

ART. XVI.—*The Organization and Plan of the United States Geological Survey*; by J. W. POWELL. With a map (Plate 1). (Communicated to the National Academy of Sciences at the October meeting in 1884.)

A SCIENTIFIC institution or bureau operating under government authority can be controlled by statute and by superior administrative authority but to a limited extent. These operations are practically carried on by specialists, and they can be controlled only in their financial operations and in the general purposes for which investigations are made. Their methods of investigation are their own,—originate with themselves, and are carried out by themselves. But in relation to the scientific operations of such a government institution, there is an unofficial authority which, though not immediately felt, ultimately steps in to approve or condemn, viz: the body of scientific men of the country; and though their authority is not exercised antecedently and at every stage of the work, yet it is so potent that no national scientific institution can grow and prosper without their approval, but must sooner or later fall and perish unless sustained by their strong influence.

As director of the Geological Survey, I deeply realize that I owe allegiance to the scientific men of the country, and for this reason I desire to present to the National Academy of Sciences the organization and plan of operations of the Survey.

A TOPOGRAPHIC MAP OF THE UNITED STATES.

Sound geologic research is based on geography. Without a good topographic map geology cannot even be thoroughly studied, and the publication of the results of geologic investigation is very imperfect without a good map; but with a good map thorough investigation and simple, intelligible publication become possible. Impelled by these considerations the Survey is making a topographic map of the United States. The geographic basis of this map is a trigonometric survey by which datum points are established throughout the country; that is, base-lines are measured and a triangulation extended therefrom. This trigonometric work is executed on a scale only sufficiently refined for map-making purposes, and will not be directly useful for geodetic purposes in determining the figure of the earth. The hypsometric work is based upon the railroad levels of the country. Throughout the greater part of the country, there is a system of railroad lines, constituting a net-work. The levels or profiles of these roads have been established with reasonable accuracy, and as they cross each other at a multipli-

city of points, a system of checks is afforded, so that the railroad surface of the country can be determined therefrom with all the accuracy necessary for the most refined and elaborate topographic maps. From such a hypsometric basis the reliefs for the whole country are determined, by running lines of levels, by trigonometric construction, and in mountainous regions by barometric observation.

The primary triangulation having been made, the topography is executed by a variety of methods, adapted to the peculiar conditions found in various portions of the country. To a large extent the plane-table is used. In the hands of the topographers of the Geological Survey the plane-table is not simply a portable drafting table for the field; it is practically an instrument of triangulation, and all minor positions of the details of topography are determined through its use by trigonometric construction.

The scale on which the map is made is variable. In some portions of the prairie region, and in the region of the great plains, the topography and the geology alike are simple, and maps on a comparatively small scale are sufficient for practical purposes. For these districts it is proposed to construct the sheets of the map on a scale of 1-250000, or about four miles to the inch. In the mountain regions of the West the geology is more complex, and the topography more intricate; but to a large extent these regions are uninhabited, and to a more limited extent uninhabitable. It would therefore not be wise to make a topographic or geologic survey of the country on an excessively elaborate plan. Over much of this area the sheets of the map will also be constructed on a scale of 1-250000, but in special districts that scale will be increased to 1-125000, and in the case of important mining districts charts will be constructed on a much larger scale. In the eastern portion of the United States two scales are adopted. In the less densely populated country a scale of 1-125000 is used; in the more densely populated regions a scale of 1-62500 is adopted, or about one mile to the inch. But throughout the country a few special districts of great importance, because of complex geologic structure, dense population, or other condition, will require charts on still larger scales. The area of the United States, exclusive of Alaska, is about three million square miles, and a map of the United States, constructed on the plan set fourth above, will require not less than 2600 sheets. It may ultimately prove to require more than that, from the fact that the areas to be surveyed on the larger scale have not been fully determined. Besides the number of sheets in the general map of the United States, there will be several hundred special maps on large scales, as above described.

Such is a brief outline of the plan so far as it has been developed at the present time. In this connection it should be stated that the map of the United States can be completed, with the present organization of the Geological Survey, in about 24 years; but it is greatly to be desired that the time for its completion may be materially diminished by increasing the topographic force of the Geological Survey. We ought to have a good topographic map of the United States by the year 1900. About one-fifth of the whole area of the United States, exclusive of Alaska, has been completed on the above plan. This includes all geographic work done in the United States under the auspices of the General Government and under the auspices of State governments. The map herewith shows those areas that have been surveyed by various organizations on such a scale and in such a manner that the work has been accepted as sufficient for the purposes of the Survey.

Much other work has been done, but not with sufficient refinement and accuracy to be of present value, though such work subserved its purpose in its time. An examination of the map will show that the triangulation of the various organizations is already largely in advance of the topography. The map of the United States will be a great atlas divided into sheets as above indicated. In all of those areas where the survey is on a scale of 1-250000, a page of the atlas will present an area of one degree in longitude and one degree in latitude. Where the scale is 1-125000, a page of the atlas-sheet will represent one-fourth of a degree. Where the scale is 1-62500, the atlas-sheet will represent one-sixteenth of a degree. The degree sheet will be designated by two numbers—one representing latitude, the other longitude. Where the sheets represent fractional degrees, they will be labeled with the same numbers, with the addition of the description of the proper fractional part.

The organization, as at present established, executing this work, is as follows: First, An astronomic and computing division, the officers of which are engaged in determining the geographic coördinates of certain primary points. Second, A triangulation corps engaged in extending a system of triangulation over various portions of the country from measured base-lines. Third, A topographic corps, organized into twenty-seven parties, scattered over various portions of the United States. Such, in brief outline, is the plan for the map of the United States, and the organization by which it is to be made. Mr. Henry Gannett is the Chief Geographer.

PALEONTOLOGY.

Before giving the outline of the plan for the general geologic survey, it will be better to explain the accessory plans and organizations. There are in the Survey, as at present organized, the following paleontologic laboratories:

1. A laboratory of vertebrate paleontology for formations other than the Quaternary. In connection with this laboratory there is a corps of paleontologists. Professor O. C. Marsh is in charge.

2. There is a laboratory of invertebrate paleontology of Quaternary age, with a corps of paleontologists, Mr. Wm. H. Dall, being in charge.

3. There is a laboratory of invertebrate paleontology of Cenozoic and Mesozoic age, with a corps of paleontologists. Dr. C. A. White is in charge.

4. There is a laboratory of invertebrate paleontology of Paleozoic age, with a corps of paleontologists. Mr. C. D. Walcott is in charge.

5. There is a laboratory of fossil botany, with a corps of paleobotanists, Mr. Lester F. Ward being in charge.

The paleontologists and paleobotanists connected with the laboratories above described, study and discuss in reports the fossils collected by the general geologists in the field. They also supplement the work of the field geologists by making special collections in important districts and at critical horizons; but the paleontologists are not held responsible for areal and structural geology on the one hand, and the geologists are not held responsible for paleontology on the other hand. In addition to the large number of paleontologists on the regular work of the Geological Survey, as above described, several paleontologists are engaged from time to time to make special studies.

CHEMISTRY.

There is a chemic laboratory attached to the Survey, with a large corps of chemists engaged in a great variety of researches relating to the constitution of waters, minerals, ores and rocks. A part of the work of this corps is to study the methods of metamorphism and the paragenesis of minerals, and in this connection the chemists do work in the field; but to a large extent they are occupied with the study of the materials collected by the field geologists. Professor F. W. Clarke is in charge of this department.

PHYSICAL RESEARCHES.

There is a physical laboratory in the Survey, with a small corps of men engaged in certain physical researches of prime importance to geologic philosophy. These researches are experimental, and relate to the effect of temperatures, pressures, etc., on rocks. This laboratory is under the charge of the Chief Chemist.

LITHOLOGY.

There is a lithologic laboratory in the Survey, with a large corps of lithologists engaged in the microscopic study of rocks. These lithologists are field geologists, who examine the collections made by themselves.

STATISTICS.

There is in the Survey a division of mining statistics, with a large corps of men engaged in statistic work, the results of which are published in an annual report entitled "Mineral Resources." Mr. Albert Williams, Jr., is the Chief Statistician of the Survey.

ILLUSTRATIONS.

There is in the Survey a division organized for the purpose of preparing illustrations for paleontologic and geologic reports. Mr. W. H. Holmes is in charge of this division. Illustrations will not hereafter be used for embellishment, but will be strictly confined to the illustration of the text and the presentation of such facts as can be best exhibited by figures and diagrams. All illustrations will, as far as possible, be produced by relief methods, such as wood-engraving, photo-engraving, etc. As large numbers of the reports of the Survey are published, this plan is demanded for economic reasons; but there is another consideration believed to be of still greater importance: illustrations made on stone cannot be used after the first edition, as they deteriorate somewhat by time, and it is customary to use the same lithographic stone for various purposes from time to time. The illustrations made for the reports of the Survey, if on relief-plates that can be cheaply electrotyped, can be used again when needed. This is especially desirable in paleontology, where previously published figures can be introduced for comparative purposes. There are two methods of studying the extinct life of the globe. Fossils are indices of geological formations, and must be grouped by formations to subserve the purpose of geologists. Fossils also have their biologic relations, and should be studied and arranged in biologic groups. Under the plan adopted by the Survey, the illustra-

tions can be used over and over again for such purposes when needed, as reproduction can be made at the small cost of electrotyping. These same illustrations can be used by the public at large in scientific periodicals, text-books, etc. All the illustrations made by the Geological Survey are held for the public to be used in this manner.

LIBRARY.

The library of the Survey now contains more than 25,000 volumes, and is rapidly growing by means of exchanges. It is found necessary to purchase but few books. The librarian, Mr. C. C. Darwin, has a corps of assistants engaged in bibliographic work. It is proposed to prepare a catalogue of American and foreign publications upon American geology, which is to be a general authors' catalogue. In addition to this, it is proposed to publish bibliographies proper of special subjects constituting integral parts of the science of geology.

PUBLICATIONS.

The publications of the Survey are in three series: Annual Reports, Bulletins and Monographs. The Annual Report constitutes a part of the Report of the Secretary of the Interior for each year, but is a distinct volume. This contains a brief summary of the purposes, plans and operations of the Survey, prepared by the Director, and short administrative reports from the chiefs of divisions, the whole followed by scientific papers. These papers are selected as being those of most general interest, the object being to make the Annual Report a somewhat popular account of the doings of the Survey, that it may be widely read by the intelligent people of the country. Of this 5650 copies are published as a part of the Secretary's report, and are distributed by the Secretary of the Interior, Senators and Members of the House of Representatives; and an extra edition is annually ordered of 15,000 copies, distributed by the Survey and members of the Senate and House of Representatives. Four Annual Reports have been published; the Fifth is now in the hands of the printer.

The Bulletins of the Survey are short papers; and through them somewhat speedy publication is attained. Each Bulletin is devoted to some specific topic, in order that the material ultimately published in the Bulletins can be classified in any manner desired by scientific men. Nine Bulletins have been published, and seven are in press. The Bulletins already published vary in size from 5 to 325 pages each; they are sold at the cost of press-work and paper, and vary in price from five to twenty cents each. 4900 copies of each Bulletin are pub-

lished; 1900 are distributed by Congress, 3000 are held for sale and exchange by the Geological Survey.

The Monographs of the Survey are quarto volumes. By this method of publication the more important and elaborate papers are given to the public. Six Monographs, with two atlases, have been issued; five Monographs, with two atlases, are in press. 1900 copies of each Monograph are distributed by Congress; 3000 are held for sale and exchange by the Survey at the cost of press-work, paper and binding. They vary in price from \$1.05 to \$11.

The chiefs of divisions supervise the publications that originate in their several corps. The general editorial supervision is exercised by the Chief Clerk of the Survey, Mr. James C. Pilling.

GENERAL GEOLOGY.

In organizing the general geologic work, it became necessary, first, to consider what had already been done in various portions of the United States; and for this purpose the compilation of a general geologic map of the United States was begun, together with a Thesaurus of American formations. In addition to this the bibliographic work previously described was initiated, so that the literature relating to American geology should be readily accessible to the workers in the Survey. At this point it became necessary to consider the best methods of apportioning the work; that is, the best methods of dividing the geologic work into parts to be assigned to the different corps of observers. A strictly geographic apportionment was not deemed wise, from the fact that an unscientific division of labor would result, and the same classes of problems would to a large extent be relegated to the several corps operating in field and in the laboratory. It was thought best to divide the work, as far as possible, by subject-matter rather than by territorial areas; yet to some extent the two methods of division will coincide. There are in the survey at present:

First, a division of glacial geology, and Prof. T. C. Chamberlin, formerly State Geologist of Wisconsin, is at its head, with a strong corps of assistants. There is an important field for which definite provision has not yet been made, namely, the study of the loess that constitutes the bluff formations of the Mississippi River and its tributaries. But as this loess proves to be intimately associated with the glacial formations of the same region, it is probable that it will eventually be relegated to the glacial division. Perhaps the division may eventually grow to such an extent that its field of operations will include the whole Quaternary geology.

Second, a division of volcanic geology is organized and Capt. Clarence E. Dutton, of the Ordnance Corps of the Army, is placed in charge, also with a strong corps of assistants.

Third and fourth, two divisions have been organized to prosecute work on the Archæan rocks, embracing within their field not only all rocks of Archæan age, but all metamorphic crystalline schists, of whatever age they may be found. The first division has for its chief, Prof. Raphael Pumpelly, assisted by a corps of geologists, and the field of his work is the crystalline schists of the Appalachian region, or eastern portion of the United States, extending from northern New England to Georgia. He will also include in his studies certain Paleozoic formations which are immediately connected with the crystalline schists and involved in their orographic structure.

The second division for the study of this class of rocks is in charge of Prof. Roland D. Irving, with a corps of geologists, and his field of operation is in the Lake Superior region. It is not proposed at present to undertake the study of the crystalline schists of the Rocky Mountain region.

Fifth, another division has been organized for the study of the areal, structural, and historical geology of the Appalachian region, extending from the Atlantic, westward, to the zone which separates the mountain region from the great valley of the Mississippi. Mr. G. K. Gilbert has charge of this work, and has a large corps of assistants.

Sixth, it seemed desirable, partly for scientific reasons and partly for administrative reasons, that a thorough topographic and geologic survey should be made of the Yellowstone Park, and Mr. Arnold Hague is in charge of the work, with a corps of assistants. When it is completed, his field will be expanded so as to include a large part of the Rocky Mountain region, but the extent of the field is not yet determined.

It will thus be seen that the general geologic work relating to those areas where the terranes are composed of fossiliferous formations is very imperfectly and incompletely organized. The reason for this is two fold: first, the work cannot be performed very successfully until the maps are made; second, the Geological Survey is necessarily diverting much of its force to the construction of maps, and cannot with present appropriations expand the geologic corps so as to extend systematic work in the field over the entire country.

ECONOMIC GEOLOGY.

Under the organic law of the Geological Survey, investigations in economic geology are restricted to those States and Territories in which there are public lands; the extension of

the work into the eastern portion of the United States included only that part relating to general geology. Two mining divisions are organized. One, in charge of Mr. George F. Becker, with headquarters at San Francisco, California, is at the present time engaged in the study of the quicksilver districts of California. The other, under charge of Mr. S. F. Emmons, with headquarters at Denver, Colorado, is engaged in studying various mining districts in that State, including silver, gold, iron and coal areas. Each division has a corps of assistants. The lignite coals of the upper Missouri, also, are under investigation by Mr. Bailey Willis, with a corps of assistants.

EMPLOYÉS.

The employés on the Geological Survey at the close of September, 1884, were as follows:

Appointed by the President, by and with the advice and consent of the Senate (Director), 1.

Appointed by the Secretary of the Interior, on the recommendation of the Director of the Survey, 134.

Employed by the chiefs of parties in the field, 148.

APPOINTMENTS.

Three classes of appointments are made on the Survey. The statute provides that "the scientific employés of the Geological Survey shall be selected by the Director, subject to the approval of the Secretary of the Interior, exclusively for their qualifications as professional experts." The provisions of this statute apply to all those cases where scientific men are employed who have established a reputation, and in asking for their appointment the Director specifically states his reasons, setting forth the work in which the person is to be employed, together with his qualifications, especially enumerating and characterizing his published works. On such recommendations appointments are invariably made. Young men who have not established a reputation in scientific research, are selected through the agency of the Civil Service Commission on special examination, the papers for which are prepared in the Geological Survey. About one-half of the employés, however, are temporary, being engaged for services lasting for a few days or a few months only, largely in the field, and coming under two classes: skilled laborers and common laborers. Such persons are employed by the Director or by the heads of divisions, and are discharged from the service when no longer needed. It will be seen that the Director is responsible for the selection of the employés, directly for those whom he recommends for appointment, and indirectly for those selected by the

Civil Service Commission, as he permanently retains in the work. If, then, improper persons are employed, it is wholly the Director's fault.

The appropriations made for the Geological Survey for the fiscal year ending June 30, 1885, aggregate the sum of \$504,040. This sum does not include the amount appropriated for ethnologic researches, \$40,000. Nor are the expenses for engraving and printing paid for from the above appropriations, but from appropriations made for the work under the direction of the Public Printer. It is estimated that the amount needed for engraving and printing for the same fiscal year will exceed \$200,000.

THE RELATION OF THE GOVERNMENT SURVEY TO STATE SURVEYS.

The United States Geological Survey is on friendly relations with the various State Surveys. Between the Government Survey and the State Survey of New York, there is direct coöperation. The State Survey of Pennsylvania has rendered valuable assistance to the Government Survey, and negotiations have been entered into for closer relations and more thorough coöperation. The State Surveys of North Carolina, Kentucky and Alabama, are also coöperating with the Government Survey, and the Director of the Government Survey is doing all within his power to revive State Surveys. The field for geologic research in the United States is of great magnitude, and the best results can be accomplished only by the labors of many scientific men engaged for a long term of years. For this reason it is believed that surveys should be established in all of the States and Territories. There is work enough for all, and the establishment of local surveys would greatly assist the general work prosecuted under the auspices of the Government, and prevent it from falling into perfunctory channels. Its vigor and health will doubtless be promoted by all thorough local research.

It may be of interest to scientific men to know that the Director finds that in presenting the general results, interests, and needs of the Survey to Congress, and to Committees of Congress, a thorough appreciation of the value of scientific research is shown by the statesmen of the country. Questions relating to immediately economic values are asked, as they should be; but questions relating to sound administration, wise methods of investigation, and important scientific results are vigorously urged, and the principle is recognized that all sound scientific research conduces to the welfare of the people, not only by increasing knowledge, but ultimately by affecting all the industries of the people.

