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OUTLOOK OF THE GEOLOGIST IN AMERICA

Annual Address by the President, **Charles D. Walcott**

Contents

INTRODUCTION

A few years ago I outlined* what to me appeared to be the proper policy to be pursued by the United States Geological Survey. A kindly critic said of it: "There will not be much left for others to do if all that you have planned is carried out." Since that time the work of the Survey has progressed steadily along the lines then laid down, the only important exception being the study of the geology of public roads, which has been taken up by the Department of Agriculture; yet state surveys continue to flourish and expand, and any active, capable student or professor connected with school, college, or university may find more geologic problems close at hand than he can possibly investigate.

I am often asked by young men, "What are the prospects for me if I take up geology as a profession? Is there work to be done and money to pay for it?" These questions have led me to make inquiries among active workers in American geology.*

* Popular Science Monthly for February, 1895.

THE PAST

GEOLOGIC WORK IN 1901

Method of treatment adopted.—Let us first note what has been done during the year just closed. It is impossible to characterize adequately the scope and quantity of this work without a larger draft on your time than I feel at liberty to make, but the examination of its units will show its great variety of theme and the breadth of its distribution. I shall attempt to include only what may be called profession work—the work of geologic surveys and museums, and of men whose researches are sustained, in whole or in part, by the funds of educational and other institutions. The labors of amateurs are by no means unworthy of mention; indeed, their contributions to geology are often of great importance; but the fact that their researches are usually private, becoming known only through publication, makes it impossible to list them for the year 1901 with any approach to completeness, and they have only indirect bearing on our primary question—the status and prospects of the professional geologist.

National organizations.—Foremost among the organizations and institutions which have sustained professional work are the national and state geologic surveys. The United States Geological Survey, including in its purview the whole country, gave continuous employment last year to thirty-six geologists and paleontologists, and availed itself temporarily of the services of about fifty geologists, paleontologists, and mining engineers. For the services and direct expenses of these officers and collaborators it expended the sum of $175,000. A still larger amount was devoted to accessory work of various kinds—chemical analyses of rocks, chemical and physical researches bearing on geologic

* In the preparation of this address I have received most valuable assistance from Mr G.K. Gilbert and Mr F.B. Weeks, and many geologists and paleontologists have furnished important data.

problems, the making of topographic maps on which to delineate geologic boundaries, clerical and other aid connected with the indoor work and business management of the organization, and publication of reports and maps. The organization was also charged with the administration of investigations not regarded as auxiliary to geologic work, but rather as involving the practical application of geologic data, the chief of these being inquiries as to water supply, with reference to irrigation and other utilities, and the survey of the forest lands with reference to their protection and management.

During the year 1901 the Geological Survey of Canada had thirty geologists in charge of parties or pursuing investigations independently of one another, in the field. Geologic reconnoissance [*sic*] surveys were mad of several of the little known areas of the Dominion, and geologic studies of the occurrence of coal, copper, and the precious metals and other economic resources were prosecuted in the various districts.

The Instituto Geologico de Mexico engages the continuous services of a limited number of geologists. During 1901 its work comprised the preparation of monographs on the coalfields and on the rhyolites of Mexico. Studies of economic minerals, eruptive rocks, paleontologic material, and structural problems connected with the geologic section from Acapulco to Vera Cruz were also prosecuted.

State organizations.—The State of New York, in continuation of the great scientific survey which gave to American geology its stratigraphic and faunal standards, maintains a bureau for paleontologic work and another for geologic, and makes provision also for the preparation of a topographic map suitable for the refined delineation of geologic boundaries. New Jersey, which some years ago completed an excellent topographic map and has been wholly covered by geologic surveys, maintains a corps of geologists, whose function it is to carry on scientific and economic researches *pari passu* with economic development. Pennsylvania, which was the companion of New York in her great pioneer work and has since then conducted a comprehensive resurvey, now provides for a moderate amount of economic work and contributes to the production of a detailed topographic map. The geologic survey of Maryland, begun but a few years ago and comprising a comprehensive study of the geology and resources of the state, is being pushed to completion with unusual energy and rapidity. West Virginia has taken a new and vigorous start that promises well for the future. Moderate appropriations are annually made for investigation of the geology and resources of North Carolina, Georgia, Alabama, Louisiana, and Texas. Ohio, having twice in the past instituted general investigations in her geology, now maintains a corps of experts, whose chief function it is to gather geologic and technical information in the interest of growing industries. She also makes annual provision toward the completion of an adequate topographic map. In Indiana a small amount of geologic work is supported by the State. Michigan, which has repeatedly called on the geologists for information as to her mineral wealth, now employs a permanent corps of geologists and mining engineers. Wisconsin, already in possession of comprehensive reports on her geologic features, makes annual provision for more refined and detailed study, both scientific and economic. In Minnesota the final results of a comprehensive survey are being elaborated and published. In Iowa a detailed areal survey is in progress, and there are also special investigations of geologic problems and mineral-using industries. Missouri, whose geologic survey has been retarded by many changes of policy and personnel, has recently placed her work in charge of one who commands our confidence as well as our good wishes. Kansas and South Dakota make moderate provisions for the prosecution of geologic research by the officers of their universities. In Colorado, Arizona, California, and Washington provision is made for a certain amount of investigation in connection with local mining industries.

Museums.—The United States National Museum provides laboratory facilities for paleontologists of the national survey and enables its curators in geology and paleontology to devote part of their time to original research. The Museum of Comparative Zoölogy, one of the institutions for research associated with Harvard University, carries on geologic and paleontologic investigations. The Peabody Museum, an institution of research associated with Yale University, is devoted chiefly to the collection and study of fossils and minerals. The American Museum of Natural History in New York, the Museum of Princeton University, and the Carnegie Museum of Pittsburg carry on important paleontologic researches, both in the field and in the laboratory.

Universities and colleges.—All of our larger universities and colleges, either directly or indirectly, give substantial aid to geologic investigations. In a few instances funds are contributed to defray research expenses in field and laboratory. In some cases the means of publication are provided. In all cases the teachers of geology are either permitted or expected to devote a portion of their time to scientific investigations. In a number of instances state surveys are by legal enactment associated with state universities, and the geologic survey of Maryland is conducted under the auspices of a university privately endowed. Prominent among the institutions which thus promote the progress of geologic science are Harvard and the Lawrence School, Yale and the Sheffield Scientific School, Columbia and the School of Mines, Cornell, Princeton, Lehigh, Johns Hopkins, Denison, Chicago, Stanford, Amherst, and the universities of Alabama, Ohio, Michigan, Wisconsin, Minnesota, Iowa, Kansas, and California; but the list might be extended so as to include practically almost every institution in which scientific instruction is so far differentiated that the subject of geology occupies the entire attention of one teacher.

Taking account of all these agencies, whether surveys, museums, or educational institutions, I estimate that seventy geologists are enabled by financial support to devote themselves wholly to professional research work; that fifty geologists, mining engineers, and technologists, though occupied chiefly in other was, receive pay for special work in the field of research, and that seventy other geologists, employed and salaried as teachers, either are urged or are permitted without prejudice to devote part of their time to scientific investigations. The total would be carried above two hundred if to these were added those mining engineers who, gaining a livelihood by the industrial application of expert geologic knowledge, devote more or less of their leisure time to research.

Publications.—In this connection should be mentioned the important aid which geologists receive through various agencies of publication. While such aid does not contribute to the support of the student, it is sometimes the factor which turns the doubtful scale and makes a contribution to geologic science possible. The Bulletin of this Society, the American Geologist, and various scientific journals which give part of their space to papers on geologic subjects, are supported by the scientific men themselves, and from one point of view may seem to give no aid to the needy investigator; but it is really the readers who pay the printer, and the investigator is called on to pay only because he is also a reader. The Journal of Geology is not altogether dependent on its subscription list, but is practically endowed by the University of Chicago; and at New York, Baltimore, Granville, Lawrence, Berkeley, and Palo Alto the results of research are published in university transactions at university expense. The Wagner Institute devotes much of its income to paleontologic publications, and other institutions and societies, local and national, include geologists among the devotees of research to which the pages of their publications are open.

Of 21,600 printed pages on American geology in 1899, 12,000 were published by state and national surveys, 1,700 by geologic journals, 2,000 by other scientific journals, 500 by the Geological Society of America, and 5,400 by other associations and institutions.

Recurring now to the enumeration of investigations in progress during the last year, it will be convenient to begin with a geographic order.

Work in the various states.—In New Hampshire, Pirsson made field studies of the crystalline rocks, Hitchcock continued the investigation both of the structure of the older rocks and of the glacial geology in the vicinity of Hanover, and Dale continued the study and mapping of Paleozoic formations on both sides of lake Champlain. Metamorphic rocks in Worcester and Franklin counties, Massachusetts, were studied and mapped by Emerson, in southwestern Connecticut by Hobbs, and in central Connecticut by Gregory and Ford. Woodworth continued his studies of glacial phenomena and of Carboniferous strata in the Norfolk area, and Taylor studied and mapped the glaciated features of the Housatonic and Taconic districts.

In southwestern New York, Glenn made detailed studies of Devonian and Carboniferous strata with special reference to coal, oil, gas, and clays. In the Adirondacks, Kemp continued the mapping of crystalline rocks. Ogilvie mapped in detail the formations of a tract near Paradox lake, and Cushing of a tract north of Little Falls. Harris mapped the region above Crown Point and North Balcon island, on lake Champlain. Fairchild studied glacial deposits of the western part of the state, and Woodworth worked on the Pleistocene history of the Champlain-Hudson valley. Clarke conducted or supervised areal work about Canandaigua and Seneca lakes and the Niagara river and studies of the stratigraphy and life of the Rondout waterlimes, of the limestone lenses in the Rochester shales, and of the pyritic bed occupying the horizon of the Tully limestones west of Canandaigua. Beecher made collections of fossils from Devonian and Silurian horizons at Sheldrake, Hornellsville, and Rochester.

In Pennsylvania, Campbell and his assistants made detailed examinations of Carboniferous strata with special reference to the occurrence of coal, oil, and gas. Girty continued a study of the relations of the Lower Carboniferous strata and their faunas. Stose worked on areal and economic geology in the vicinity of Mercersburg and Chambersburg, and Bascom in the vicinity of Philadelphia. Williams studied the changing constitution of fossil faunas as traced westward from the central eastern counties.

In New Jersey, Ries continued the investigation of clay deposits; Kümmel and Weller studied Paleozoic formations at the northwest, and Woolman was occupied with the collection and correlation of data regarding artesian wells at the south. Wolff completed the study of a pseudo-leucite dike near Beemerville. Salisbury and Shattuck studied Pleistocene problems of the coastal plain region of New Jersey and Delaware.

Field work by the Geological Survey of Maryland included the mapping of Prince George, Harford, and Garrett counties, with local studies of clay and iron deposits; and laboratory studies of coal and fossils were prosecuted.

In West Virginia, I.C. White was engaged in the preparation of a report on the coals of the state.

Watson made a petrographic study of a part of the Piedmont plateau in Virginia and North Carolina.

Holmes studied the Columbia and Lafayette gravels and loams of North Carolina, tracing their equivalents in the Tennessee valley across the states of Georgia, Alabama, and Tennessee. Pratt made local studies of mineral deposits in the crystalline rocks of North Carolina west of the Blue Ridge, and was associated with Lewis in the study of the origin and relations of the corundum-bearing rocks of the western portion of the state. Keith revised earlier areal work in the Great Smoky mountains in North Carolina and Tennessee, and was otherwise occupied with areal surveys in Oconee, Pickens, Greenville, and Anderson counties, South Carolina.

Areal and economic work was continued by the State Survey of Alabama. Smith assembled and correlated the records of artesian wells in Alabama and Mississippi and made a local study in connection with borings for oil in Mobile county, Alabama. McCalley mapped a portion of the crystalline area in northern Alabama, and a portion of the Cahaba coalfield. Hall prosecuted a systematic investigation of the water powers of the state.

The gas wells of Louisiana, in Natchitoches, Winn, and Grant counties, were examined by Adams. Harris continued the study of underground waters, and Veatch worked on the geology of the Pliocene formations.

Ashley studied the Carboniferous strata of northern Kentucky and southern Indiana with special reference to the occurrence of coal.

In Ohio, Orton studied those resources which are likely to aid in the development of the Portland cement industry. Peppel investigated limestones with reference to their use for the manufacture of lime and lime mortars. Bownocker continued work on the oil and gas districts, and Lord on the fuel values, absolute and comparative, of the Ohio coals. Prosser studied the stratigraphy of Carboniferous, Devonian, and Silurian formations in various parts of the State and made a geologic map of the vicinity of Columbus.

Blatchley and Hopkins studied the partings between certain formations in the southern part of Indiana for the purpose of securing exact data for a geologic map, and Blatchley was further occupied with an investigation of mineral waters. Cummings made collections of Ordovician fossils.

In Michigan, Leverett and Taylor continued work on moraines and other features of the drift. Lane investigated the occurrence of coal in Saginaw county, and made studies also of underground temperatures and of the relations of formations penetrated by deep wells. Grabau continued a study of Devonian limestones. Davis investigated the origin of marls. Russell continued the investigation of the Portland cement industry of the state. Bayley continued work on structural and economic problems of the Menominee and Iron River districts. Gordon examined the oil and gas wells of the region about Port Huron, and McLouth studied the surface geology and oil wells about Muskegon.

In Wisconsin, Buckley continued the investigation of road materials and road construction, and Fenneman a physiographic survey of the lakes of the southern and eastern districts. Weidman made a study of the formations of Marathon and adjacent counties, and Hobbs of the pre-Cambrian volcanic rocks of the Fox River valley. Hobbs also completed his study of the pre-Cambrian volcanic rocks of the Fox River valley. [*sic*] Bayley continued work on the Florence iron district. Grant continued laboratory work on the geology and petrology of the Keweenawan rocks.

In Minnesota, Winchell was occupied with final publications of the state survey, and Van Hise and Clements continued the investigations of the Vermilion Lake iron district.

Calvin and his assistants, of the Iowa survey, continued the field investigation of clays and the collection of data as to artesian wells and the tracing of the boundary of the Iowa drift, besides carrying on areal work in Howard, Tama, Buena Vista, Cherokee, Monroe, Wapello, and Jefferson counties.

Buckley, after his appointment as state geologist of Missouri, began investigations of the quarrying industries, of materials for road construction, and of the lead and zinc deposits of the central district. In other lead and zinc districts the work of W.S. Tangier Smith was continued.

Adams made a field study of the relations of the Red Beds of Oklahoma to the Permian and Carboniferous series in Kansas. Taff made an areal survey of the Tahlequah and Salisaw districts, in Indian Territory, and a reconnoissance [*sic*] of Arbuckle mountain and the Wichita uplift.

In Kansas, Haworth made economic studies of petroleum, natural gas, and ores of lead and zinc, and Williston worked in the field and laboratory on vertebrate paleontology.

The Tertiary measures of Sioux county, Nebraska, were explored for vertebrate remains by a part from the Carnegie Museum.

In South Dakota, Darton and Todd continued the systematic and economic investigation of underground waters of Butte, Jerauld, and Sanborn counties, and Wieland and Granger searched for dinosaurian remains on the rim of the Black hills. Hovey worked on the geology of the Red Beds and Jura of the Black hills. Darton and Hall made areal surveys in North Dakota with special reference to the geology of artesian waters.

Weed continued detailed investigations of the Butte and Marysville districts of Montana. Willis, in a reconnoissance [*sic*] along the international boundary, examined the local structure and stratigraphy of the Rocky mountains. Winchell studied the problem of the age of the coal in the Great Falls region with special reference to its relation to that of the Little Belt region. Shaler worked on the general and structural geology of the Tobacco Root mountains.

Knight studied the Newcastle oilfield of Wyoming and made a detailed investigation of the Laramie quadrangle with special reference to underground waters. Adams studied water supply problems in Laramie and Converse counties. Two parties visited the state for the purpose of collecting vertebrate fossils, one operating at the north near Como lake, the other at the south in Albany county.

Cross continued areal work in southwestern Colorado; Emmons revisited the Leadville mining district and investigated recent developments, and Adams studied geologic structure in Weld county with reference to artesian problems. Matthew and Brown made a collection of vertebrate fossils in the eastern part of the state, and a party from the Carnegie Museum successfully exploited Jurassic formations near Canyon.

In Texas, Phillips examined state lands west of the Pecos river with respect to their mineral value. Hill completed field work on the general geology of the Rio Grande region. The oilfields in the southeastern part of the state were studied by Phillips, Harris, Hayes, Adams, and Kennedy. Cragin continued laboratory studies on the Jurassic formations. Gridley made a successful search for remains of Pliocene horses.

In the southern part of New Mexico, Permian and Upper Carboniferous strata and faunas were studied by Girty.

Jaggar and Palache conducted an areal geologic survey and an investigation of mineral deposits in Yavapai county, Arizona. Lindgren made a geologic and economic survey of the Clifton-Morenci mining district, and Ransome of the Globe mining district. Blake made a reconnoissance [*sic*] of the vicinity of the Rincon Mountain region with reference to the possible presence of petroleum, investigated the lacustrine formations and the diatomite deposits of San Pedro valley, and continued stratigraphic and structural studies in various mountain ranges. Walcott and Gilbert studied the Algonkian rocks of the Grand canyon of the Colorado.

In western Utah, Gilbert studied the stratigraphy and structure of mountain ranges and the physiographic expression of faults.

In connection with a reconnoissance [*sic*] survey of the international boundary, there was a study of the general geology of northern Idaho by Willis, and of northern Washington by Ransome and G.O. Smith.

Diller resumed the study of Crater lake, Oregon, and made a geologic reconnoissance [*sic*] of the Klamath mountains.

Becker made detailed studies of the Mother lode of California with special reference to the manner in which the gold was deposited. Lindgren continued the study of auriferous gravel channels of the Sierra Nevada and attacked also certain physiographic problems. Merriam began the systematic collection of fossils from the gravels, and traversed Mesozoic areas at the north for the collection of fossils. Branner made an areal geologic survey of coastal ranges in San Mateo, Santa Cruz, and Santa Clara counties. Diller made local surveys in Shasta county and the Honey Lake region. Eldridge investigated the distribution and conditions of the occurrence of petroleum, and Hershey studied the geology and physiography of the Klamath mountains.

In Alaska, Schrader studied the section along the 51st meridian from the Koyukuk river to the Arctic ocean. Mendenhall made a reconnoissance [*sic*] from the Koyukuk to Kotzebue sound via the Koyuk river. Collier was engaged in areal mapping in the northwestern part of Seward peninsula. Brooks was engaged in areal mapping and a study of the ore deposits of the Ketchikan mining district.

In Cuba, Hayes, Vaughan, and Spencer made a geologic reconnoissance [*sic*] with special reference to a study of the economic resources of the island.

Economic work.—In economic geology—that department of applied geology which pertains to minerals of recognized economic value—the year’s work shows also a wide range. Geologic problems in relation to the occurrence of coal were studied in various parts of Pennsylvania, in western Maryland, in northern Kentucky and in North Dakota. The problems of petroleum and natural gas received attention in Pennsylvania, Ohio, Michigan, Kansas, Wyoming, Texas, Louisiana, Arkansas, and California. Problems of the precious metals were investigated in Colorado, Montana, California, and Arizona; of copper in Arizona, Michigan, and Wisconsin, and of lead and zinc in Kansas and Missouri. The geology of iron was studied in Wisconsin and Minnesota; the geology of artesian waters in New Jersey, Iowa, and North Dakota. Water resources for irrigation and power were investigated in the east from Maine to Alabama, in the central Mississippi River region, and in all the more westerly states and territories. Mineral waters received special attention in Indiana. Clays were studied from the economic standpoint in Maryland, Iowa, Tennessee, Mississippi, and New Jersey. The relation of clays and other rocks to the cement industry in Ohio and Michigan was investigated, and special investigations of materials available for road construction were made in Wisconsin and Missouri.

General researches.—Of more general researches, such as are not regularly classified by states, my list probably lacks much of completeness because many of them are not reported in the ordinary way.

Cross, Iddings, Pirsson, and Washington continued join investigations bearing directly on the systematic classification of igneous rocks.

Van Hise continued a comprehensive study of the phenomena of metamorphism.

Merrill extended his studies of meteorites in their bearing on the problems of the earth's history. Much of the early work was crude and, in the light of today, unsatisfactory. With the refinements of modern chemical and petrographic methods, important results may be expected, and detailed work on the structure and composition of these interesting bodies is being carried on under the direction of the United States National Museum.

Lane is accumulating data on the grain of rocks as a function of position and composition, etcetera, and is extending his theoretical researches, especially of intrusives and of geothermal gradient.

Reid is engaged in the study of glaciers, their structure, stratification, movements, and the variations in size which they undergo. He is also engaged in the study of seismologic phenomena occurring in the vicinity of Baltimore, Maryland.

Shaler continued his studies of coast lines in general, with reference to recent changes in ocean level, and of the comparison of the lunar surface with that of the earth.

Gulliver continued the study of shoreline forms.

Davis completed a general study of the river terraces of New England.

Chamberlin was occupied with some of the broader and more fundamental problems of the science, including the mode of origin of the earth in connection with the development of the solar system; the origin and early constitution of the atmosphere and the ocean; the origin and early states of the earth's growth, which is entirely distinct from the early conception of meteoroidal aggregation; the mode of evolution of the oceanic basins and continental platforms; the original distribution and the secular change of distribution of internal heat and its function in the deformation of the earth; the autogenic thermal conditions of the earth and their relation to early life, and the secular changes of land, sea, and atmosphere which constitute the basic features of historical geology.

Crosby completed a study of the Neponset Valley area of the Boston basin and investigated special problems in economic geology in various western states and in Canada. Becker and Day carried forward two physical investigations bearing especially on metamorphism and the problems of the inner earth, the measurement of the linear force of crystallization, and the study of the general theory of elasticity.

PALEONTOLOGIC WORK IN 1901

Mention has already been made of purely local studies involving paleontology, but the greater part of paleontologic work is better adapted to stratigraphic or geologic classification than to geographic.

Dall's work pertained to the faunas of the Tertiary formation of Florida and the Tertiary formation and faunas of the Pacific coast between San Francisco and Crescent City.

Vaughan was occupied with studies of Tertiary faunas. Knowlton began the investigation of Upper Cretaceous strata in southern Colorado and their fossil plants. He also collected and studied plant remains from Tertiary beds in California, Oregon, and Wyoming, and from the auriferous gravels of California.

Stanton continued a comprehensive work on the Lower Cretaceous faunas of the Texas region and began the study of the Cretaceous faunas of the Pacific coast.

Whitfield described new species from the Jurassic of South Dakota and Wyoming and from various other localities and horizons.

Wieland continued the monographic study of American fossil cycads.

Ward studied the geology of the Little Colorado valley in Arizona and continued the preparation of a second paper on the status of the Mesozoic floras of the United States.

Fontaine was engaged in studying Jurassic floras from Oregon, and also continued the study of the flora of the older Potomac formation.

Ward and Clark coöperated in the study of the Potomac terrane and its life.

White continued the stratigraphic and paleontologic study of data for the correlation of the lower terranes of the Coal Measures of the Appalachian region, and continued also a systematic work on the entire flora of the Coal Measures.

Weller studied the Kinderhook fauna of the Mississippi valley.

Girty worked on invertebrate fossils from Lower Carboniferous rocks in northern Pennsylvania and from Permian and Upper Carboniferous strata of southern New Mexico.

Williams continued his special work on Devonian faunas.

Clarke studied the origin of the invertebrate life of the Ithaca group, and made special investigation of the Guelph, Marcellus, and Hudson River faunas.

Beecher investigated Phyllocarida and Merostomata from Eodevonian strata.

Wortman continued the study and description of Eocene mammals of the Marsh collection.

Osborn, besides continuing the preparation, study, and description of vertebrate fossils, gave much attention to the general correlation of American Tertiary and mammalian faunas with those of Europe. In conjunction with Matthew he also studied the American Tertiary faunas with reference to their geologic classification, and he was associated with Fraas in a study of the comparative age of American and European Jurassic vertebrate faunas.

Hyatt has nearly completed a monograph on the Pseudoceratites of the Cretaceous and a monograph on the Endoceratidæ and their allies. He has also prepared a table of formulæ representing the ontogenies of the principal types of ammonoids forming the genetic stock from which Lytoceras was derived.

J.P. Smith continued his work on the Triassic faunas of the Pacific coast.

Matthew was engaged in restudying the Cambrian areas and faunas of Cape Breton.

Hollick studied the later Tertiary floras of New Jersey and Maryland.

Walcott continued the preparation of a monograph on Cambrian brachiopods.

Scott was engaged in the exploration of portions of Patagonia and the collection of vertebrate remains.

Dean completed a memoir describing new types of placoderms and discussing the systematic position of the Mylostoma. He also began a study of the primitive sharks of the American Devonian.

GEOGRAPHIC SCOPE OF WORK IN 1901

The geographic range of the various studies in geology and paleontology was practically coextensive with the continent. In the United States the enumeration made has noted local studies in nearly every state and territory. The tracing of geologic boundaries or the mapping of formations was carried on in at least twenty-eight of these political divisions, or considerably more than half. Stratigraphic studies included the measurement and description of sedimentary series, and usually the collection of fossils pertaining to formations, of every geologic period. Collections of fossils for paleontologic study, and especially for the study of faunas, were made from every rock system from Algonkian to Recent.

How completely the field was occupied in petrography, dynamic geology, and geomorphology is not easy to say, because so large a share of progress on those lines is incidental. Most rock collections and much petrographic description and study are incidental to general geologic work, and the contributions to petrographic science which thus accrue find no place in current notices of work in progress, but only in final publications. Nevertheless, the ideas which make for the development of petrographic science are largely suggested in the course of such accessory and routine work, and, if it were possible to chronicle the year’s progress in petrographic science, the increments made and recorded in connection with structural and areal geology would probably be found no less important than those made by the monographic study of series of rock specimens, and they would certainly have a wider range. The same is true in the whole range of dynamic geology. The students who go to the field or the laboratory for the purpose of solving specific problems as to the processes of terrestrial changes are comparatively few. The great body of workers in what may be called applied geology—the classification of local rock bodies according to existing categories, their description, and their delineation in maps and sections—these men are continually on the alert for phenomena which throw light on the many unexplained factors of geologic process, and it is mainly through their alertness that dynamic geology is advancing.

THE PRESENT

The outline which has been presented shows, approximately, the great variety of the geologic studies that are being prosecuted at the present time. A better conception of the extent and relations of these broadly outlined geologic studies would be afforded if it were practicable, in this connection, to state the problems which are known to geologists of the present day. But it is certain that even the briefest statement of known problems would extend this address far beyond its reasonable limit.

To illustrate: In a paper on the correlation of the Cambrian, published in 1891, was given an outline of the problems affecting our knowledge of the Cambrian series as a whole or in large part, and also many important local problems. It was recognized, however, that many of the local problems not given might, on investigation, be bound to be of equal, if not greater, importance than many that were suggested. This brief outline of the Cambrian problems occupied 11 pages of printed matter. It will be readily seen that to extend such an outline to cover all the known problems of other time divisions would be an impracticable task at this time.

The larger problems of stratigraphy, correlation, oscillations between land and sea, the migrations of faunas, lines of descent, parallel development, etcetera, are all awaiting the student. The extent of the land areas and the variations in character, thickness, and distribution of the marginal and deep-sea deposits are imperfectly known. Structural and dynamic problems of the most far-reaching importance are awaiting solution. If the principle is accepted that the classification and delimitation of the divisions of the Paleozoic, Mesozoic, and Cenozoic eras must rest on the broad biologic characters of their included faunas and floras, and not on local breaks or differences of sedimentation, important problems remain as to where these lines of demarcation shall be drawn in most geologic provinces.

In studying the problems connected with the occurrence of ore deposits, the determination of their continuation in depth is of general interest. The terrestrial chemistry of ore deposits is one of the most important problems and requires investigation in many regions. The geologic conditions under which ores were originally deposited, whether they are all forms of concentration by aqueous solution or in part concentration from eruptive magmas, are subjects for continued study.

The field for research in physical geology is almost boundless, and so little has it been cultivated that the harvest will surely be abundant. Thus far geology has been pursued mainly by biologists, mineralogists, and stratigraphers. A few physicists have, indeed, applied their professional knowledge to the elucidation of the past and present condition of the earth and have reached results of first importance. Physicists, however, rarely have a sufficient acquaintance with geology to become deeply in interested in the subject, while geologists seldom have a firm grasp of physics. A new school of geologists is needed, whose preparatory training should be mathematical and experimental physics, as that of a paleontologist is zoology.

Physical geology begins with the primeval nebula and the genesis of the earth-moon binary system. The causes of the heterogeneity of the earth's density evinced by the distribution of oceans and land masses and of the retardation of the earth's rotation and its effect on the arrangement of continental outlines are yet unknown. The thermodynamic problems of upheaval and subsidence, and the questions of deformation, of compression, of plastic solids and of rupture as affecting mechanics of orogeny, must be established. The effects of changes of climate in geologic time, the causes of glacial epochs, volcanic phenomena, the physics and chemistry of high temperatures, and many other problems of geologic physics have yet to be determined. The solution of these problems must fundamentally affect the science of geology.

In the early stages of American paleontology it was necessary that the fossils should be given names, and at the beginning of the present century we are more or less acquainted with many thousand forms. This great wealth of known forms will be very materially increased by future collections and studies; yet, with this great mass of material to be described, along with a reworking of many known forms, the paleontologist of the next decades will busy himself rather with the broad problems of stratigraphy, correlation, geographic distribution of found fossils, relations of movements of uplift and subsidence, etcetera.

All our text-books refer to the historical formations as if they were so many clean-cut superimposed time elements, but, speaking broadly, this indicates that we do not know the transition faunas. In these problems, and there are nearly as many as there are formations, local investigators will do their best work, since no great collections or libraries are necessary for the working out of local faunas. The fossils need to be collected in abundance, and the material from one zone and locality carefully kept together. The new species need to be carefully described and accurately figured and the type specimens deposited in one of the large central museums of paleontology, since in these centers of research the final sifting takes place. In this connection the large centers of research can cooperate with the local workers by advice, loan of material, and access to collections. In every geologic province a great field awaits the local institution, and no class of fossils can be neglected. One of the great omissions in paleontology has been the general neglect to gather the microscopic fossils like the Ostracoda, small Bryozoa, Foraminifera, and the young of the Brachiopoda and Mollusca.

With the working out of the local faunas the solution of the intricate problems of time correlation will be possible, and we shall also be certain of the duration of species in time. With the species thus limited and restricted, lines of migration will become apparent, and in evolution our phylogenetic classification will have now more certainty on account of the ascertained chronogenesis.

The investigations of the paleontologist have materially increased the subject-matter of the two biologic sciences, zoology and botany, and have anticipated them by many important histologic discoveries. The connection of paleontology with geology is even more intimate. Only by a study of their included faunas can the chronologic succession of clastic rocks be determined in many cases. In the main, paleontology is the ultimate foundation of historical geology.

The problems of structural geology may be said to be comprised in the relations of rock masses, the mechanics of movements involved in bringing the rocks from some original position into those which they now occupy, and the study of the effective forces.

New lines of theory to account for oceanic basins and continental plateaus, for thalassic deeps and mountain rangers, for rock folding, igneous intrusions, and volcanism are opening before the student. From the conception of a heterogeneous earth comes the idea of isostasy, which, in its largest statement, is the theory that heavier masses beneath ocean basins are in balance with lighter masses under continents. The facts of folding are now understood to be of very superficial character considered relatively to the earth’s radius, and any particular anticlinal or synclinal structure may be studied as a simple problem in mechanics involving certain materials, loads, and stresses. The sequence of sediments in any marine basin is the record of changing physical conditions along the shores and on the adjacent land. The development of a shore from youth to age, the growth of coastal plains, and the general topographic phases which passed on the adjacent lands are to be read in the rocks. Through such keys we shall decipher the history of the physical geography of the earth and the succession of mountain growths, and we shall approach the greater problem of continental growth.

Structural studies are now pursued with a better understanding of the mechanics of mountain growth, and through physiography and stratigraphy the history of deformation, past and present, may be made out. The science of structural geology may be said to be in its youth, with a future of great promise before it.

In the interaction between applied geology and pure geologic science lies the charm and the recompense of every-day routine geologic work. For the sake of future generalizations and for the sake of indicating the distribution of formations having economic value, the geologist performs a great deal of routine labor—observing phenomena of familiar kinds, grouping them in well known categories, and making a record for future use, chiefly by others. He describes rock masses, with measurements of thickness, extent, and dip. He sorts rock specimens, giving to the familiar names and describing the characters of the novel. He sorts collections of fossils, recognizing species already known and describing such as are new. In performing these various duties he uses well established methods, and merely applies to new material the known principles of the science. Such work is necessarily monotonous, and the active mind would soon lose interest and its operation become perfunctory were it not for the possibility of discovering new principles. But ever and anon a fact is found for which the science has provided no pigeon-hole—a phenomenon which is not explained by any known principle—and thus a problem is presented which it is the delight of the investigator to attack. Geologic science, or the body of geologic principles, makes applied geology, or geologic art, possible, and reciprocally the practice of geologic art opens the way to progress in geologic science.

THE PRESENT

The preceding portions of the address have served to show the present condition of professional geologic work in the United States; that is, they give some suggestion of the quantity of work and indicate more fully its range in several respects. They show that geology, although affording occupation to a somewhat limited number of persons, is nevertheless a well-established profession—a profession which flourishes in so many places and under such a variety of conditions that it may be assumed to have altogether passed the experimental stage. If its recent history were reviewed in connection with its present status, its development as a profession would be seen to have fully kept pace not only with population but with the general development of culture factors. There is no reason to doubt that this expansion will continue.

The area work and other labors constituting the geologic survey of the country are but begun, and the task would require decades for its completion if no change were made either in the scope of the work or in the size of the working force; and this work is regarded as fundamental not only to scientific generalizations but to the intelligent guidance of economic enterprises. But experience warrants the prediction that the standards of the future will be progressively higher and higher, and that it will become necessary to increase the number of classes of facts to be covered by areal surveys. In the field of pure science there is even less suggestion of approaching completion of the work. Every investigation undertaken to solve some geologic problem, whether it prove successful or not, is sure to develop other problems, and the geologic Alexander will never lack worlds to conquer. This is a law of growth for every science and is merely an expression of the infinite complexity of nature.

It is impossible to forecast the problems of the future. When investigators are questions they respond only with the problems of the present, but the problems of the present were equally unknown to an earlier generation. Suffice it to say that the work to be done in the field of geologic science is no less assured and no less important than the work in applied geology and in economic geology. Geology, as is so well stated by Sollas,* is in its evolutional stage, having passed through the catastrophic and uniformitarian phases of development. In becoming evolutional—

> "Not merely the earth's crust, but the whole of earth-knowledge is the subject of our research. To know all that can be known about our planet, this, and nothing less than this, is its aim and scope. From the morphological side, geology inquires, not only into the existing form and structure of the earth, but also into the series of successive morphological states through which it has passed in a long and changeful development. Our science inquires also into the distribution of the earth in time and space. On the physiological side it studies the movements and activities of our planet; and, not content with all this, it extends its researches into ætiology and endeavors to arrive at a science of causation. In these pursuits geology calls all the other sciences to her aid. In our commonwealth there are no outlanders; if an eminent physicist enters our territory we do not begin at once to prepare for war, because the very fact of his undertaking a geological inquiry of itself confers upon him all the duties and privileges of citizenship. A physicist studying geology is by definition a geologist."

* W.J. Sollas, Evolutional Geology, Nature, v. 62, 1900.

The question whether the geologist of the future can make his profession support him finds its answer equally in the interpretation of the history of the past. The support of the geologist depends on public appreciation of the value of his services. The growth of that appreciation is shown not only by the growing demand for researches in economic geology, but by the increasing willingness of legislatures and men of wealth to endow researches having for their immediate end only the acquisition of knowledge. It is more and more understood by men whose ability puts them in positions of responsibility that material progress depends, in the ultimate analysis, on the growth of knowledge, and from this increasing confidence in the ultimate utility of pure science research is reaping a generous harvest of endowment.

As we look back over the field of geologic work of the last century the retrospect may lead the young geologist to think that the great problems have been largely solved, that the future offers only the routine of areal work and local problems. That was my thought concerning the region east of the Mississippi in 1870, when reading the works of James Hall, the Rogers Brothers, Dana, and others. Once well into active work, however, I found that new and broad problems were opening up in the field I had chosen, the pre-Silurian sedimentary rocks, which I then thought to be limited as compared with those of the later geologic periods. Question after question, both local and continental, has come up for investigation. Most of them are still unsolved, and their study will bring a host of others that will line up before the mind of the student like the aisles of pines in the forests of the Sierras—some small and dwarfed, others strong and attractive, that are nearby, and farther away the less defined but silent mass that awaits his coming. We are only on the threshold of the golden era of geologic development in America.

We older men are still endeavoring to do our part, but in a few years all the work will be turned over to the young men of today. Some persons here will look back from 1950 as we look back to 1850. There has been an advance since we began—20 to 40 years ago—and we have full faith that it will be sustained as generation after generation of geologists carry the grand work forward throughout the twentieth century.

In closing, I wish to say a word about the training of the men who will probably reap the largest results from the great opportunities in geology that will be offered during the century. The practical economic geologist will undoubtedly receive the largest financial returns, but in this field the man with the broadest, most thorough training will win out as competition becomes more and more active. In the more purely scientific lines a broad, general culture should be the groundwork for the special geologic training. A few months of business training will be almost invaluable to any student who aspires to be more than a directed assistant throughout his career. Business method and habit must underlie all successful administration work, whether it be of a small party or of a great survey. It is needless to say that, as in modern business life so in science, character of the highest standard is essential to permanent success. The outlook of the well balanced, well trained student in geology in America is most encouraging—far more so than when I began work with an honored leader, James Hall, a quarter of a century ago.