, at 305 Customhouse, is the headquarters for California and Oregon.

### TOPOGRAPHIC BRANCH.

#### ORGANIZATION.

The organization of the topographic branch is as follows:

Acting chief geographer, W. H. Herron.  
 Atlantic division, Frank Sutton, geographer, in charge.  
 Central division, G. S. Smith, topographic engineer, in charge.  
 Rocky Mountain division, C. H. Birdseye, topographic engineer, in charge.  
 Northwestern division, T. G. Gerdine, geographer, in charge.  
 Pacific division, G. R. Davis, geographer, in charge.  
 Inspectors of topography, J. H. Renshaw, geographer; W. M. Beaman and A. M. Walker, topographic engineers.

#### PERSONNEL.

The technical corps of the topographic branch was increased during the year by the reinstatement of 2 assistant topographers and was reduced 14 by death, transfers, and resignations. With these changes the corps now includes 1 acting chief geographer, 47 geographers and topographic engineers, 17 topographers, 40 assistant topographers, 35 junior topographers, and 7 draftsmen—a total of 147. In addition, 36 technical field assistants were employed during the whole or a part of the field season. One topographic engineer, 1 topographer, and 6 junior topographers are on furlough. The clerical force comprises 11 clerks of various grades.

#### PUBLICATIONS.

The published work of the topographic branch for the fiscal year consists of 153 maps and six bulletins, giving results of spirit leveling in Arizona, Colorado, Louisiana, Maine, Missouri, and West Virginia. Brief summaries of the book publications (Bulletins 565, 568, 573, 632, 633, and 634) are given on pages 21 and 30. Manuscript for results of triangulation and primary traverse in the United States, 1913–1915 (Bulletin 644), in 18 parts, was brought up to date and two parts were published. Manuscript for a new edition of “Geographic tables and formulas” (Bulletin 650) and for all results of leveling in Ohio (Bulletin 651) was transmitted for publication.

#### ALLOTMENTS.

The total appropriations for topographic surveys for the fiscal year 1916 were:

Topographic surveys.....	\$350, 000
Surveying national forests.....	75, 000
Statutory salaries.....	9, 200
	<hr/>
	434, 200

Allotments of these appropriations were made as follows:

*Allotments from funds appropriated for topographic work, fiscal year 1916.*

	Topo- graphic surveys and statutory salaries.	Survey- ing national forests.
General administration.....	\$22,896	\$4,500
Clerical assistance and supervision.....	17,149	3,271
Map editing.....	3,735	765
Purchase and repair of instruments, stationery, etc.....	12,242	2,508
Millionth-scale map.....	20,000	.....
Work by land-classification board.....	9,000	2,500
Field work:		
Atlantic division.....	67,950	.....
Central division.....	59,488	.....
Rocky Mountain division.....	62,135	21,206
Northwestern division.....	33,663	26,250
Pacific division.....	50,942	14,000
	359,200	75,000

#### COOPERATION.

Cooperation has been maintained in 17 States, which contributed the following amounts:

California.....	\$14,000.00	New York.....	\$10,000.00
Illinois.....	9,000.00	Ohio.....	23,900.00
Illinois drainage.....	3,000.00	Oregon.....	4,000.00
Iowa.....	1,750.00	Texas.....	35,000.00
Kentucky.....	10,000.00	Vermont.....	2,500.00
Maine.....	5,000.00	Virginia.....	4,500.00
Michigan.....	15,000.00	Washington.....	11,500.00
Minnesota.....	4,250.00	West Virginia.....	7,639.39
Missouri.....	4,000.00		
Nebraska.....	1,750.00		166,789.39

#### GENERAL OFFICE WORK.

Progress maps were kept up to date and new ones were compiled when necessary, the new 1: 500,000 State maps being used so far as available. Results of computations for vertical and horizontal control work were copied and catalogued.

The computations of control data were made principally by D. H. Baldwin, T. M. Bannon, D. S. Birkett, G. T. Hawkins, Oscar Jones, C. B. Kendall, L. S. Leopold, F. J. McMaugh, E. L. McNair, J. B. Metcalfe, jr., C. L. Nelson, H. S. Senseney, Frank Tweedy, and J. H. Wilson, under the immediate supervision of E. M. Douglas, geographer. Computing by L. F. Biggs and C. F. Urquhart was done in the Sacramento office. S. S. Gannett, geographer, was engaged in preparing manuscript and compiling data for the bulletins submitted for publication, in miscellaneous computations, and in furnishing triangulation and leveling data for field and office use.



J. H. Renshawe was engaged during the year in preparing relief maps of the United States and of the Mesa Verde National Park, and in revising the relief map of Alaska for the division of Alaskan mineral resources.

In the preparation of the special topographic maps to be used in the transcontinental guidebooks the available Survey atlas sheets were used, and for areas for which such sheets were not available the data were filled in on field sheets on the scale of 5 miles to the inch. The different railroads assisted in every way possible, supplying all available profile and alignment data and rendering other valuable assistance. The maps are to be published on a scale of 1: 500,000, or about 8 miles to the inch, and cover the Denver & Rio Grande Railroad from Denver, Colo., to Salt Lake City, Utah, and the Southern Pacific Railroad from El Paso, Tex., to San Francisco, Cal., by way of Los Angeles and San Joaquin Valley. The maps for the Denver & Rio Grande Route were completed; those for the other route have just been begun.

#### SUMMARY OF RESULTS.

The condition of topographic surveys to June 30, 1916, distinguished as to scale, etc., is shown on Plate II.

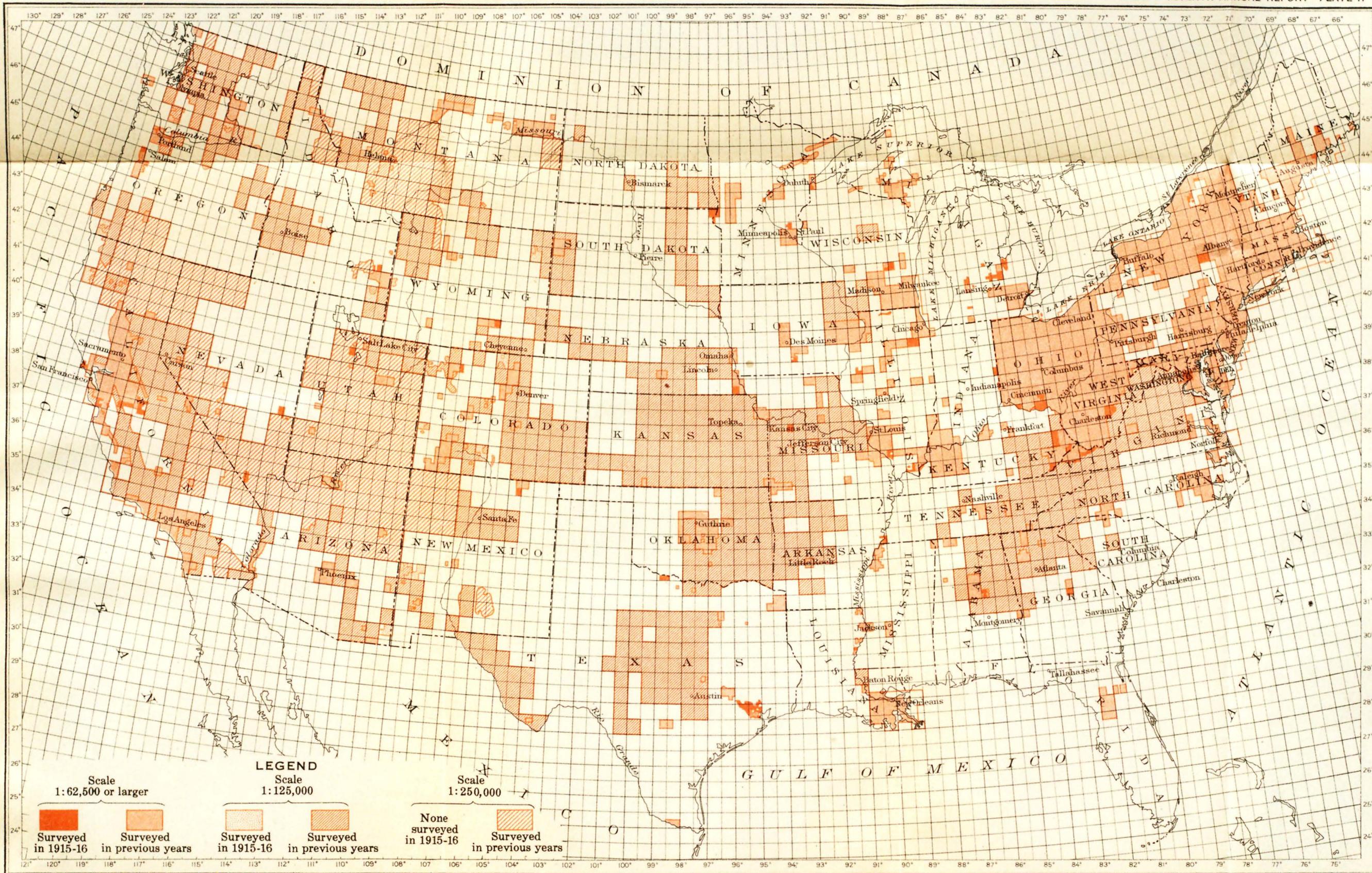
As shown in the following tables, the total new area mapped was 19,230 square miles, making the total area surveyed to date in the United States 1,237,520 square miles, or 40.9 per cent of the entire country. In addition, 3,486 square miles of resurvey was completed, making the total area of surveys during the year 22,716 square miles.

In connection with these surveys, 5,462 linear miles of primary levels were run, making 259,821 miles of primary and precise levels run since the authorization of this work by Congress in 1896. In the course of this work 1,321 permanent bench marks were established. In addition, 604 linear miles of river surveys were run.

Triangulation stations to the number of 244 were occupied, and 200 were permanently marked. Primary traverse lines aggregating 2,905 miles were run, in connection with which 331 permanent marks were set. In the course of this work areas aggregating 23,384 square miles were covered by primary control.

The area covered by topographic surveys in Alaska during the fiscal year, as reported in detail on page 91, was 10,412 square miles.





MAP OF THE UNITED STATES, SHOWING AREAS COVERED BY TOPOGRAPHIC SURVEYS PRIOR TO JULY 1, 1916  
AND THE SCALE EMPLOYED FOR EACH AREA



*Present condition of topographic surveys of the United States and new area surveyed July 1, 1915, to June 30, 1916.*

	New area mapped July 1, 1915, to June 30, 1916.	Total area mapped to June 30, 1916.	Percentage of total area of State mapped to June 30, 1916.
	<i>Sq. miles.</i>	<i>Sq. miles.</i>	
Alabama.....		19,192	37
Arizona.....	546	69,542	61
Arkansas.....	114	21,494	40
California.....	2,262	116,970	74
Colorado.....	1,667	50,450	49
Connecticut.....		4,965	100
Delaware.....		1,202	51
District of Columbia.....		70	100
Florida.....		2,339	4
Georgia.....	250	17,587	29
Idaho.....	1,069	27,254	32
Illinois.....	693	15,244	27
Indiana.....	168	3,609	10
Iowa.....	113	11,765	21
Kansas.....		64,159	78
Kentucky.....	41	18,014	44
Louisiana.....	47	8,366	17
Maine.....	404	9,765	29
Maryland.....		12,327	100
Massachusetts.....		8,266	100
Michigan.....	1,077	7,095	12
Minnesota.....	424	6,965	8
Mississippi.....		2,126	4
Missouri.....	15	36,725	53
Montana.....	626	57,789	39
Nebraska.....	228	26,752	36
Nevada.....		51,115	46
New Hampshire.....		3,380	36
New Jersey.....		8,224	100
New Mexico.....	1,333	38,580	31
New York.....	806	44,359	90
North Carolina.....		18,390	35
North Dakota.....	98	9,814	14
Ohio.....	1,022	41,040	100
Oklahoma.....		39,851	57
Oregon.....	997	24,403	25
Pennsylvania.....		24,908	55
Rhode Island.....		1,248	100
South Carolina.....		5,640	18
South Dakota.....	299	18,893	24
Tennessee.....	130	21,283	50
Texas.....	1,518	69,300	26
Utah.....		68,797	81
Vermont.....	216	4,406	46
Virginia.....		29,980	70
Washington.....	1,713	27,746	40
West Virginia.....		24,170	100
Wisconsin.....	399	12,602	22
Wyoming.....	955	29,359	30
Total, United States.....	19,230	1,237,520	40.9
Hawaii.....		1,393	22

## ATLANTIC DIVISION.

## FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Alabama, Georgia, Louisiana, Maine, New Hampshire, New York, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia and in a small area in Arkansas. This work comprised the completion of the survey of 10 quadrangles and of the resurvey of 4 quadrangles, in addition to which 2 quadrangles were partly surveyed and 10 were partly resurveyed. The total new area mapped

was 1,967 square miles, for publication on the scale of 1:62,500, and the area resurveyed was 1,164 square miles, for publication on the same scale. The map of one quadrangle was partly revised, the area covered by this revision being 21 square miles. In connection with this work, 796 miles of primary levels were run and 199 permanent bench marks were established.

Primary triangulation and primary traverse were carried on by six parties in Georgia, Maine, New York, Arkansas, Vermont, and West Virginia. The total area covered by this work was about 1,525 square miles. The primary traverse covered 900 square miles, 300 miles being run and 30 permanent marks set. In the triangulation 29 stations were occupied and 18 were permanently marked. This work made control available in 15 quadrangles.

*Topographic surveys in Atlantic division from July 1, 1915, to June 30, 1916.*

State.	Con- tour inter- val.	For publication on scale of 1:62,500.		Total area sur- veyed.	Primary levels.		Primary tra- verse.		Triangulation.	
		New.	Resur- vey.		Dis- tance run.	Bench marks.	Dis- tance run.	Perma- nent marks.	Sta- tions occu- pied.	Sta- tions marked.
	<i>Feet.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Miles.</i>		<i>Miles.</i>			
Alabama.....	20	.....	151	151	.....	.....	.....	.....	.....	.....
Georgia.....	20	250	.....	250	90	29	211	17	.....	.....
Louisiana.....	5, 10	47	.....	47	.....	.....	.....	.....	.....	.....
Maine.....	20	404	.....	404	67	16	.....	.....	8	.....
New Hampshire.....	20	.....	59	59	32	9	.....	.....	.....	.....
New York.....	20	806	.....	806	98	31	87	13	.....	.....
Pennsylvania.....	.....	.....	.....	86	86	10	.....	.....	.....	.....
Tennessee.....	5, 10	130	.....	130	40	9	.....	.....	.....	.....
Vermont.....	20	216	.....	216	66	22	.....	.....	3	5
Virginia.....	50	.....	355	355	34	9	.....	.....	.....	.....
West Virginia.....	50	.....	599	599	245	55	.....	.....	18	13
Arkansas.....	5, 10	114	.....	114	38	9	2	.....	.....	.....
.....	.....	1,967	1,164	3,131	796	199	300	30	29	18

*Alabama.*—The resurvey of the Weogufka quadrangle, in Coosa, Shelby, and Talladega counties, was completed by Duncan Hannegan and W. H. S. Morey, the area mapped being 151 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet.

*Arkansas.*—(See Tennessee and Arkansas, p. 112.)

*District of Columbia, Maryland, and Virginia.*—During the year the revision of the culture on the map of Washington and vicinity was completed.

*Georgia.*—The mapping of the Black Lake quadrangle, in Baldwin, Hancock, Washington, and Wilkinson counties, was begun by J. I. Gayetty, C. W. Arnold, K. E. Schlachter, and E. W. Bowler, the area mapped being 250 square miles, for publication on the scale of 1:48,000, with a contour interval of 20 feet. For the control of this area Mr. Arnold, Mr. Schlachter, and Kostka Mudd ran 90



miles of primary levels and established 29 permanent bench marks, and for the control of this area and of the Griswoldville, Milledgeville, Sandersville, Macon, Meriweather, and Jefferson quadrangles, in Baldwin, Bibb, Jones, Twiggs, Wilkinson, Hancock, Putnam, Pulaski, Washington, Monroe, and Laurens counties, C. B. Kendall, Mr. Arnold, Mr. Schlachter, Mr. Mudd, and Mr. Bowler ran 211 miles of primary traverse and set 17 permanent marks.

*Louisiana and Mississippi.*—The mapping of the Natchez quadrangle, in Concordia County, La., and Adams and Jefferson counties, Miss., was begun by E. I. Ireland, W. H. S. Morey, T. F. Slaughter, and F. W. Crisp, the area mapped being 47 square miles, for publication on the scale of 1:62,500, with contour intervals of 5 and 10 feet. This work was in Louisiana.

*Maine.*—For the continuation of cooperative topographic surveys the Public Utilities Commission allotted \$5,000 and the United States Geological Survey allotted an equal amount. The survey of the Belfast and Passadumkeag quadrangles, in Knox, Waldo, and Penobscot counties, was completed and that of the Winn quadrangle, in Penobscot County, was begun by W. H. Griffin, J. I. Gayetty, James McCormick, J. B. Metcalfe, jr., and C. S. Wells, the total area mapped being 404 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Passadumkeag quadrangle Mr. Wells ran 67 miles of primary levels and established 16 permanent bench marks, and for the control of the Seboeis quadrangle, in Penobscot County, Oscar Jones occupied 8 triangulation stations.

*Maine and New Hampshire.*—The resurvey of the Dover and York quadrangles, in York County, Maine, and Rockingham and Strafford counties, N. H., was begun by Hersey Munroe and J. H. Wheat, the area mapped being 59 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Dover quadrangle C. H. Stewart ran 32 miles of primary levels and established 9 permanent bench marks. All this work was in New Hampshire.

*New York.*—The mapping of the Hornell, Russell, Moira, Oneonta, and Unadilla quadrangles, in Allegany, Livingston, Steuben, St. Lawrence, Franklin, Delaware, Otsego, and Chenango counties, was completed and that of the Oswegatchie, Andes, and Cranberry Lake quadrangles, in Herkimer, Lewis, Delaware, Sullivan, Ulster, Hamilton, and St. Lawrence counties, was begun by G. S. Smith, Hersey Munroe, Robert Muldrow, W. J. Lloyd, A. P. Meade, T. F. Slaughter, J. M. Whitman, J. I. Gayetty, J. B. Metcalfe, jr., C. S. Wells, K. E. Schlachter, C. H. Davey, and E. W. Bowler, the total area mapped being 806 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet.

For the control of the Cranberry Lake and Andes quadrangles C. B. Kendall and F. J. McMaugh ran 87 miles of primary traverse and set 13 permanent marks, and Mr. Schlachter and F. L. Shalibo ran 98 miles of primary levels and established 31 permanent bench marks.

*Pennsylvania.*—For the control of the Newville quadrangle, in Cumberland, Adams, Franklin, and Perry counties, De Witt McLaughlin ran 86 miles of primary levels and established 10 permanent bench marks. The revision of a part of the map of the Houtzdale quadrangle, in Clearfield and Center counties, was completed by J. I. Gayetty, the area covered being 21 square miles.

*Tennessee and Arkansas.*—The mapping of the Memphis quadrangle, in Shelby County, Tenn., and Crittenden County, Ark., was begun by E. I. Ireland, W. H. S. Morey, T. F. Slaughter, F. W. Crisp, and Kostka Mudd, the area mapped being 244 square miles, for publication on the scale of 1:62,500, with contour intervals of 5 and 10 feet. Of this area 114 square miles is in Arkansas. For the control of this area H. S. Senseney ran 78 miles of primary levels and established 18 permanent marks, of which 38 miles and 9 marks were in Arkansas, and Mr. Crisp and Mr. Mudd ran 2 miles of primary traverse, also in Arkansas.

*Vermont.*—For the continuation of cooperative topographic surveys the governor of Vermont allotted \$2,500 and the United States Geological Survey allotted an equal amount. The survey of the Rochester quadrangle, in Addison, Orange, Rutland, and Windsor counties, was completed by Hersey Munroe and K. F. Maxcy, the area mapped being 216 square miles, for publication on the scale of 1:62,500, with a contour of 20 feet. For the control of this area K. E. Schlachter ran 66 miles of primary levels and established 22 permanent bench marks, and D. H. Baldwin occupied 3 triangulation stations and marked 5.

*Virginia.*—For the continuation of cooperative topographic surveys the State geologist allotted \$4,500 and the United States Geological Survey allotted an equal amount. The resurvey of the Virginia portion of the Nolansburg quadrangle, in Lee County, and that of the coal areas in the Cleveland, Richlands, and Burkes Garden quadrangles and in the Virginia portion of the Pounding Mill quadrangle, in Buchanan, Russell, and Tazewell counties, was completed and that of the coal area in the Coeburn quadrangle, in Russell and Wise counties, was begun by Fred McLaughlin, C. W. Arnold, and Kostka Mudd, the area mapped being 355 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of the Pounding Mill and Nolansburg quadrangles Mr. Arnold and S. R. Archer ran 34 miles of primary levels and established 9 permanent bench marks.

*West Virginia.*—For the continuation of cooperative topographic surveys the State geologist expended \$7,639.39 and the United States Geological Survey expended \$2,407.39. A resurvey of the Cowen and Webster Springs quadrangles and of the portions of the Mingo, Lobelia, and Richwood quadrangles lying in Nicholas and Webster counties was completed by E. I. Ireland, W. H. S. Morey, F. W. Farnsworth, and Klett McKinley, the total area mapped being 599 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. This work completed the mapping of Nicholas and Webster counties on the scale of 1:62,500. In connection with this work H. S. Senseney ran 147 miles of primary levels and established 31 permanent bench marks. For the control of the West Virginia portions of the Davis, Elk Garden, and Keyser quadrangles, in Tucker and Mineral counties, J. B. Metcalfe, jr., occupied 18 triangulation stations and marked 13, and for the control of the Piedmont quadrangle, in Tucker and Mineral counties, K. F. Maxey ran 98 miles of primary levels and established 24 permanent bench marks.

#### OFFICE WORK.

The drafting of the following sheets was completed: Gantts Quarry, Ala.; Interlachen, Fla.; Belfast and Passadumkeag, Maine; Vicksburg, Miss.-La.; Hornell, Malone, Moira, Oneonta, Russell, and Unadilla, N. Y.; Houtzdale, Pa. (revision); Rochester, Vt.; Cowen and Webster Springs, W. Va.; and Washington and vicinity, D. C.-Md.-Va.

Progress in the drafting of additional sheets was made as follows: Cleveland, Va., 17 per cent; Pounding Mill, Va., 33 per cent; Richlands, Va., 78 per cent; Lobelia, W. Va., 4 per cent; Mingo, W. Va., 9 per cent; Richwood, W. Va., 43 per cent.

Primary-level circuits were adjusted for the following quadrangles: Weogufka, Ala.; Passadumkeag, Maine; Natchez, Miss.; Gastonia, N. C.; Andes and Oneonta, N. Y.; Memphis, Tenn.; Pounding Mill, Va.; Rochester, Vt.; and Clay, Cowen, Fayetteville, Gassaway, Richwood, Summersville, Sutton, Webster Springs, and Winona, W. Va.

Geographic positions were computed for the following quadrangles: Black Lake, Ga.; Memphis, Tenn.; Rochester, Vt.; and Cowen, Davis, Elk Garden, Keyser, Richwood, and Webster Springs, W. Va.

#### CENTRAL DIVISION.

#### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Mis-

souri, Ohio, and Wisconsin. The work comprised the completion of the survey of 11 quadrangles and the resurvey of 6 quadrangles, in addition to which 29 quadrangles were partly surveyed and 3 quadrangles and 1 special area were partly resurveyed. The total new area mapped was 3,852 square miles, 3,798 square miles for publication on the scale of 1:62,500 and 54 square miles for publication on the scale of 1:24,000; and the area resurveyed was 1,524 square miles, 1,515 square miles for publication on the scale of 1:62,500 and 9 square miles for publication on the scale of 1:24,000. In connection with this work 2,527 miles of primary levels were run and 589 permanent bench marks were established.

Primary triangulation and primary traverse were carried on by six parties in Illinois, Indiana, Kansas, Kentucky, Michigan, Minnesota, and Missouri. The total area covered by this work was about 6,350 square miles. The primary traverse covered 5,250 square miles, 1,924 miles being run and 164 permanent marks set. In the triangulation 13 stations were occupied and 13 marked. The result of this work was to make control available in 58 quadrangles.

*Topographic surveys in central division from July 1, 1915, to June 30, 1916.*

State.	Con- tour inter- val.	For publication on scale of—					Total area sur- veyed.	Primary levels.		Primary traverse.		Triangulation stations.	
		1:62,500		1:24,000				Dis- tance run.	Bench marks.	Dis- tance run.	Perma- nent marks.	Occu- pied.	Marked.
		New.	Resur- vey.	New.	Resur- vey.								
	<i>Feet.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Miles.</i>		<i>Miles.</i>				
Illinois....	5, 20	639	421	54		1, 114	417	116	321	28			
Indiana....	20	168				168	32	7	60	4			
Iowa.....	20	113				113							
Kentucky..	20, 50	41	857			898	412	98	24	2	13	13	
Michigan..	5	1, 077				1, 077	1, 080	237	968	81			
Minnesota.	10	324				324	244	66	310	28			
Missouri...	20	15	237		9	261	224	37	163	14			
Ohio.....	10, 20	1, 022				1, 022							
Wisconsin.	20	399				399	118	28					
Kansas....									78	7			
	.....	3, 798	1, 515	54	9	5, 376	2, 527	589	1, 924	164	13	13	

*Illinois.*—The governor of Illinois allotted \$9,000 for the continuation of cooperative topographic surveys, and the United States Geological Survey allotted an equal amount. The governor also made an additional allotment of \$3,000 for a survey of the Pecatonica drainage basin, which was met by an allotment of \$1,500 by the Federal Survey. The survey of the Illinois portions of the Brownfield and Altenberg quadrangles, in Jackson, Johnson, Massac, and Pope counties, was completed and that of the Vienna and Good Hope quadrangles and of the Illinois portion of the Campbell Hill quadrangle, in Jackson, Johnson, McDonough, Massac, Perry,



Pulaski, Randolph, and Warren counties, was begun by C. W. Goodlove, Gilbert Young, J. A. Duck, F. W. Hughes, J. M. Rawls, R. M. Herrington, M. A. Roudabush, and H. E. Burney, the total area mapped being 639 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. The resurvey of the Morris quadrangle, in Grundy and Kendal counties, was completed and that of the Wilmington quadrangle, in Will and Kankakee counties, was begun by R. L. Harrison, the area mapped being 421 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Campbell Hill, Wilmington, and Vienna quadrangles R. G. Clinite, J. M. Perkins, and Mr. Rawls ran 281 miles of primary levels and established 80 permanent bench marks, and for the control of these areas and of the Peotone, Essex, Joliet, Dongola, Joppa, and Marion quadrangles and of the Illinois portions of the Jonesboro and Thebes quadrangles, in Kankakee, Cook, Will, Alexander, Grundy, Livingston, Massac, Pulaski, Dupage, Johnson, Union, and Williamson counties, J. H. Wilson ran 209 miles of primary traverse and set 19 permanent marks.

The survey of the Pecatonica drainage basin, covering parts of the Freeport, Pecatonica, and Rockford quadrangles, in Stephenson and Winnebago counties, was completed by L. L. Lee, R. M. Herrington, and W. S. Gehres, the area mapped being 54 square miles, for publication on the scale of 1:24,000, with a contour interval of 5 feet. For the control of this area Mr. Perkins and Mr. Gehres ran 136 miles of primary levels and established 36 permanent bench marks and Mr. Wilson ran 112 miles of primary traverse and set 9 permanent marks.

*Indiana.*—The mapping of the Indiana portion of the Lynn quadrangle, in Randolph and Wayne counties, was begun by W. L. Miller and L. B. Glasgow, the area mapped being 168 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of this area Mr. Glasgow ran 32 miles of primary levels and established 7 permanent bench marks, and for the control of this area and the Farmland quadrangle and of the Indiana portions of the Fort Recovery and New Paris quadrangles, in Delaware, Henry, Jay, Randolph, and Wayne counties, J. H. Wilson ran 60 miles of primary traverse and set 4 permanent marks.

*Iowa.*—The State geologist allotted \$1,750 for the continuation of cooperative topographic surveys in Iowa, and the United States Geological Survey allotted an equal amount. The survey of the Chariton quadrangle, in Lucas, Marion, and Warren counties, was continued by W. L. Miller, the area mapped being 113 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet.

*Kansas.*—For the control of the Joplin district J. H. Wilson ran 78 miles of primary traverse and set 7 permanent marks in the Columbus quadrangle, in Cherokee county.

*Kentucky.*—The Kentucky Geological Survey allotted \$10,000 for the continuation of cooperative topographic surveys, and the United States Geological Survey allotted an equal amount. The survey of the Kentucky portion of the Golconda quadrangle, in Crittenden and Livingston counties, was begun by C. W. Goodlove and R. F. Wilcox, the area mapped being 41 square miles, for publication on the scale of 1:48,000, with a contour interval of 20 feet. The resurvey of the Goodloe and Paintsville quadrangles and of the Kentucky portions of the Regina and Nolansburg quadrangles, in Breathitt, Floyd, Harlan, Johnson, Lawrence, Letcher, Magoffin, Morgan, Perry, and Pike counties, was completed and that of the Baxter quadrangle, in Harlan and Leslie counties, was begun by J. R. Eakin, C. S. Wells, Howard Clark, W. A. Reiter, F. W. Farnsworth, W. S. Gehres, G. W. Lucas, S. A. Judson, and E. J. Essick, the area mapped being 857 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of these areas and of the Hyden and Fords Ferry quadrangles, in Harlan, Leslie, Perry, Crittenden, Livingston, and Caldwell counties, Mr. Judson, S. R. Archer, G. W. Lucas, and F. L. Whaley ran 412 miles of primary levels and established 98 permanent bench marks. For the control of the Kentucky portions of the Fords Ferry and Golconda quadrangles J. H. Wilson ran 24 miles of primary traverse and set 2 permanent marks, and for the control of the Hyden quadrangle and of the Corbin, Maynardsville, Pineville, Barbourville, and Log Mountain quadrangles, in Bell, Campbell, Claiborne, Granger, Jefferson, Clay, Knox, Laurel, Harlan, Leslie, Sevier, and Whitley counties, E. L. McNair occupied and marked 13 triangulation stations.

*Michigan.*—For the continuation of cooperative topographic surveys the State geologist allotted \$15,000 and the United States Geological Survey allotted an equal amount. The survey of the Chesaning quadrangle, in Saginaw and Shiawassee counties, was completed and that of the Elsie, Perrinton, Bay City, Cedar Springs, Kalamazoo, Lowell, Saginaw, and Mount Pleasant quadrangles, in Clinton, Gratiot, Kent, Allegan, Barry, Kalamazoo, Bay, Ionia, Isabella, Shiawassee, and Saginaw counties, was begun by J. H. Jennings, C. L. Sadler, Robert Muldrow, A. T. Fowler, A. B. Searle, J. G. Staack, Fred Graff, jr., L. L. Lee, E. L. Hain, S. H. Birdseye, E. C. Burt, and H. E. Burney, the area mapped being 1,077 square miles, for publication on the scale of 1:62,500, with a contour interval of 5 feet. For the control of these areas and of the Carson City, Vestaburg, Fenwick, Ionia, Muir, Ithaca, and Merrill quad-

rangles, in Barry, Eaton, Gratiot, Montcalm, Clinton, Ionia, Isabella, Midland, and Saginaw counties, H. S. Senseney, E. C. Bibbee, and R. G. Clinite ran 1,080 miles of primary levels and established 237 permanent bench marks. For the control of the Cedar Springs, Kalamazoo, Carson City, Fenwick, Lowell, Ionia, Muir, Springport, Rives Junction, Maple City, Traverse City, Elk Rapids, Saginaw, Mount Pleasant, Vestaburg, and Bay City quadrangles, in Kent, Allegan, Barry, Kalamazoo, Clinton, Gratiot, Ionia, Montcalm, Bay, Eaton, Isabella, Saginaw, Jackson, Calhoun, Ingham, Leelanau, Benzie, Grand Traverse, Antrim, and Alkaska counties, Oscar Jones ran 968 miles of primary traverse and set 81 permanent marks.

*Minnesota.*—The State drainage engineer of Minnesota allotted \$4,250 for the continuation of cooperative topographic surveys, and the United States Geological Survey allotted an equal amount. The survey of the Brainerd quadrangle, in Crow Wing County, was completed and that of the Tarn and Sylvan quadrangles, in Anoka, Isanti, Cass, Crow Wing, and Morrison counties, was begun by S. G. Lunde, F. B. Barrett, J. L. Lewis, and W. S. Gehres, the total area mapped being 284 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. For the control of the Tarn and Sylvan quadrangles and of the Cushing quadrangle, in Morrison and Todd counties, E. C. Bibbee and C. E. Mills ran 244 miles of primary levels and established 66 permanent bench marks. For the control of the Sylvan, Tarn, Lakenetta, Walbo, Elk River, Pine River, Belle Prairie, Swanville, Cushing, Motley, Lastrup, Little Falls, and Browerville quadrangles, in Cass, Crow Wing, Morrison, Anoka, Isanti, Chisago, Washington, Kanabec, Sherman, Wright, Todd, Benton, and Stearns counties, J. H. Wilson ran 310 miles of primary traverse and set 28 permanent marks. The mapping of the Minnesota portion of the Superior quadrangle was completed by L. B. Roberts, the area mapped being 40 square miles, for publication on the same scale as the Wisconsin portion. (See also p. 122.)

*Missouri.*—For the continuation of cooperative topographic surveys the State geologist allotted \$4,000 and the United States Geological Survey allotted an equal amount. The resurvey of the Knobnoster quadrangle, in Johnson and Lafayette counties, was completed and that of the Halltown quadrangle and of the Spring City special area, in Christian, Greene, Lawrence, and Newton counties, was commenced by F. W. Hughes, J. M. Rawls, and F. L. Whaley, the area mapped being 246 square miles, 237 square miles for publication on the scale of 1:62,500, with a contour interval of 10 feet, and 9 square miles for publication on the scale of 1:24,000, with a contour interval of 10 feet. For the control of the Knobnoster and Halltown quadrangles and of the Stotts City and Sarcovie quadrangles, in Jasper,

Lawrence, and Newton counties, Mr. Rawls and Mr. Whaley ran 224 miles of primary levels and established 37 permanent bench marks, and for the control of the Halltown, Stotts City, and Sarcoxie quadrangles J. H. Wilson ran 124 miles of primary traverse and established 11 permanent marks.

The mapping of the Missouri portion of the Campbell Hill quadrangle, in Perry County, was commenced by Gilbert Young and M. A. Roudabush, the area mapped being 15 square miles, for publication on the same scale as the Illinois portion.

In addition to the cooperative work Mr. Wilson ran 39 miles of primary traverse and set 3 permanent marks for the control of the Joplin district, in Jasper and Newton counties.

*Ohio.*—For the completion of the cooperative topographic survey of Ohio the governor allotted \$23,900 and the United States Geological Survey allotted \$10,000. The survey of the Bainbridge, Piketon, Seaman, Peebles, Otway, and Kelleys Island quadrangles and of the Ohio portions of the Felicity, College Corner, Higginsport, Vanceburg, Garrison, Morningview, Maysville, and Springdale quadrangles, in Adams, Highland, Pike, Ross, Brown, Clermont, Butler, Preble, Scioto, and Ottawa counties, was completed by J. H. Jennings, C. W. Goodlove, A. B. Searle, W. L. Miller, Gilbert Young, R. L. Harrison, J. A. Duck, W. S. Gehres, H. E. Burney, E. C. Burt, M. A. Roudabush, G. W. Lucas, W. A. Reiter, and Howard Clark, the total area mapped being 1,022 square miles, for publication on the scale of 1:62,500, with contour intervals of 10 and 20 feet.

*Wisconsin.*—The State geologist of Wisconsin allotted \$4,000 during the fiscal year 1915 for the beginning of cooperative topographic surveys, and the United States Geological Survey allotted an equal amount. As all the State funds were not expended, the work was continued during the last year. The survey of the Neshkoro and Ripon quadrangles and of the Wisconsin portion of the Superior quadrangle, in Fond du Lac, Green Lake, Marquette, Waushara, Winnebago, and Douglas counties, was completed by L. L. Lee, S. G. Lunde, L. B. Roberts, and R. M. Herrington, the total area mapped being 399 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of the Neshkoro and Ripon quadrangles J. M. Perkins ran 118 miles of primary levels and established 28 permanent bench marks. As the cooperative funds were not sufficient to complete this work, an additional allotment was made from Federal funds.

#### OFFICE WORK.

The drafting of the following sheets was completed: Morris and Pecatonica drainage basin, Ill.; Goodloe and Paintsville, Ky.; Regina, Ky.-Va.; Matewan, Naugatuck, and Williamson, Ky.-W. Va.; Che-saning, Mich.; Brainerd, Minn.; Eminence and Knobnoster, Mo.;



Bainbridge, Hillsboro, Otway; Piketon, Sardinia, and Seaman, Ohio; Neshkoro, Wis.; Superior, Wis.-Minn.

Progress in the drafting of additional sheets was made as follows: Altenberg, Ill., 9 per cent; Brownfield, Ill.-Ky., 98 per cent; Campbell Hill, Ill., 38 per cent; Chariton, Iowa, 90 per cent; Hurley, Ky.-Va., 87 per cent; Perrinton, Mich., 10 per cent; Tarn, Minn., 15 per cent; College Corner, Ohio-Ind., 25 per cent; Felicity, Ohio-Ky., 82 per cent; Fort Recovery, Ohio-Ind., 22 per cent; Garrison, Ohio-Ky., 36 per cent; Harrison, Ohio-Ind., 27 per cent; Higginsport, Ohio-Ky., 95 per cent; Lawrenceburg, Ohio-Ind.-Ky., 15 per cent; Lynn, Ohio-Ind., 23 per cent; Maysville, Ohio-Ky., 9 per cent; Morningview, Ohio-Ky., 5 per cent; New Paris, Ohio-Ind., 25 per cent; Peebles, Ohio, 45 per cent; Springdale, Ohio-Ky., 35 per cent; Vanceburg, Ohio-Ky., 41 per cent; Ripon, Wis., 27 per cent.

Primary-level circuits were adjusted for the following quadrangles: Memphis, Ark.; Campbell Hill, Freeport, Morris, Pecatonica, Rockford, Vienna, and Wilmington, Ill.; Baxter, Goodloe, Hurley, Hyden, Matewan, Naugatuck, Nolansburg, Paintsville, Regina, and Williamson, Ky.; Burt, Chesaning, Elsie, Ithaca, Kalamazoo, Merrill, and Perrinton, Mich.; Cushing, Sylvan, and Tarn, Minn.; Knobnoster, Mo.; Felicity, Morningview, Piketon, Roxabell, and Seaman, Ohio; and Neshkoro and Ripon, Wis.

Geographic positions were computed for the following quadrangles: Memphis, Ark.; Belvidere, Campbell Hill, Dongola, Essex, Joliet, Joppa, Marion, Oregon, Pecatonica, Peotone, Rockford, Vienna, and Wilmington, Ill.; Farmland, Fort Recovery, and New Paris, Ind.; Lynn, Ohio-Ind.; Fords Ferry, Goodloe, Golconda, and Paintsville, Ky.; Bay City, Burt, Carson City, Cedar Springs, Chesaning, Elk Rapids, Elsie, Empire, Fenwick, Ionia, Kalamazoo, Lowell, Maple City, Mount Pleasant, Muir, Perrinton, Rives Junction, Saginaw, Smyrna, Springport, Traverse City, and Vestaburg, Mich.; Belle Prairie, Browerville, Cushing, Lastrup, Little Falls, Motley, Pine River, Sylvan, and Tarn, Minn.; Halltown, Sarcxie, Stotts City, and Joplin, Mo.; and Brodhead, Wis.

#### ROCKY MOUNTAIN DIVISION.

##### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Colorado, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming, with a small area extending into Minnesota. Montana was included in the northwestern division during the year, and therefore the results for the entire year are reported under that division (p. 126). The work comprised the completion of the survey of 19 quadrangles, in addition to which 36 quad-

rangles were partly surveyed. The total new area mapped was 6,198 square miles, 3,329 square miles for publication on the scale of 1:125,000, 1,323 square miles for publication on the scale of 1:62,500, and 1,546 square miles for publication on the scale of 1:31,680. In addition, the revision of the maps of 2 quadrangles was begun, the area covered being 8 square miles. In connection with this work, 1,280 miles of primary levels were run and 326 permanent bench marks were established. Profile surveys were made of parts of five rivers, the distance traversed being 230 linear miles, in connection with which 28 square miles were surveyed on the scale of 1:31,680.

Primary traverse and primary triangulation were carried on by eight parties in Colorado, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The total area covered by this work was 4,979 square miles. The primary traverse covered 2,201 square miles, 681 miles being run and 137 permanent marks set. In the triangulation 36 stations were occupied and 16 marked. This work made control available in 43 quadrangles.

*Topographic surveys in Rocky Mountain division from July 1, 1915, to June 30, 1916.*

State.	Con- tour inter- val.	For publication on scale of—					Primary levels.		Primary traverse.		Triangulation.	
		1:125,000	1:62,500	1:31,680	Total area sur- veyed, new.		Dis- tance run.	Bench marks.	Dis- tance run.	Perma- nent marks	Sta- tions occu- pied.	Stations marked.
	<i>Feet.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Miles.</i>			<i>Miles.</i>			
Colorado.....	50, 100	1,531	136	.....	1,667	84	22	.....	.....	.....	24	8
Nebraska.....	20	.....	228	.....	228	45	12	54	17	.....	.....	.....
New Mexico.....	{ 5, 25, } 50, 100	1,065	240	28	1,333	119	31	.....	.....	.....	8	5
North Dakota.....	10	.....	98	.....	98	33	9	15	3	.....	.....	.....
Oklahoma.....	.....	.....	.....	.....	.....	.....	.....	162	23	.....	.....	.....
South Dakota.....	10	.....	299	.....	299	134	38	104	10	.....	.....	.....
Texas.....	1, 5	.....	1,518	.....	1,518	645	180	270	75	.....	.....	.....
Wyoming.....	50, 100	733	222	.....	955	166	33	.....	.....	.....	4	3
Minnesota.....	10	.....	100	.....	100	54	1	76	9	.....	.....	.....
		3,329	1,323	1,546	6,198	1,280	326	681	137	36	.....	16

*Colorado.*—The survey of the northwest quarter of the Pagoda quadrangle, in Moffat and Routt counties, was continued by D. H. Watson and C. H. Stewart, the area mapped being 136 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of this area Mr. Stewart ran 47 miles of primary levels and established 12 permanent bench marks. For the control of the Pagoda and Elkhead quadrangles, in Garfield, Moffat, Rio Blanco, and Routt counties, C. B. Kendall occupied 12 triangulation stations and marked 7. The mapping of the Del Norte quadrangle, lying partly in the Rio Grande and Cochetopa national forests, in Alamosa, Rio Grande, and Saguache counties, was completed and that of the Naturita and Home quadrangles, lying partly in the

La Sal, Arapahoe, and Colorado national forests, in Montrose, San Miguel, Jackson, and Larimer counties, was continued by Basil Duke, R. C. Seitz, C. L. Nelson, W. F. Hicks, C. A. Ecklund, and Cornelius Schnurr, the total area mapped being 1,531 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 415 square miles is within the national forests. For the control of the Naturita quadrangle R. W. Burchard ran 37 miles of primary levels and established 10 permanent bench marks, and in connection with the mapping of this area Mr. Nelson made a profile survey of Dolores River, the distance traversed being 19 linear miles, for publication on the scale of 1:48,000. For the control of the Home quadrangle Mr. Kendall and G. R. Ruby occupied 12 triangulation stations and marked 1.

A survey for the location of the Fall River Road, in the Rocky Mountain National Park, was made by W. O. Tufts, all expenses of this work being borne by the Interior Department.

*Minnesota.*—See North Dakota, South Dakota, and Minnesota (p. 122).

*Nebraska.*—The mapping of the Humboldt quadrangle, in Richardson County, was completed by S. H. Birdseye and F. W. Crisp, the area mapped being 228 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. For the control of this area Mr. Birdseye ran 45 miles of primary levels and established 12 permanent bench marks, and Mr. Birdseye and Mr. Crisp ran 54 miles of primary traverse and set 17 permanent marks.

*New Mexico.*—The mapping of the Koehler quadrangle, in Colfax and Union counties, was completed by R. W. Berry, the area mapped being 240 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. The mapping of the Reserve quadrangle, lying wholly in the Datil and Socorro national forests, in Socorro County, was completed and that of the Patterson quadrangle, lying partly in the Datil National Forest, in Socorro County, was begun by C. C. Gardner, S. T. Penick, and R. W. Burchard, the total area mapped being 1,065 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 682 square miles is in the national forests. For the control of the Patterson quadrangle C. B. Kendall occupied 8 triangulation stations and marked 5, and Mr. Burchard ran 119 miles of primary levels and established 31 permanent bench marks.

Profile surveys were made of the Rio Grande from the Colorado and New Mexico State line to Embudo and from Ildefonso to Pena Blanca, and of Pecos, Gila, and Mora rivers, lying partly in the Rio Grande, Carson, Pecos, and Gila national forests, in Taos, Rio Arriba, Sandoval, Santa Fe, San Miguel, Grant, and Mora counties, the total distance traversed being 211 linear miles, for publication on

the scale of 1:31,680, with 5 and 25 foot contour intervals. Of this distance 34 miles is in the national forests. In connection with the survey of Gila River reservoir sites covering 28 square miles were mapped, for publication on the scale of 1:31,680. This work was done by R. C. Seitz and C. R. Fisher.

The revision of the map of the Tyrone district, in Grant County, was begun by O. G. Taylor, the area covered being 8 square miles.

*Oklahoma.*—For the control of the Gray Horse, Kaw, Belford, and Foraker quadrangles, in Osage, Pawnee, Kay, and Noble counties, B. H. Yoakum ran 162 miles of primary traverse and set 23 permanent bench marks. The revision of the mapping of the roads in the Hominy quadrangle was begun by C. C. Holder.

*North Dakota, South Dakota, and Minnesota.*—The mapping of the New Effington and White Rock quadrangles, in Roberts County, S. Dak., Richlands County, N. Dak., and Traverse County, Minn., was completed and that of the Peever quadrangle, in Roberts County, S. Dak., and Big Stone and Traverse counties, Minn., was begun by C. E. Cooke, S. P. Floore, and A. J. Kavanagh, the total area mapped being 497 square miles, for publication on the scale of 1:62,500, with a contour interval of 10 feet. Of this area 299 square miles is in South Dakota, 98 square miles in North Dakota, and 100 square miles in Minnesota. For the control of these areas G. T. Hawkins and Mr. Kavanagh ran 195 miles of primary traverse and set 22 permanent marks—104 miles and 10 marks in South Dakota, 15 miles and 3 marks in North Dakota, and 76 miles and 9 marks in Minnesota—and Mr. Kavanagh ran 221 miles of primary levels and established 48 permanent bench marks—134 miles and 38 marks in South Dakota, 33 miles and 9 marks in North Dakota, and 54 miles and 1 mark in Minnesota.

*Texas.*—For the continuation of cooperative topographic mapping in Harris County the county allotted \$35,000 and the United States Geological Survey allotted \$5,000. The mapping of the Deepwater, Webster, Addicks, Harmaston, Cypress, Ashford, Aldine, and Hildahl quadrangles, of the Harris County portions of the Almeda, Alief, Mykawa, Sugarland, Holik, Huffman, Joseph, Hockley, Clodine, Katy, Trinity Bay, Gaston, Seabrook, Waller, and Swanson quadrangles, and of the portions of the Park Place, Bellaire, Houston Heights, and Settegast quadrangles outside of the city of Houston was completed and that of the La Porte, Rose Hill, Louetta, Spring, Weeden, Pauli, Burnett Bay, and Humble quadrangles was begun, the area mapped being 1,310 square miles, for publication on the scale of 1:31,680, with contour intervals of 1 and 5 feet. This work was done by C. H. Birdseye, B. A. Jenkins, W. B. Lewis, E. R. Bartlett, A. J. Ogle, Olinus Smith, T. H. Moncure, O. H. Nelson, S. T. Penick, H. W. Peabody, J. H. Wilke, J. B. Leavitt, L. B. Roberts, T. P. Pendleton, C. C. Holder, Cornelius Schnurr, F. A.



Danforth, D. H. Watson, R. R. Monbeck, C. A. Stonesifer, and F. W. Hicks. For the control of the Deepwater, Park Place, Mykawa, Seabrook, Webster, Settegast, Weeden, Pauli, Fauna, Huffman, Burnett Bay, New Caney, Scott Ranch, Waller, Stilson, Spring, La Porte, Cedar Bayou, Morgans Point, Crosby, Walley, Louetta, Hempstead, Brenham, Brookshire, Sealy, and Humble quadrangles E. L. McNair, F. W. Hicks, and D. S. Birkett ran 270 miles of primary traverse and set 75 permanent bench marks. For the control of the Deepwater, Park Place, Mykawa, Katy, Seabrook, Webster, La Porte, Cedar Bayou, Morgans Point, Crosby, Walley, Hockley, Rose Hill, Louetta, Spring, Houston Heights, Settegast, Stuebner, Weeden, Pauli, Fauna, Huffman, Burnett Bay, Harmaston, Waller, Hempstead, Brenham, Brookshire, Sealy, Cypress, Ashford, Aldine, Humble, and Hillendahl quadrangles R. R. Monbeck and D. S. Birkett ran 525 miles of primary levels and established 147 permanent bench marks.

In addition to the cooperative work, the mapping of the Burkburnett, Clara, and Barwise School quadrangles, in Wichita County, was completed and that of the Electra and Wichita Falls quadrangles, in Wichita County, was begun by R. W. Berry, R. H. Reineck, C. A. Ecklund, Cornelius Schnurr, K. W. Trimble, and D. H. Watson, the area mapped being 208 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. For the control of these areas and of the Beaver Creek, Fowlkes, Iowa Park, and Wichita Falls quadrangles, in Wichita County, Mr. Watson and C. R. Fisher ran 120 miles of primary levels and established 33 permanent bench marks.

*Wyoming.*—The mapping of the Moorcroft and Como Ridge quadrangles, in Crook, Weston, Albany, and Carson counties, was completed and that of the Smoot quadrangle, lying partly in the Wyoming National Forest, in Lincoln County, was begun by R. H. Reineck, J. H. Wilke, F. W. Crisp, C. R. Fisher, and G. M. Ruby, the total area mapped being 955 square miles, 733 square miles for publication on the scale of 1:125,000, with contour intervals of 50 and 100 feet, and 222 square miles for publication on the scale of 1:62,500, with a contour interval of 50 feet. Of this area, 65 square miles lies in the national forest. For the control of these areas Mr. Crisp, Mr. Fisher, Mr. Ruby, and D. S. Birkett ran 166 miles of primary levels and established 33 permanent bench marks. For the control of the Medicine Bow quadrangle, in Albany and Carson counties, G. T. Hawkins occupied four triangulation stations and marked three.

#### OFFICE WORK.

The drafting of the following topographic maps was completed: Del Norte, Colo.; Humboldt, Nebr.; Koehler, Reserve, and Mogollon

mining district, N. Mex.; New Effington, S. Dak.-N. Dak.; White Rock, S. Dak.-N. Dak.-Minn.; Addicks, Alief, Sugarland, Almeda, Barwise School, Bellaire, Burkburnett, Clara, Clodine, Cypress, Deepwater, Hillendahl, Houston Heights, Katy, Gaston, Mykawa, and Park Place, Tex.; Como Ridge and Moorcroft, Wyo.

The drafting of profile sheets of the following rivers was completed: Dolores, Colo.; Gila, Mora, Pecos, Rio Grande from Colorado to Embudo, and Rio Grande from Ildefonso to Pena Blanca, N. Mex.

Progress in the drafting of additional sheets was made as follows: Home, Colo., 90 per cent; Naturita, Colo., 39 per cent; Pagoda (northwest quarter), Colo., 50 per cent; Drummond, Mont., 33 per cent; Patterson, N. Mex., 35 per cent; Swanson, Tex., 50 per cent.

Primary-level circuits were adjusted for the following quadrangles: Pagoda, Colo.; Falls City and Humboldt, Nebr.; Ray, N. Dak.; Patterson, N. Mex.; New Effington and White Rock, S. Dak.; Aldine, Alief, Almeda, Archer City, Ashford, Bellaire, Bobbin, Burkburnett, Burnett Bay, Cedar Bayou, Crosby, Cypress, Dallas, Deepwater, Eschite, Fauna, Harmaston, Hillendahl, Hockley, Holik, Houston Heights, Huffman, Humble, La Porte, Louetta, Morgans Point, Mykawa, Park Place, Pauli, Rose Hill, Rosenberg, Scotts Ranch, Seabrook, Settegast, Spring, Stuebner, Swanson, Waller, Walley, Webster, and Weeden, Tex.

Geographic positions were computed for the following quadrangles: Boulder, Eagle, Glenwood Springs, Home, Kremmling, Leon Peak, Livermore, Longs Peak, Mount Powell, Pagoda, Rabbit Ears, Rifle, and Snow Mass, Colo.; Beardsley, Minn.; New Effington, N. Dak.; Humboldt, Nebr.; Patterson, N. Mex.; Beardsley, New Effington, and Peever, S. Dak.; Aldine, Alief, Almeda, Ashford, Bellaire, Burnett Bay, Cedar Bayou, Crosby, Cypress, Deepwater, Fauna, Harmaston, Hillendahl, Hockley, Holik, Houston Heights, Huffman, Humble, La Porte, Louetta, Morgans Point, Mykawa, Park Place, Pauli, Rose Hill, Scotts Ranch, Seabrook, Settegast, Spring, Stuebner, Swanson, Waller, Walley, Webster, and Weeden, Tex.

#### NORTHWESTERN DIVISION.

##### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Idaho, Montana, Oregon, and Washington. The work comprised the completion of the survey of 7 quadrangles, in addition to which 9 quadrangles were partly surveyed. The total new area mapped was 4,405 square miles, 3,747 square miles for publication on the scale of 1:125,000, 534 square miles for publication on the scale of 1:62,500, and 124 square miles for publication on the scale of 1:31,680. In addition, the revision of the map of part of one

quadrangle was completed, this revision covering 90 square miles. In connection with this work 516 miles of primary levels were run and 120 permanent bench marks were established. Profile surveys were made of two rivers, the distance traversed being 261 linear miles, in connection with which 37 square miles were surveyed for publication on the scale of 1:31,680.

Primary triangulation was carried on by four parties in Idaho and Washington. The total area covered by this work was 6,840 square miles, 77 triangulation stations being occupied and 59 marked. This work made control available in 21 quadrangles.

*Topographic surveys in northwestern division from July 1, 1915, to June 30, 1916.*

State.	Contour interval.	For publication on scale of—			Total area surveyed, new.	Primary levels.		Triangulation stations.	
		1:125,000.	1:62,500.	1:31,680.		Distance run.	Bench marks.	Occupied.	Marked.
	<i>Feet.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Miles.</i>		<i>Miles.</i>	
Idaho.....	5, 25, 50, 100	763	286	20	1,069	91	23	63	45
Montana.....	100	605	21	-----	626	-----	-----	-----	-----
Oregon.....	5, 25, 50, 100	780	130	87	997	134	41	-----	-----
Washington....	5, 25, 50, 100	1,599	97	17	1,713	291	56	14	14
		3,747	534	124	4,405	516	120	77	59

*Idaho.*—The mapping of the Cranes Flat quadrangle, in Bannock, Bingham, and Bonneville counties, was completed and that of the Custer quadrangle and of the southwest quarter of the Irwin quadrangle, in Bannock, Bonneville, and Custer counties, was begun by Albert Pike, C. G. Anderson, and F. L. Whaley, the area mapped being 376 square miles, 90 square miles for publication on the scale of 1:125,000, with a contour interval of 100 feet, and 286 square miles for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of these areas and of the Irwin, Portneuf, Henry, and Lanes Creek quadrangles and the southwest quarter of the Ammon quadrangle, in Bannock, Bingham, and Bonneville counties, H. H. Hodgeson occupied 16 triangulation stations and marked 7, and for the control of the Henry quadrangle and of the Custer and Bay Horse quadrangles, in Custer County, Mr. Whaley and E. M. Bandli ran 77 miles of primary levels and established 19 permanent bench marks. The mapping of the Preston quadrangle, lying partly in the Cache National Forest, in Bannock, Bear Lake, and Franklin counties, was completed by Albert Pike and Mr. Whaley, the area mapped being 673 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 235 square miles is in the national forest. For the control of

this area and of the Argo, No. 1, Dickey, Crooks, Bay Horse, Hailey, Circular Butte, Nicholia, Rabbits Foot, Tilden, Edie, and Mackay quadrangles, lying partly in the Challis, Lemhi, Salmon, and Sawtooth national forests, in Bannock, Blaine, Power, Custer, Minidoka, Bingham, Jefferson, Fremont, Lemhi, and Lincoln counties, T. M. Bannon and D. S. Birkett occupied 47 triangulation stations and marked 38. For the control of the Bay Horse quadrangle, in Custer County, Mr. Bandli ran 14 miles of primary levels and established 4 permanent bench marks. A profile survey of Snake River was made by Mr. Anderson, the total distance traversed being 43 linear miles in Fremont County, for publication on the scale of 1:31,680, with contour intervals of 5 and 25 feet. In connection with this profile survey 20 square miles of reservoir site was surveyed.

*Idaho and Montana.*—The mapping of the St. Regis quadrangle, lying partly in the St. Joe, Lolo, and Cabinet national forests, in Shoshone County, Idaho, and Mineral and Sanders counties, Mont., was continued by J. E. Blackburn, the area mapped being 227 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 139 square miles is in the national forests. All this area is in Montana.

*Montana.*—The mapping of the Nameless quadrangle, in Valley County, was continued by R. C. Seitz, the area mapped being 21 square miles, for publication on the scale of 1:62,500, with a contour interval of 20 feet. The mapping of the Drummond quadrangle, lying partly in the Deerlodge and Missoula national forests, in Granite, Missoula, and Powell counties, was begun by K. W. Trimble, the area mapped being 378 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 64 square miles is in the national forests.

*Oregon.*—For the continuation of cooperative topographic surveys the State engineer allotted \$4,000 and the United States Geological Survey allotted an equal amount. In the survey of the Willamette Valley the mapping of the Salem quadrangle, in Marion and Polk counties, was completed by Fred Graff, jr., Charles Hartmann, and R. B. Kilgore, the area mapped being 87 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. The mapping of the Oregon portion of the Hillsboro quadrangle, in Columbia, Multnomah, and Washington counties, was completed and that of the Oregon portion of the southwest quarter of the Troutdale quadrangle and of the Twickenham quadrangle, in Multnomah, Crook, Jefferson, Wasco, and Wheeler counties, was begun by C. L. Sadler, Mr. Graff, A. O. Burkland, Mr. Hartmann, and Bishop Moorhead, the total area mapped being 187 square miles—130 square miles for publication on the scale of 1:62,500, with a contour interval of 25 feet, and 57 square miles for publication on the scale of 1:125,000,



with a contour interval of 50 feet. For the control of the Twickenham quadrangle and of the Heisler quadrangle, in Crook, Jefferson, and Wasco counties, D. S. Birkett ran 88 miles of primary levels and established 28 permanent bench marks.

In addition to the cooperative work, the mapping of the Kerby quadrangle, lying partly in the Siskiyou National Forest, in Curry and Josephine counties, was completed by J. G. Staack, A. O. Burkland, C. P. McKinley, R. M. Wilson, and John McCombs, the area mapped being 723 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. For the control of this area L. F. Biggs ran 46 miles of primary levels and established 13 permanent bench marks.

*Washington.*—For the continuation of cooperative topographic surveys the Washington State Board of Geological Survey allotted \$11,500 and the United States Geological Survey allotted an equal amount. The mapping of the Prosser and Wallula quadrangles, in Benton, Klickitat, Yakima, Franklin, and Walla Walla counties, was completed and that of the Walla Walla quadrangle, in Columbia and Walla Walla counties, was begun by C. L. Sadler, Albert Pike, H. L. McDonald, J. F. McBeth, and Charles Hartmann, the area mapped being 1,364 square miles—1,270 square miles for publication on the scale of 1:125,000, with a contour interval of 50 feet, and 94 square miles for publication on the scale of 1:62,500, with a contour interval of 50 feet. The remainder of these quadrangles, covering 195 square miles, was mapped by the Reclamation Service. In connection with the survey of the Prosser quadrangle the work of the Reclamation Service in that area, covering 90 square miles, was revised. For the control of these areas and of the Walla Walla, Pomeroy, and Winona quadrangles and the Washington portion of the Asotin quadrangle, in Walla Walla, Columbia, Garfield, Adams, Whitman, and Asotin counties, D. S. Birkett ran 172 miles of primary levels and established 42 permanent bench marks. A profile survey of Skagit River and tributaries above Concrete was made by S. G. Lunde, the distance traversed being 218 linear miles, for publication on the scale of 1:31,680. In connection with this work 17 square miles of reservoir site was surveyed, for publication on the scale of 1:31,680. The mapping of the Washington portion of the Hillsboro quadrangle, in Clarke County, was completed, the area mapped being 3 square miles, for publication on the same scale as the Oregon portion. For the control of the Connell and Riparia quadrangles, in Adams, Franklin, and Columbia counties, G. T. Hawkins occupied and marked 14 triangulation stations.

In addition to the cooperative work in Washington, the mapping of the Mount St. Helens quadrangle, lying partly in the Columbia National Forest, in Clarke, Cowlitz, Lewis, and Skamania counties,

was continued by C. P. McKinley, E. M. Bandli, and L. V. Fees, the area mapped being 329 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 182 square miles is within the national forests. For the control of this area and of the Kalama quadrangle, in Cowlitz and Lewis counties, L. F. Biggs ran 119 miles of primary levels and established 14 permanent bench marks.

#### OFFICE WORK.

The drafting of the following topographic maps was completed: Cranes Flat and Preston, Idaho; Hillsboro, Kerby, and Salem, Oreg.; Prosser and Wallula, Wash.

The drafting of profile sheets of the following rivers was completed: Snake, Idaho; Skagit and tributaries above Concrete, Wash.

Progress in the drafting of additional sheets was made as follows: St. Regis, Idaho-Mont., 38 per cent; Mount St. Helens, Wash., 53 per cent.

Primary-level circuits were adjusted for the following quadrangles: Ammon and Preston, Idaho; Heisler, Kerby, and Twickenham, Oreg.; Kalama, Mount St. Helens, Pomeroy, Portland, Prosser, Riparia, St. Helens, Troutdale, Walla Walla, and Wallula, Wash.

Geographic positions were computed for the Arco, Argo, Bancroft, Bay Horse, Crooks, Custer, Dickey, Hailey, Henry, Mackay, Mink Creek, Nicholia, No. 1, Portneuf, Soda Springs, and Tilden quadrangles, Idaho.

#### PACIFIC DIVISION.

##### FIELD WORK.

*Summary.*—During the season topographic mapping was carried on in Arizona, California, Nevada, and Utah. This work comprised the completion of the survey of 14 quadrangles and the resurvey of 3 quadrangles and 1 special area, in addition to which 11 quadrangles were partly surveyed and 3 were partly resurveyed. The total new area mapped was 2,808 square miles—1,493 square miles for publication on the scale of 1:125,000, 561 square miles for publication on the scale of 1:62,500, and 754 square miles for publication on the scale of 1:31,680. The area resurveyed was 798 square miles—728 square miles for publication on the scale of 1:62,500 and 70 square miles for publication on the scale of 1:31,680. The map of part of a quadrangle was revised to bring it up to date with the new work, the area covered by this revision being 250 square miles. In connection with this work 343 miles of primary levels were run and 87 permanent bench marks were established. In addition, profile surveys were made of portions of four rivers, the distance traversed being 113 linear miles.

Primary triangulation was carried on by three parties in California, Nevada, and Utah. The total area covered by this work was about 3,690 square miles, 89 triangulation stations being occupied and 94 marked. The result of this work was to make control available in 41 quadrangles.

*Topographic surveys in Pacific division from July 1, 1915, to June 30, 1916.*

State.	Contour interval.	For publication on scale of—						Total area surveyed.	Primary levels.		Triangulation.	
		1:125,000		1:62,500		1:31,680			Distance run.	Bench marks.	Stations occupied.	Stations marked.
		New.	New.	Resurvey.	New.	Resurvey.						
	<i>Feet.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Sq. mi.</i>	<i>Miles.</i>				
Arizona.....	100	546	.....	.....	.....	70	.....	546	56	11	.....	.....
California.....	5-25-100	947	561	6	754	.....	2,338	57	14	51	61	
Nevada.....	50	.....	.....	494	.....	.....	494	107	28	22	20	
Utah.....	50	.....	.....	228	.....	.....	228	123	34	16	13	
		1,493	561	728	754	70	3,606	343	87	89	94	

*Arizona.*—The mapping of the Chiricahua quadrangle, lying partly in the Chiricahua National Forest, in Cochise County, Ariz., and Grant County, N. Mex., was begun by J. E. Blackburn, the area mapped being 546 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. Of this area 144 square miles is in the national forest. For the control of this area C. R. Fisher ran 56 miles of primary levels and established 11 permanent bench marks. All this work was done in Arizona. Profile surveys were made of Verde and Salt rivers, in Yavapai and Gila counties, by Mr. Fisher, the distance traversed being 83 linear miles, for publication on the scale of 1:31,680, with contour intervals of 5 and 25 feet.

*California.*—For the continuation of cooperative topographic surveys the California Department of Engineering allotted \$14,000 and the United States Geological Survey allotted an equal amount. In the continuation of the survey of San Joaquin Valley the mapping of the Planada, Newman, Atwater, No. 7, No. 9, Stevinson, Arena, Gustine, Le Grand, and Ingomar  $7\frac{1}{2}$ -minute quadrangles and of the valley portions of the No. 74, Merced Falls, and Orestimba Creek  $7\frac{1}{2}$ -minute quadrangles, in Merced, Stanislaus, Tuolumne, Mariposa, and Madera counties, was completed, and that of the Plainsberg and Las Garzas Creek quadrangles and of the Indian Gulch 15-minute quadrangle, in Mariposa, Madera, Merced, and Stanislaus counties, was begun by E. P. Davis, R. T. Evans, A. J. Ogle, H. W. Peabody, J. H. LeFeaver, J. B. Leavitt, N. E. Ballmer, Roscoe Reeves, and R. M. Wilson, the area mapped being 844 square miles—754 square miles for publication on the scale of 1:31,680, with a contour inter-

val of 5 feet, and 90 square miles for publication on the scale of 1:62,500, with a contour interval of 25 feet. The resurvey of the Snelling quadrangle and of the valley portion of the La Grange quadrangle, in Merced, Stanislaus, and Tuolumne counties, was completed by R. T. Evans, J. B. Leavitt, and Roscoe Reeves, the area mapped being 70 square miles, for publication on the scale of 1:31,680, with a contour interval of 5 feet. For the control of the Jamison, Fresno, Madera, No. 10, No. 14, No. 15, No. 16, No. 18, No. 19, No. 20, No. 21, No. 22, No. 23, No. 24, No. 25, Kerman, Kearney Peak, Kings River, Elgin, Chowchilla Slough, Center School, Dos Palos, Tranquillity, Oxalis, Firebaugh, Mendota, San Joaquin, Sanger, Wahtoke, Sultana, Sheep Ranch, and Chaney Ranch quadrangles and the Rudley special area, in Fresno, Madera, Merced, and Tulare counties, L. F. Biggs occupied 46 triangulation stations and marked 60. For the control of the Volta, Las Garzas Creek, Los Banos, and San Luis Creek quadrangles, in Merced and Stanislaus counties, Mr. Reeves ran 42 miles of primary levels and established 10 permanent bench marks.

In addition to the cooperative work in California, the survey of the Cholame, San Juan Bautista, and Morgan Hill quadrangles, in San Luis Obispo, Kings, Monterey, Fresno, Kern, San Benito, Santa Clara, and Santa Cruz counties, was completed and that of the New Almaden and Point Reyes quadrangles, in Santa Clara, Santa Cruz, and Marin counties, was begun by A. T. Fowler, J. P. Harrison, E. P. Davis, R. T. Evans, A. J. Ogle, Olinus Smith, H. W. Peabody, J. H. Le Feaver, C. A. Ecklund, C. P. McKinley, N. E. Ballmer, and J. B. Leavitt, the area mapped being 741 square miles—270 square miles for publication on the scale of 1:125,000, with a contour interval of 100 feet, and 471 square miles for publication on the scale of 1:62,500, with a contour interval of 25 feet. In connection with the mapping of the Cholame quadrangle part of the work previously done was revised to bring the entire map up to date. The area covered by this revision is 250 square miles. The mapping of the Preston Peak quadrangle, lying wholly in the Klamath and Siskiyou national forests, in Del Norte and Siskiyou counties, was completed by J. W. Muller and J. P. Harrison, the area mapped being 677 square miles, for publication on the scale of 1:125,000, with a contour interval of 100 feet. For the control of this area Mr. Biggs ran 15 miles of primary levels and established 4 permanent bench marks. In connection with this work Frederick Rider made a profile survey of the South Fork of Smith River as far as Quartz Creek and of Klamath River, the total distance traversed being 30 linear miles, for publication on the scale of 1:48,000.

*California and Nevada.*—The resurvey of the Yellow Pine mining district, in Clark County, Nev., and San Bernardino County, Cal.,



was completed by N. E. Ballmer and Roscoe Reeves, the area mapped being 236 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. Of this area 6 square miles is in California. For the control of this area L. F. Biggs occupied 13 triangulation stations and marked 8, of which 5 were occupied and 1 marked in California, and ran 80 miles of primary levels and established 21 permanent bench marks, all in Nevada.

*Nevada.*—The resurvey of the Bristol Range quadrangle, in Lincoln County, was completed and that of the northwest quarter of the Panaca quadrangle and the northeast quarter of the Delamar quadrangle, in Lincoln County, was begun by H. H. Hodgeson, N. E. Ballmer, and Roscoe Reeves, the area mapped being 264 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. This work covers part of the Pioche district. For the control of this area Mr. Hodgeson occupied 14 triangulation stations and marked 13, and Mr. Reeves ran 27 miles of primary levels and established 7 permanent bench marks.

*Utah.*—The resurvey of the Fairfield quadrangle, in Salt Lake, Tooele, and Utah counties, was completed by A. T. Fowler and W. O. Tufts, the area mapped being 228 square miles, for publication on the scale of 1:62,500, with a contour interval of 50 feet. For the control of this area and of the Mercur, Nephi, Mammoth, and Provo quadrangles, in Tooele, Utah, Salt Lake, Wasatch, Juab, Millard, and Sanpete counties, C. W. Urquhart occupied 16 triangulation stations and marked 13, and for the control of the Fairfield, Mercur, Saltair, and Dunstein quadrangles, in Salt Lake, Tooele, and Utah counties, Roscoe Reeves ran 123 miles of primary levels and established 34 permanent bench marks.

#### OFFICE WORK.

The drafting of the following topographic maps was completed: Christmas, Ariz.; Arena, Atwater, Cholame, Elizabeth Lake, Gustine, Morgan Hill, Newman, Orestimba Creek, Owens Creek, Planada, Preston Peak, San Juan Bautista, Snelling, and Stevinson, Cal.; Hilo, Hawaii; Bristol Range, Nev.; White Mountain, Nev.-Cal.; Fairfield, Utah.

The drafting of profile sheets of the following rivers was completed: Klamath and South Fork of Smith, Cal.

Progress in the drafting of additional sheets was made as follows: La Grange, Cal., 5 per cent; Le Grand, Cal., 5 per cent; New Almaden, Cal., 15 per cent.

Primary-level circuits were adjusted for the following quadrangles: Crescent City and Preston Peak, Cal.; Bristol Range, Nev.; Yellow Pine mining district, Cal.-Nev.; Mercur and Saltair, Utah.

Geographic positions were computed for the following quadrangles: Pioche district (Bristol Range, Delamar, Ely Range, Newland, and Panaca), Nev.; Yellow Pine mining district, Cal.-Nev.; Merced, Planada, No. 11, Indian Gulch, Plainsberg, Le Grand, No. 9, Deadman Creek, Owens Creek, Chowchilla Slough, Mariposa Slough, Salt Slough, Ingomar, Las Garzas Creek, Berendo, Minturn, and No. 10, Cal.; Mercur, Utah; and Mount St. Helens, Wash.

#### INSPECTION OF TOPOGRAPHIC MAPPING.

W. M. Beaman spent four months and A. M. Walker one month in a field inspection of topographic mapping in the five topographic divisions. Mr. Beaman continued the supervision of the field and office work on the map of Washington and vicinity, and Mr. Walker spent four months in field work and two months in office work on this map.

The office duties of Messrs. Beaman and Walker consisted largely in the supervision of the preparation of all topographic field sheets and reports for publication and their proper transmission. L. S. Leopold continued as assistant under this section.

#### MILLIONTH-SCALE MAP OF THE UNITED STATES.

Of the work in progress last year on the 1:1,000,000 scale map of the United States, under the direction of A. F. Hassan, 90 per cent of the base map of Idaho (parts of sheets K-11, K-12, L-11, L-12, M-11) was completed. International sheets K-18 and J-18 were completed, and the base maps of Florida and North Carolina were revised. New work included the completion of the base map of an area comprising approximately one-third of Colorado (parts of sheets J-13 and K-13) and the compilation of 80 per cent of the township lines of the rest of the State, the compilation and inking of 60 per cent of the base map of the Coastal Plain area of Texas (sheets I-14, I-15, H-14, and H-15), and the completion of international sheet I-18.

The problem of showing relief by contours, generalized to meet the conditions imposed by the small scale so as to preserve legibility and still show topographic character, received much study, and a number of experimental drawings of intricately dissected plateau types were made.

#### WORK OF SECTION OF FIELD EQUIPMENT.

During the year this section continued the custody of field instruments and camp equipment, as well as office property in the Survey offices outside of Washington, for the geologic, topographic, and water-resources branches. The personnel and duties of the section remained unchanged during the year, consisting of E. M. Douglas

in charge, Ernest Kubel in immediate charge of the instrument shop, two clerks, one skilled mechanic, and one laborer, with the occasional help of a second laborer.

The records of field instruments included 100 items and those of camp outfits 93 items. This year's inventory includes among the more important items 406 alidades, 837 compasses, 591 levels, 202 current meters, 107 registers, 226 leveling rods, 797 tapes, and 42 transits. Under camp outfits are listed 496 horses and mules, 8 automobiles, 6 boats and canoes, 2 well-drilling outfits, 709 pack and riding saddles, 525 tents, and 162 buckboards and wagons.

The topographic record books are also in the custody of this section, and during the year 430 vertical and horizontal control books, 193 vertical-angle record books, and about 50 envelopes of manuscript were catalogued and filed.

In the instrument shop repairs were made to over 2,000 instruments, including 107 telescopic alidades, 30 Y levels, 25 transits, and 180 compasses. The instrument shop also made, resurfaced, or electrotyped over 152,000 square inches of plates.

#### WATER-RESOURCES BRANCH.

##### ORGANIZATION AND SCOPE OF WORK.

The water-resources branch includes three divisions—surface water, ground water, and water utilization—each of which is subdivided into sections for field work. The organization is as follows:

Chief of branch, N. C. Grover, chief hydraulic engineer.

Division of surface waters, J. C. Hoyt, hydraulic engineer, in charge.

Division of ground waters, O. E. Meinzer, geologist, in charge.

Division of water utilization, N. C. Grover, chief hydraulic engineer, in charge.

##### PERSONNEL.

During the year the technical force of the water-resources branch has been reduced 14 by transfers and resignations and has been increased 8 by new appointments. At the end of the year the force consisted of 1 chief hydraulic engineer, 12 hydraulic engineers, 25 assistant engineers, 24 junior engineers, 1 geologist, 2 associate geologists, 3 assistant geologists, 1 geologic aid, and 1 chemist, a total of 70. Of this number, 1 hydraulic engineer, 1 assistant engineer, and 1 junior engineer are on furlough, and 1 hydraulic engineer, 3 assistant engineers, and 1 assistant geologist are employed occasionally.

In the clerical force there were 4 separations and 3 accessions, and at the end of the year it numbered 25 members.

##### ALLOTMENTS.

The appropriation was the same as in the preceding year—\$150,000. The cooperative funds made available by State allotments

have been increased in some States and decreased in others, making necessary corresponding adjustments of the work.

The appropriation for the fiscal year was allotted as follows:

Administrative expenses of the Survey-----	\$10,624
Branch administration-----	7,280
Computations and reports-----	18,000
Inspection-----	1,000
Stream gaging:	
New England States-----	\$4,500
New York-----	2,500
Virginia and Maryland-----	600
South Atlantic and Gulf States-----	4,500
Texas-----	3,335
Ohio Valley-----	6,000
Upper Mississippi Valley States-----	5,500
Colorado, Wyoming, and New Mexico-----	8,500
Montana-----	4,000
Utah-----	4,000
Nevada-----	2,500
Idaho-----	4,000
Oregon-----	4,000
Washington-----	4,000
California-----	4,000
Arizona-----	3,500
Hawaii-----	4,500
Yellowstone National Park-----	200
	<hr/> 70,135
Investigation of ground waters, including quality of waters-----	19,000
Land-classification board-----	11,000
Water-power investigations-----	11,000
Contingent-----	1,961
	<hr/> 150,000

Of the total appropriation, 64 per cent was allotted for work in public-land States.

#### COOPERATION.

*States.*—Cooperative funds were allotted by several States, as follows:

Alabama-----	\$200
Arizona-----	3,960
California:	
State engineer-----	\$9,000
State Water Commission-----	3,630
City of San Francisco-----	3,930
	<hr/> 16,560
Colorado-----	485
Connecticut-----	1,555
Hawaii-----	20,090
Illinois-----	2,355
Iowa-----	500
Kentucky-----	315



Maine .....	\$4,515
Massachusetts .....	2,520
Minnesota .....	2,400
Montana .....	2,875
Nevada .....	3,140
New York:	
State engineer .....	\$1,560
Conservation Commission .....	12,240
	<hr/> 13,800
North Dakota .....	500
Oregon .....	7,300
Texas .....	8,500
Utah .....	5,015
Vermont .....	1,440
Washington .....	6,020
Wisconsin .....	6,000
Wyoming .....	5,010

The work done under cooperative agreements in the several States has been limited to stream gaging, except as indicated below.

In California, in addition to a large amount of stream gaging, investigations of ground waters were continued in San Jacinto and Santa Clara valleys and in San Diego County, and measurements of depths to ground-water level were made in southern California. The report on the ground water of Sacramento Valley, based on work which has been in progress for several years, was practically completed.

In Connecticut the cooperative work consisted chiefly of ground-water surveys.

In Hawaii, besides stream gaging, measurements of precipitation were made, and the water losses in irrigation canals were studied.

The stream-flow records in Oregon, compiled in cooperation with the State, were published as Water-Supply Paper 370.

A compilation of stream-flow records in Massachusetts is now in press as Water-Supply Paper 415.

A detailed study of the water supply and the present and possible future use of Sevier River, Utah, begun in 1914, was still in progress at the end of the fiscal year.

In addition to the cooperative work tabulated above, in which the States furnished a part of the money for examinations made by the Survey staff, investigations of ground waters in Arizona were continued as in previous years in cooperation with the State Agricultural Experiment Station, analyses of water being made at the experiment station. An investigation of the ground waters of Montana was also begun in cooperation with the State engineer, who collected well records throughout the State, and with the State Board of Health and Montana State College, at the chemical laboratory of which analyses of water were made.

*Reclamation Service.*—Cooperation with the Reclamation Service in stream gaging has been continued. The gaging stations operated at the expense of the reclamation fund are on streams that are to furnish water to reclamation projects under construction by that Service. The field work of stream gaging is done by Survey engineers who are engaged in such work in the locality, and repayment of actual cost is made by the Reclamation Service through a transfer of funds.

*Office of Indian Affairs.*—Stream gaging was continued on the following Indian reservations, in accordance with authorizations of the Office of Indian Affairs: Colville, Crow, Fort Hall, Klamath, La Pointe, Menominee, Pine Ridge, Quinault, Rosebud, San Carlos, Standing Rock, Warm Springs, Yakima, and Duck Valley.

*United States Engineer Office.*—Stream gaging in connection with navigation and flood studies in the Ohio River basin is in progress in cooperation with the United States Engineer Office.

*Forest Service.*—A study of the stream flow in the Angeles National Forest, in southern California, is in progress in cooperation with the Forest Service.

*City of San Francisco.*—Stream gaging has been continued on Tuolumne River in cooperation with the city of San Francisco in connection with the utilization of the water to be stored in the Hetch Hetchy Valley as a water supply for the city.

#### PUBLICATIONS.

The publications of the year prepared by the water-resources branch comprised 24 reports and 9 separate chapters. Titles and brief summaries of these publications are given on pages 31–36. At the close of the year 24 other reports were in press and 8 manuscripts were awaiting editorial work.

#### GENERAL SUMMARY.

In the investigation of surface waters the water-resources branch has maintained gaging stations for measuring the discharge of streams in 39 States and in Hawaii and Alaska. It is, however, only through extensive cooperation with States and other Federal organizations that the relatively large amount of work now in progress can be carried on. Twenty-four cooperating States (including Hawaii) have contributed more than \$115,000 for work in those States, and the Indian Office, Engineer Office, Reclamation Service, and Forest Service have also cooperated largely in the study of the flow of particular rivers. The cooperating States include, besides many of the Northern and Eastern States, all the States in the Great Basin and on the Pacific slope and nearly all those in the Rocky Mountain and western Gulf groups, where water is necessary for agriculture by irrigation.

Investigations of ground water have been made in 17 States (including Alaska), but the lack of funds prevents the comprehensive study of the occurrence, quantity, and quality that is commensurate with the importance of the subject. Several water-supply papers containing the results of ground-water investigations are published each year.

Many investigations of the present and probable future use of both surface and ground waters have been made in connection with the classification of the 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.

#### DIVISION OF SURFACE WATERS.

##### ORGANIZATION.

The work of the division of surface waters consists primarily of the measurement of the flow of rivers but includes also special investigations of conditions affecting stream flow and utilization of the streams. In carrying on the work the United States is divided into 16 districts, including Hawaii. One of these districts (Texas) was established during the year, having been formed by dividing the South Atlantic district. The following list gives the districts, names of district engineers, and location of offices:

- New England: C. H. Pierce, Customhouse, Boston, Mass.
- New York: C. C. Covert, Federal Building, Albany, N. Y.
- Middle Atlantic: G. C. Stevens, Washington, D. C.
- South Atlantic and eastern Gulf: W. E. Hall, Federal Building, Atlanta, Ga.
- Texas: G. A. Gray, Old Post Office Building, Austin, Tex.
- Ohio Valley: A. H. Horton, Federal Building, Newport, Ky.<sup>1</sup>
- Upper Mississippi River: W. G. Hoyt, Capitol Building, Madison, Wis.; suboffice, Old Capitol Building, St. Paul, Minn.
- Upper Missouri: W. A. Lamb, Montana National Bank Building, Helena, Mont.
- Rocky Mountain: Robert Follansbee, New Post Office Building, Denver, Colo.
- Great Basin: E. A. Porter (to February 29), C. C. Jacob (after February 29), Federal Building, Salt Lake City, Utah.
- Idaho: G. C. Baldwin, Idaho Building, Boise, Idaho.
- Oregon: F. F. Henshaw, Couch Building, Portland, Oreg.
- Washington: G. L. Parker, Federal Building, Tacoma, Wash.
- California: H. D. McGlashan, Customhouse, San Francisco, Cal.; suboffice, Federal Building, Los Angeles, Cal.
- Arizona: C. C. Jacob (to February 29), M. D. Anderson, acting (after February 29), Fleming Building, Phoenix, Ariz.
- Hawaii: G. K. Larrison, Kapiolani Building, Honolulu.

<sup>1</sup> Office temporarily closed during the year; work conducted from Washington office.

## CHARACTER AND METHODS OF WORK.

Field investigations incident to the work are made from the district offices, where the results are sufficiently analyzed to insure their accuracy and completeness. At selected places, known as gaging stations, measurements of discharge are made and other data are collected from which the daily flow of the streams is computed. At the end of the year 1,302 gaging stations were maintained, including 100 in Hawaii and 9 in Alaska. During the year 384 stations were discontinued and 327 stations established. In addition, records ready for publication were received for about 150 stations from other Government bureaus and private persons. During the year 8,271 measurements of discharge were made. Many of the stations are maintained in cooperation with other Federal bureaus, State organizations, or private persons.

*Gaging stations and cooperating parties for the year ended June 30, 1916.*

State.	Geological Survey alone.	Reclamation Service.	Forest Service.	Indian Service.	Army engineers.	Weather Bureau.	Other Federal bureaus.	State cooperation.	Municipal cooperation.	Private persons.	Counted more than once.	Maintained at end of year.	Established during year.	Discontinued during year.	Regular gagings during year.	Miscellaneous gagings during year.
Alabama.....					1			4		2		5			8	
Arizona.....				4	2			19		2	4	23	5		306	31
California.....		36	24			2	7	147	17	42	106	147	19	44	1,087	299
Colorado.....	5	3				1		13		3	2	47	4	6	252	1
Connecticut.....								1		1		2	1		4	
Georgia.....	1					4			3	14	1	21	5	2	96	1
Idaho.....	5	16	4	11		2				33	1	70	19	13	454	31
Illinois.....						1		23				24	2	3	81	1
Indiana.....						1				1		2			2	
Iowa.....						2		14			2	14			23	
Kentucky.....								5				5			1	5
Maine.....								16		2	2	16	4	10	66	
Maryland.....	3											3			7	
Massachusetts.....								17		1	1	17	7	7	85	2
Michigan.....								1		1		2		3		
Minnesota.....					2	2	1	30		1	6	30	3	1	168	2
Montana.....	11	56	14	7		1		21		1	1	110	3	5	480	25
Nevada.....		2		2		1		41		14	18	42	13	13	169	65
New Hampshire.....										4		1			24	
New Jersey.....	1									4		7				
New Mexico.....	1			2		4				4			23		17	
New York.....					1	4		51	1	5	11	51	12	1	405	15
North Carolina.....	2					1				6		9		2	13	
North Dakota.....				1				5				6		2	38	
Ohio.....	1				5							6		2	13	
Oklahoma.....		4										6			5	
Oregon.....			5	8		4	1	26	3	73	1	119	100	69	354	148
Rhode Island.....										1		1			12	
South Carolina.....							1					1				
South Dakota.....				4						1		5			29	
Tennessee.....	1					2				5		3	4		5	2
Texas.....						6		33	1	3	10	33	25	5	331	13
Utah.....		4	2					124	9	95	101	124	54	61	1,098	158
Vermont.....								9		4	4	9	2		1	
Virginia.....	7					1				2		10		3	8	
Washington.....	5	1	8	12				4	2	30	1	61	4	31	354	57
West Virginia.....	22				17	1				2		42	5	2	58	2
Wisconsin.....				3				44		12	15	44	4	6	250	1
Wyoming.....		8	2			1	4	55		1	3	68	9	3	292	1
Hawaii.....					3			100		48	51	100	23	52	585	108
	65	94	95	56	31	37	14	802	28	412	341	1,293	327	384	7,307	964



Results of field data collected from the district offices are transmitted to the Washington office, where they are reviewed in the computing section and prepared for publication. This review insures accuracy in the data and brings the results from different parts of the country to a uniform standard. Regular field inspections are made, and through annual conferences of the engineers the work in the several districts is standardized.

## PUBLICATIONS.

For convenience and uniformity in publication the United States has been divided into 12 primary drainage basins, as shown in the following table, 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 reports for the twelfth division have been published as three separate papers.

In 1913 a seasonal or climatic year—October 1 to September 30—was adopted for the presentation of reports on regions west of the Rocky Mountains and on the upper Mississippi and Ohio rivers; in 1914 the use of the climatic year was extended to all districts.

*Numbers of water-supply papers containing results of stream measurements, 1910-1915.*

Part.	Area.	1910	1911	1912	1913	1914	1915
I	North Atlantic.....	281	301	321	351	381	401
II	South Atlantic and eastern Gulf of Mexico.....	282	302	322	352	382	402
III	Ohio River.....	283	303	323	353	383	403
IV	St. Lawrence River and Great Lakes.....	284	304	324	354	384	404
V	Hudson Bay and upper Mississippi River.....	285	305	325	355	385	405
VI	Missouri River.....	286	306	326	356	386	406
VII	Lower Mississippi River.....	287	307	327	357	387	407
VIII	Western Gulf of Mexico.....	288	308	328	358	388	408
IX	Colorado River.....	289	309	329	359	389	409
X	Great Basin.....	290	310	330	360	390	410
XI	California.....	291	311	331	361	391	411
XII	North Pacific.....	292	312	332	362	.....	.....
	Pacific basins in Washington and upper Columbia River.....	.....	.....	332-A	362-A	392	412
	Snake River basin.....	.....	.....	332-B	362-B	393	413
	Lower Columbia River and Pacific basins in Oregon.....	.....	.....	332-C	362-C	394	414

In addition to the regular progress reports, special reports on various hydraulic subjects have been completed for publication during the year, as is indicated in the list on pages 31-36.

## DIVISION OF GROUND WATERS.

## SCOPE OF WORK.

The function of the division of ground waters is to make a survey of the waters that occur below the surface of the ground with reference to their utilization. Because of the great interest throughout the West in irrigation with ground water and the prospects for

considerable developments of this kind, most of the work has been done in the arid and semiarid States and with special reference to irrigation.

During the year 41 investigations of ground water or quality of water (including the reports in press) were in progress, covering areas in Alaska, Arizona, Arkansas, California, Connecticut, Florida, Georgia, Mississippi, Montana, Nebraska, Nevada, New Mexico, Ohio, South Dakota, Texas, Wisconsin, Wyoming, and the United States naval station in Cuba. Of these investigations 8 were conducted in cooperation with the geologic branch of this Survey, 6 were made for and in part paid for by other branches of the Federal Government, including the Navy Department, the War Department, the Department of Justice, and the Office of Indian Affairs, and 20 were made in cooperation with State organizations, including 2 geological and natural history surveys, 2 departments of engineering, 2 experiment stations, 1 agricultural college, and 1 board of health.

A paper entitled "The divining rod, a history of water witching, with a bibliography," was prepared by A. J. Ellis and is to be published as Water-Supply Paper 416.

A bibliography and index of ground-water papers published by the United States Geological Survey was begun by O. E. Meinzer. Plans have also been made for a comprehensive manual on ground water.

The chemical investigations, which are under the supervision of R. B. Dole, cover both surface and ground waters. Some progress was made during the year in the preparation of a report on the chemical composition of the surface waters of the United States by Mr. Dole, assisted by A. A. Chambers. The chapter on the production of mineral waters for the annual volume *Mineral Resources of the United States* was prepared by Mr. Dole.

Maps and manuscripts for geologic folios were reviewed so far as they relate to ground water.

#### WORK BY STATES.

*Alaska.*—Through cooperation with the division of Alaskan mineral resources an investigation of the mineral springs in Alaska was made by G. A. Waring, and samples of water were also collected by him from Yukon River. The analytical work was done by R. B. Dole, A. A. Chambers, and S. C. Dinsmore. A report based on this investigation by Mr. Waring, with a chapter on the quality of waters by Messrs. Dole and Chambers, has been completed and will be published as Water-Supply Paper 418.

*Arizona.*—The report on the Navajo country, a geographic and hydrographic reconnaissance of parts of Arizona, New Mexico, and

Utah, by H. E. Gregory, is in press as Water-Supply Paper 380. A brief report on ground water in an area west of Little Colorado River is being prepared by Prof. Gregory. Both reports are based on investigations made in previous years through financial cooperation by the Office of Indian Affairs.

The report on ground water in Paradise Valley, by O. E. Meinzer and A. J. Ellis, was published as Water-Supply Paper 375-B.

A report on an investigation made in the fall of 1914 of the ground-water conditions in the San Carlos Reservation was completed by A. T. Schwennesen. This investigation was made in order to advise the Office of Indian Affairs with respect to sinking test wells to develop artesian supplies for irrigation. The report was transmitted in manuscript to the Indian Office.

An investigation of the artesian and other ground-water conditions in San Simon Valley, Ariz. and N. Mex., was begun in December, 1913, and several series of measurements of discharge and pressure of the artesian wells have been made since that date. In the summer of 1915 A. T. Schwennesen made a systematic ground-water survey of this valley and of the San Bernardino Valley, Ariz., which lies farther south. A preliminary report on the San Simon Valley is now in preparation. A comprehensive report on both valleys and of the Gila Valley from San Simon Valley to San Carlos is also being prepared by Mr. Schwennesen.

Through cooperation with the Arizona Agricultural Experiment Station the water analyses in connection with the Paradise Valley, San Carlos, and San Simon investigations were made by A. E. Vinson, of the Experiment Station staff.

*Arkansas.*—The report on the geology and ground waters of northeastern Arkansas, by L. W. Stephenson and A. F. Crider, with a discussion of the chemical character of the waters, by R. B. Dole, was published as Water-Supply Paper 399. This report was prepared in previous years in cooperation with the section of Coastal Plain investigations of the geologic branch.

*California.*—The final report on ground water in San Joaquin Valley, Cal., by W. C. Mendenhall, R. B. Dole, and Herman Stabler, was published as Water-Supply Paper 398.

A survey of the ground waters in the San Jacinto Valley, begun several years ago by W. C. Mendenhall and interrupted because of his duties as chief of the land-classification board, was resumed during the current year by G. A. Waring, and the report based on this survey was nearly completed.

An investigation of the ground water in the part of San Diego County lying west of the divide was begun by A. J. Ellis and C. H. Lee in September, 1914. Practically all the field work and most of the office work was completed by June 30, 1916. The results are to

be embodied in a comprehensive report on the water resources of the county. The analytical work was done by S. C. Dinsmore. Financial cooperation was furnished by the city of San Diego.

During the year Kirk Bryan nearly completed a report on the Sacramento Valley, based on a ground-water survey begun in September, 1912.

Some progress was made during the year by W. O. Clark in the ground-water survey of the Santa Clara Valley, which was begun in August, 1912. The work was, however, interrupted because of another investigation that was assigned to Mr. Clark. At the request of the Department of Agriculture a special report was prepared by Mr. Clark on the ground-water supply of the Morgan Hill area, which lies in the Santa Clara Valley. This report is to be published as Water-Supply Paper 400-E. Levels were run by L. F. Biggs to determine the altitudes of observation wells in parts of the Santa Clara Valley.

Since 1900 measurements of depths to the water level in a series of wells in southern California have been made at intervals for the purpose of obtaining a record through many years of the relation between the contributions to the underground reservoirs in the rainy seasons and the withdrawals from them in the dry seasons, when ground water is pumped for irrigation and is withdrawn in large quantities by evaporation and transpiration. As in the previous year, these measurements were made by F. C. Ebert.

All the ground-water work in California is done in financial cooperation with the State Department of Engineering.

In response to a request from the War Department, a brief investigation to determine the possibility of developing ground-water supplies for the garrison on Angel and Alcatraz islands, in San Francisco Bay, was made in September, 1915, by G. A. Waring, and a report in manuscript was transmitted to the War Department on October 8.

*Connecticut.*—The report on ground water in the Hartford, Stamford, Salisbury, Willimantic, and Saybrook areas, Conn., by H. E. Gregory and A. J. Ellis, which was completed before the beginning of this fiscal year, was published as Water-Supply Paper 374.

The report on ground water in the Waterbury area, by A. J. Ellis, was published as Water-Supply Paper 397.

Observations in connection with an investigation of the relations between precipitation, ground-water storage, evaporation, run-off, and quality of water in the Pomperaug Valley, begun in July, 1913, by A. J. Ellis, were continued during the year, and considerable work was done in compiling the results. Porosity determinations and various field observations were made by O. E. Meinzer in July, 1915. Samples of well water were analyzed by S. C. Dinsmore, and



daily samples from Nonnewaug River were tested by A. A. Chambers for chlorine and carbonate.

A report on ground water in the Meriden area was practically completed by G. A. Waring, who had made the field survey of the area in the spring of 1915. Analyses of 25 samples of water were made by Mr. Dinsmore.

The ground-water survey in the Southington-Granby area, including the vicinity of Plainville and covering 18 towns, which was begun in the fall of 1914, was continued this year by H. S. Palmer, and on June 30, 1916, the report on this area prepared by Mr. Palmer was nearly completed. Analyses of 102 samples of water were made by Messrs. Dinsmore and Chambers.

All the work in Connecticut is done in cooperation with the State Geological and Natural History Survey under the supervision of H. E. Gregory.

*Florida.*—On account of the pressure of other work little progress was made in the investigation of the quality of ground waters in Florida begun in a previous year by R. B. Dole.

Examination of daily samples of sea water from Fowey Rocks Light, a study conducted in cooperation with the Bureau of Fisheries and T. W. Vaughan, of the geologic branch, for investigating certain phases of submarine deposition of limestone, was discontinued, and the results of the year's series of determinations of salinity were tabulated and discussed. The analyses were made by R. B. Dole, A. A. Chambers, C. D. Parker, and E. C. Bain.

*Georgia.*—A special investigation of the artesian waters which furnish the municipal supply for the city of Savannah, Ga., was made in the fall of 1915 by R. B. Dole, with special reference to sanitary problems. A manuscript report based on this investigation was transmitted to the city officials.

*Mississippi.*—A general investigation of the ground waters in Mississippi, begun in a previous year, was continued in cooperation with the section of Coastal Plain investigations of the geologic branch. (See p. 68.) The analytical work was supervised by Mr. Dole.

*Montana.*—A comprehensive investigation of the ground waters in Montana was begun in August, 1915, and a general survey of about 5,700 square miles of the Yellowstone River basin was made by A. J. Ellis, who is to continue the work in the ensuing year. This investigation is carried on in cooperation with State organizations. The chemical analyses are made by Carl Gottschalck at the laboratory of the State Board of Health and the Montana State College, under the supervision of W. M. Cobleigh, director of the laboratory. Records of wells were collected throughout the State by A. W.

Mahon, State engineer of Montana, in cooperation with W. A. Lamb, district engineer of the United States Geological Survey.

An investigation of the artesian water in the Little Bitterroot Valley, with special reference to its use for irrigation, was made in August, 1915, by O. E. Meinzer. Through cooperation with the State Board of Health and the Montana State College 10 samples of water from the valley were analyzed by Mr. Gottschalck. A report on the results of the investigation was completed by Mr. Meinzer and will be published as Water-Supply Paper 400-B.

Water-level measurements begun in 1912 in a well near Butte, in the Silverbow Valley, were continued during the year.

*Nebraska.*—In response to a request from the local irrigation association a brief special investigation of the ground-water supplies available for irrigation in the Lodgepole Valley, in Nebraska and Wyoming, was made in September, 1915, by O. E. Meinzer, and a report on the valley was partly prepared.

*Nevada.*—A preliminary report on ground water in the Big Smoky Valley, Nev., by O. E. Meinzer, was published as Water-Supply Paper 375-D. In the spring of 1915 additional discharge measurements of streams flowing into this valley were made by A. B. Purton, of the division of surface waters, chiefly for the purpose of ascertaining more definitely the amount of percolation into the underground reservoir. The water-level measurements begun in 1913 were continued during the year. The final report on the geology and water resources of Big Smoky, Clayton, and Alkali Spring valleys, by O. E. Meinzer, was sent to the printer and will be published as Water-Supply Paper 423.

An investigation of the ground-water conditions on the Truckee-Carson irrigation project, to determine the cause of the rise of the water levels in Big Soda and Little Soda lakes, was made for the Department of Justice by C. H. Lee and W. O. Clark. At the end of the fiscal year the report on this investigation was nearly completed.

*New Mexico.*—A report on ground water in the Animas, Playas, Hachita, and San Luis basins, in Grant County, N. Mex., was completed by A. T. Schwennesen. This report is based on field work done in 1913. Analyses of water samples and of the water-soluble contents of soil samples from these basins were made by R. F. Hare through cooperation with the New Mexico Agricultural Experiment Station.

The Navajo country, which was investigated by H. E. Gregory, and the San Simon Valley, which was investigated by A. T. Schwennesen, lie partly in New Mexico but more largely in Arizona. The ground-water surveys in these areas are described on pages 140-141.

*Ohio.*—In response to a request from the citizens of Canton, Ohio, a brief special investigation of the ground-water supplies available for municipal use in that city was made in March, 1916, by G. A. Waring. The results of this investigation were transmitted in manuscript to the Canton Chamber of Commerce.

*South Dakota.*—A report on the artesian water in the vicinity of the Black Hills, S. Dak., was prepared by N. H. Darton and is to be published as a water-supply paper. This report is a revision of earlier reports on the area by Mr. Darton and includes many new data.

*Texas.*—The work in Texas was done in cooperation with the section of Coastal Plain investigations of the geologic branch.

A report on the ground-water supply of Lasalle and McMullen counties, by Alexander Deussen and R. B. Dole, was published as Water-Supply Paper 375-G.

Work was continued on the ground-water resources of the part of the Texas Coastal Plain not covered by Water-Supply Paper 335, and two papers on this area are being prepared.

*Wisconsin.*—A report on the ground and surface water supplies of Wisconsin, which was prepared in previous years in cooperation with the Wisconsin Geological and Natural History Survey, by Samuel Weidman and A. R. Schultz, was published by the State as Bulletin 35 of the State Survey.

*Wyoming.*—A brief investigation of the ground waters available for irrigation in the Lodgepole Valley, which lies partly in Wyoming and partly in Nebraska, was made in September, 1915, by O. E. Meinzer, who is preparing a report on the area.

A special investigation for the purpose of assisting the city of Rawlins, Wyo., in developing ground water for a public supply was made by C. H. Wegemann, of the geologic branch, and a report in manuscript was transmitted to the city officials.

*Cuba.*—An investigation of the vicinity of Guantanamo Bay, Cuba, was made by O. E. Meinzer in November and December, 1915, for the purpose of advising the Navy Department in regard to sinking test wells to develop a water supply for the United States naval station situated on this bay. A manuscript report with geologic map of the reservation was transmitted to the Bureau of Yards and Docks.

#### DIVISION OF WATER UTILIZATION.

The organization of the division of water utilization has been continued during the year as described in previous annual reports. E. C. La Rue and E. C. Murphy, hydraulic engineers, have done the greater part of the field work involved in the examination of water-power withdrawals, rights of way, and Carey Act segregations. The

work of examining land for designation under the enlarged-homestead act has been done in part by Messrs. La Rue and Murphy and in part by W. B. Heroy, geologist, and W. N. White, assistant classifier, in the land-classification board, who were detailed to the work during a part of the field season. Mr. Murphy has completed field examinations of the possibilities of water-power and reservoir development in Arizona and New Mexico, in order that lands valuable for such purposes may be designated in accordance with the act of Congress admitting Arizona and New Mexico to statehood.

Part 3 of the report on the water powers of the Cascade Range, covering the Yakima River basin, by G. L. Parker and F. B. Storey, was published as Water-Supply Paper 369, and Mr. La Rue's report on Colorado River and its utilization (Water-Supply Paper 395) was in press at the end of the year. Other reports containing the results of the work of the division of water utilization are Water-Supply Papers 376, 377, 378, and 379. Titles and brief summaries of these publications are given on page 34.

#### LAND-CLASSIFICATION BOARD.

##### ORGANIZATION.

The plan of organization of the land-classification board has not changed during the present year, remaining essentially as indicated in the last annual report. Such changes as have taken place are minor and are closely related to changes in personnel due to resignations or transfers. M. W. Ball, in charge of the oil section of the mineral division and the General Land Office cooperation, resigned at the end of March for transfer to the Bureau of Mines. After this resignation A. R. Schultz, geologist, was placed in charge of the division of mineral classification and E. H. Finch was made vice chairman of the phosphate section. Mr. Schultz will continue as chairman of the metalliferous section and W. B. Emery, vice-chairman, will act, under the direction of Mr. Schultz, as chairman of the oil section. The organization at the close of the year in outline is as follows:

W. C. Mendenhall, chief.

Elsie Patterson, secretary.

Division of mineral classification: A. R. Schultz, in charge of division. Coal section, G. H. Ashley, chairman; E. R. Lloyd, vice chairman. Oil section, W. B. Emery, vice chairman. Phosphate section, E. H. Finch, vice chairman. Metalliferous section, A. R. Schultz, chairman.

Division of hydrographic classification: Section of utilization, Herman Stabler, chairman. Section of classification, W. B. Heroy, chairman.

H. E. Grosbach and H. D. Padgett resigned during the year from the division of hydrographic classification, and R. M. Davis and C. E. Nordeen were added to the staff. Howard Clark, topographic



engineer, was transferred to the land-classification board to assist the coal section as computer and draftsman.

The permanent force of the board at the close of the year included 6 geologists, 8 engineers, 18 clerks, 3 draftsmen, and 2 messengers, a total of 37 persons.

#### FUNDS.

Because of the reduction in the appropriation made for geologic work and the resulting necessity for curtailment of operations the allotments to the board for the year were reduced slightly below those of the preceding year. These allotments amounted for the year 1916 to \$57,120 and were distributed among the general appropriations as follows:

Geologic surveys.....	\$29, 720
Topographic surveys.....	11, 500
Gaging streams.....	11, 000
Salaries of scientific assistants and skilled laborer.....	4, 900
	<hr/>
	57, 120

#### SUMMARY OF WORK OF CLASSIFICATION.

As set forth elsewhere, 3,018,442 acres of lands were classified as to their coal character. Of this amount 2,217,579 acres were classified as noncoal land and 800,863 as coal land. Coal-land withdrawals during the year amounted to 637,274 acres, and coal-land restorations to 2,945,594 acres. The area withdrawn for classification as to coal at the close of the year was 45,935,954 acres.

The general activity in the oil industry during the year has been reflected in a measure in the classification of lands as to oil. The Survey geologists have been alert to the possibility of the existence of favorable structure in the Western States and to the association of suitable reservoirs and sources of oil with such structure. The results of their research have been reflected in the areas reserved because of their possible oil content. New withdrawals amounting to 1,001,300 acres were made during the year, and areas aggregating 154,558 acres were restored because examination determined that the lands were not favorable for the accumulation of oil. The result of the year's work, therefore, has been an increase of the area of oil reserves from 4,774,418 to 5,621,160 acres.

The classification of 1,466,471 acres of land in Colorado, Wyoming, and Utah as mineral land because they contain shales from which, it is believed, great quantities of petroleum and by-products may be distilled is a matter of much more than passing interest.

Phosphate reserves were decreased during the year. The withdrawals amounted to only 45,669 acres, while the restorations in-

cluded 199,567 acres. The result was a decrease of phosphate reserves from 2,660,376 to 2,506,478 acres.

There has been marked activity recently in the designation of lands for entry in homesteads of 320 acres under the enlarged-homestead acts. During the year the Secretary, on the recommendation of the Geological Survey, designated 27,254,442 acres of land as non-irrigable under this act. At the same time the designations of 237,805 acres, which were found to have been erroneously designated, were canceled, the result being a net increase in this classification of lands of a little more than 27,000,000 acres during the year. At the end of the year 262,612,817 acres had been classified in this manner as being not susceptible of irrigation. The number of petitions received for such designation during the year was 14,913, of which 11,202 were acted upon; 7,038 were awaiting action at the end of the year.

Withdrawals for power-site purposes aggregated 150,646 acres, and restorations of lands previously withdrawn but found to be without value for power amounted to 26,099 acres. The increase of outstanding withdrawals from 2,228,105 to 2,352,652 acres was the net result of these actions.

During the year areas amounting to 11,327 acres were withdrawn as public-water reserves and 708 acres were eliminated from such reserves. The net increase in lands withdrawn as public watering places was from 182,653 to 193,272 acres.

#### CORRESPONDENCE.

During the year 27,468 letters were referred to the land-classification board, an increase of about 43 per cent over the preceding year. In addition, some 4,500 copies of correspondence from various bureaus were sent to the board for its information and files; this material is largely made up of copies of General Land Office letters to registers and receivers of local land offices, of reports made by agents of the General Land Office, and of copies of departmental decisions.

In the same period 16,135 letters, reports, acknowledgments, and notifications were prepared in the board. This is a decrease from last year of about 12 per cent; the total number of 16,135 includes 1,073 postal cards, less than one-fourth of the number sent out during the preceding year, and this reduction in postals accounts for the decrease in outgoing mail.

For the working days of the year these figures show a daily average of about 90 for the incoming and 53 for the outgoing mail.

The problem of so filing correspondence as to make it more accessible and convenient for reference has received careful attention, and material progress has been made in putting into effect advantageous

modifications of the general filing system. Essentially, two files are now kept. One is a file of "cases," including mainly applications for entry or use of specific areas of public land, arranged by States and then serially under appropriate minor subdivisions. Cases of various types heretofore filed separately have been incorporated into the one general case file, and many bound sets have been separated into individual cases. The result of these changes, so far as they have been effected, is a material increase in convenience of use at the expense of a moderate increase in space requirements. The other file now kept in the board contains general correspondence and material that can not be reduced to cases. It is proposed to revise the subject system on which this file is based and to bring together all related correspondence, but a practicable plan of revision has not yet been adopted.

#### PUBLICATIONS.

A bulletin entitled "Petroleum withdrawals and restorations affecting the public domain" was prepared by M. W. Ball and Miss L. W. Stockbridge in 1914-15 and submitted for publication as Bulletin 623. This bulletin has been printed and was made available to the public in June. It gives true copies of all petroleum withdrawals and restorations, contains chapters on the purpose and history of withdrawals, oil-land law, and orders and correspondence, and is illustrated by nine State maps showing all lands included in withdrawals on January 15, 1916. Additional withdrawals and restorations have been made in some of the States since that date. These and future similar actions it is planned to make available to the public by the issue of revised reprints or appendixes to this bulletin.

#### COOPERATION WITH THE GENERAL LAND OFFICE.

The cooperation between the General Land Office and the Geological Survey, by which the Survey's information on the mineral and power value of lands sought under the public-land laws is made available to the department through the General Land Office, was continued during the fiscal year along the same lines as in 1914-15. The Survey received during the year 6,067 requests from the General Land Office for information as to the mineral character or the relation to water supply of public lands sought and furnished information in 6,396 cases. It also received for consideration 1,610 reports of field examinations by the General Land Office and acted on 1,461 reports of this character.

During a part of the fiscal year 1913-14 cooperation with the General Land Office was partly suspended because the staff and allotments of the board were insufficient to keep the work current. As a consequence of the suspension cases awaiting action in the Survey

were nearly all disposed of by the beginning of the fiscal year 1914-15, and cooperation was resumed in part soon thereafter. At the opening of the fiscal year 1915-16 there were pending more than 2,100 cases involving the mineral character of lands. The number of mineral cases handled during the fiscal year is slightly greater than those received, so that the pending cases at the end of the year are fewer than at the beginning. The cases received involving both mineral character and water resources essentially balance the number answered, so that the pending cases of this class at the end of the fiscal year are approximately the same in number as at the beginning. The total number of cases covered by the cooperative agreement with the General Land Office pending at the end of the year is 2,065, somewhat less than the number pending at the beginning of the year. Of the pending cases 289 are concerned only with the mineral character of the land, 50 only with the water resources, and 1,726 with both mineral character and water resources.

During the year numerous applications for classification of lands included in withdrawals were received. A number of requests were sent to the Survey for the reclassification of lands as to mineral or power-site possibilities, and a large number of applications of other types were referred for consideration and report. These are considered in more detail under hydrographic and mineral classifications.

The following table shows the year's record in the several classes of cooperative cases, including those discussed above and including also requests for the designation of lands under the enlarged-homestead act and other miscellaneous cases. With the passage of the preference-right act (38 Stat., 1163) and the consequent tendency to file enlarged-homestead petitions in the local land offices instead of in the Geological Survey, work of this type has come to resemble more closely in the manner in which it is handled the other cooperative work between the two bureaus. During the year 14,913 cases of this class were received; 3,327 were pending at the beginning of the year, 11,202 were disposed of during the year, and 7,038 were awaiting action at its end.

*General summary of cooperative cases, fiscal year 1915-16.*

Class.	Pending July 1, 1915.	Received.	Disposed of.	Pending June 30, 1916.	Gain or loss.
Mineral character only:					
General Land Office requests for information....	180	245	335	90	+ 90
General Land Office field service reports.....	156	1,004	961	199	- 43
Applications for reclassification as to coal.....	1	7	7	1	0
Applications for classification as to coal.....	4	25	15	14	- 10
Applications for classification as to phosphate....	0	19	19	0	0
Applications for classification as to oil.....	0	59	56	3	- 3
	341	1,359	1,393	307	+ 34



*General summary of cooperative cases, fiscal year 1915-16—Continued.*

Class.	Pending July 1, 1915.	Received.	Disposed of.	Pending June 30, 1916.	Gain or loss.
<b>Water resources only:</b>					
General Land Office requests for information....	21	49	40	30	— 9
General Land Office field service reports.....	18	36	34	20	— 2
Cases in national forests.....	6	32	37	1	+ 5
Applications for reclassification as to water re- sources.....	11	70	69	12	+ 1
Applications for rights of way.....	105	343	350	98	— 7
Lists under Carey Act.....	1	8	8	1	0
Petitions under enlarged-homestead acts.....	3,327	14,913	11,202	7,038	—3,711
Desert-land proofs under irrigation projects.....	90	98	137	51	+ 39
	3,579	15,549	11,877	7,251	—3,672
<b>Mineral character and water resources:</b>					
General Land Office, requests for information....	1,699	5,600	5,834	1,465	+ 234
General Land Office, field service reports.....	76	397	279	194	— 118
General Land Office requests for information as to water resources, accompanied by field ser- vice reports as to mineral character.....	81	173	187	67	+ 14
Indian Office requests for information.....	10	75	65	20	— 10
	1,866	6,245	6,365	1,746	+ 120
<b>Grand total.....</b>	<b>5,786</b>	<b>23,075</b>	<b>19,560</b>	<b>9,301</b>	<b>—3,515</b>

## MINERAL CLASSIFICATION.

## COAL.

*Regulations.*—The regulations governing the classification and valuation of coal lands approved by Secretary Fisher February 20, 1913,<sup>1</sup> have continued in force during the fiscal year in the same form as at the end of 1914 and 1915. The only change that has been made in the regulations since their adoption occurs in the last part of paragraph 2, which was revoked by a decision of Secretary Lane on February 16, 1915 (43 L. D., 520), the department holding that legally classification of coal land must be made by quarter quarter sections and surveyed lots and not by minor subdivisions of  $2\frac{1}{2}$  or 10 acres.

In the comparatively short time that these regulations have been in force they have proved the soundness of the principles underlying them. Although not materially affecting the classification and valuation of the lignite-bearing lands, as accomplished under the old procedure, the new regulations have furnished a more rational basis for the classification and valuation of the lands containing coal of higher grade. Certain modifications may become necessary as knowledge of the chemistry of coal is increased and as further statistics are collected bearing on the cost of mining and other factors affecting the value of coal lands. The regulations as they now stand furnish what is believed to be a sound and reasonable standard for the classification and valuation of land underlain by coal of any quality or thickness.

<sup>1</sup> U. S. Geol. Survey Bull. 537, pp. 96, 97, 1913; Land Dec., vol. 41, pp. 528-530, 1913.

*Withdrawals and restorations.*—The total area of coal-land withdrawals made during the fiscal year was 637,274 acres. These withdrawals for the most part affect lands in Colorado and New Mexico which had been previously classified as coal land at the minimum price but which are now known to be much more valuable. Coal lands not hitherto known have been discovered in Utah and Montana and have been withdrawn by Executive order until detailed examination can be made. Like other recent years, the fiscal year 1915–16 has shown a substantial decrease in the area of land included in outstanding withdrawals of coal lands, because, although over 600,000 acres of land has been withdrawn during the year, a much larger area has been classified and restored. Restorations have been made as rapidly as field work and classifications have been completed, and the restorations thus effected during the year exceed the withdrawals by over 2,300,000 acres.

*Coal withdrawals and restorations, fiscal year 1915–16, in acres.*

State.	Withdrawals out- standing July 1, 1915.	Withdrawals, 1915–16.	Restora- tions, 1915–16.	Withdrawals out- standing June 30, 1916.
Arizona.....	118,718	.....	.....	118,718
California.....	17,643	.....	.....	17,643
Colorado.....	4,609,566	17,305	4,122	4,622,749
Idaho.....	338,452	.....	.....	338,452
Montana.....	12,999,115	230,301	2,097,699	11,131,717
Nevada.....	83,833	.....	.....	83,833
New Mexico.....	5,423,655	341,889	55,784	5,709,760
North Dakota.....	15,202,068	.....	344,726	14,857,342
Oregon.....	26,561	.....	22,200	4,361
Utah.....	5,696,616	47,779	317,665	5,426,730
Washington.....	847,892	.....	637	847,255
Wyoming.....	2,880,155	.....	102,761	2,777,394
	48,244,274	637,274	2,945,594	45,935,954

*Classifications.*—Examinations made for coal-land classification during the year have resulted in eliminating from withdrawal a large area of noncoal land in Montana and smaller areas in other States, thus continuing the policy of examining and eliminating from withdrawal as rapidly as possible areas of doubtful coal value.

During the fiscal year more than 800,000 acres have been classified as coal land and more than 2,200,000 acres as noncoal land, a total classification of 3,018,442 acres. This is considerably in advance of the results of the previous year but far below those attained annually prior to that time. The decrease in classified areas within the last two years is due partly to the elimination of the larger noncoal areas from withdrawal and the consequent restriction of field examinations to a detailed study of known coal fields and partly to a decrease in

allotments for coal-land examination on account of increased demands for the examination of other mineral deposits.

In the first of the following tables the classifications made during the year are summarized by States. In the same table the classifications are divided into two groups—reclassifications, which constitute a revision of previous classifications, and new classifications, which comprise the classification of withdrawn areas or areas not previously considered. The sum of these two groups is the total classification. The net increase or decrease in total areas classified in any given State, as shown in the last two columns, is not in every case obtained directly from the other columns of the table. The figures in these two columns involve and are affected by the withdrawal of 17,305 acres in Colorado and 248,994 acres in New Mexico, previously classified as coal land, and of 76,475 acres in New Mexico and 21,439 acres in Utah, previously classified as noncoal land.

*Lands classified as coal and noncoal land during fiscal year 1915-16, in acres.*

State.	Total classification.			Reclassification.		New classification.		Net increase or decrease in areas classified.	
	Coal.	Noncoal.	Total.	Previous noncoal, now coal.	Previous coal, now noncoal.	Coal.	Noncoal.	Coal.	Noncoal.
Colorado.....	722	3,720	4,442	.....	.....	722	3,720	- 16,583	+ 3,720
Montana.....	713,478	1,426,798	2,140,276	33,844	8,733	679,634	1,418,065	+704,745	+1,392,954
New Mexico.....	4,164	59,979	64,143	2,359	5,000	1,805	54,979	-249,830	+ 18,855
North Dakota.....	74,992	209,654	344,646	.....	.....	74,992	209,654	+ 74,992	+ 209,654
Oregon.....	2,243	17,607	19,850	.....	.....	2,243	17,607	+ 2,243	+ 17,607
South Dakota.....	2,585	2,349	4,934	2,585	2,349	.....	.....	+ 236	-
Utah.....	279	336,274	336,553	.....	80	279	336,194	+ 199	+ 314,835
Washington.....	.....	637	637	.....	.....	.....	637	.....	+ 637
Wyoming.....	2,400	100,561	102,961	.....	200	2,400	100,361	+ 2,200	+ 100,561
	800,863	2,217,579	3,018,442	38,788	16,362	762,075	2,201,217	+518,202	+2,080,877

*Classifications of coal and noncoal land, June 30, 1916, in acres.*

State.	Classification outstanding July 1, 1915.		Net result of classification, 1915-16.		Classification outstanding June 30, 1916.		
	Coal.	Noncoal.	Coal.	Noncoal.	Coal.	Noncoal.	Total.
Arizona.....	.....	42,492	.....	.....	.....	42,492	42,492
Arkansas.....	60,715	70,038	.....	.....	60,715	70,038	130,753
California.....	8,720	228,502	.....	.....	8,720	228,502	237,222
Colorado.....	3,365,147	9,246,918	- 16,583	+ 3,720	3,348,564	9,250,638	12,599,202
Idaho.....	2,113	7,936,925	.....	.....	2,113	7,936,925	7,939,038
Montana.....	4,855,390	20,187,282	+704,745	+1,392,954	5,560,135	21,580,232	27,140,371
Nevada.....	5,880	2,428	.....	.....	5,880	2,428	8,308
New Mexico.....	978,044	3,572,958	-249,830	- 18,855	728,214	3,554,103	4,282,317
North Dakota.....	2,099,643	2,911,671	+ 74,992	+ 269,654	2,174,635	3,181,325	5,355,960
Oregon.....	14,921	1,044,448	+ 2,243	+ 17,607	17,164	1,062,055	1,079,219
South Dakota.....	249,887	6,956,344	+ 236	- 236	250,123	6,956,108	7,206,231
Utah.....	1,066,464	2,919,498	+ 199	+ 314,835	1,066,663	3,234,333	4,300,996
Washington.....	148,940	1,561,671	.....	.....	148,940	1,562,308	1,711,248
Wyoming.....	7,621,125	14,840,728	+ 2,200	+ 100,561	7,623,325	14,941,289	22,564,614
	20,476,989	71,521,903	518,202	2,080,877	20,995,191	73,602,780	94,597,971

*Area and valuation of coal lands June 30, 1916.*

State.	Appraised coal land July 1, 1915.	Coal land appraised, 1915-16.		Net result of appraisals, 1915-16.	Total appraised coal land outstanding June 30, 1916.	Total valuation of appraised coal land outstanding June 30, 1916.	Average value per acre.
		Total coal land appraised.	Coal land reclassified as noncoal land and rewithdrawn.				
	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>		
Arkansas.....	60,715	.....	.....	.....	60,715	\$1,473,762	\$24.20
California.....	7,720	.....	.....	.....	7,720	585,086	75.70
Colorado.....	2,862,863	722	.....	+ 722	2,863,585	186,158,446	65.00
Idaho.....	2,113	.....	.....	.....	2,113	51,824	24.50
Montana.....	4,740,847	713,478	8,733	+704,745	5,445,592	128,849,832	23.60
Nevada.....	5,880	.....	.....	.....	5,880	117,600	20.00
New Mexico.....	960,092	4,164	253,994	-249,830	710,262	16,302,834	22.90
North Dakota.....	2,099,643	74,992	.....	+ 74,992	2,174,635	35,565,775	16.30
Oregon.....	4,672	2,243	.....	+ 2,243	6,915	122,451	17.70
South Dakota.....	249,887	2,585	2,349	+ 236	250,123	2,758,587	11.00
Utah.....	1,048,343	279	80	+ 199	1,048,542	44,081,949	42.00
Washington.....	740	.....	.....	.....	740	16,000	21.60
Wyoming.....	7,466,256	2,400	200	+ 2,200	7,448,456	385,444,847	51.70
	19,489,771	800,863	265,356	+535,507	20,025,278	801,528,993	40.00

*Applications for classification and reclassification.*—During the fiscal year the Survey received 25 applications for the classification of withdrawn lands either as coal or noncoal land and 7 applications for the revision of outstanding coal and noncoal classifications. Only 3 of these applications for classification of withdrawn areas were approved, 2 for coal and 1 for noncoal land; 12 were disapproved, and 14 have been held pending, most of them for detailed field examination. Eight applications relating to withdrawn areas regarding which the Survey has no detailed data were rejected because the evidence submitted by the applicants to show that the land is noncoal land was of little value and could not be made the basis of a noncoal classification. Four applications for classification as coal land were also rejected. Three requests for reclassification have been granted, one coal and two noncoal, and four rejected, one coal and three noncoal. Some of the requests for reclassification as noncoal land have related to areas of flat-lying beds where, because no coal is exposed on or near the land, claimants have been unwilling to accept the coal classification.

**OIL.**

*Withdrawals and restorations.*—The examination and withdrawal of the public lands with reference to their prospective value for deposits of petroleum and natural gas was continued during the year in California, Wyoming, Montana, North Dakota, and Louisiana. The examinations were made for the purpose of reducing the outstanding oil withdrawals in so far as the data indicated that the



withdrawn lands were not valuable for oil and of adding new areas to the oil reserves wherever the data indicated the presence of oil. These examinations resulted in eliminating from withdrawal 154,558 acres of nonoil land and added to the withdrawals 1,001,300 acres of prospective oil land, a net increase of 846,742 acres for the year.

In California more than 150,000 acres in the Salinas Valley, principally in Monterey County but in part in San Luis Obispo County, was restored to entry, field examination by the Survey having shown these lands to be barren of oil. Field work in Salinas Valley also resulted in the withdrawal of a little more than 12,000 acres of land in Monterey County believed to be favorable for oil accumulation. A restoration of about 5,000 acres on the border of the reserve in San Benito County was made to permit the issuance of title in certain cases referred to the Survey from the General Land Office.

In Wyoming an area less than 500 acres in extent in Hot Springs County was restored to entry during the year, and about 211,000 acres was included in withdrawals. Approximately 60,000 acres of land on the east side of the Bighorn Basin, for the most part lying in Big Horn County but embracing also smaller areas in Washakie and Hot Springs counties, has been withdrawn on the basis of detailed field examination and office work. The discovery of oil in the fall of 1915 near the Wyoming-Montana line made it advisable to withdraw certain areas in the northern part of the Bighorn Basin previously known to the Survey but not included in an oil withdrawal. The area so withdrawn lies in Big Horn and Park counties and embraces nearly 31,000 acres. A careful consideration of information collected by the Survey during a former season's field work resulted in the withdrawal of about 120,000 acres of prospective oil land along the Rock Springs dome, in Sweetwater County, Wyo.

The keen interest manifested in the possible occurrence of oil in Montana after the discovery of oil near the Montana-Wyoming State line caused the Survey to recommend the withdrawal of all areas of favorable structure known in this part of the State, in continuance of the departmental policy of holding prospective oil lands until appropriate legislation for their disposition can be enacted. The withdrawn lands in this part of Montana may be geographically separated into two general divisions—the south-central Montana area, embracing nearly 362,000 acres in Musselshell, Meagher, Park, Sweetgrass, Stillwater, and Carbon counties, and the eastern Montana area, covering about 280,000 acres in Dawson and Custer counties.

The favorable territory extends southwestward from eastern Montana into North Dakota, and approximately 85,000 acres of land in Billings and Bowman counties in this State has accordingly been withdrawn.

In northwestern Louisiana slightly more than 52,000 acres of land has been withdrawn. This withdrawal covers vacant public lands and unsurveyed lake areas, title to which is at the present time awaiting determination.

*Oil withdrawals and restorations, fiscal year 1915-16.*

State.	Withdrawals outstanding July 1, 1915.	Withdrawals 1915-16.	Restorations 1915-16.	Withdrawals outstanding June 30, 1916.
Arizona.....	230,400			230,400
California.....	1,507,547	12,338	153,938	1,365,947
Colorado.....	87,474			87,474
Louisiana.....	414,720	52,310		467,030
Montana.....		641,622		641,622
North Dakota.....		84,894		84,894
Utah.....	1,952,326			1,952,326
Wyoming.....	581,951	210,236	620	791,467
	4,774,418	1,001,300	154,558	5,621,160

The lands examined and included in oil withdrawals have not definitely been classified as oil lands, and no classification of oil lands was made during the fiscal year. The lands on which oil is known or believed to be present in commercial quantities have been included in oil withdrawals pending further detailed examinations, in order to determine the mineral character of these lands and to hold the lands until legislation providing for their disposition is enacted. Lands included in oil withdrawals may therefore be considered tentatively as oil lands, although they have not been classified as such.

Of especial interest during the year was the classification of 1,466,471 acres of oil-shale land in western Colorado and adjoining areas in Utah and Wyoming. Field examination by the Survey during the seasons of 1913, 1914, and 1915 has shown that the latent potentiality of the oil shale of this region as a source of petroleum is enormous. There is also locked up in these shales a vast amount of nitrogen which can be recovered as a by-product in the refining of the shale and used in the manufacture of fertilizers, explosives, etc.

*Classification of oil-shale land, June 30, 1916, in acres.*

State.	County.	Area.
Colorado.....	Rio Blanco and Garfield....	893,418
Utah.....	Uinta.....	112,950
Wyoming.....	Sweetwater.....	460,103
		1,466,471

*Applications for classification.*—During the fiscal year the Survey received 59 applications for classification of withdrawn oil lands as nonoil land. One of these was approved and the lands were re-

stored to entry; 55 were disapproved for the reason that the lands were included in an outstanding oil reserve and the data on file indicate that the lands are valuable for deposits of oil. In the other 3 cases no detailed information is available to the Survey, and the data submitted by the applicants were rejected because the evidence submitted did not show that the land is nonoil land and could not be used as a basis for nonoil classification.

#### PHOSPHATE.

*Regulations.*—There has been no change in the procedure affecting classification of phosphate lands during the fiscal year. The regulations defining phosphate lands, adopted by the Survey on March 2, 1912, to guide its recommendations for the withdrawal and restoration of phosphate lands, have continued in force. Under these regulations lands underlain by deposits containing less than 30 per cent of tricalcium phosphate are considered nonmineral lands. Phosphate beds that are from 1 foot to 6 feet or more in thickness and contain 70 per cent or more of tricalcium phosphate are held to depths ranging from zero along the outcrop to the maximum of 5,000 feet in direct ratio to the variation of the thickness of the bed from 1 to 6 feet. For beds containing less than 70 per cent of tricalcium phosphate the depth limit varies from zero to the depth of a 70 per cent bed of any given thickness in direct ratio to the variation in tricalcium phosphate content from 30 to 70 per cent.

*Withdrawals and restorations.*—During the last year, as in previous years, every effort has been made to obtain information regarding the phosphate character of public lands in order that the nonphosphate areas might be eliminated from the phosphate reserves and newly discovered phosphate areas might be included. The total area of phosphate withdrawals made during the fiscal year amounted to 45,699 acres. The data upon which these withdrawals were based were obtained chiefly from detailed and reconnaissance examinations made by the Survey, but in part from field investigations made by mineral inspectors of the General Land Office. The withdrawal of the areas not previously known to contain phosphate was much more than balanced by the elimination of areas found not to contain phosphate, so that the net result of the season's work is a substantial decrease in the reserved areas. The outstanding withdrawals were continued so far as the data available would permit. The restorations made affected three States—Florida, Montana, and Wyoming—and amounted to nearly 200,000 acres. The net reduction of the area withdrawn therefore amounted to more than 150,000 acres.

*Phosphate withdrawals and restorations, fiscal year 1915-16, in acres.*

State.	Withdrawals outstanding July 1, 1915.	Withdrawals, 1915-16.	Restorations, 1915-16.	Withdrawals outstanding June 30, 1916.
Florida.....	120, 217	40	440	119, 817
Idaho.....	966, 377	.....	.....	966, 377
Montana.....	130, 215	.....	10, 988	119, 227
Utah.....	260, 751	41, 714	.....	302, 465
Wyoming.....	1, 182, 816	3, 915	188, 139	998, 592
	2, 660, 376	45, 669	199, 567	2, 506, 478

*Classifications.*—Classifications as phosphate or nonphosphate land, because of the presence or absence of phosphate deposits of workable character, are expressed as withdrawals and restorations—that is, when it is determined that lands not included in a withdrawal actually contain phosphate, they are recommended for withdrawal, and when it is determined that lands included in a withdrawal do not contain phosphate they are recommended for restoration. Indian lands, however, such as those included in the Fort Hall Indian Reservation, Idaho, and in the Shoshone or Wind River Indian Reservation, Wyo., are not public lands, and therefore lands included in these reserves can not legally be withdrawn. Examinations of lands in such reservations are frequently made for the information of the Office of Indian Affairs in its administration of them. If these examinations are made for the purpose of determining whether or not the lands contain phosphate, the results are transmitted not as withdrawals or restorations but as classifications either as phosphate or nonphosphate lands.

In addition, therefore, to the classifications that are reported as withdrawals and restorations in the preceding table, direct classifications of lands in the Fort Hall Indian Reservation, Idaho, and the Wind River Indian Reservation, Wyo., have been made as indicated in the following table:

*Phosphate classifications of Indian lands, fiscal year 1915-16, in acres.*

State.	Phosphate land.	Nonphos- phate land.
Idaho.....	4, 080	17, 440
Wyoming.....	20, 576	85, 515

*Applications for classification.*—During the fiscal year the Survey received 19 applications for classification of withdrawn lands as non-phosphate land. Two of these were approved and the lands restored to entry; the other 17 were disapproved because the data on file indicate that the lands are valuable for deposits of phosphate or because no detailed information is available to the Survey and the evidence submitted by the applicants was not sufficiently definite to be used as a basis for a nonphosphate classification.



## POTASH.

Field work in search of commercial deposits of potash was continued by the geologic branch of the Survey during the fiscal year. The year's activities resulted in the restoration of all the withdrawn area in the Black Rock and Smoke Creek deserts, Nev., amounting to 211,384 acres. This area had been withdrawn pending the completion of tests by drilling. No new areas were withdrawn, and no changes were made in the two existing potash reserves in California or in the Columbus Marsh potash reserve in Nevada.

*Potash withdrawals and restorations, fiscal year 1915-16, in acres.*

State.	Withdrawals outstanding July 1, 1915.	Withdrawals, 1915-16.	Restorations, 1915-16.	Withdrawals outstanding June 30, 1916.
California.....	91,207	.....	.....	91,207
Nevada.....	250,806	.....	211,384	39,422
	342,013	.....	211,384	130,629

## METALLIFEROUS LANDS.

The act of February 26, 1895 (28 Stat., 683), made provision for classifying the lands within the Northern Pacific Railroad grant in certain land districts in Montana and Idaho with respect to their mineral or nonmineral character, the work to be done by commissioners appointed for the purpose. The classifications made in many areas were unsatisfactory, and a reclassification was provided for in the sundry civil act of June 25, 1910 (36 Stat., 739). At the request of the General Land Office the work is being done by the Geological Survey. Field examination of these lands was first undertaken by the Survey during the field season of 1910. The work was continued during subsequent years and is nearing completion. Field examination of all lands thus far listed to the Survey for examination and report has been completed.

*Lands in Northern Pacific Railroad grant in Idaho and Montana classified, fiscal years 1911-1916, in acres.*

State.	1911	1912	1913	1914	1915	1916	Total.
Idaho:							
Mineral.....	45,645	19,444	1,000	.....	.....	.....	65,789
Nonmineral.....	90,712	53,055	1,200	.....	.....	478	145,445
	136,357	72,199	2,200	.....	.....	478	211,234
Montana:							
Mineral.....	130,386	1,134	19,800	480	6,629	.....	158,429
Nonmineral.....	21,802	83,981	65,570	7,696	7,911	2,229	189,189
	152,188	85,115	85,370	8,176	14,540	2,229	347,618
Total:							
Mineral.....	176,031	20,278	20,800	480	6,629	.....	224,218
Nonmineral.....	112,514	137,036	66,770	7,696	7,911	2,707	334,634
Grand total.....	288,545	157,314	87,570	8,176	14,540	2,707	558,852

In addition to the above work certain lands in Custer County, S. Dak., were examined, and a report was made to the Secretary of the Interior July 7, 1915. A complete report was furnished to the Secretary of the Interior covering certain areas included in mining claims in the Grand Canyon National Monument, Ariz., examined by the Survey in April and May, 1915. Classification plats and reports of certain lands within the Fort Peck Indian Reservation previously examined by the Survey were furnished to the Commissioner of Indian Affairs and the Commissioner of the General Land Office. Certain tracts in the Molson mining district were reexamined, and a supplemental report as to the mineral character of these lands submitted to the Secretary of the Interior and the Commissioner of the General Land Office.

*Metalliferous nonmineral classifications made during fiscal year 1915-16, in acres.*

Montana .....	722, 454
South Dakota .....	107
	<hr/> 722, 561

#### HYDROGRAPHIC CLASSIFICATION.

##### WATER POWER.

*Withdrawals and restorations.*—The classification of the public lands with relation to their value in connection with water-power development was continued during the year, the withdrawals being made under the authority conferred by the two acts of June 25, 1910 (36 Stat., 847; 36 Stat., 858), and the act of August 24, 1912 (37 Stat., 497). On July 1, 1915, the area included in outstanding withdrawals was 2,228,105 acres. During the year 150,646 acres additional were withdrawn, and 26,099 acres previously included in power-site reserves were restored to the public domain. On June 30, 1916, the total area withdrawn in connection with water power was 2,352,652 acres.

*Power sites withdrawn, restored to entry, and outstanding, fiscal year 1915-16, in acres.*

State.	Outstand- ing July 1, 1915.	New with- drawals during fiscal year.	Restora- tions during fiscal year.	Outstand- ing June 30, 1916.
Alabama.....	120			120
Alaska.....	68, 200	1, 100		69, 300
Arizona.....	337, 431		1, 640	335, 791
Arkansas.....	17, 704	4, 650		22, 354
California.....	255, 690	400		256, 090
Colorado.....	270, 390	3, 280		273, 670
Idaho.....	252, 973	11, 532	3, 760	260, 745
Michigan.....	1, 240			1, 240
Minnesota.....	11, 020	1, 289		12, 309
Montana.....	155, 351	17, 060	510	171, 891
Nebraska.....	761			761
Nevada.....	26, 311	42	200	26, 153
New Mexico.....	13, 577			13, 577
Oregon.....	263, 326	350	2, 000	261, 676
Utah.....	362, 590	103, 095	14, 468	451, 217
Washington.....	104, 056	7, 858	3, 321	108, 593
Wyoming.....	87, 365		200	87, 165
	<hr/> 2, 228, 105	<hr/> 150, 646	<hr/> 26, 099	<hr/> 2, 352, 652

*Applications for reclassification.*—At the beginning of the fiscal year 11 applications for the reclassification of lands included in power-site reserves were awaiting action, and during the year 70 were received. Out of this total of 81 cases action was taken on 69, leaving 12 pending at the close of the year.

*Right of way applications.*—Departmental regulations of January 6, 1913, under the act of Congress approved March 4, 1911 (36 Stat., 1253, 1254), and of March 1, 1913, under the act of Congress approved February 15, 1901 (31 Stat., 790), charge the Geological Survey with important administrative duties in connection with applications for rights of way over the public lands for purposes related to the development of water power. Such applications, when received in proper form at the General Land Office, are forwarded to the Survey for consideration of such matters as relative priority of applications, incompatibility of works, relative beneficial utilization of resources, and the engineering and economic features involved in the applications and permits. If the approval of an application is found to be compatible with the public interest, a draft of agreement is prepared, and a report is made to the Secretary of the Interior on the circumstances in the case. This agreement, after execution by the applicant and issuance of the permit by the Secretary of the Interior, defines the conditions under which the power is to be developed, the tenure of the site, and the provisions for the protection of the public interest as regards distribution of output, rates, and service.

In addition to applications for rights of way for hydroelectric development, a large number of applications of other types are referred to the Geological Survey for consideration and report. These embrace applications for rights of way 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 the construction of the railroad will interfere with power or irrigation development on streams in the vicinity of the right of way; applications for rights of way for irrigation uses, under the act of March 3, 1891 (26 Stat., 1095), 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, fiscal year 1915-16.*

Class.	Pending July 1, 1915.	Received during fiscal year.	Acted on during fiscal year.	Pending June 30, 1916.
Railroad: Acts of Congress approved Mar. 3, 1875 (18 Stat., 482), May 13, 1898 (30 Stat., 409), Mar. 2, 1899 (30 Stat., 990), etc....	29	53	54	28
Irrigation: Acts of Congress approved Mar. 3, 1891 (26 Stat., 1095), and May 11, 1898 (30 Stat., 404), etc.....	29	122	127	24
Power: Acts of Congress approved Feb. 15, 1901 (31 Stat., 790), Mar. 4, 1911 (36 Stat., 1253, 1254), etc.....	39	19	25	33
Miscellaneous: Acts of Congress approved Jan. 21, 1895 (28 Stat., 635), May 21, 1896 (29 Stat., 127), Jan. 13, 1897 (29 Stat., 404), May 11, 1898 (30 Stat., 404), Feb. 15, 1901 (31 Stat., 790), Feb. 1, 1905 (33 Stat., 628), Mar. 4, 1911 (36 Stat., 1253, 1254), etc.....	8	149	144	13
Total number of applications for original consideration..	105	343	350	98
Additional applications for reconsideration.....	38	79	81	36

NOTE.—The first application received from the Secretary's Office was dated October 11, 1909; from the General Land Office, November 11, 1909; from the Office of Indian Affairs, December 23, 1909.

**IRRIGATION.**

*Reservoir withdrawals.*—A number of reservoir sites, valuable principally for the storage of water for irrigation, have been examined by the Geological Survey, and, on its recommendation, the lands they include have been withdrawn from entry. The change in status of such withdrawals during the fiscal year is shown in the following table:

*Reservoir sites restored to entry and outstanding, fiscal year 1915-16, in acres.*

State.	Outstand- ing July 1, 1915.	Restora- tions during fiscal year.	Outstand- ing June 30, 1916.
Arizona.....	23,040	.....	23,040
Montana.....	15,640	6,560	9,080
North Dakota.....	1,569	.....	1,569
Oregon.....	10,619	.....	10,619
Washington.....	35,943	.....	35,943
	86,811	6,560	80,251

*Carey Act segregations.*—During the year eight proposed segregation lists under the Carey Act were received for report as to available water supply, general feasibility of plan of reclamation, and mineral character of the lands. One such list was pending report on July 1, 1915. Reports on eight of these lists had been submitted before the end of the fiscal year, and supplemental reports on eight other lists were also furnished.

*Irrigation projects.*—The Geological Survey, by instructions of the Secretary of the Interior, dated March 15, 1913, furnishes to the Commissioner of the General Land Office information relative to the available water supply and the feasibility of irrigation projects whose water rights or shares are presented as evidence of compli-



ance with the requirements of the desert-land act. During the year 98 such cases were received, and 90 were carried over from the preceding year. Of these 188 cases 137 were reported on and 51 were pending June 30, 1916. Supplemental reports were rendered on 16 cases.

#### 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), and March 4, 1915 (38 Stat., 1163), was continued during the year. These acts are now applicable to 14 States. No additional legislation was enacted during the fiscal year. As a result of the investigations of surface and underground water conditions, designations during the fiscal year have added a large area of land to that previously classified.

*Enlarged-homestead designations, fiscal year 1915-16, in acres.*

State.	Outstanding July 1, 1915.	Designations during fiscal year.	Cancellations during fiscal year.	Outstanding June 30, 1916.
Arizona.....	25,032,017	93,338	.....	25,125,355
California.....	1,996,598	2,878,599	.....	4,875,197
Colorado.....	24,722,162	1,304,760	.....	26,026,922
<b>Idaho:</b>				
Sections 1-5 only.....	8,455,105	1,332,397	32,893	9,754,609
Section 6.....	86,793	38,995	960	124,828
	8,541,898	1,371,392	33,853	9,879,437
<b>Kansas.....</b>	277,605	95,079		372,684
<b>Montana.....</b>	46,760,813	1,895,818	153,824	48,502,807
<b>Nevada.....</b>	46,305,197			46,305,197
<b>New Mexico.....</b>	23,374,541	2,093,491		25,468,032
<b>North Dakota.....</b>	8,739,507	821,203		9,560,710
<b>Oregon.....</b>	16,936,548	942,913	4,749	17,874,712
<b>South Dakota.....</b>	1,756,332	12,669,860		14,426,192
<b>Utah:</b>				
Sections 1-5 only.....	7,147,393	39,902	36,559	7,150,736
Section 6.....	1,219,032	55,092		1,274,124
	8,366,425	94,994	36,559	8,424,860
<b>Washington.....</b>	4,016,887	1,179,415		5,196,302
<b>Wyoming.....</b>	18,769,650	1,813,580	8,820	20,574,410
	235,596,180	27,254,442	237,805	262,612,817

The general provisions of the acts, which apply in all 14 States, permit the entry by one person of 320 acres of "nonmineral, non-irrigable, unreserved, and unappropriated surveyed public lands which do not contain merchantable timber." As a prerequisite to the allowance of such entry, the land 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. By the act of March 3, 1915 (38 Stat., 956), the enlarged-homestead act was amended so as to permit, under certain conditions, an additional entry, though final proof had already been submitted on the original entry.

Designations under the enlarged-homestead acts are made either in large, compact areas, as a result of field investigations covering rather large districts, or in small units, as a result of investigations made at the request of prospective entrymen. These requests are referred to as enlarged-homestead petitions. The passage of the act of March 4, 1915 (38 Stat., 1163), which provides that a preference right or entry in the event of designation can be procured by filing an application at the local land office of the district in which the lands are situated has led to a very large increase in the number of applications received.

*Action on petitions under the enlarged-homestead acts, fiscal year 1915-16.*

State.	Pend- ing July 1, 1915.	Re- ceived, 1915- 16.	Action taken, 1915-16.					Pend- ing June 30, 1916.	Cases recon- sidered.
			All desig- nated.	Part desig- nated.	Re- fused.	Re- called.	Total.		
Arizona.....	13	112	12	.....	.....	1	13	112	.....
California.....	162	782	298	2	17	8	325	619	15
Colorado.....	142	1,896	952	14	61	14	1,041	997	27
Idaho.....	392	1,834	931	26	175	30	1,162	1,064	106
Kansas.....	129	256	369	.....	3	.....	372	13	6
Montana.....	1,075	2,552	2,039	113	401	19	2,572	1,055	227
Nevada.....	9	36	.....	.....	2	.....	2	43	.....
New Mexico.....	88	1,126	213	7	30	16	266	948	16
North Dakota.....	23	302	234	4	7	2	247	78	6
Oregon.....	64	483	334	11	41	5	391	156	27
South Dakota.....	851	2,920	3,255	21	47	3	3,326	445	11
Utah.....	214	911	217	2	56	5	280	845	5
Washington.....	48	329	249	2	12	.....	263	114	12
Wyoming.....	117	1,374	832	30	78	2	942	549	20
	3,327	14,913	9,935	232	930	105	11,202	7,038	478

A set of maps of the States affected, showing areas designated under the enlarged-homestead acts and the status of designations on June 30, 1916, has been printed.

**PUBLIC WATER RESERVES.**

As information has become available recommendations have continued to be made for the creation of public water reserves, in order that important springs and sources of stock water on the desert and semiarid range lands may remain accessible to the public. Additions amounting to 10,619 acres have been made during the year to reserves of this type.

*Public water reserves withdrawn from entry and restored to entry, fiscal year 1915-16, in acres.*

State.	Outstand- ing July 1, 1915.	With- drawals, 1915-16.	Restora- tions, 1915-16.	Outstand- ing June 30, 1916.
Arizona.....	2,992	6,930	.....	9,922
California.....	50,554	.....	708	49,846
Colorado.....	480	.....	.....	480
Idaho.....	5,765	405	.....	6,170
Montana.....	1,040	.....	.....	1,040
Nevada.....	1,464	2,872	.....	4,336
New Mexico.....	1,440	.....	.....	1,440
Oregon.....	2,500	.....	.....	2,500
Utah.....	33,987	.....	.....	33,987
Wyoming.....	82,431	1,120	.....	83,551
	182,653	11,327	708	193,272

## PUBLICATION BRANCH.

## DIVISION OF BOOK PUBLICATION.

## SECTION OF TEXTS.

During the year 76,336 pages of manuscript were edited and prepared for printing, and proof sheets for 22,030 final printed pages were read and corrected, this work involving the handling of 5,443 galley proofs and 30,656 page proofs. The corresponding figures for 1914-15 were 48,911 pages of manuscript, 21,407 final printed pages, 5,099 galley proofs, and 35,522 page proofs. Indexes were prepared for 71 publications, covering 14,924 pages; the figures for the previous year were 66 publications and 16,723 pages. The list given on pages 18-37 shows the number, scope, and character of the reports issued during the year. A third edition of the pamphlet "Suggestions to authors of papers submitted for publication by the United States Geological Survey," by G. M. Wood, editor, was prepared and sent to press near the end of the year.

Nine persons were employed in this section.

## SECTION OF ILLUSTRATIONS.

The number of illustrations prepared was 3,730, comprising 205 maps, 516 photographs prepared for reproduction, 678 diagrams and sections, 2,080 paleontologic drawings and photographs, and 251 miscellaneous illustrations. The illustrations sent to the printer were reproduced by chromolithography, 43 subjects; photolithography, 175 subjects; 4-color process, 10 subjects; mezzotint, 4 subjects; halftone engraving, 426 subjects; zinc etching, 462 subjects; wax engraving, 10 subjects; cuts already engraved, 107 subjects. Proofs to the number of 1,514, including 383 revises, were received and compared critically. The finished work representing the editions of 263 inserts furnished by contractors (mostly lithographic) was examined. Electrotypes of 44 cuts were furnished to outside appli-

cants. At the close of the year material for illustrating 24 reports was in preparation.

As in previous years, a cost record has been maintained. The personnel of the section at the end of the year consists of the chief of the section, nine draftsmen, one under clerk, and one messenger boy.

#### SECTION OF DISTRIBUTION.

During the year the section of distribution received editions of 210 new books and pamphlets, 33 reprinted books and pamphlets, 6 new geologic folios, 12 new geologic maps, 137 new or revised topographic maps, 93 reprinted topographic maps, 16 new photolithographed maps, and 16 reprinted photolithographed maps, a total of 523 publications. In addition, it received many pamphlets and forms prepared for administrative use, such as index map circulars.

The total units of all publications received numbered 711,397 books and pamphlets, 20,837 folios, 3,705 geologic maps, and 927,853 topographic maps, a grand total of 1,663,792.

The section distributed 603,575 books, 23,534 folios, and 597,149 maps, a total of 1,224,258, of which 180 books, 14,717 folios, and 399,490 maps were sold.

The total amount received and turned into the Treasury as the result of sales of publications was \$30,160.90. The sales of topographic and geologic maps amounted to \$28,627.25, of topographic and geologic folios \$1,202.10, and of books \$331.55.

Eighteen persons were employed in this section during the year, and 92,831 letters were received and answered.

#### DIVISION OF MAP EDITING.

##### SECTION OF GEOLOGIC MAPS.

Nineteen folios were handled by the section of geologic maps during the year, of which six were completed and published—Nos. 196 to 201, including one folio that covers two quadrangles (Galena and Elizabeth, Ill.) and one that covers four quadrangles (Minneapolis, St. Paul, Anoka, and White Bear, Minn.).

At the close of the fiscal year the maps and illustrations of the Eureka Springs-Harrison, Ark., Colorado Springs, Colo., and Tolchester, Md., folios were completed. The maps of the Detroit, Mich., Leavenworth-Smithville, Mo.-Kans., and Deming, N. Mex., folios were printed and the illustrations were nearly completed. The maps of the Colchester-Macomb, Ill., and Newell, S. Dak., folios were partly engraved. The maps of the Elkton-Wilmington, Md.-Del., and Herman-Morris, Minn., folios were prepared for engraving and were awaiting approval of their texts. The Bessemer-Vandiver, Ala., Montevallo-Columbiana, Ala., Cleveland, Ohio, Pittsfield-Becket,



Mass., and Sheffield-Sandisfield, Mass., folios were partly prepared and were awaiting revision by their authors.

In addition to the maps and illustrations of folios, the illustrations for 72 other reports were critically reviewed. The work included the revision of maps, sections, and numerous smaller text illustrations and the preparation of color schemes for the maps.

#### SECTION OF TOPOGRAPHIC MAPS.

At the beginning of the year 178 topographic maps were on hand for publication, and the accessions during the year were 124, making a total of 302 maps. Of these, 153 have been published, 97 are in process of engraving and printing, and 52 have not been edited. Of the 153 maps published and noticed in the list of publications on pages 37-38, 126 are new engraved maps, 16 are photolithographs, and 11 are new editions. The following statement shows the comparative status of map editing and map publication on June 30 for the last six years:

*Progress of map publication for six years ended June 30, 1916.*

	1911	1912	1913	1914	1915	1916
Published during the year.....	86	114	101	102	107	153
In process of engraving.....	56	65	89	69	87	97
Unedited.....	95	102	105	114	91	52

The manuscripts edited during the year comprise 147 maps prepared for engraving, 3 maps for photolithography, 94 sheets of plans and profiles of 19 rivers, 214 maps or sheets for the illustration of 33 Survey reports, and corrections for 142 engraved maps about to be reprinted. The proof read comprises 143 new topographic maps and corrections to 59 old maps. The index maps for 11 circulars of the series 9-323 were revised and reprinted, 12 of the State index circulars were revised and reprinted, and texts were adapted for 9 new State circulars, which also have been published.

Except that the editor of topographic maps was engaged in topographic field work for two months, six men were continuously employed in this work.

#### DIVISION OF ENGRAVING AND PRINTING.

##### TOPOGRAPHIC MAPS AND GEOLOGIC FOLIOS.

During the fiscal year 126 topographic maps were engraved and printed; 11 topographic maps were corrected after field revision and new editions printed; and 16 State maps, on a scale of 1:1,000,000, were photolithographed and printed, making the total of new maps and revised editions printed 153.

Corrections were engraved on the plates of 139 maps, of which 93 were for reprint editions. Sixteen photolithographic maps were

corrected and reprinted, of which 11 were State maps on a scale of 1:500,000 and 5 were three-color topographic maps. Of the new and reprinted maps 264 different editions, amounting to 927,853 copies, were printed and delivered to the map room. This is an increase of 58 editions and 221,621 copies of maps over the previous year.

Six new geologic folios were published during the year, the same number as in the preceding year. Of these, one (the Galena-Elizabeth) was a double folio, and one (the St. Paul-Minneapolis) contained four sets of geologic maps. State and octavo editions of one folio were issued during the year. Editions and partial editions amounting to 20,840 copies were printed and delivered, a decrease of 3,226 copies from the number printed in the preceding year.

#### OTHER GOVERNMENT MAP PRINTING.

For the Government Printing Office the following items were printed and delivered: Illustrations for the annual reports of the governor of Alaska, the governor of Hawaii, the governor of the Panama Canal, the Commissioner General of Immigration, the Commissioner of Indian Affairs, and the Superintendent of the Coast and Geodetic Survey; Department of Commerce Special Publications 18 and 33; Department of Agriculture Bulletins 234, 299, and 327; Census reports, volume 5 (Agriculture, general report and analysis); reports of the Federal Trade Commission on the fertilizer industry and on pipe-line transportation of petroleum; report of the Bureau of Education on the education of the natives of Alaska; soil surveys of Chautauqua County, N. Y., Frederick County, Va., Brazos County, Tex., Pennington County, Minn., and Polk County, Ga.; Bureau of Mines Bulletins 98 and 107; Tariff book, Washington-Alaska military cable; United States Coast Pilot, Atlantic Coast Section E, Gulf of Mexico from Key West to the Rio Grande; American Ephemeris and Nautical Almanac, 1917 and 1918; Plane-table manual (Appendix 7, report of the Superintendent of the Coast and Geodetic Survey, 1905); Interstate Commerce Commission Valuation Order No. 20; Regulations for leasing of coal lands in Alaska; Five per cent cases (Senate Doc. 466, 63d Cong., 2d sess.); Electric power development in the United States, vol. 2 (Senate Doc. 316, 64th Cong., 1st sess.); Index to report of Chief of Engineers, United States Army, from 1866 to 1912 (House Doc. 740, 63d Cong., 2d sess.); The Glacier National Park (House Doc. 1154, 63d Cong., 2d sess.); Condition of Aqueduct Bridge, Washington, D. C. (House Doc. 539, 64th Cong., 1st sess.); Report of the Alaskan Engineering Commission (House Doc. 610, 64th Cong., 1st sess.); Report of the Mississippi River Commission (House Doc. 645, 64th Cong., 1st sess.); Geological Survey Bulletins 522, 582, 606, 611, 613, 614, 619, 620, 621, 622, 623, 626, 627, 629, 630, 641, 648, 649, Professional Paper

98, Water-Supply Papers 358, 376, 377, 378, 379, 395, 398, Mineral Resources, 1914. In addition, the following separate illustrations were printed and delivered to the Government Printing Office: Diagrams of two bird reservations, two national monuments, and four reservations for use of the natives of Alaska; panoramic view of the Mesa Verde National Park; sketch map of Mount Rainier and its glaciers; map showing the origin of the scenic features of Glacier National Park; map showing glaciers of Glacier National Park; map showing route of Government railroad in Alaska; map of the United States west of Mississippi River; map of portion of Hot Springs Reservation; map of Alaska, for Bureau of Education; base map of United States, for General Land Office; outline map of United States by counties, for Department of Agriculture; map of Matanuska coal fields, Alaska; map of Bering River coal fields, Alaska; map giving general information regarding Territory of Alaska, for Department of the Interior; charts of the United States and Canada boundary lines; charts showing shad and alewife fisheries, Chesapeake Bay, 1915; Township plat, Form 4-675a; Protractor, Form 4-678, for Department of the Interior.

The following work was done for other Government departments and bureaus: For the Forest Service, maps of 30 national forests, 24 fire folders and tourist's maps, 15 proclamation diagrams of national forests, 9 enlargements of field sheets, annual program of work, allotment-estimate forms, grazing-data chart, map of southern Appalachian region, map of White Mountain region, map of national forests of Washington and Oregon showing telephone lines, and other miscellaneous work; for the General Land Office, 1,388 township plats, 600 mineral plats, 12 State maps showing homesteads, 41 plats of Colville Indian Reservation, township-plat diagram, map of Fort Berthold Indian Reservation, and other miscellaneous work; for the War Department, 50 maps of portions of Mexico; for the Navy Department, 162 hydrographic charts. Work was also done for the Department of State, Division of Militia Affairs, Interstate Commerce Commission, Bureau of Standards, Army Military Instruction Camp, Panama-Pacific International Exposition, Office of Indian Affairs, Department of the Interior, Department of Commerce, Department of Labor, District of Columbia, District Engineer, United States Army, Reclamation Service, Bureau of Insular Affairs, Coast Artillery School, Biological Survey, United States Army Signal Service, Army War College, Bureau of Lighthouses, Bureau of Foreign and Domestic Commerce, Alaskan Engineering Commission, Superintendent of National Parks, Bureau of Mines, United States and Canada Boundary Survey, Alaska Boundary Survey, Bureau of Soils, United States Military Academy, Office of Public Roads and Rural Engineering, Bureau of Plant Industry,

and States Relations Service. This work for various branches of the Government amounted to about \$75,000, 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 Anthracite Bureau of Information, Wilkes-Barre, Pa.; the Edward T. Miller Co., Columbus, Ohio; the Eckert Lithographing Co., Washington, D. C.; the Redfield-Kendrick-Odell Co., New York, N. Y.; A. Hoen & Co., Baltimore, Md.; the Geological Survey of Virginia; the Georgia State College of Agriculture; and Arthur W. Gray, Milford, Del.; and the money received in payment for the work, amounting to about \$540, was turned into the Treasury of the United States, to be credited to miscellaneous receipts. On requisition of the Government Printing Office, 280 transfer impressions were made and shipped to contracting printers. Under cooperative agreements, transfer impressions were furnished without charge to the State surveys of Illinois, Indiana, Kentucky, New York, and West Virginia.

There was also a large amount of miscellaneous work relating to the map publications, including index circulars, lists of geologic folios and topographic maps, and State maps.

Of contract and miscellaneous printing of all kinds, the total number of copies delivered was 3,024,143, which required 9,028,843 printings. The total number of copies printed, including topographic maps and geologic folios, was 3,972,836, requiring 14,058,326 impressions.

The sales of maps and folios, itemized on page 166, together with the \$540 of miscellaneous receipts, aggregated over \$30,000, so that more than one-fourth of the amount appropriated for engraving and printing the Survey maps was returned to the Treasury.

#### PHOTOGRAPHIC LABORATORY.

The output of the photographic laboratory consisted of 13,961 negatives, of which 3,001 were wet, 2,970 were dry, 1,598 were paper, 6,392 were field negatives developed, 826 were lantern slides, and 1,790 were made for photolithographs; 3,805 zinc plates; 400 zinc etchings; 212 celluloids; and 43,133 prints, of which 19,549 were maps and diagrams and 23,584 were photographs for illustrations. In addition, 1,830 prints were mounted and 78 lantern slides were colored.

#### ADMINISTRATIVE BRANCH.

##### EXECUTIVE DIVISION.

The work in the executive division was of the same scope as in the preceding year.

*Mails, files, and records.*—During the year 160,769 pieces of mail, of which 2,377 were registered, were opened and referred. In addi-



tion, 94,735 letters were received direct by the other divisions, making a total of 255,504 for the Survey, an increase of 11 per cent compared with the fiscal year 1915.

Of the letters opened in this division, 23,642 contained a total of \$32,012.92 remitted for Survey publications, a decrease of less than 2 per cent in number of letters and an increase of \$3,491.12 in amount compared with the fiscal year 1915.

The recording, referring, filing, and mailing of correspondence required practically the entire services of eight clerks. The number of letters mailed through the division was 185,970, an increase of 36 per cent over the preceding year. This number does not include the outgoing registered mail, which numbered 12,732 pieces, or 238,104 pieces of letter mail sent direct from other divisions. The total for the Survey was therefore 436,806, an increase of 12 per cent over 1915.

*Personnel.*—The roll of Secretary's appointees numbered 872 at the end of the fiscal year, 37 less than at the end of the fiscal year 1915. The total number of changes in the personnel for the year was 546, which included 107 new appointments, 144 separations, 273 promotions, 4 demotions, and 18 miscellaneous changes.

During the year 13,946 days of annual leave and 3,045 days of sick leave were granted, being only 58 per cent of the amount of annual leave and 13 per cent of the amount of sick leave which it is permissible to grant under the law; 4,722 days of leave without pay were also granted.

#### DIVISION OF ACCOUNTS.

A condensed statement covering the financial transactions of the fiscal year is given below, including disbursements up to September 30. The unexpended balances of that date largely represent outstanding obligations.

*Amounts appropriated for and expended by the United States Geological Survey pertaining to the fiscal year ended June 30, 1916.<sup>a</sup>*

Title of appropriation.	Appropriation.	Repayments.	Available.	Disbursements.	Balance.
Salaries, office of Director .....	\$35,340.00	.....	\$35,340.00	\$35,054.44	\$285.56
Salaries, scientific assistants .....	29,900.00	.....	29,900.00	29,566.66	333.34
Skilled laborers, etc. ....	20,000.00	.....	20,000.00	19,999.82	.18
Gaging streams, etc. ....	150,000.00	\$30,694.92	180,694.92	180,468.94	225.98
Chemical and physical researches .....	40,000.00	.10	40,000.10	39,783.43	216.67
Preparation of illustrations .....	18,280.00	51.93	18,331.93	18,080.01	251.92
Mineral resources of United States .....	75,000.00	.75	75,000.75	74,692.03	308.72
Geologic maps of United States .....	110,000.00	75,128.85	185,128.85	180,946.85	4,182.00
Books for the library .....	2,000.00	.....	2,000.00	1,255.09	744.91
Topographic surveys .....	350,000.00	2,036.11	352,036.11	350,771.87	1,264.24
Geologic surveys .....	350,000.00	1,888.41	351,888.41	351,007.41	881.00
Mineral resources of Alaska .....	100,000.00	183.38	100,183.38	98,738.19	1,445.19
Surveying national forests .....	75,000.00	2.40	75,002.40	74,558.67	443.73
	1,355,520.00	109,986.85	1,465,506.85	1,454,923.41	10,583.44

<sup>a</sup> In addition to these appropriations amounts aggregating \$215,000, for Survey publications and for rent of the building occupied by the Survey, were allotted from other appropriations but not disbursed by Survey officials.

## Classification of expenditures by the United States Geological Survey pertaining to the fiscal year ended June 30, 1916.

Appropriation.	Total.	Salaries and wages.	Transportation of persons.	Transportation of things.	Subsistence and support of persons.	Subsistence and care of animals.	Communication service.	Printing, engraving, lithographing, etc.	Advertising and publication of notices.	Furnishing heat, light, power, etc.	Special and miscellaneous service.	Materials.
Salaries, office of the Director.....	\$35,054.44	\$35,054.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salaries, scientific assistants.....	29,566.66	29,566.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Skilled laborers, etc.....	19,999.82	19,999.82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gaging streams, etc.....	180,468.94	135,464.34	\$16,942.18	\$939.59	\$9,249.63	\$266.31	\$879.12	\$1,385.54	.....	\$8.40	\$1,444.52	\$1,975.22
Chemical and physical researches.....	39,783.43	27,798.95	2,382.88	2,765.53	800.10	207.72	87.70	106.79	.....	361.61	423.43	1,226.45
Preparation of illustrations.....	18,080.01	16,762.91	.....	.....	.....	.....	14.65	990.49	.....	.....	13.00	18.56
Mineral resources of the United States.....	74,692.03	68,617.02	2,088.73	108.77	1,600.70	.....	654.46	169.19	.....	.....	316.20	.18
Geologic maps of the United States.....	180,946.85	133,147.81	36.90	7.96	74.95	.....	74.12	3,818.14	.....	2,089.85	2,480.95	5,380.04
Books for the library.....	1,255.09	.....	.....	4.38	.....	.....	1.77	.....	.....	.....	.....	.....
Topographic surveys.....	350,771.87	236,160.66	27,224.43	4,471.61	44,597.75	10,147.30	1,147.33	5,057.78	.....	.....	1,853.36	1,789.42
Geologic surveys.....	351,007.41	298,444.85	16,405.83	1,153.34	13,373.58	4,480.10	723.20	4,065.41	\$46.08	.....	1,734.45	249.53
Mineral resources of Alaska.....	98,738.19	65,761.35	11,200.67	5,794.60	3,743.08	212.15	176.64	869.58	.....	.....	1,500.80	405.04
Surveying national forests.....	74,558.67	49,044.05	2,441.42	871.01	9,761.74	5,000.28	54.48	524.69	.....	.....	419.49	313.17
	1,454,923.41	1,115,822.86	78,723.04	16,116.79	83,201.53	20,313.86	3,813.47	16,987.61	46.08	2,459.86	10,186.20	11,357.61

Appropriation.	Stationery, drafting, etc., supplies.	Fuel.	Mechanic's, engineer's, etc., supplies.	Cleaning and toilet supplies.	Wearing apparel.	Forage and other supplies for animals.	Provisions.	Ammunition and explosives.	Special and miscellaneous supplies.	Equipment (including live stock).	Structures (bench marks).	Rent.
Gaging streams, etc.....	\$1,689.89	\$295.76	\$333.55	\$2.91	\$3.25	\$46.50	\$92.29	\$1.95	\$26.34	\$7,340.40	\$90.00	\$1,991.25
Chemical and physical researches.....	658.00	293.18	171.20	14.06	.....	141.39	879.30	.....	105.70	1,133.75	.....	225.69
Preparation of illustrations.....	160.84	.....	2.23	.....	.....	.....	.....	.....	.....	117.33	.....	.....
Mineral resources of the United States.....	649.07	.....	2.26	6.60	.....	.....	.....	.....	1.00	297.85	.....	180.00
Geologic maps of the United States.....	27,187.26	89.56	690.55	158.12	.....	.....	.....	.....	13.26	5,697.38	.....	.....
Books for the library.....	39.69	.....	.....	.....	.....	.....	.....	.....	.....	1,209.25	.....	.....
Topographic surveys.....	1,895.44	410.45	146.72	30.60	12.50	5,524.49	185.16	.....	.....	6,871.56	2,854.90	162.02
Geologic surveys.....	1,453.46	103.83	154.27	27.57	11.35	1,168.27	2,984.94	22.85	228.39	191.70	.....	10.28
Mineral resources of Alaska.....	1,001.93	165.51	188.15	26.78	26.25	1,223.34	2,009.35	74.25	105.41	4,230.96	5.40	16.95
Surveying national forests.....	345.63	85.10	13.36	24.05	1.55	2,612.57	2.20	3.36	45.21	2,983.06	.....	12.25
	35,086.21	1,443.39	1,702.29	290.69	54.90	10,716.56	6,153.24	102.41	717.01	34,079.06	2,950.30	2,598.44

## LIBRARY.

During the year the library received 10,793 books, pamphlets, and periodicals and 439 maps, a total of 11,232 publications.

It has become increasingly difficult to obtain European publications, particularly from Germany and Austria-Hungary. The files of technical and scientific serials published in those countries since the war began are much broken, and almost all the new books are lacking. With these exceptions practically all the new literature of geology has been obtained, and also a few important older publications.

Current accessions were catalogued as received and included 6,276 items. The catalogue was increased by the addition of 9,646 new cards. Systematic efforts have been made by correspondence with societies, institutions, and individuals to fill out and complete sets of serials. These efforts are bringing many valuable additions to the library.

Titles sent to the Library of Congress for printing numbered 998; letters received, 3,682; letters written, 2,984; books collated and sent to the bindery, 2,375.

The loans during the year included 6,922 books and 354 maps, a total of 7,276. This number does not include books consulted in the library by 8,198 readers.

The bibliography of North American geology for 1915 (Bulletin 645) was completed and the proof read. Work on the cumulated bibliography of North American geology has been continued, and the compiler has cooperated with the committee on geologic names in preparing tables of geologic formations. Many bibliographic lists have been prepared, and a large amount of research work has been done for members of the Survey, this work including the translation of 52 letters and papers.

The reports and maps published by the Survey during the year were promptly distributed to the exchanges of the United States, Canada, and Mexico. Foreign sendings were made four times during the year, but it has been necessary to withhold distribution to addresses in the countries at war, the international exchanges having been suspended to all these countries except Great Britain, France, and Italy.





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