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J. W. POWELL, DIRECTOR

NOTES

ON THE

GEOLOGY

OF

NORTHERN CALIFORNIA

BY

J. S. DILLER

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., January 4, 1886.

SIR: Herewith I have the honor to transmit a paper by Mr. J. S. Diller, "Notes on the Geology of Northern California," and I recommend that it be published as a bulletin of the Geological Survey. During the last summer it was my privilege to go over a large part of the region to which his Notes refer, and I am entirely in accord with him so far as my opportunities for observation enabled me to judge. Mr. Diller's investigations have yielded valuable results, and already go far towards the elucidation of some of the broader and primary geological problems which are presented to the north of the northern end of the Sierra Nevada. They have resulted also in the collection of a very large amount of detailed information of high value.

Very respectfully, sir, your obedient servant,

C. E. DUTTON,
Captain of Ordnance, U. S. A.

The DIRECTOR OF THE U. S. GEOLOGICAL SURVEY.

GEOLOGY OF NORTHERN CALIFORNIA.

By J. S. Diller.

INTRODUCTORY.

Under the general supervision of Capt. C. E. Dutton, I have spent three field seasons in Northern California and Oregon among those complex groups of mountain ridges and ranges whose relations to one another have frequently been a subject of discussion, and it is in the hope of throwing some light upon the structure and connection of these ranges that I desire to note a few observations.

A hasty reconnaissance of both slopes and of most of the prominent peaks of the Cascade Range was followed by a more detailed examination of Mount Shasta and the neighboring elevations of the Coast and Sierra Nevada Ranges to a little beyond the fortieth parallel. The short but well defined volcanic ridge of Lassen's Peak appeared to afford an excellent field for studying some of the important problems of volcanology, and it was decided that this range, with the adjacent portions of the Sierra and Coast Ranges, should be subjected to careful investigation.

While tracing the southern limit of the lavas from this volcanic ridge a preliminary examination was made of the northern portion of the Sierra Nevada Range, and the results are considered of sufficient importance to warrant their presentation in advance of a more detailed study. The stratigraphy of the region is very complicated; before it can be properly discussed it is necessary to consider not only the general topographical features of the country but also the character and distribution of the rocks whose position in the geologic series can be most readily determined by fossils.

GENERAL TOPOGRAPHIC DIVISIONS OF NORTHERN CALIFORNIA AND OREGON.

The surface features of Northern California and Oregon may be grouped into two valleys and three mountain ranges. Concerning the extent of the Willamette and the Sacramento Valleys all agree, but the

limits between the Cascade, Coast, and Sierra Nevada Ranges have not been definitively ascertained. The southern end of the Cascade Range is well defined at Mount Shasta, but the boundary between the Sierra and Coast Ranges is still a matter of discussion. For reasons hereafter given we will consider the northern end of the Sierra Nevada Range to be in the vicinity of the North Fork of Feather River, before reaching Lassen's Peak. From this point the elevation is continued for about fifty miles on the trend of the Sierras in the *Lassen's Peak volcanic ridge*, which terminates near Pitt River. All else south and west of Mount Shasta belongs to the Coast Range. There appears to be a want of appropriateness in including the ridges east of the Sacramento River, about the headwaters of the McCloud, in the Coast Range, but it is evident that they are more closely related geologically to the Trinity and Scott Mountains of the Coast Range than to any portion of the Sierra Nevada Range.

CHARACTER AND DISTRIBUTION OF THE CARBONIFEROUS LIMESTONE.

The presence of a limestone of Carboniferous age on the McCloud River was made known many years ago by Dr. J. B. Trask. Prof. J. D. Whitney discovered one of the same age near Pence's Ranch, and also one in Genesee Valley, where it is associated with strata containing Mesozoic fossils.[1] This is the only fossiliferous portion yet discovered in the paleozoic rocks of Northern California, and on this account it affords the most important means available for determining their stratigraphic relations. It is peculiar, however, in being a series of disconnected, sometimes widely separated, lenticular masses[2] of various dimensions, instead of one continuous stratum. That this is really the case is clearly shown at a number of places where it appears in the side of a cañon. In the complete section it is seen to thin out and disappear in all directions. There are many of these limestone lenses in Northern California. I have examined nearly a score of them, and in more than half a dozen new localities have discovered fossils, which have been submitted to Mr. C. D. Walcott for identification. His results are given in the following list:

[1] Geol. Surv. of California. Geology, vol. i, p. 308.

[2] This peculiarity was noted by Prof. Whitney. *Ibid*, p. 210.

Fossils from the Carboniferous limestone of California.

Localities.	Fossils.
NORTHERN END OF SIERRA NEVADA RANGE.	
Western base of Sierra Nevada Range, Butte County.	
1 mile northeast of Pence's Ranch	Fragments of crinoidal columns.
W. Branch of North Fork of Feather River[a]	Coral, probably Zaphrentis sp.?
Cañon of Chico Creek, 16½ miles east of Chico	Fragments of crinoidal columns.
Middle portion of Sierra Nevada Range, Plumas County.	
Divide between Yellow and Mosquito Creeks, south of Humbug Valley.	Fragments of crinoidal columns; Lithostrotion Whitneyi; Lophophyllum proliferum?; Spirifera sp.?
Eastern portion of Sierra Nevada Range, Plumas County.	
1½ miles northeast of Taylorville	Fragments of crinoidal columns; Bryozoans; Athyris subtilita.
1½ miles east of Hossellkus', Genesee Valley	Fragments of crinoidal columns; Athyris or Terebratula; Bellerophon sp.?
BETWEEN LASSEN'S PEAK, VOLCANIC RANGE, AND MOUNT SHASTA.	
Cedar Creek, between Buzzards' Roost and Furnaceville, Shasta County.	Fragments of crinoidal columns; Diphyphyllum sp.?; Spirifera sp.?; Spiriferina cristata; Terebratula sp.?
Northeastern base of Grizzly Peak, Siskiyou County.	Fusulina cylindrica; Productus semireticulatus; Productus cora; Athyris royssi.

[a] Professor Whitney reports other fossils from the same region. Geol. Surv. of Cal. Geology, vol. , p. 210.

Besides the fossils enumerated in the above list, a few were collected at other localities, but unfortunately these were lost before reaching the hands of a paleontologist. Along Soda Creek, a few miles northeast of Lower Soda Springs, near the boundary between Shasta and Siskiyou Counties, a fossiliferous limestone contains many branching and cylindrical forms very like the Fusilina in the limestone near Grizzly Peak. A most important outcrop of fossiliferous limestone occurs in the Coast Range, west of Shasta Valley, along Willow Creek, near Gazelle (Edsons'). At this locality, among other fossils, was found an excellent specimen of *Lithostrotion*, and I think there can be no doubt concerning the geological age of the strata in which it occurs.

As is well known, there are many outcrops of limestone in the Sierra Nevada Range and northern portion of California, and every opportunity was embraced to examine them for fossils in order to determine

their geological relations. In many places the rock is so metamorphosed as to obliterate all traces of organic remains, but there is good reason to hope that fossils will yet be discovered in new localities. Fortunately, the localities at which fossils have already been found are widely distributed in the central and eastern portion of the Coast Range as well as in the Sierra Nevada. In answer to my inquiries Mr. Walcott replies:

As far as I can determine from the specimens submitted, there is no reason to suppose the existence of any other than the Carboniferous horizon, although the limestone at Cedar Creek is probably low in the formation.

The evidence thus far adduced all points in the same direction, and gives strong support to the proposition that all the limestone among the metamorphic rocks of Northern California is of Carboniferous age.[1]

STRUCTURE OF THE SIERRA NEVADA RANGE.

The Sierra Nevada Range at its northern end has a width of about 80 miles, extending from the Sacramento Valley to Honey Lake. It has three distinct crests, which are characterized by long, gentle slopes to the southwestward and short abrupt ones in the opposite direction.

The western crest, to which Claremont Hill belongs, is near the middle of the range and attains an altitude of about 7,000 feet. From this point the long, gentle slope extends to the Sacramento Valley at an elevation less than 300 feet above the sea. It is more or less undulating and deeply cañoned by numerous streams. From Claremont Hill the slope is abrupt towards American Valley, which at Quincy has an altitude of 3,375 feet. Continuing to the eastward the slope again rises more gently to 7,300 feet, the middle crest, in which Hough's Mountain is a prominent feature, and then descends steeply to Indian Valley at an elevation of about 3,500 feet. Further on the topography is irregular, but becomes an even slope, rising to 6,000 feet in the summit of the eastern crest, the bold escarpment overlooking Honey Lake. The outline of the Sierra Nevada Range, as seen in cross-section, is such as to at once suggest that, like the Basin Province,[2] it is composed of tilted orographic blocks, which are separated from one another by faults. The fact that Indian Valley and American Valley, which are the depressions between the crests of the range, were occupied by lakes during the Quaternary or later times greatly heightens the analogy; but to either establish or disprove the hypothesis suggested by the topography

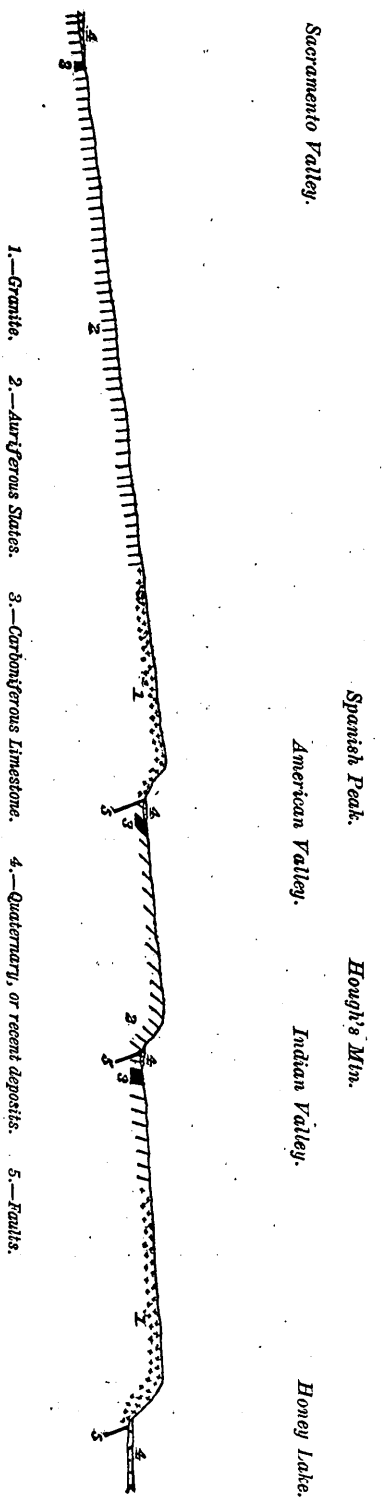
[1] Prof. J. D. Whitney, many years ago, thought it probable that all the limestone of the Sierra Nevada Range is of the same (Carboniferous) age. Geol. Surv. Cal. Geology, vol. i, p. 328; also, Aurif. Gravels, p. 41.

As far as I am aware the only limestones in California which are not of Carboniferous age are the Quaternary calcareous tufas of the Great Basin and one of the Knoxville beds, referred to by Mr. Becker in his Notes on the Stratigraphy of California. U. S. Geol. Surv. Bull. No. 19, p. 9.

[2] Geol. of the Uinta Mts., by J. W. Powell, p. 7.

it is necessary to examine the stratigraphy of the several masses. For convenience in this discussion, the three blocks will be designated western, middle, and eastern, respectively, according to geographical position.

The older strata, of which the range is in large part composed, are highly inclined and considerably metamorphosed. Near the western base of the mountain, as far as I have observed, the slates and limestones are usually inclined at an angle greater than 65° to the eastward, *i. e.*, towards the mass of the range, and if we accept without qualification their present order of superposition as the order of age, we should be obliged to admit that from the western base towards the middle of the range the strata are successively newer. There are good reasons, however, for supposing that instead of being newer they are either of approximately the same age or older, and that their present position is due to an overthrow. The only fossiliferous strata which have been recognized among the metamorphic rocks in the north end of the western block occur near its western base in the cañon of Chico Creek, along West Branch, and at Pence's Ranch, where the highly tilted limestone beds contain small crinoid stems and other fossils of Carboniferous age. It is a significant fact that a large portion of the auriferous slates lie east of the known outcrops of Carboniferous limestone. The broad belt of metamorphic strata upon the western slope of Claremont Hill is succeeded to the eastward by a mass of granite, which forms the western crest of the range.



1.—*Granite.* 2.—*Auriferous Slates.* 3.—*Carboniferous Limestone.* 4.—*Quaternary, or recent deposits.* 5.—*Faults.*

GENERALIZED SECTION ACROSS NORTHERN END OF THE SIERRA NEVADA RANGE.

If now we pass over the middle block of the range to the eastern one, which, lying between Indian Valley and Honey Lake, culminates in Thompson's Peak, we shall find a corresponding arrangement. The lower western portion of the block is made up of highly tilted strata, among which occur the limestones, shale, and sandstone containing fossils of the Carboniferous and Mesozoic ages.[1] To the eastward is exposed a mass of stratified old volcanic tufas, highly metamorphosed, and succeeded by granite, which forms the greater portion of the block. The inclination of the strata, although variable in degree and direction, is generally westward at a high angle, and in this respect differs from the position of the strata in the western block.

The middle block, lying between American and Indian Valleys and culminating in Hough's Mountain, is narrower and the strata are less disturbed than anywhere else in the northern portion of the range. The bold escarpment which faces Indian Valley exposes several thousand feet of apparently conformable slates, the position of which is very uniform for that region. Their strike is parallel to the face of the escarpment, and the dip generally less than 50° to the westward, plunging beneath American Valley. Near the western foot of the middle block in American Valley a limestone occurs which has been used quite extensively for lime. Unfortunately, I have not had an opportunity to examine this locality for fossils, but from the facts that it occurs near the suppressed western limit of the block, as does the known Carboniferous of the other two blocks, and is approximately on the strike of a limestone which outcrops further northward and contains *Lithostrotion* with other Carboniferous fossils, it appears to be highly probable that it also is of the same age.

The recurrence of the same fossiliferous strata in a cross-section of the Sierra Nevada Range in exactly analogous topographic and stratigraphic positions confirms the hypothesis suggested by its profile, that the northern end of the Sierra Nevada Range is made up of three orographic blocks separated from one another and from those of the Great Basin by profound faults, and shows that the Basin Range structure extends as far west as the Sacramento Valley. Mr. G. K. Gilbert[2] several years ago pointed out the characteristic features in the structure of the Sierra Nevada Range,[3] although Prof. Joseph Le Conte[4] had previously called attention to a profound fault along its eastern base in the vicinity of Owen's Lake. By far the greater portion of the range appears to be formed of one great orographic block, which is continuous with the west-

[1] This locality was first noted by Prof. J. D. Whitney. Geological Survey of California, vol. i, pp. 308, 309.

[2] Science, March 23, 1883, p. 195.

[3] Maj. J. W. Powell and Capt. C. E. Dutton had independently arrived at essentially the same conclusion as Mr. Gilbert.

[4] Am. Jour. Sci., vol. xvi, p. 101.

ern block of the range at its northern termination. Its long gentle slope westward is expressed in the drainage lines, and its eastern crest is the divide between the Great Basin and the Pacific. Almost throughout its whole extent, the Sierra Nevada faults are impassable to important streams, but at the northern end of the range, where the number of fault blocks is increased, the forks of Feather River cross two of the lines of great displacement. These streams, like nearly all of those that flow down the western slope, are in deep cañons. That of the North Fork of Feather River where it crosses the western fault has a depth of 4,000 feet, affording an excellent section of the folded strata, and its terraces indicate the character of the uplifting in forming the mountain range.

Structurally the Sierra is like the Great Basin Range, differing chiefly in the magnitude and in the present elevation of the blocks. Like the orographic blocks of the Great Basin area, they are composed of plicated strata, the folding of which, as has been pointed out by a number of observers, took place long before the faulting that gave birth to the peculiar features of the ranges. It is important to remember the fact that at the time the strata of which the Sierra Nevada Range is composed were folded, *i. e.*, about the limits between the Jurassic and Cretaceous periods, the Sierra Nevada Range was not differentiated from the continental mass of the Great Basin region, and it was not until a very much later period that this separation occurred.

AGE OF THE FAULTING OF THE SIERRA NEVADA RANGE.

The age of the faulting which originated the Sierra Nevada as a distinct range has not yet been definitely determined, but the recency of the dislocations can scarcely be questioned. This is clearly shown by the fact that the amount of erosion upon the fault escarpments has been very slight. As in the Great Basin, the faults in the northern portion of the Sierra Nevada Range have given rise to lakes upon the depressed border of the blocks, but whether these lakes existed during the Quaternary period or are more recent has not yet been ascertained. At the present time the lakes have entirely disappeared, and their beds are the most fertile lands of the whole region. That the displacements are comparatively recent is indicated also by their relation to the lavas. It appears that the dislocations along the eastern side of the two lateral blocks of the range have extended into the lavas of the great volcanic field about Lassen's Peak, and if the age of the fractured lavas can be determined the period of the Sierra displacements can be more nearly ascertained. While it is possible that the faulting may have continued through a long period, it is evident that most of the movement occurred since the great volcanic effusions in that region. According to Profs. J. D. Whitney[1] and Joseph Le Conte[2] these took place among the clos-

[1] Amer. Jour. Sci., Sept., 1864; also, Auriferous Gravels, p. 74.
[2] Amer. Jour. Sci., vol. xix, p. 188.

ing events of the Pliocene[1] or the beginning of the Quaternary, and as far as my observations have extended I have no reason to differ materially from this conclusion. The faulting of the Sierra probably commenced about that time, and, if we may accept small earthquakes as evidence, it is still in progress.[2]

AGE OF THE AURIFEROUS SLATES.

There is considerable difference of opinion concerning the age of the auriferous slates, but there is no good reason whatever for dissenting from the view generally accepted that at least a portion of the auriferous slates are Mesozoic. The fact that the Carboniferous limestone is intimately associated with the gold-bearing slates about the northern end of the Sierra Nevada Range suggests that a portion of these may

[1] In the neighborhood of Pence's Ranch the auriferous gravels are distinctly overlaid by stratified deposits which Professor Whitney regarded as Upper Pliocene (Geol. Surv. of Cal., vol. i, p. 211). A few imperfect leaf impressions were collected from these strata and submitted to Prof. L. F. Ward for examination. One of the specimens has been doubtfully determined as Cinnamomum or Paliurus, and Professor Ward remarks, "If it were certain that the specimen is either Cinnamomum or Paliurus, I should say that it could scarcely have come from a higher horizon than the Miocene and more likely from a lower. But the specimen may possibly represent a Populus unlike any modern form. At any rate I would not have been surprised at just such a collection from the Eocene or Laramie Group." That the strata containing the leaf impressions overlie the auriferous gravels at the Cherokee mine near Pence's Ranch there can be no question. Professor Whitney showed that the auriferous gravels probably represent the whole of the Tertiary (Aurif. Gravels, p. 283), and may it not be possible that the old stream bed of the Cherokee mine is Eocene or Miocene? In the same vicinity the Tertiary strata overlie the rocks of the Chico Group, and the two series of strata are almost, if not altogether, conformable. Dr. C. A. White, who visited the region lately, is of the impression that the strata referred to are not older than the Upper Pliocene. All that can be definitely stated at present concerning the strata containing the leaf impressions is that they are more recent than strata known to belong to the Chico Group, and that their flora, as far as Professor Ward can judge from the few imperfect specimens at hand, has a pre-Pliocene aspect. The great volcanic outburst in the vicinity of Lassen's Peak succeeded the deposition of these strata of questionable age, probably occurring, as stated above, about the close of the Pliocene.

[2] Small earthquake shocks are frequently felt about the northern end of the Sierra Nevada Range, especially in the vicinity of the fault scarps. Prof. Joseph Le Conte (Am. Jour. Sci., vol. xvi, p. 101) regarded the Inyo earthquake in 1872 as almost certainly due to a slight readjustment along the eastern fault of the Sierra near Owen's Lake. Some unpublished observations by I. C. Russell and W J McGee show that there has been actual post-Quaternary displacement near the eastern base of the Sierra.

There is evidence of a slight post-Quaternary elevation of the Lassen's Peak volcanic ridge along an interesting monoclinal fold which marks the limit between the Piedmont region of the range and the Sacramento Valley, a few miles east of Red Bluff. The displacement is less than a hundred feet and the latest yet discovered in that region, but does not properly belong to movements of the Sierra Nevada Range, as the fold runs out to the southward before reaching the limit of the volcanic tufas.

belong to Paleozoic or older formations.[1] The lenticular character of the limestone and the complex plications of the strata among which it occurs render it very difficult to determine in most cases, without fossils, whether the slates are above or below the limestone. I have already suggested that it appears to be a somewhat significant fact that a large portion of the auriferous slates lie east of the known outcrops of the Carboniferous limestone near the western base of the range. The folding of the strata brought them at many places into an approximately vertical position. At the time of the subsequent faulting the eastern edge of the largest block was so elevated as to make the strata which were formerly vertical dip steeply to the eastward, and in this manner strata upon the western slope of the Sierra Nevada Range may have been made to overlie more recent ones nearer its base. This explanation is suggested simply to show that the present eastern inclination of the strata upon the western slope of the range does not militate against the view that a portion of the auriferous slates are more ancient than the Carboniferous limestone.

Mr. Clarence King[2] called attention to the great thickness of Paleozoic littoral deposits of the Great Basin region and inferred the existence of a large land mass further westward from which these sediments were derived. Prof. Joseph Le Conte has argued that upon the marginal sea-bottom bordering the western shore of this ancient Paleozoic and Mesozoic land were laid down a great accumulation of sediments, out of which the Sierra Nevada Range has been formed.[3] It was, therefore, with great interest that I examined the eastern escarpments of the great fault-blocks of the Sierra Nevada Range, in the hope of being able to demonstrate the presence or absence of a considerable thickness of strata older than the Carboniferous limestone.[4] The stratified rocks of the eastern and western blocks of the Sierra Nevada Range are highly contorted, and the eastern escarpments are formed of granite, but in the middle block, lying between American and Indian Valleys, the strata, although tilted, are not so profoundly plicated. The bold escarpment facing Indian Valley, as has already been stated, exposes thousands of feet of apparently conformable auriferous slates which dip steeply westward beneath the supposed Carboniferous limestone of American Valley. These strata are so slightly metamorphosed as to encourage the hope of finding fossils in them, and I was greatly disappointed in having to

[1] Note sur la Géologie de la Californie, par M. Jules Marcou. Bull. de la Soc. géol. de France, 3me s., tome xi, p. 407.

[2] Geol. Exp. of the Fortieth Parallel. Syst. Geol., vol. i, p. 534.

[3] Am. Jour. Sci., III, vol. iv, p. 460, and vol. xvi, p. 103.

[4] Professor Whitney remarks that the age of the bed rock series can be set down with certainty as being nowhere more recent than Jurassic, and that it is not impossible but quite improbable that any portion of the metamorphic belt of the Sierra may prove to be older than the Carboniferous (Aurif. Gravels, p. 314). Mr. George F. Becker noted sandstones below and probably older than the Carboniferous limestone of the McCloud River (U. S. Geol. Surv. Bull. 19, p. 21).

give up a brief but fruitless search. Nevertheless, the stratigraphic relations are such as to render it very probable that at this point there is a great thickness of Paleozoic strata exposed and that a large part of the gold-bearing slates are older than the Carboniferous limestone.[1]

GENERAL DISTRIBUTION OF THE METAMORPHIC, VOLCANIC, AND CRETACEOUS ROCKS.

There are in Northern California two large areas of metamorphosed Mesozoic and Paleozoic rocks. The one occupies the northwestern corner of the State, entering from Oregon and extending as far southeast as Pitt River; this area is insular in its relation to later formations. The other is of continental dimensions, stretching into California from Nevada, and embraces the whole region of the Sierra Nevada Range. The great faults of this range run out in the vicinity of the North Fork of Feather River, apparently vanishing through short monoclinal folds where the platform of ancient metamorphic rocks is gradually depressed northwesterly, and disappears beneath the lavas of the great volcanic field. Continuing in the same direction, these rocks reappear upon the surface near Pitt River, and form the insular area to which reference has already been made. Concerning the depth of the depression in the metamorphic rocks between the two areas now exposed we have but little knowledge; however, there is no reason as far as I am aware for supposing it to be very great.

Following the trend of the Sierra Nevada Range northward from the North Fork of Feather River to Pitt River we find a volcanic ridge made up of numerous adjoining cones, among which Lassen's Peak is most prominent. This ridge has been designated Lassen's Peak volcanic ridge, and is composed almost exclusively of accumulated lavas rising to an average elevation of over 5,000 feet, with several peaks above 8,000 feet in altitude. The numerous craters of various magnitudes are irregularly distributed, and no definite relation to the lines of great displacement in the Sierra Nevada Range is apparent. In fact, as has already been shown, the great faulting occurred towards the close of the period of greatest volcanic activity. To the north and northeastward of this volcanic range the recent lavas stretch far into Oregon, Idaho, and Washington Territory.

Mr. Becker and others have called attention to the great uncon-

[1] Professor Whitney refers to the fossils found in Genesee Valley in demonstrating that a large part of the auriferous slates are Mesozoic (Aurif. Grav., p. 309). These slates in Hough's Mountain ridge, upon the southwestern side of Indian Valley, are regarded by miners as the "home of the mother ledge" of that country, and being apparently older than the Mesozoic strata containing the fossils are separated from them by a profound displacement.

Dr. White asserts that the auriferous slate series is known to include strata of Carboniferous age and some that are apparently older. Notes on the Mesozoic and Cenozoic Paleontology of California, U. S. G. S. Bull. No. 15, p. 25.

formity between the rocks of the Chico Group and those upon which they rest. The geography of our western coast during the deposition and plication of the older strata is a matter concerning which we have as yet but little knowledge. Its development is first distinctly outlined in the rocks of the Chico epoch. These rocks are generally fossiliferous, and their identification is a matter of no great difficulty. They are exposed at many points along the western base of the northern portion of the Sierras, and are either horizontal or dip away from the mountain at a very low angle. In the latitude of Oroville the rocks of this group rise to an elevation of 800 feet above the sea. Further northward, along Chico Creek, they reach 1,700 feet, and continuing in the same direction the elevation becomes greater. Two miles east of Montgomery Creek, on the road from Redding to Burney Valley, they have an elevation of over 2,400 feet. At this point they are coarse deposits, evidently formed near a shore which lay a short distance to the northwest in the vicinity of Pitt River. They dip eastward, disappearing beneath the Lassen's Peak volcanic ridge, and very probably connect beneath the great lava fields with the rocks of the same age in Shasta Valley and Crooked River in Oregon east of the Cascade Range.[1] In the northwest part of Shasta Valley, besides the fossiliferous sandstone, there are coarse shore deposits of the same age clinging upon the sides of the Scott Mountains and reaching far up towards their summits. The distribution of the rocks of the Chico Group clearly indicates that during the Chico epoch the northwestern portion of California, with the adjacent part of Oregon, embracing the Trinity, Salmon, Scott, Siskiyou, and other mountain ridges of the Coast Range, was a large island, separated from the still larger continental land mass of the same strata in the Great Basin and Sierra region by a wide strait now bridged over by the Lassen's Peak volcanic ridge.

RELATION OF THE SIERRA, COAST, AND CASCADE RANGES.

The geography of the western coast during the Chico epoch enables us to define sharply the limits between the Sierra Nevada and the Coast Ranges. The former has been from its inception joined to the continental land, while the latter embraces all the ridges developed out of the cretacean island, and the Lassen's Peak volcanic ridge separates them. Both ranges contain plicated Paleozoic as well as Mesozoic strata. The Coast Range received large tertiary additions not represented in the Sierras, but, on the other hand, the latter was differentiated from a continental mass by the development of a peculiar structure not yet recognized in the Coast Range. The relation between the Coast and the Cascade Ranges is not so sharply defined, but when we consider their

[1] Mr. Eugene Ricksecker, a topographer of the Geological Survey, informs me that he observed a number of fossils where a well had been recently dug a short distance north of Rhett Lake, Oregon, and it is possible that the locality may afford fossils of the Chico group.

widely diverse modes of origin their limitation is not a matter of so great difficulty. South of the Rogue River Valley the cretacean island lay completely west of the position now occupied by the Cascade Range. To the northward its extension is but partially known. Near the summit of the Cascade Range, upon its western slope, about half a dozen miles from Mount Hood, is a large mass of coarsely crystalline eruptive rock, closely related to the gabbros. A similar rock occurs near the western base of the range, 8 miles east of Lebanon, and Mr. Becker[1] has said that east of Roseberg granite and metamorphic rocks occur about the headwaters of the Umpqua. Such rocks make up the Coast Range west of Mount Shasta, and it may be that they form an elevated foundation for a considerable portion of the Cascade Range between the headwaters of Rogue River and Mount Hood, but this is rendered less probable by the complete section along the Columbia River, where the range is cut across nearly to the sea level, showing, according to Le Conte,[2] that it is composed almost wholly of modern lavas resting upon undisturbed strata of Miocene age. The excellent section of the southern portion of the range afforded by the Klamath River shows, at least as far as I have observed, that it is made up at that point[3] completely of recent eruptive rocks.

Between the Siskiyou Mountains and the Cascade Range, in Southern Oregon, as Whitney has shown,[4] the Cretaceous strata of the narrow belt are highly tilted. They dip eastward beneath that portion of the Cascade Range, as do those of Shasta Valley as well, and probably connect with the rocks of the same age east of the Cascade Range. The apparently complete absence of older rocks in the Klamath River cañon through the Cascade Range and the relation of the Cretaceous strata on both sides of the range indicate clearly that the region now occupied by the southern portion of the Cascade Range was beneath the sea during the Chico epoch. As far as is definitely known the Cascade Range was not represented by a ridge of older metamorphic rocks which were folded and upheaved at the same time with the Sierra and older portion of the Coast Range, and is entirely distinct from them in structure and origin. On the contrary, however, the region occupied by it as well as the short range north of Lassen's Peak are but parts of the great volcanic field that occupies the area which during the Chico epoch was one of depression between the island and the continent.[5]

[1] U. S. Geol. Surv. Bull. No. 19, p. 20.

[2] Amer. Jour. Sci., III, vol. vii, pp. 167, 259.

[3] Two miles below Shovel Creek, on the left bank of the Klamath River, by the road from Yreka, Cal., to Linkville, Oreg., in a ledge of gray rock which in the field I regarded as one of the metamorphic slates, but under the microscope it is seen to be a lava.

[4] Geol. Surv. of Cal., vol. i, page 354.

[5] See Dr. White's remarks, "Notes on the Mesozoic and Cenozoic Paleontology of California," U. S. G. S. Bull. No. 15, p. 31.

CONCLUSIONS.

The points to which it is desired to call especial attention may be briefly summarized as follows:

It appears that all the limestone among the metamorphic rocks of the Coast and Sierra Nevada Ranges is of Carboniferous age.

The northern portion of the Sierra Nevada Range, like that of the Great Basin, is composed of tilted orographic blocks separated from one another by great faults.

The greater portion of the range is formed by one of these blocks, with a short abrupt slope towards the Great Basin and a long gentle slope in the opposite direction.

The displacements by which the Sierra Nevada Range was separated from the Great Basin land mass probably began about the close of the Tertiary, and may be yet in progress.

A large portion of the auriferous slate series is apparently older than the Carboniferous limestone.

During the Chico epoch a large part of the region now occupied by the Coast Range was an island separated by a wide strait from the continental mass to which the Sierra Nevada Range belonged, which strait has since been filled by the lavas of the Lassen's Peak volcanic ridge.

As far as is definitely known, the Cascade Range was not represented by a ridge of metamorphic rocks corresponding to the Sierra and Coast Ranges, but belongs rather to the great volcanic field which now occupies the area once depressed between the cretacean island and the continent.

ADDENDUM.

While completing the survey of the Lassen's Peak volcanic belt during the field season of 1886, much additional evidence was obtained supporting the views expressed in this paper. Geologically considered, Lassen's Peak belongs to the Cascade Range, and several of the foregoing assertions should be somewhat extended.

Mr. Walcott has examined a few fossils from Willow Creek, a locality referred to on page 11. He identified the following forms: Lithostrotion mamillare, Terebratula, Pleurotomaria, Orthoceras, Zaphrentis, Favosites, and crinoidal columns.

Some fossils recently collected near Rhett Lake do not belong to the Chico group but to a much later horizon.

OCTOBER 14, 1886.

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[Bulletin No. 34.]

The publications of the United States Geological Survey are issued in accordance with the statute, approved March 3, 1879, which declares that —

"The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said Survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States and form a part of the library of the organization: And the money resulting from the sale of such publications shall be covered into the Treasury of the United States."

On July 7, 1882, the following joint resolution, referring to all Government publications, was passed by Congress:

"That whenever any document or report shall be ordered printed by Congress, there shall be printed, in addition to the number in each case stated, the 'usual number' (1,900) of copies for binding and distribution among those entitled to receive them."

Under these general laws it will be seen that none of the Survey publications are furnished to it for gratuitous distribution. The 3,000 copies of the Annual Report are distributed through the document rooms of Congress. The 1,900 copies of each of the publications are distributed to the officers of the legislative and executive departments and to stated depositories throughout the United States.

Except, therefore, in those cases where an extra number of any publication is specially supplied to this Office, the Survey has no copies of any of its publications for gratuitous distribution.

ANNUAL REPORTS.

Of the Annual Reports there have been already published:

I. First Annual Report to the Hon. Carl Schurz, by Clarence King. 1880. 8°. 79 pp. 1 map.—A preliminary report describing plan of organization and publications.

II. Report of the Director of the United States Geological Survey for 1880-'81, by J. W. Powell. 1882. 8°. lv, 588 pp. 61 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881-'82, by J. W. Powell. 1883. 8°. xviii, 564 pp. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882-'83, by J. W. Powell. 1884. 8°. xxxii, 473 pp. 85 pl. and maps.

V. Fifth Annual Report of the United States Geological Survey, 1883-'84, by J. W. Powell. 1885. 8°. xxxvi, 469 pp. 58 pl. and maps.

The Sixth Annual Report is in press.

MONOGRAPHS.

Of the Monographs, Nos. II, III, IV, V, VI, VII, VIII, and IX are now published, viz:

II. Tertiary History of the Grand Cañon District, with atlas, by Clarence E. Dutton, Capt. U. S. A. 1882. 4°. xiv, 264 pp. 42 pl. and atlas of 24 sheets folio. Price $10.12.

III. Geology of the Comstock Lode and the Washoe District, with atlas, by George F. Becker. 1882. 4°. xv, 422 pp. 7 pl. and atlas of 21 sheets folio. Price $11.

IV. Comstock Mining and Miners, by Eliot Lord. 1883. 4°. xiv, 451 pp. 3 pl. Price $1.50.

V. Copper-bearing Rocks of Lake Superior, by Roland D. Irving. 1883. 4°. xvi, 464 pp. 15 l. 29 pl. Price $1.85.

VI. Contributions to the Knowledge of the Older Mesozoic Flora of Virginia, by Wm. M. Fontaine. 1883. 4°. xi, 144 pp. 54 l. 54 pl. Price $1.05.

VII. Silver-Lead Deposits of Eureka, Nevada, by Joseph S. Curtis. 1884. 4°. xiii, 200 pp. 16 pl. Price $1.20.

VIII. Paleontology of the Eureka District, by Charles D. Walcott. 1884. 4°. xiii, 298 pp. 24 l. 24 pl. Price $1.10.

IX. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey by Robert P. Whitfield. 1885. 4°. xx, 338 pp. 35 pl. Price, $1.15.

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The following are in press, viz:

X. Dinocerata. A Monograph of an Extinct Order of Gigantic Mammals, by Othniel Charles Marsh. 1885. 4°. xviii, 237 pp. 56 pl.

XI. Geological History of Lake Lahontan, a Quaternary Lake of Northwestern Nevada, by Israel Cook Russell. 1885. 4°. xiv, 288 pp. 46 pl.

XII. Geology and Mining Industry of Leadville, with atlas, by S. F. Emmons. 1886. 4°. xxix, 770 pp. 45 pl. and 35 atlas sheets.

The following are in preparation, viz:

I. The Precious Metals, by Clarence King.
— Geology of the Eureka Mining District, Nevada, with atlas, by Arnold Hague.
— Lake Bonneville, by G. K. Gilbert.
— Sauropoda, by Prof. O. C. Marsh.
— Stegosauria, by Prof. O. C. Marsh.
— Geology of the Quicksilver Deposits of the Pacific Slope, with atlas, by George F. Becker.
— The Penokee-Gogebic Iron-Bearing Series of North Wisconsin and Michigan, by Roland D. Irving.
— Description of New Fossil Plants from the Dakota Group, by Leo Lesquereux.
— Younger Mesozoic Flora of Virginia, by William M. Fontaine.
— Report on the Denver Coal Basin, by Samuel F. Emmons.
— Report on Ten-Mile Mining District, Colorado, by Samuel F. Emmons.
— Report on Silver Cliff Mining District, by Samuel F. Emmons.
— Flora of the Dakota Group, by J. S. Newberry.

BULLETINS.

The Bulletins of the Survey will contain such papers relating to the general purpose of its work as do not properly come under the heads of Annual Reports or Monographs.

Each of these Bulletins contains but one paper and is complete in itself. They are, however, numbered in a continuous series, and may thus be united into volumes of convenient size. To facilitate this, each Bulletin has two paginations, one proper to itself and another which belongs to it as part of the volume.

Of this series of Bulletins Nos. 1 to 34 are already published, viz:

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 42 pp. 2 pl. Price 10 cents.

2. Gold and Silver Conversion Tables, giving the coining value of troy ounces of fine metal, etc., by Albert Williams, jr. 1883. 8°. ii, 8 pp. Price 5 cents.

3. On the Fossil Faunas of the Upper Devonian, along the meridian of 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by Henry S. Williams. 1884. 8°. 36 pp. Price 5 cents.

4. On Mesozoic Fossils, by Charles A. White. 1884. 8°. 36 pp. 9 pl. Price 5 cents.

5. A Dictionary of Altitudes in the United States, compiled by Henry Gannett. 1884. 8°. 325 pp. Price 20 cents.

6. Elevations in the Dominion of Canada, by J. W. Spencer. 1884. 8°. 43 pp. Price 5 cents.

7. Mapoteca Geologica Americana. A catalogue of geological maps of America (North and South), 1752–1881, by Jules Marcou and John Belknap Marcou. 1884. 8°. 184 pp. Price 10 cents.

8. On Secondary Enlargements of Mineral Fragments in Certain Rocks, by R. D. Irving and C. R. Van Hise. 1884. 8°. 56 pp. 6 pl. Price 10 cents.

9. A Report of work done in the Washington Laboratory during the fiscal year 1883–'84. F. W. Clarke, chief chemist; T. M. Chatard, assistant. 1884. 8°. 40 pp. Price 5 cents.

10. On the Cambrian Faunas of North America. Preliminary studies, by Charles Doolittle Walcott. 1884. 8°. 74 pp. 10 pl. Price 5 cents.

11. On the Quaternary and Recent Mollusca of the Great Basin; with Descriptions of New Forms, by R. Ellsworth Call; introduced by a sketch of the Quaternary Lakes of the Great Basin, by G. K. Gilbert. 1884. 8°. 66 pp. 6 pl. Price 5 cents.

12. A Crystallographic Study of the Thinolite of Lake Lahontan, by Edward S. Dana. 1884. 8°. 34 pp. 3 pl. Price 5 cents.

13. Boundaries of the United States and of the several States and Territories, by Henry Gannett, 1885. 8°. 135 pp. Price 10 cents.

14. The Electrical and Magnetic Properties of the Iron Carburets, by Carl Barus and Vincent Strouhal. 1885. 8°. 238 pp. Price 15 cents.

15. On the Mesozoic and Cenozoic Paleontology of California, by Dr. C. A. White. 1885. 8°. 33 pp. Price 5 cents.

16. On the higher Devonian Faunas of Ontario County, New York, by J. M. Clarke. 1885. 8°. 86 pp. 3 pl. Price 5 cents.

17. On the Development of Crystallization in the Igneous Rocks of Washoe, by Arnold Hague and J. P. Iddings. 1885. 8°. 44 pp. Price 5 cents.

18. On Marine Eocene, Fresh-water Miocene, and other Fossil Mollusca of Western North America, by Dr. C. A. White. 1885. 8°. 26 pp. 3 pl. Price 5 cents.

19. Notes on the Stratigraphy of California, by George F. Becker. 1885. 8°. 28 pp Price 5 cents.

20. Contributions to the Mineralogy of the Rocky Mountains, by Whitman Cross and W. F. Hillebrand. 1885. 8°. 114 pp. 1 pl. Price 10 cents.

21. The Lignites of the Great Sioux Reservation, by Bailey Willis. 1885. 8°. 16 pp. 5 pl. Price 5 cents.

22. On New Cretaceous Fossils from California, by Charles A. White, M. D. 1885. 8°. 25 pp. 5 pl. Price 5 cents.

23. The Junction between the Eastern Sandstone and the Keweenaw Series on Keweenaw Point, by R. D. Irving and T. C. Chamberlin. 1885. 8°. 124 pp. 17 pl. Price 15 cents.

24. List of Marine Mollusca, comprising the Quaternary fossils and recent forms from American localities between Cape Hatteras and Cape Roque, including the Bermudas, by W. H. Dall. 1885. 8°. 336 pp. Price 25 cents.

25. The Present Technical Condition of the Steel Industry of the United States, by Phineas Barnes. 1885. 8°. 82 pp. Price 10 cents.

26. Copper Smelting, by Henry M. Howe. 1885. 8°. 107 pp. Price 10 cents.

27. Work done in the division of Chemistry and Physics, mainly during the fiscal year 1884–'85. 1886. 8°. 80 pp. Price 10 cents.

28. The Gabbros and Associated Hornblende Rocks occurring in the neighborhood of Baltimore, Md., by George H. Williams. 1886. 8°. 78 pp. 4 pl. Price 10 cents.

29. On the Fresh-water Invertebrates of the North American Jurassic, by Dr. C. A. White. 1886. 8°. 42 pp. 4 pl. Price 5 cents.

30. Second contribution to the studies on the Cambrian Faunas of North America, by Charles D. Walcott. 1886. 8°. 379 pp. 33 pl. Price 25 cents.

31. A systematic review of our present knowledge of Fossil Insects, including Myriapods and Arachnids, by Samuel H. Scudder. 1886. 8°. 128 pp. Price 15 cents.

32. Mineral Springs of the United States, by Albert C. Peale, M. D. 1886. 8°. 235 pp. Price 20 cents.

33. Notes on the Geology of Northern California, by Joseph S. Diller. 1886. 8°. 23 pp. Price 5 cents.

34. On the relation of the Laramie Molluscan Fauna to that of the succeeding Fresh-water Eocene and other groups, by Dr. Charles A. White. 1886. 8°. 54 pp. 5 pl. Price 10 cents.

Numbers 1 to 6 of the Bulletins form Volume I; Numbers 7 to 14, Volume II; Numbers 15 to 23, Volume III; and Numbers 24 to 30, Volume IV. Volume V is not yet complete.

The following are in press, viz:

35. The Physical Properties of the Iron Carburets, by Carl Barus and Vincent Strouhal.

36. The Subsidence of small particles of Insoluble Solid in Liquid, by Carl Barus.

37. Types of the Laramie Flora, by Lester F. Ward.

38. Peridotite of Elliott County, Kentucky, by Joseph S. Diller.

39. The Upper Beaches and Deltas of the Glacial Lake Agassiz, by Warren Upham.

In preparation:

40. Geologic notes in Northern Washington Territory, by Bailey Willis.

41. Fossil Faunas of the Upper Devonian—the Genesee Section, by Henry S. Williams.

— Bibliography of North American Crustacea, by Lieut. A. W. Vogdes.

STATISTICAL PAPERS.

A fourth series of publications, having special reference to the mineral resources of the United States, has been undertaken.

Of that series the following have been published, viz:

Mineral Resources of the United States [1882], by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

Mineral Resources of the United States, 1883 and 1884, by Albert Williams, jr. 1885. 8°. xiv, 1,016 pp. Price 60 cents.

In preparation:

Mineral Resources of the United States for calendar year 1885, by Albert Williams, jr.

Correspondence relating to the publications of the Survey, and all remittances, which must be by POSTAL NOTE or MONEY ORDER (not stamps), should be addressed

TO THE DIRECTOR OF THE
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

WASHINGTON, D. C., *October* 1, 1886.