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Author(s): Marcus Baker

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deposits of coral sand and the remains of other organisms. It is certain that for over 600 feet the reef has been built up in the immediate neighbourhood of growing coral; but apparently the possibility of the boring being situated on a very steep slope of volcanic rock, covered by a talus of coral *débris* from a reef on the summit, is not excluded. The atoll was completely surveyed, and biological collections made both from the land and from the surrounding sea.

GEOGRAPHICAL RESEARCH IN THE UNITED STATES.*

By MARCUS BAKER, U.S. Geological Survey.

It was in April of the present year that the National Geographical Society received from the President of this Section an intimation that a series of brief papers on the present status of geographical knowledge as to and of activity in the United States, touching geographical matters, would prove an acceptable contribution to your programme. When I recall the pleasure experienced at your meeting in Montreal thirteen years ago, and the eagerness with which every man and woman I met from over the sea were seeking and devouring information about America; when I recall the questions asked, the interest, nay, consuming interest, shown in everything relating to this country, then first visited by many of your members, I can well understand that it would have been ungracious not to accept this flattering intimation, and to offer a contribution which it is hoped may prove to be neither disappointing nor unprofitable.

In arranging our programme, a series of the most interesting and important topics was selected, and leading students of those topics invited to prepare papers thereon. The task of tying all these topics together, of showing their interdependence and relations, and sketching the great general outlines of the whole field of geographical work in the United States, devolved most naturally and fittingly upon the President of the Society, Hon. Gardiner G. Hubbard. To this task he addressed himself, and had gathered some material when, about five weeks ago, he found, to my regret and to yours also I fear, that his duties at the Nashville Exposition would prevent both the preparation of this introduction and his attendance here. As one of the Vice-Presidents of the Society, I was summoned to fill this gap. I felt this call to be one of duty; as such I accepted it, but with misgivings, feeling sure that the place, which he so worthily fills, is one that I can only occupy. I therefore crave your sympathetic indulgence for a brief interval, while I sketch in broadest outline the present state of our knowledge of the extent and geographical character of the United States, and the agencies by which such information has been and is being acquired.

The United States, now little more than a century old, comprise an area of 3,600,000 square miles—an area a little greater than that of Canada, and a little less than that of Europe. From easternmost Maine to westernmost Alaska it stretches through 120° of longitude, or about one-third of the Earth's circumference. Thus in midsummer the sun has risen in Eastern Maine twenty minutes before it has set in westernmost Alaska. From southernmost Florida, reaching to the verge

* Paper read before Section E (Geography) at the Toronto meeting of the British Association, August, 1897.

of the torrid zone, it stretches northward to northernmost Alaska, more than 300 miles within the arctic circle; while in altitude it ranges from 200 or more feet below sea-level in the deserts of Southern California to heights of more than 18,000 feet in Alaska.

Beginning with the close of the war for independence 114 years ago, as thirteen distinct and independent states stretching along the Atlantic seaboard from New Hampshire to Georgia, we have first a loose confederation of states which, speedily breaking down, was replaced by the present constitutional union of the people, bound together in forty-five sovereign states and five territories. In 1790 the thirteen states had an area of about 350,000 square miles, and a population of a little less than 4,000,000. A century later its area was nearly eleven times as great, and its population about seventeen times as great, or between 65,000,000 and 70,000,000.

The discovery of what is now the United States began just four centuries ago this very year, when the Bristol merchant, Cabot, the first white man (after the Norsemen) to set foot on the American continent, antedating Columbus by fourteen months, landed on the bleak coast of Labrador, and then cruised southward as far as Virginia. This, like all discoveries, was only a beginning, which pointed the way to and stimulated other discoveries. These are still unfinished, and within the limits of the United States some tracts exist which have never been seen by the white man. Of other tracts, though seen and long vaguely known, our knowledge is still dim and shadowy. For a century after Cabot small advance was made in our knowledge of the continent, formally taken possession of by him in the name of his sovereign lord, King Henry VII. The outline of the Atlantic and Gulf coasts were crudely delineated, but of the Pacific coast north of California our maps, until about 1750, were either blank or filled with fabled lands or monsters. Bering's voyage of 1741 yielded the first definite knowledge of North-Western America; but it was not until nearly forty years later, in 1778, that Cook, the great English navigator, gave to the world the general outlines of Alaska as we now know them. The general features of the coast of western North America obtained by Cook were, some sixteen years later, vastly improved, from Southern California to Kadiak, by another English navigator, the equal if not the superior of Cook, whom every American student delights to honour—Captain George Vancouver.

The period of the war for independence in the last quarter of the last century was one of great geographical activity, and stimulated the production of maps of the revolted colonies. The numerous and excellent, for their time, maps by the English geographer, Thomas Jefferys, may be taken as the best exponent of American geography a hundred years ago. They show fairly well the Atlantic coast-line from the maritime provinces of Canada to Georgia, and so much of the interior as was the scene of hostilities; but west of the Appalachian mountain chain the delineation was conjectural. The existence of the Great Lakes, of the mighty Mississippi, and of the fertile valley drained by it, were barely known. Such was the world's geographical knowledge of what is now the United States when those states united in 1789. The knowledge subsequently acquired is the work of the United States.

THE GENERAL LAND OFFICE.—One of the earliest agencies by which geographical knowledge was increased was the General Land Office. The general government found itself, in 1783, possessed of a region called the North-West Territory, lying beyond the mountains. Into this region settlers came about the beginning of the century. That they might acquire title to lands for their homes, the government early devised a system of land partition. Surveyors were sent into the wilderness to subdivide the land for purposes of record and sale or gift. The land

was divided into square tracts 6 miles on each side, called towns or townships, and their corners marked, sometimes by axe-marks on trees, called *blazes*, and sometimes by artificial marks. A row of such towns running north and south is called a range, and numbered east and west from some arbitrary meridian. Similarly, a row of towns running east and west is called a town, and is numbered north and south from an arbitrary base-line. Each town was further subdivided into thirty-six squares, each containing 1 square mile, or 640 acres, called a section. The sections are similarly numbered from 1 to 36 in every town. Each corner of each section was marked by the surveyors, who were thus required actually to chain over every mile, to keep a record of their measures, to note all streams and lakes, and the character of soil and timber; to note the magnetic declination, and to submit to the General Land Office a skeleton map of each town subdivided, together with their field notes. These maps, called town plats, now constitute a vast body of original records in the General Land Office at Washington, and are the sole dependence of map-makers for hundreds of thousands of square miles of our territory. Every state and territory in the Union, except the original thirteen—Maine, Vermont, Kentucky, Tennessee, Texas, and Alaska—has been thus, in whole or in part, surveyed and subdivided. This work, now far advanced toward completion, has always been under the control of the General Land Office, now a part of the Department of the Interior. For geographical purposes, the results are shown in a series of state maps and a general map of the United States. The work was, for about a century, done by contract, but within the past two or three years a part has been done by the United States Geological Survey in connection with its topographical surveys.

Thus indirectly the General Land Office has, for a century, been, and still continues to be, one of the important geographical agencies of the United States.

COAST AND GEODETIC SURVEY.—Another old and important geographical agency is the Coast and Geodetic Survey, under the Treasury Department. The primary purpose of this bureau is to accurately chart the coast for purposes of commerce and defence. Its field of work is tidewater, with a fringe of topography landwards, and a somewhat extensive border of sea-bottom seawards. Created in 1807, it made little progress till 1832. In that year it was revived, and has continued uninterruptedly until the present day. Of the details of the accurate results secured by this organization, it is not my province to speak. From the beginning its ideals were high. Great accuracy has ever been and is its motto. It has been a leader, and not a follower. It has developed its own methods and instruments, and to its officers—civil, military, and naval—we are indebted, among other things, for the zenith telescope for the most accurate determination of latitudes; for the application of the telegraph to longitude determinations; for the invention, construction, and use of a machine for predicting tides, and for great improvements in apparatus for measuring the force of gravity. The polyconic projection, now so extensively used, was developed and applied by officers of this bureau, as also were appliances for deep-sea sounding and the study of the ocean depths. Its field of work was extended in 1871 to include geodetic work in the interior, and in 1876 it received the name of Coast and Geodetic Survey, by which it is officially designated, though often referred to as the Coast Survey. It is one of the active geographical agencies of the United States, and is not only making charts, coast pilots, and tide tables, but is contributing to our knowledge of ocean physics, terrestrial magnetism, and of the size, shape, and structure of our planet.

ENGINEER CORPS, U.S.A.—The United States Engineers, though not now actively prosecuting geographical research, have in the past made notable contributions to geography. Prior to, and even since, the war of the rebellion, 1861–1865,

numerous expeditions in the far west were made by army officers, and each of these added something to our geographical knowledge. Aside from these various military reconnaissances, two noteworthy surveys have been carried on in the past by the United States Engineers. One was a survey of the northern and north-western lakes, which, after an existence of forty years, was concluded in 1881. It made a series of detailed and accurate charts of all the Great Lakes, and a valuable collection of data. Its series of lake-levels has very recently been put to use in determining certain secular changes in the crust of the Earth, forming the great basin in which those lakes lie. If the slow tilting of this basin southward, which these levels show when compared with recent ones, continues for a period of about 6000 years, then it is calculated that Niagara will have vanished, and all the lakes except Ontario will drain to the Mississippi by way of the Chicago outlet. These highly interesting and somewhat startling conclusions have just been presented at the Detroit meeting of the American A.A.S., by Mr. G. K. Gilbert, of the United States Geological Survey.

Another noteworthy geographical work by the United States Engineers was a general map-making survey in the far west, under the direction of Captain M. Wheeler, U.S.E., and usually referred to as the Wheeler Survey. A considerable tract of the country was mapped by it on a scale of 8 miles to 1 inch. This survey, with two others, the so-called Hayden and Powell Surveys, were merged in the present Geological Survey in 1879.

The work of improving rivers and harbours in the interest of commerce is now carried on by the United States Engineers, and their geographical work consists in special surveys for these improvements, and of a new survey of the Great Lakes.

GEOLOGICAL SURVEY.—The chief agency for increasing geographical knowledge of the United States at the present time is the United States Geological Survey, now eighteen years old. Nearly or quite one-half of its energies and funds are expended in the production of topographical maps, and thus it is in fact, though not in name, the United States Topographical and Geological Survey. The conditions confronting this survey at its creation differed in one important particular from those similarly confronting European geological surveys. Those surveys had, in almost if not quite every case, been preceded by topographical surveys, and the geologists found maps, adequate to their needs, ready made. But in the United States topographical maps were not available, as there had been no topographical survey. Thus progress in geological mapping was impeded at the outset by the lack of suitable maps. Accordingly, in 1882 authority was given to make topographical maps, and since then about one-half of the energies of the survey have been given to their production. Since 1882 the survey has surveyed and mapped, on scales of 1, 2, and 4 miles to the inch, an area of 760,000 square miles, about equal to the combined area of Great Britain, France, Germany, Spain, and Portugal. The results are contained in 980 atlas sheets, 460 on the 1-mile scale, 460 on the 2-mile scale, and 60 on the 4-mile scale. These surveys have been made in nearly every state and territory. Following these came the geological surveys. But before much progress was possible, a large amount of preliminary investigation was needful to determine the great features whose details were to be wrought out and mapped. A system of rock classification uniformly applicable to so great and complex an area as the United States, required much careful preliminary work. That has been accomplished, and systematic geological mapping has been in progress for some years.

The aspect of the country and its utility for man's use is largely dependent on the annual rainfall. This ranges from a very few inches in the driest part of the arid or desert regions of the south-west, to nearly or quite 8 feet per year on the

coast of Southern Alaska. As the humid regions were settled up, population gradually pushed into the semi-arid and desert regions of the far west, where agriculture without artificial irrigation is impossible, but *with* irrigation marvellously successful. Thus came a demand for knowledge as to water-supply, and to this work one division of the Geological Survey is wholly devoted.

Intimately associated with water-supply is the forestry problem. The proper administration of the forests—their preservation from destruction by carelessness or greed—is a question now attracting serious attention. A number of large forest tracts in the west have been recently set apart as reservations, and these, with the Yellowstone National Park, the Yosemite, and others previously reserved, comprise a total area estimated at 38,880,000 acres, or more than 60,000 square miles. In the budget for this year the Congress has included an item of \$150,000 (£30,000) for the survey of these forest reserves. This work is under the direction of the United States Geological Survey.

The output of the mines and quarries of the United States has grown in value from \$369,000,000 (£74,000,000) in 1880 to \$622,000,000 (£124,000,000) in 1896. That authentic information on this subject might be promptly available, a Division of Mineral Statistics has existed in the Geological Survey from the beginning, charged with the duty of gathering and publishing statistics. This it does in an annual volume, and the state of the mining industry from year to year finds permanent record in these volumes.

NAVY DEPARTMENT.—The Hydrographic Office of the Bureau of Navigation has for a primary aim the securing and publication of information useful to those who go down to the sea in ships. This includes surveys and chart-making of all coasts (except those of the United States), ocean meteorology, terrestrial magnetism, and ocean physics. The charting of the coasts of the United States is done exclusively by the Coast Survey, which has nearly completed the Atlantic and Gulf coasts, and about three-fifths of the Pacific coast, except Alaska, of which only a small part is as yet surveyed. Of foreign coasts, the Hydrographic Office has recently surveyed and charted the western coast of the peninsula of Lower California, one of the Mexican states, about 1000 miles in extent. It has extended our knowledge of the sea abysses by various lines of soundings in the interest of projected cable lines; it lessens the perils of ocean travel by the monthly issue of pilot charts of the North Pacific and North Atlantic oceans, containing information as to derelicts, ice-fields, storm-tracts, and other information useful to the mariner. The systematic and constant collection of data for these pilot charts results in a constant increase in our knowledge of the geography of the sea.

WEATHER BUREAU.—To investigate the history, structure, and contents of the Earth is the peculiar province of the Geological Survey; to study the currents, movements, and characteristics of the Earth's salt water envelope is the province of the Coast Survey and Hydrographic Office; to investigate the character, amount, habits, and migrations of its contained life is the province of the Fish Commission. The study of the all-enveloping gaseous ocean in which we live and move, that invisible sea of air with its ever-varying moods of restful calm and fierce storm, now delightfully transparent, and now sombre or menacing with storm-cloud, sometimes scorching and sometimes freezing; the study of this gaseous envelope, of the laws which govern its behaviour, and the daily deductions from these laws foretelling to the sailor, the farmer, the traveller, what he may expect, is the peculiar province of the Weather Bureau. May we not properly call this field of study the geography of the air? And has it not ever formed a large chapter in our physical geographies?

The weather service in the United States is twenty-seven years old, dating from

1870. At first it was a military organization called the Signal Service, and its purpose was to give "notice on the northern lakes and on the sea-coast, by magnetic telegraph and marine signals, of the approach and force of storms." Its primary object was, therefore, not the study of climate, but the prediction of storms. It seeks to tell the weather of to-morrow rather than that of the last year or the last century. But as we are forced to judge the future by the past, the study of meteorological records is not neglected, and within the bureau there has ever been a corps of scientific experts at work upon such lines as gave promise of producing something new or useful for the forecaster.

The bureau is now a civilian one, having been transferred from the War Department to the Department of Agriculture. Its present field of activity is far wider than I have indicated—so wide, indeed, that time will not permit even a mention of details.

I ought to at least mention a few more of the agencies still at work and actively contributing to a fuller and better knowledge of our geography.

The total railroad mileage of the United States, not counting second or third tracks or sidings, is, in round numbers, 180,000 miles, or about forty-five per cent. of the world's mileage. To locate and construct these thousands of miles of road, much of it running through districts little or quite unknown when preliminary surveys began, has involved vast expenditures of money, by which geographical knowledge has been increased. It has been estimated, perhaps I ought to say guessed, that the sums expended on these railroad surveys is enough to have produced a topographical map of the entire country. The chief geographical contribution from these surveys is a knowledge of altitudes. Over all these railroad lines of level have been run, and by collecting and platting those levels and adding to them those obtained from other sources, it has been possible for the Geological Survey to produce a fairly approximate contour-map of the United States.

The Mississippi river, with its tributaries in the great central valley of the United States, drains an area of about 1,200,000 square miles, or about one-third of the United States. From the sources of the Missouri to the passes at the mouth of the Mississippi, in the Gulf of Mexico, is 4200 miles. These two great rivers, with their affluents, afford thousands of miles of navigable water through the great central valley. So important is this artery of commerce that two distinct commissions, one for the Mississippi and one for the Missouri, have existed for some years, for the purpose of surveying, mapping, studying, and improving them. Detailed maps of the rivers and a fringe of topography on either side have been made over a considerable portion of the navigable parts of these rivers, and the results are shown on 240 atlas sheets. Much precise levelling has also been carried on in connection with these surveys.

Independent of the Federal Government, various states to the number of twenty or more, particularly those known to possess mineral wealth, have conducted geological surveys, or perhaps I should say geological reconnaissances. Two have conducted topographical surveys, and four have co-operated with the general government in making topographical surveys. These four, Massachusetts, Rhode island, Connecticut, and New Jersey, as also the district of Columbia, are now completely mapped on a scale of one mile to the inch, and in contours with a vertical interval of 20 feet.

The Post-office Department, for its own purposes in administering the seventy thousand post-offices under its control, compiles state maps, showing post routes and political divisions. The boundary-lines shown on these maps are compiled from the laws and by correspondence, and constitute an authentic source of information as to minor boundaries.

I have alluded to the work of the Fish Commission in studying the character, habits, and migrations of marine life, and by its side should be mentioned the similar work on land carried on by the Biological Survey in the Department of Agriculture.

Of the great advances in geographical knowledge resulting from the exploration of Lewis and Clarke, near the beginning of the century, from the work of Fremont, the pathfinder, from the Pacific railroad surveys of fifty years ago, and from numerous military expeditions, time fails me for more than a bare mention.

Thus I have passed in rapid review the greater geographical agencies of the United States. Some of these will be presented to you more at large by the gentlemen actually conducting the works outlined. As to the future, it will easily appear that the amount already achieved is but a small part of what remains to be done. Geographical research and progress in the United States has never been more active or swifter than it is to-day, and knowledge of environment and resources is gathered in large instalments each year. To discover and develop its resources, the United States is now employing about five thousand persons, and expending nearly \$8,000,000 annually. Just as the Royal Geographical Society of London sixty-seven years ago began its work of fostering and promoting geographical research, so the National Geographical Society of Washington nine years ago entered upon similar work. Great and lasting good has resulted from each undertaking. May their efforts continue until dark continents and unexplored regions shall have vanished from our maps!

THE INDIAN SURVEY REPORT FOR 1895-96.

THE Indian Survey Report, which usually arrives in England in April or May, has been considerably delayed this year, and has only recently come to hand. This appears to be due to the fact that the operations reviewed therein extend up to September 30, 1896, instead of March 31, 1896, as would have been the case had the old practice been adhered to of assimilating the survey year to the financial year. We are not told the reason of the change, but it may be assumed that it fits in more conveniently with the plan of operations and rotation of work in the field, which naturally opens with the commencement of the cold season, and which thus forms a better starting-point for an annual review of work. Colonel C. Strahan, R.E., was surveyor-general during the year, assisted by Colonels W. H. Wilkins and J. E. Sandeman, in charge of the Revenue and Bengal Survey branches, and Lieut.-Colonel St. G. C. Gore, R.E., in superintendence of the Trigonometrical Surveys. Principal triangulation was executed during the year, both in Upper Burmah and in Baluchistan. In the former, the series which will connect the Mandalay Meridional series with the Assam triangulation was carried across the flat forest-clad valley of Chindwin, but, owing to the haze and the difficult nature of the country, it was found impracticable to complete the connection. In Baluchistan a beginning was made with the principal longitudinal series, which, starting from the Great Indus series of the main triangulation of India, is to be pushed westwards through Baluchistan and Makran, and will thus form an accurate basis for the mass of secondary triangles and detailed reconnaissances which have from time to time been carried out in the regions immediately west of India. This fabric of triangulation will undoubtedly be extended in process of time, so as to link up the trigonometrical systems of Europe and Asia. During 1895-96 three figures,