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REPORT OF CAPT. C. E. DUTTON.

DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
DIVISION OF VOLCANIC GEOLOGY,
Washington, July 1, 1887

SIR: Herewith I have the honor to submit my report of the operations of the division under my charge during the fiscal year ending June 30, 1887.

FIELD WORK.

My report for the last fiscal year covered operations in the southern part of the Cascade range, in California, and as far northward as Ashland, Oreg., which is situated twelve or fifteen miles north of the California boundary. On the 1st of July I was camped with my party in Ashland and engaged in making preparations for a somewhat thorough examination of Crater lake. This remarkable lake is situated upon the axis of the Cascade range, about sixty-five miles north of the California boundary and near the intersection of the forty-third parallel and the one hundred and twenty-second meridian. So striking are its physical and geological features that it was deemed well worthy of a special examination. The difficulties to be overcome, though not extremely great in themselves, were of an unusual kind. The lake occupies a profound depression in the Cascade platform and is girt about by lofty walls which descend at once into deep water. Boats are absolutely necessary for traveling about within its basin. Accordingly I had arranged for the construction of a good boat which could be used for sounding and also for two small skiffs for auxiliary purposes. A simple sounding apparatus had also been devised and fitted to the large boat. Tackle for lowering the boats into the water from the cliffs above was also provided. One other requisite was a number of stalwart men, who could lower the boats, row them, and do the hard labor connected with the examination of the lake. For the latter purpose I wrote to General Gibbon, commanding the military department of the Columbia, requesting that ten enlisted men be placed at my disposal. He at once detailed them from the troops at Vancouver barracks, and, placing them in command of Capt. Geo. W. Davis, Fourteenth Infantry, directed the party to proceed to Ashland, to act as an escort and to render whatever assistance might be necessary. Captain Davis arrived with the men at Ashland on July 4.

The large boat was mounted upon the running gear of a wagon upon which a framework had been built in such a manner that the boat could be suspended in slings and bear a journey of a hundred miles over rough mountain roads without injury from shocks or strains. The small boats were mounted upon wagon gears in a sim-

pler manner. On the 7th of July the party left Ashland and proceeded northward, crossed the Rogue river, and turning eastward soon began the ascent of the valley of that river. A journey of four days brought us near the locality. Within a mile of the Cascade divide it was necessary to leave the road and ascend the mountain or truncated cone in the summit of which is the lake basin. With great labor the wagons were hauled up the incline over snow banks and through the forest until they rested upon the brink of the cliff which looks down into the lake. Preparations for lowering the boats were at once begun. Captain Davis took charge of this work and accomplished it with perfect success.

The cliff here is about nine hundred and fifty feet above the water surface and is broken down into a slope of about 40°, with numerous small ledges. A cradle was made of scantlings, to which the boat was lashed, and the tackle, made fast to trees, was used to hold back the boat, while the men urged it forward and downward over the great snow banks, talus, and ledges. The process was not without peril. Apart from the danger of working upon so steep a slope, the melting snow frequently detached large stones, which went crashing down, threatening the men and boat alike. The task, however, was accomplished without accident, though there were numerous narrow escapes. The lowering of the small boats was a much easier matter. Next followed the work of cutting a trail from the summit to the water, in order to reduce the severe labor of ascending and descending the cliff. To camp below was impossible; there was no room to lie down in a position approaching horizontality.

The sounding apparatus was then set up in the large boat and a series of soundings was begun. At the first experimental cast, a few hundred feet from shore, a depth of 1,480 feet was reached. Although the depth was believed to be great, this result exceeded the anticipations. A series of soundings was begun and pushed forward with as much diligence as possible. In all 168 soundings were made, distributed over the area of the entire lake as uniformly as practicable. The position of the boat at each cast was determined by two plane tables planted upon the walls above. The general results of the soundings may be summarized as follows:

The inferred configuration of the bottom may be conceived of as a nearly plane surface for the most part, upon which stand three abruptly rising prominences. The largest of these rises above the surface of the water and discloses itself as a large cinder cone. This one stands near the western margin of the lake. Several streams of lava project from the base of the cone and are seen above the water between the cone and the nearest part of the lake wall. The height of the cone above the water is about 650 feet. The other two prominences are disclosed only by the plummet, for their tops are submerged, one at a depth of about 450 feet, the other at a depth of about

825 feet. The depth of the floor upon which these prominences stand varies from 1,600 to 2,000 feet. At the deepest cast the wire gave a reading of 1,996. To this should be added a small but unknown correction for the stretching of the wire, which will make the true depth of this cast fully 2,000 feet. So far as known to me this is the deepest fresh water in the United States.

Had time permitted an effort would have been made to ascertain with greater precision the shape of the submerged prominences; but it would have required the whole available time remaining to accomplish it, and this work can be resumed later if opportunity should offer.

Before leaving Ashland arrangement had been made with Mr. M. B. Kerr, topographer, and his assistant, Mr. Eugene Ricksecker, to meet me at the lake in the latter part of July for the purpose of making a good map of the lake and of the country immediately surrounding it. As the progress of the triangulation required that both of them should make a primary station upon Mt. Scott, in the immediate vicinity, this arrangement in no wise interfered with their plan of work. They arrived duly, and in the course of a week they obtained the data for making a map, which has since been drawn by Mr. Kerr. The dimensions of the lake prove to be 6¼ miles in length and 4¼ miles in width. Its shape is nearly elliptic, with only a few moderately well marked bays.

While the soundings progressed a study of the surroundings of the lake was made by myself upon the platform above and around the inner walls by boat below. The lake has no visible outlet. Its watershed is limited to the area within the sharp crestline of the cliff which incloses it. From this crestline, in directions away from the lake, the profile of the country descends at every point of its periphery with a rapid slope. In a word, the basin is the heart of a great volcanic cone, truncated far down toward its base, so that only the basal portions of the volcanic pile remain. The origin of this great depression is I think capable of explanation by processes which have their counterparts and illustrations in other volcanic countries and without the necessity of appealing to any action which is not abundantly exemplified elsewhere. Without going into details here, and reserving for future discussion an explanation and synthesis of the related facts, I will confine myself to saying that the evidence is satisfactory to the effect that this depression was formed in the same manner as the great calderas at Kilauea, Mauna Loa, and Haleakala, in the Hawaiian islands; the Volcan de Taal, in the Philippines; the great cirque of Teneriffe; and the large calderas of Central America. It possesses no feature which is not to be found in some one or more of those striking formations, and its most characteristic features are to be found in all the others.

My work at Crater lake was completed on the 5th of August, and on that day I started upon the return journey down the Rogue River valley to Medford, on the Oregon and California railroad. Here the wagons were turned into depot and preparations were speedily made for taking the field with a pack train. I had contemplated a long journey northward, crossing and recrossing the Cascade range wherever practicable and advantageous, for the purpose of obtaining knowledge of the geological features presented on its western flank and in its axial portions. I designed prosecuting the journey in this way until the Columbia river was reached. Leaving Medford on the 11th of August, I followed down the left side of the Rogue River valley as far as Gold Hill.

My previous observations on the route from the Klamath river northward as far as Medford had indicated the general structure of the western flank of the Cascade system up to that point. Along this line the late Cretaceous and early Tertiary beds, consisting of sandstones, shales, and fine stratified tuffs, with interbedded conglomerates and lavas, are seen to turn upward toward the west, while their edges are inferred to be similarly turned up beneath the alluvium of the Rogue River valley and to lie against the metamorphic masses which constitute the Coast range in southern Oregon. Immediately north of the Rogue river, however, these strata have a diminished dip to the eastward and their margins trend northwestward and even westward. It begins to be apparent now that this part of the Coast range, during later Mesozoic and early Cenozoic times, was a large island, and in the vicinity of the Rogue river its ancient coast line swings to the westward, as if gradually turning around its northern end. The stratified beds of the Cascade system meantime reach farther and farther westward, until near the mouth of the Rogue river they at last extend to the Pacific shore. My first plan of following this ancient shore line was therefore seen to be inconsistent with the project of studying the Cascades, as it would have carried me to the westward among sedimentary formations.

Leaving the Rogue River valley at Grant's pass, I pursued the road to the northward. The country passed through is one offering singular obstacles to the study of geology. It is rugged in the extreme, being a maze of deep, V shaped gorges separated by knife edges clothed with the gigantic forest trees peculiar to the region. In spite of the steepness of every gorge and hillside, the trees, chapparal, and undergrowth are so effective in holding the soil firmly to the hillsides that it is hard to find a rock exposure or even a stone big enough to throw at a bird, except in the beds of the running streams. We are left to infer as best we may the stratigraphy of the country from the very few exposures of rocks, from the nature of the soil exposed by the cuts of the roadway, from pebbles in the streams and washes, and from the topographic features of the country. These

at best serve only to tell us whether the country rock is volcanic, metamorphic, or sedimentary, and that only at a few points here and there. They give no clew to the ages and the relations of the inferred rock masses. This is one of those districts where the geologist must work out his map on his hands and knees. All that could be gleaned was that the road passed through tracts which changed frequently from sedimentary to metamorphic and volcanic. The volcanic rocks, however—and these were generally the best exposed—were mostly of ancient types, the most abundant of all being those forms of peridotite which are displayed in enormous masses and with a wide distribution throughout the contorted Paleozoic or older slates and metamorphics of northern California and southern Oregon.

The geological relations here are worth dwelling upon for a moment. This part of Oregon during the later Mesozoic and early Cenozoic was probably an archipelago. To the eastward stretched a mediterranean whose farther shore was the great island which in those ages occupied the area that is now the great basin of Nevada, eastern Oregon, and southern (perhaps also northern) Idaho. The straits and passes between the islands which were scattered throughout this old mediterranean were loaded with sediments, large remnants of which still remain, though a great portion of them has been removed again by the erosion of subsequent periods. This state of affairs is plainly disclosed north and south of Shasta and in Shasta valley, and is revealed with remarkable clearness in the middle courses of the Klamath valley and upon the northern flanks of the Siskiyou. Many portions of the Rogue River valley disclose it. To the eastward the traces of this earlier history are buried beneath the enormous masses of lavas and conglomerates which constitute the Cascade platform, but in the great gorges excavated in its western flank we still find many proofs of the same general fact.

Whatever observations could be made in a country so obscure as that which lies between the Rogue river and the South Umpqua betokened the same order and system of facts as that described. The route led from metamorphic country rocks to sedimentaries, and vice versa, the sediments becoming more frequent and extensive and the metamorphics fewer. The fossils obtained were either of the Chico group or Miocene, sometimes one, sometimes the other. None of Eocene age were found, nor were any of Miocene age collected until we approached the vicinity of the upper Willamette valley, though I believe that other observers have found them in some portions of the valley of the Umpqua.

Reaching Eugene City, I spent a few days in examining the head of the Willamette valley. It is a Miocene basin, with abundant characteristic fossils. A feebly pronounced watershed or divide separates it on the westward from a region draining more directly into the Pacific and covered with strata mostly of the same age.

Leaving Eugene City I ascended the valley of the McKenzie fork to cross the mountains again. This valley is cut deeply into the range, and, though the heights on either hand are massive lavas, there is a considerable stretch of the valley in which the metamorphics are again laid bare. These rocks are also disclosed over a considerable area and are margined on the west by the Miocene and Cretaceous and on the east by overlying lavas. The area in which these rocks are disclosed was probably one of the islands of the old archipelago.

As we ascend the McKenzie fork traces of glaciation at length appear, and as the Three Sisters come into view the traces become indicative of glaciation upon a much grander scale than any observed to the southward. In the southern Cascades the relics of the glacial period indicate glaciers, often of large size, upon the peaks and larger mountains, but seldom anything more; but as we began, at an elevation of about sixteen hundred feet, the ascent of the main ridge of the Cascades in the McKenzie drainage it speedily became apparent that these phenomena were of a different order. In these latitudes the whole summit platform of the Cascades has been powerfully glaciated by a continuous ice sheet covering the entire summit and flowing away to the westward, down into the great gorges which lead into the Willamette valley. It would be difficult to find anywhere relics of the glacial period more eloquent or more characteristic. Their freshness is remarkable. Above an altitude of four thousand feet they are omnipresent, except where they are overflowed with lavas which are younger still. The great gorge which leads from the McKenzie up to the bases of the Three Sisters is a magnificent example of a glaciated gorge whose appearance could not fail to strike the crudest observer as much by the peculiar features which the ice has sculptured upon its precipices as by the magnificence of the scenery to which they give rise. Upon the Middle Sister there is now a large glacier descending from the upper amphitheaters of the mountain at an altitude of about six thousand feet. It has a length of over four miles and a width of nearly three-fourths of a mile and exhibits fine lateral and terminal moraines.

The volcanic rocks in this portion of the Cascades were found to differ much from those farther southward. In the southern Cascades the dominant type of rock is a true andesite, generally bearing hypersthene and less frequently hornblende or augite; many basalts are found, but they show little olivine or augite and approach the andesites in composition; rhyolitic rocks are very uncommon. But in the vicinity of the Three Sisters the basalts, which are very numerous, are of a more basic type; rhyolites and dacites are abundant, and indeed the two varieties shade into each other. The older rocks, however, are still andesitic. The andesite almost everywhere appears to form the main bulk of the Cascade platform. The rhyolites and the dacites are younger and form some of the dominant

mountain piles which stud the platform, while youngest of all are the heavy basic basalts. The middle and highest peak of the Sisters has been in action since the close of the glacial period and its upper cone has been remodeled and reconstructed at a comparatively recent epoch. Some of the younger flows are rhyolite or dacite, for here the two types approach each other so closely that a distinction is difficult. There are large masses of obsidian, many of which present those spherulitic concretions which are so characteristic of the acid lavas of Yellowstone Park. In many places the same lava shows a curious admixture of the highly glassy with the lithoid form, and the two are intermingled in thin, contorted bands, from a few millimeters to a few inches in thickness, and thoroughly kneaded together.

Perhaps the most impressive features of the lithology are vast fields of young basalt. These are postglacial, and indeed are in some cases probably but a few hundred years old. There are some grand expanses of these basalts immediately north of the Sisters. One of them covers an area which was estimated to exceed one hundred square miles. This lava is so recent that no vegetation has as yet taken root upon it and it presents a scene of blackness and roughness fully equal to anything I saw in the Hawaiian Islands. The greater portion of it emanated from a vent seven or eight miles north of the Sisters, which is now conspicuously marked by a broad, flat lava cone. A good many copious outpours have issued from it, for it is plainly seen that some of the lava sheets are older than others, though all are postglacial. There are also several broad streams of similar scoriaceous basalt which have flowed from parasitic vents on the northern flank of the north Sister and have become interbedded with those just referred to. Farther northward, around Jefferson and at intervening places, are found many great and recent basaltic eruptions.

There are few localities equal in geological interest to the neighborhood of the Three Sisters. The glacial phenomena are exceptionally well defined, and there is a large existing glacier where comparison can be made between the action of a mountain glacier and that of an ice sheet such as once covered this broad platform. It is also rare to find within such a restricted area so many forms of eruptive rocks, whether we consider them with reference to their lithologic contrasts or with reference to their widely varying modes of occurrence.

From the Three Sisters I descended the eastern flank of the Cascades to Camp Polk, and there turned back for a few miles along the Santiam road as far as a notable mountain, called in the vicinity the Black Butte. I somewhat regret now that I did not go farther eastward, across the Des Chutes river as far as Prineville, in order to to get a preliminary view of the sedimentary and probably lacustrine

formations through which that river runs. But, intent upon gaining more knowledge of the eastern flank of the Cascades, I chose the rugged route from the Black Butte northward. At the base of this butte is the head of the Metolias (White Salmon) river. It starts from two enormous springs, situated within a few hundred yards of each other, from which it flows away in a stream seventy or eighty feet wide, too deep to ford and with an exceedingly swift current. Several very large springs also help to swell its volume farther down. This river has been delineated on the maps as flowing from Mt. Jefferson: in reality it is only a small tributary of the Metolias that heads there. The course of the river from the Black Butte is a little west of north and it lies in a gradually deepening gorge for about twenty-five miles. It then suddenly swings at more than a right angle to the east-southeast and at length joins the Des Chutes. Its gorge becomes a cañon twelve hundred to fifteen hundred feet deep, and some difficulty was experienced in getting into it and out again.

At the bend of the Metolias I left the river and struck across the country to the Warm Spring Indian reservation. The only interest excited by the valley of the Metolias is in the curious question, How came the river to flow in such a direction, in apparent conflict with the natural slopes and topographic features of the country?

Entering upon the Warm Spring reservation was like entering another world. It is a typical plateau country, a mild desert, though not absolutely treeless, for the juniper, so characteristic of the plateaus, grows luxuriantly in some places. It is a land of mesa and cañon, with a trunk stream, the Des Chutes, running through a great cañon. The strata are nearly horizontal, with feeble dips of varying azimuth, the northward dip predominating. The beds are almost wholly—indeed, so far as seen, entirely—composed of tuff, usually fine, sometimes pulverulent, and all stratified by deposition in water. The beds disclosed at the reservation are presumed to be continuous with those which, in other parts of the valley of the Des Chutes and of the John Day river, have yielded an abundance of middle and late Cenozoic mammalian remains. Some remarkably even and uniform sheets of columnar basalt are frequently intercalated between these beds and are exposed in the cañon walls and upon the tops of the denuded mesas. The study of this series of deposits will in future be highly instructive, for it can hardly fail to disclose much information relating to the physical evolution of this part of the continent. That there has been a comparatively recent uplifting (possibly relative, if not absolute) of a very large region in these parts is suggested by many of the geological features.

A few miles north of the Warm Spring agency is a large tract, called the Mutton mountains. It contains an irregular and extensive group of hills or small mountains composed wholly, so far as seen, of rhyolite. It is much the largest field of rhyolitic eruptions which

I have thus far encountered in the Cascades. Lithologically it suggests nothing of special interest. The mass overlies the tufaceous beds of the Des Chutes, which are seen to be capped by this lava in many places.

After passing northward across this rhyolitic field I again ascended the Cascade platform in the direction of Mt. Hood. Here the first stormy weather for many weeks set in and travel was accomplished in the midst of rain, sleet, and snow and in the heart of the Cascade forest. Of course such travel was without much result, but I was anxious to reach the base of Mt. Hood, and, after the storm was over, to ascend it if possible. When the storm cleared, as it did after six days, it was evident that so much snow had fallen upon the upper cone that an ascent was impracticable. I therefore proceeded onward to East Portland and to Vancouver barracks, where I was most kindly received and cared for by the officers of the post. The indications being abundant that the season was too far advanced (September 15) and the rainy weather too imminent to permit of further profitable field work with a pack train. I determined to send my animals to their winter range and to disband my party, but also to take advantage of occasional good weather to make a brief reconnaissance of the gorge of the Columbia river through the Cascade platform. The animals were sent by railroad to Ashland.

After visiting the Cascade Locks and The Dalles, where many highly interesting facts are presented, I concluded my work for the season and returned to Washington.

FIELD WORK OF MR. J. S. DILLER.

The work of Mr. Diller was the continuation of the detailed geology of the district in the vicinity of Lassen peak. He has been engaged for three seasons upon it and has completed it in a highly satisfactory manner. The condensed results of his survey have already been embodied in a brief paper which will be published as one of the contributions to this volume.

EARTHQUAKE INVESTIGATIONS.

During the past year universal interest has been awakened in the subject of earthquakes by the great disaster at Charleston on August 31, 1886. Upon receiving information of its general character, Mr. W J McGee, of this Survey, was sent to Charleston, in company with Prof. T. C. Mendenhall, of the Signal Service, for the purpose of gathering such information as was practicable.

Upon my return from the field in October measures were taken for eliciting information from all parts of the country as to the effects of the earthquake. This work has been diligently pursued, and the data collected are very considerable. I think I am justified in say-

ing that this is the best observed earthquake that has ever occurred. In the collection of the data great zeal and intelligence were shown by my assistant, Mr. Everett Hayden, who has since resigned from the Survey. During the winter my time and attention have been fully occupied in this work and in putting the observations into form and in discussing them. A monograph upon the subject is now in progress and will be completed, I hope, in the course of a few months.

The Sonora earthquake of May 3 received careful attention. As soon as it was reported a large number of circulars were distributed and answers were received to most of them. As the focal point of this earthquake was in Mexico and as no expenditure of money upon work outside of the limits of the United States is allowed by law, the investigation was restricted to places within our own boundaries. The results obtained will enable us to draw with considerable precision the isoseismal lines, and there are numerous time reports, some of which will probably be of use in determining the velocity of propagation.

Very respectfully,

C. E. DUTTON,
Captain of Ordnance.

HON. J. W. POWELL,
Director U. S. Geological Survey, Washington, D. C.

REPORT OF MR. LAWRENCE C. JOHNSON.

DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
LOUISIANA DIVISION OF GEOLOGY,
Potts Camp, Miss., July 1, 1887.

SIR: I have the honor to submit herewith my report for the fiscal year ending June 30, 1887.

With the exception of one trip across the lines of the formations from Starkville and through Aberdeen, Miss., to the Carboniferous in Alabama, attention was directed to the older Eocene, viz, the Claiborne, including the great Lignitic. An examination of the section through Aberdeen enabled me to establish the boundaries between the Tuscaloosa and Eutaw formations and the line between the Ripley, Flatwoods, and the Lignitic, accepting for the present the divisions made by Dr. Eugene W. Hilgard: the Ripley, the Rotten Limestone, the Tombigbee sands, and the Eutaw.

By sections across the State—one from the Carboniferous to the Mississippi bottom, through Aberdeen and Duckhill, and the other from Macon, Miss., to the salt water at the mouth of Pearl river—I have endeavored to show the relation of the geological strata of the