ART. XXX.—Progress of the Geological Survey of California.

PROFESSOR WHITNEY, having recently returned from California, is now engaged in superintending the publication of a portion of the materials collected by the Geological Survey of California. He communicates the following statement in regard to the present condition and probable future of the Survey:—

Those interested in the California Survey will already have learned something of its progress from the brief reports, or letters to the Governor of that State, which have appeared from time to time, during the past three years, and of which extracts or notices, more or less complete, have appeared in this Journal. (See Journal for July, 1863, and May, 1864.)

No serious opposition has been made to the continuance of the Survey, during any of the Legislative sessions, except on the score of economy, an argument which was urged with more reason than usual before the last Legislature; since, owing to a variety of causes, which it is not necessary here to specify, the finances of the State, for the past three or four years, have been in a deplorable condition. The vast extent of area to be explored, the variety of subjects claiming attention, and the necessarily heavy expense of travelling everywhere on the Pacific slope, make it impossible to carry on this work with anything like satisfaction, even with appropriations which would be deemed ample on the Atlantic side

of the continent. The heavy and entirely unprecedented rains of the winter of 1861-2, and the equally unprecedented drought which has prevailed since that time, have been great obstacles to the progress of the field-work, partly by impeding communication, and partly by increasing the price of provisions and forage, so that the field-expenses have been double or triple what they would have been in ordinary seasons.¹

The sessions of the Legislature being, under the new Constitution of the State, which has come in force, biennial, at the last session an appropriation was made for the two fiscal years commencing July 1st, 1864. The sum appropriated for the continuance of the Survey for two years was \$31,600;² of which, however, \$6000 was to be set apart for the publication of two volumes of the Report, making, with \$3000 previously appropriated for that purpose, \$9000 available for printing and engraving—or, rather, which will be available when the money is received from the Treasury.

The old law organizing the Survey having expired by constitutional limitation, a new one was passed, somewhat modifying the details of the work, and especially in regard to the method of publication. The Act, the essential portion of it at least, is worded as follows: "It shall be his (the State Geologist's) duty, with the aid of such assistants as he may appoint, to complete the geological survey of the State, and to prepare a report of said survey for publication. Such Report shall be in the form of a geological, botanical, and zoological history of the State," &c.

In accordance with the Act now in force, it is presumed that the Survey will be continued for four years longer; and it is the intention of the State Geologist to close it up within that time, at least the active field-work, if spared to continue it so long.

The appropriation being so small, for the next two years the work will necessarily be continued on a rather small scale; but it is thought that, if the State returns to its normal condition of prosperity, the extreme disturbing influences of the past three years passing away, a liberal appropriation will be made by the next Legislature for closing up the work and for the publication of its results.

Following the provisions of the present Act, each volume of the Reports now and hereafter to be published will form a part of the Final Report, which it is believed will comprise about ten large royal-octavo volumes.

The first volume to be issued will comprise the first installment of the Paleontology of the State. It will be illustrated by 32 crowded plates on steel and stone, which have been for some time in the hands of the engravers, and of which the accompanying text is now passing rapidly through the press.³

¹ Professor Brewer, now in charge of a party exploring in the central portion of the Sierra Nevada, in a letter recently received, describes the journey from San Francisco to Visalia, through Pacheco's Pass, and across the plain of the San Joaquin, as one of great hardship, owing to the extreme difficulty of procuring water or forage along the whole route.

² It will be observed that *gold* is the only circulating medium in California.

³ As the engraving of the plates will still require some time, the letter-press, which will soon be completed, will be issued by itself, in a limited number of copies, to which the plates will be added on their appearance.

This volume includes the Carboniferous, Triassic, Jurassic and Cretaceous fossils; the Carboniferous and Jurassic by Mr. Meek, the Triassic and Cretaceous by Mr. Gabb. Of the Cretaceous fossils 249 new species are described, from a formation not distinctly recognized in California previous to the commencement of this survey; but now known to extend through the State from one end to the other, and indeed from Mexico to British Columbia, and to be in many localities rich in well-preserved fossils.

The second volume of the Paleontology of California will be devoted to the Tertiary formation, and to such additions to what had already been done in the lower formations as may have been accumulated during the continuance of the Survey.

Immediately after the appearance of the first volume above-mentioned, a second will be put to press, which will be devoted to the General Geology of California. This volume, it is hoped, may be issued early in the next year. In a third volume, which will follow soon after the appearance of the second, it is proposed, although not definitely determined, to make a beginning with the Zoological history of the State.

A party is now in the field, in charge of Professor Brewer, engaged in exploring the region of the high Sierra Nevada, south of the Mono Pass and the region examined last year: a portion of the State which is almost entirely unexplored, and of which we know only that it contains some of the loftiest and most extensive mountain-groups of the Sierra.

Some of the principal results of the Survey, up to the present time, may be thus briefly summed up:

1. *Topography*.—For a sketch of what had been done in this department up to the beginning of the season for field-work in 1863, see this Journal, vol. xxxvi, p. 119. During that season a reconnaissance was made in the High Sierra, from the region adjacent to the Mono trail (which trail leads from Big Oak Flat or Coulterville, along the edge of the Yosemite valley, to Aurora, a little south of the 38th parallel of latitude) to the northern line of the State. Nearly all the high points of the Sierra Nevada, on this line of reconnaissance, were ascended and measured barometrically. The highest portion of the Sierra Nevada is that near the head-waters of the Tuolumne river, west and southwest of Mono Lake. The culminating peak of the Sierra, the highest point in the State, with the exception of Mt. Shasta, we found to be just north of the Mono trail, eight miles southwest of Mono Lake; it is 13,200 feet high, and, being one of the numerous unnamed peaks of the Sierra, was called by us Mount Dana, in honor of Professor J. D. Dana. The next point in height to this—the centre of a magnificent group of snow-covered peaks—we named Mount Lyell: it is about 15 miles, a little west of south, from Mt. Dana, and about 100 feet lower than that elevation. The scenery of this portion of the Sierra is truly Alpine, and can hardly be surpassed in grandeur.

One of the most interesting facts observed here, for the first time in the Sierra, was the proof everywhere surrounding us of the former existence of glaciers, on an immense scale of magnitude. All the phenomena of former glacier action are exhibited to the greatest advantage in the upper Tuolumne valley, through which once flowed a mass of ice nearly 1000

feet in thickness. Thousands of acres of granite retain the most exquisite glacial polish, and the existence of lateral, medial, and terminal moraines is as easily observed as in the Alps at the present day.

These traces of extinct glacier action were afterward discovered by us in many other places to the north of this, through to Mt. Shasta.

The work of laying down the topography will be continued during the present season by Mr. Hoffman in the region south of the Mono trail, and by Mr. Wackenreuder in that north from Silver Mountain to the Henness pass. Thus our observations, when combined, will enable us to give the first approach to a tolerably accurate map of this great chain of mountains. It is uncertain, as yet, how and in what form our topographical work will be laid before the public, except that the publication of the maps of the vicinity of the Bay of San Francisco and of the Monte Diablo region has been determined on, and they will be soon placed in the engravers' hands. It is believed, however, that such arrangements will be made as shall ensure the publication of a map of the entire State, greatly improved on anything which has yet appeared, and as large as can be conveniently used for a wall-map—say, on a scale of twelve miles to the inch. A map of the central portion of the State, on a scale of about six miles to the inch, embracing the principal mining regions, and covering the area occupied by at least four-fifths of the population of the State, will also probably form a part of the materials prepared for publication by the Survey.

2. *Physical Geography.*—Observations in this department have been steadily carried on during the progress of the Survey, and one of the volumes of the Report will be devoted to this department of our work. Allusion may be made here to the very important investigations which have been carried on in California, for some years past, by Major R. S. Williamson, U. S. Engineers, on the laws governing the fluctuations of the barometer on the Pacific coast. These investigations, for which small amounts have been appropriated by the Topographical Bureau, and which have been prosecuted by Major Williamson with the greatest zeal, will, when their results are published, be of material aid to the Geological Survey, and we shall be able to use them in the final working up of our own very numerous hypsometrical observations. The data collected in the course of these investigations have been employed by Major Williamson in working up the observations taken by the U. S. and California Boundary Commission in 1861, in and near Death's Valley, enabling him to fully confirm and give a scientific basis to the idea previously vaguely entertained, that this remarkable valley, which is 180 miles from the Pacific and which may be compared to that of the Dead Sea of Palestine, is indeed considerably depressed below the level of the ocean.

3. *Geology.*—Up to the present time, and including this season of field-work, we may be said to have been chiefly engaged in making a general geological reconnaissance of the State, and we have travelled very extensively over it, in all directions. But considerable areas remain, for various reasons, yet unexplored. The northwestern counties have remained inaccessible on account of Indian troubles; and portions of the southeastern for the same reason—with the additional one, that the drought has seriously interfered, for the last two years, with operations in that quarter.

In addition to work carried on within the boundaries of California, we have considerably extended the area of our field of labor by observations made in the adjacent territories, and not considered, or paid for, by the State as part of the regular work of the Survey. Mr. Gabb was employed by me, in the autumn of last year, to make a reconnoissance in Oregon and Washington Territory, and also on Vancouver Island, where he made important additions to the little previously known of the geology of that region. He has now joined an exploring party through south-eastern Oregon, emphatically a geological *terra incognita*, and from which region he can hardly fail to bring back geological facts of importance. The expedition was to start from Fort Klamath, on the north end of Klamath Lake, about the 15th of June. Mr. Clarence King made, during the early part of the present season, some important explorations in the Humboldt range, and the ranges east of that, in Nevada Territory. Mr. Rémond has been for some time in Sonora, Mexico, and has made interesting discoveries, which will enable us to prove the continuance of the geological formations of California far to the south, and which connect with our line of observation, so as to form a chain—broken at many points, it is true—of about 2000 miles in length. It may here be added, as an important item in the development of the geological structure of the western side of the continent, although not connected with the Geological Survey of California, that Baron Richthofen, the eminent geologist formerly attached to the Reichsanstalt, or Austrian Geological Survey, has been for some time engaged in investigating the geology of the Pacific coast, and that he is specially devoting himself to the study of the Washoe region; those who have consulted this gentleman's publications on the districts examined by him in the Alps, especially in Tyrol, and also in Hungary, will not need to be told that whatever he may give to the world in regard to this, in many respects, strikingly similar region of Nevada Territory, will be of the greatest interest.

On the whole, it may be said that the labors of the past three, and of the coming four, years can hardly fail to furnish us with the means of giving a tolerable approximation to a geological map of the Pacific coast of our continent, and one, it may be added, which will have little resemblance to those which have heretofore been published. For anything like a detailed knowledge of the whole of this vast, mountainous, and extremely difficult region, we shall have to wait many years.

In alluding to a few of the results of the Geological Survey in this department, it will be necessary to be extremely brief; for, even if this were a suitable place for it, details would hardly be intelligible without maps and sections.

Perhaps the most striking result of the Survey is the proof we have obtained of the immense development, on the Pacific side of our continent, of rocks equivalent in age to the Upper Trias of the Alps, and paleontologically closely allied to the limestones of Hallstadt and Aussee, and the St. Cassian beds, that extremely important and highly fossiliferous division of the Alpine Trias.

This great Triassic belt of the Pacific coast has been most fully explored by the Survey in the latitude of 40°, and over a width east and west of nearly four degrees of longitude (117° to 121°). It is from this

region that the largest portion of the fossils have been obtained, both from the three parallel ranges in long. 117° to 118° , called the Humboldt ranges, and from localities in Plumas county, California. But sufficient paleontological evidence has been obtained to enable us to state that this formation extends from Mexico to British Columbia, occupying a vast area, although much broken up, interrupted, and covered by volcanic and eruptive rocks, and usually highly metamorphosed.

Among the specimens from the Humboldt and Plumas county, Mr. Gabb recognizes at least four species as identical with European, while the whole facies of the collection is most strikingly like that of the Hallstadt beds—the same intermixture of orthoceratites, ceratites, goniatites, nautili and ammonites, the latter frequently of those peculiar globose forms occurring in the Alps, together with *Halobia*, *Monotis*, *Avicula*, *Pecten*, &c., a *Monotis* being the most widely diffused and the most abundant of all.

Accompanying this Triassic formation in the Sierra Nevada, and probably also in the Humboldt ranges, is an extensive development of Jurassic rocks, usually highly metamorphosed and extremely barren of fossils. Enough, however, have been found to justify the assertion that the sedimentary portion of the great metalliferous belt of the Pacific coast of North America is chiefly made up of rocks of Jurassic and Triassic age, with a comparatively small development of Carboniferous limestone, and that these two formations are so folded together, broken up, and metamorphosed in the great chain of the Sierra Nevada, that it will be an immense labor, if indeed possible at all, to unravel its detailed structure. While we are fully justified in saying that *a large portion of the auriferous rocks of California consist of metamorphic Triassic and Jurassic strata*, we have not a particle of evidence to uphold the theory that has been so often maintained, that all, or even a portion, of the auriferous slates are older than the Carboniferous; not a trace of a Devonian or Silurian fossil even having been discovered in California, or indeed anywhere to the west of the 116th meridian. On the other hand, we are able to state, referring to the theory of the occurrence of gold being chiefly limited to Silurian rocks, that this metal occurs in no inconsiderable quantity in metamorphic rocks belonging as high up in the series as the Cretaceous.

Allusion has already been made to the wide-spread occurrence in California of the Cretaceous formation. The coast-ranges of California and Oregon, indeed, are to a large extent made up of rocks of this age, usually more or less metamorphic in their condition, and frequently highly so; but still, on the whole, forming the richest fossiliferous formation of the State, having already yielded fossils at over thirty localities. According to Mr. Gabb, it appears that the formation, so far as is yet known, is represented on the Pacific coast by but a single member—the upper, or white chalk; and that it may be divided into two well-marked groups, the lower of which corresponds to the No. 4 of Meek and Hayden, or the Fort Pierre group. This division (Div. A of the California Report) has yielded 152 species in California, out of about 260 collected, and of these only about half a dozen are common to this and the upper division (Div. B). This latter should probably, judging from its stratigraphical position, correspond with the Fox Hill group, or No. 5 of Meek and Hayden;

although all the species, with a single doubtful exception, are peculiar to California, and that species is referred to one described from No. 4 in New Jersey and Tennessee.

Rocks of Tertiary age are extensively developed in the coast ranges, although not so much so as the Cretaceous, the greatest development of the former being in latitude about 34° and 35° . Although fossiliferous in many localities, the Tertiary beds do not usually retain their organic remains in as good a state of preservation as the Cretaceous, and there is a much greater variety of distinct groups of species. The paleontology of the Tertiary rocks has not yet been thoroughly worked out, but it will be taken up by Mr. Gabb during the coming winter. It will probably require a long period of time before the Tertiary of the Pacific coast will be wholly elaborated, and the exact equivalency of its divisions with those of the Eastern Tertiary be made out.

In regard to the relative ages of the different mountain-chains of the Pacific coast, a few words may be added, premising that this subject will be as fully discussed as our materials will admit, in the Report.

There can be no doubt that the chain of the Sierra Nevada is older than the Rocky Mountain chain, or that group of chains or ranges which forms the eastern border of the great mountain region of the western side of the continent. The great mass of the Sierra was uplifted and metamorphosed after the termination of the Jurassic epoch, and prior to the deposition of the Cretaceous, for we find the last-named formation resting horizontally and unaltered on the flanks of the Sierra, all through Central California. The same statement is probably true with regard to the ranges east of the main crest of the Sierra Nevada, as far at least as the 116th meridian. But, although we have good reason to believe that these last-mentioned ranges were uplifted and metamorphosed after the close of the Jurassic period, we have not positive evidence that this took place prior to the Cretaceous epoch. Still, combining all we know of the geology of New Mexico and Nevada Territory, there appears to be little doubt that the system of the Sierra Nevada extends over a considerable area, east and west, embracing a number of nearly parallel ranges of mountains, some of which, indeed, are little inferior in extent and elevation to the Sierra Nevada proper.

We have recognized at least three distinct periods of upheaval and metamorphic action in the coast-ranges. The main one was at the close of the Cretaceous epoch; the next in importance was after the deposition of the Miocene tertiary—or, at least, of a group of strata which, for the present, may be referred to that age. The next in age is a system of east and west upheavals, which took place at the close of the Miocene; and the third is one which appears to have commenced during the later Pliocene, and to be still going on.

It is a very interesting fact, that the exterior of the coast-ranges—that is to say, the mountains nearest the Pacific—are of earlier date, or older geologically, than the interior ones, or those which border the Sacramento and San Joaquin valleys. This is a repetition on a smaller scale of what has been the course of events in the formation of the whole continent, the exterior lines having been first marked out, and the interior filled up afterwards.

The vast Tertiary formations on the flanks of the Sierra Nevada, so important as being the locality of the hydraulic mining operations, are not of marine origin, as has been so often asserted. The history of these deposits, their position, age, and other characters, are exceedingly interesting; but it is impossible, in this connection, to do more than hint at some of their main features.

There is perhaps no subject connected with the geology of the Pacific coast, in regard to which there are so many misapprehensions, as there are in what has been published by geologists on the nature and distribution of the detrital deposits which are so extensively worked by the methods known as hydraulic and tunnel mining. It has been assumed that these deposits are of marine origin, and that they originally extended over the whole western slope of the Sierra Nevada, a condition of things which, were it true, it would be of vast importance for California to know; but the real facts of the case are entirely different.

In the first place, these deposits are not of marine origin, as is proved by the fact that, although frequently found to contain impressions of leaves, masses of wood and imperfect coal, and even whole buried forests, as well as the remains of land animals, and occasionally those of fresh water, not a trace of any marine production has ever been found in them.

Again, these detrital deposits are not distributed over the flanks of the Sierra in any such way as they would have been if they were the result of the action of the sea. On the contrary, there is every reason to believe that they consist of materials which have been brought down from the mountain-heights above and deposited in preëxisting valleys: sometimes in very narrow accumulations, simple beds of ancient rivers, and at other times in wide lake-like expansions of former water-courses; and this under the action of causes similar to those now existing, but probably of considerably greater intensity. This deposition of detritus, for the most part auriferous, took place during the later Pliocene epoch, and not as late as the drift or diluvial period, as is abundantly proved by the character of the remains of plants and land animals which are imbedded in it.

The deposition of this auriferous detritus was succeeded, throughout the whole extent of the Sierra Nevada, by a tremendous outbreak of volcanic energy, during which the auriferous gravel was covered by heavy accumulations of volcanic sediments, ashes, pumice, and the like, finally winding up by a general outpouring of lava, which naturally flowed from the summits of the Sierra through the valleys, into the lake-like expansions, filling them up and covering over the auriferous gravels, which were to remain for ages, as it were, in a hidden treasure chamber, concealed under hundreds of feet in thickness of an almost indestructible material.

The effect of the denudation which has taken place since these streams of lava flowed down the mountains, has been most extraordinary. For now, these deposits of gravel and overlying volcanic materials, instead of occupying the depressions of the surface, are found forming high plateaux between the present river cañons and flat-topped ridges, known as "Table mountains," hundreds, or even thousands, of feet above the present river beds. Thus the topography of the country is exactly the reverse of what

it was at the commencement of the present geological epoch : what were once valleys are now ridges, and the ridges of former times were where the immense cañons of the rivers flowing down the western slope of the Sierra now are. The proof of this assertion, and the interesting bearing it has on the tunnel and hydraulic mining interests of California, will be fully set forth in the Reports of the Survey.

The Mammalian remains found in the tunnel and placer diggings of California seem to belong to two distinct epochs. The oldest represents the Pliocene, the other the Post-tertiary. The former are found under the volcanic beds, the latter in deposits which have been formed since the period of greatest volcanic activity, and which apparently belong to the epoch of Man. For it appears that the facts collected by this Survey, when fully laid before the public, will justify the assertion *that the mastodon and elephant, whose remains are so widely and abundantly scattered through California, have been contemporaneous with Man in that region.*

The above are a few of the more interesting facts developed by the Geological Survey of California, and of which the full details will be laid before the scientific public with as little delay as possible.

4. *Metallurgy and Mining.*—Particular attention will be paid to these departments of the Survey during its continuance, and no pains will be spared to throw all possible light on the mode of occurrence of the valuable metals and ores, the method of working them, and the processes now in use on the Pacific coast. It is estimated that two volumes will be required for this division of the Report.

5. *Botany.*—It is believed that the progress in this department, under Prof. Brewer's direction, has been sufficient to warrant the assertion that a "Manual of the Botany of California" will form a portion of the work of the Survey. The large collections of plants already made have been distributed to different high authorities in each department, and Prof. Brewer expects to return to the East in a short time, to commence the preparation of such a work as, it is believed, will be a most important help to the study of the botany of the Pacific coast.

6. *Zoology.*—The working up of the zoological collections of the Survey is now in progress under Dr. Cooper's direction. It has not yet been decided how many volumes will be required for their full description and illustration.

The publication of so large a mass of materials will necessarily occupy several years, and it will of course depend on the action of future Legislatures how fully and how rapidly our results are laid before the public in a printed form. Three volumes are already provided for, and, as has been already stated, they will be sold at a moderate price, and the proceeds, as required by law, paid over to the common school fund of the State.

J. D. WHITNEY.

Northampton, Mass., Aug. 1, 1864.