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ART. XXXVII.—*An Auriferous Conglomerate of Jurassic Age from the Sierra Nevada;* by W. LINDGREN.

SOME of the largest quartz veins of the gold belt of the Sierra Nevada intersect the Mariposa beds, the most recent sedimentary member of the bedrock series of that range. The age of these beds has long been in some doubt but the latest investigations* appear to render it almost certain that they should be considered as belonging to the uppermost Jurassic. Hence the quartz veins of the gold belt have generally been conceded to have been formed shortly after the post-Mariposa mountain building disturbance; the time limits would be the end of the Jurassic on the one hand and the beginning of the Chico-Cretaceous on the other. The disintegration of these auriferous veins has furnished the material for the Cretaceous, Tertiary and Pleistocene gravel beds.

There is evidence that the Sierra Nevada has remained elevated above the sea since the beginning of the Chico Cretaceous, for beds of that age are found in nearly horizontal position along the western foot of the range. The accumulation of the auriferous gravels must thus have begun already during the earlier part of the Chico period; at Folsom, for instance, a small area of these Cretaceous sandstones is found in the deepest part of a depression occupied by Neocene gravel deposits; below them, on the granitic bedrock, a thin layer of auriferous gravel occurs. The configuration of the bedrock

* Alpheus Hyatt, Trias and Jura in the Western States. Bull. Geol. Soc. Am., vol. v, p. 395. James Perrin Smith, Age of the Auriferous Slates of the Sierra Nevada. Bull. Geol. Soc. Am., vol. v, p. 243.

at this point proves that already during the Cretaceous the river courses were outlined which, during the Tertiary, were further eroded and then filled with gravel. From the northern part of the State Mr. R. L. Dunn has recently, in a paper written for the State Mineralogical Bureau but not yet published, described an interesting occurrence of auriferous river gravel from underneath the Chico sandstones.

A most marked unconformity exists at Folsom between the horizontal Chico sandstones and the vertical and highly compressed Mariposa beds; the latter are besides cut off and metamorphosed by the adjoining intrusive mass of granodiorite.

In view of the facts presented above it is of some interest to find an auriferous conglomerate in the Mariposa beds indicating that at least some of the quartz veins antedate the post-Mariposa upheaval.

Before describing the occurrence it may not be amiss to devote a few lines to the sedimentary formations of the vicinity. The larger part of the sedimentary area of the gold belt is, as shown by the work of the U. S. Geological Survey, of pre-Jurassic age. Most prominent are the Paleozoic, probably mostly Carboniferous rocks and smaller belt only belong to the Trias, the Jura-Trias and to the Jura. Some of the results attained in the gold belt south of the fortieth parallel have been set forth by Mr. H. W. Turner in a paper published in the American Geologist, April, 1894.

The locality to be described here is found in Placer County, on the ridge between the North and Middle Forks of the American river at an elevation of about 2100 above the sea and is mapped on the Placerville atlas sheet, N.W. corner.

Beginning from the edge of the Great Valley there is first a broad area of granodiorite, followed by a belt of diabase and greenstone schists, which again are adjoined on the east by a series of Paleozoic sedimentary rocks, probably all Carboniferous (Calaveras formation). They consist of black, not very fissile clayslates and fine, dark colored sandstones, but besides these and characteristic of the formation in this vicinity, there are heavy beds and lenticular masses of crystalline limestone very frequently changed to a black or gray chert or phthanite. The strike is nearly N.–S., the dip 70°–90° E.

Adjoining this series on the east are the Mariposa beds. Through the southern part of Eldorado Co. they can be traced without difficulty as a belt from $\frac{1}{2}$ to 2 miles wide. At Placerville they begin to widen and intrusive bodies of diabase and porphyritic in part made schistose by dynamo-metamorphic action appear in them, splitting the series into two and three belts. The eastern line of demarcation towards the Paleozoic beds adjoining again on the east, as laid down on Placerville

sheet, is somewhat doubtful between Placerville and the northern edge of the sheet; both at Spanish Flat and at Georgetown, Mesozoic fossils have been found and the line has therefore been drawn so as to include both these localities. Up to the Middle Fork of the American river the prevailing rock of the Mariposa beds is a black fissile slate sometimes, as at Greenwood, alternating with thin beds of dark tufaceous sandstone. At the latter place the contact with the underlying Calaveras formation is well exposed with apparent conformity both dipping 70°–80° east. From here up to Colfax, a distance of about 12 miles the character of the Mariposa beds change. Conglomerates appear in places near the western contact, the black slates become less fissile and more jointed and contain abundant beds of dark tufaceous sandstones and breccias; the latter are composed of slate, phthanite and limestone from the Calaveras formation together with fragments of basic igneous rocks. Besides dikes and masses of the latter cut across the strata. The breccias appear mostly conformably in the series and should probably be explained as intercalated mud flows. Short distance north of Colfax a massive of diabase, gabbro and diorite cuts off the Mariposa beds, which here predominatingly consist of pyroclastic rocks. A breccia of diabase mixed with fragments of limestone, etc., extends from the massive and cuts across the beds at Colfax. It is most probable that the basic intrusive area to the north of Colfax represents the core of a volcano the eruptions of which were contemporaneous with the deposition of the Mariposa beds and the ejecta of which intermingled with the sediments.

The older rocks adjoining the Mariposa beds on the east extend northward but to the west of these where the continuation of the Mariposa beds should be sought no certain trace of them can be found. Diorites, diabases and other principally basic rocks occupy, on Smartsville sheet, nearly the whole area to the west down to the valley. Both the Mariposa and most of the western area of the Calaveras formation appear to be engulfed in the igneous rocks if indeed the former ever continued to the north of Colfax. The evidence appears to favor the theory that the Mariposa beds were deposited in a gulf or bay, enclosed on both sides by older rocks and ending in the vicinity of Colfax. In the igneous areas to the N.N.W. of Colfax and extending up towards Grass Valley and Nevada City some narrow bands and smaller areas of sedimentary rocks occur. The limestone and phthanite in most of them indicate that they belong to the Calaveras formation; there is however one narrow band of black tufaceous slates and sandstones, between Grass Valley and Nevada City which may possibly belong to the Mariposa beds.

Although the Mariposa slates usually show an apparent conformity with the older rocks, there is, between Colfax and the Middle Fork of the American river, some structural evidence strongly tending to show an unconformity. Between these two localities the Mariposa beds have about the same strike as the enclosing slates of the Calaveras formation, but while the latter nearly uniformly have a steep dip of from 75° to 90° to the east, the former show throughout a considerably smaller dip of from 50° to 60° in the same direction. Mr. H. W. Turner recognizes from evidence gathered in the southern counties, the probable unconformity of the two formations and brings the following points to support it:* First, the lithologic difference between the formations; second, the occurrence of a conglomerate with phthanite pebbles in the Mariposa beds near Texas ranch, Calaveras Co.; third, the occurrence of a narrow streak of the Mariposa beds cutting obliquely across the Calaveras formation; fourth, the large paleontologic break between the formations.

Coming up the ridge between the two forks of the American river, which here are not more than three miles apart, the Calaveras formation ends a quarter of a mile to the east of Sheridan's Ranch. Between this formation and the Mariposa beds is here intercalated an elongated body of diabase porphyrite and volcanic breccias extending nearly across the divide. The diabase porphyrite forms the westerly summit of Mile Hill; in the breccia accompanying it some well washed pebbles of phthanite are found. A thousand feet west of Mile Hill toll house the Jurassic sedimentary rocks begin and continue for three-quarters of a mile eastward when basic igneous rocks again are met with. The exposures are at first poor along the road which runs in a flat, broad gulch with much loose soil containing well washed pebbles derived from the conglomerate. On the hill south of the United States ranch (E. 2200′) the conglomerate shows in abundant outcrops both on the top and in the ravines. North of the road, on top of Mile Hill there are more outcrops though deep laterite mostly covers the ridge. At the United States ranch there is a good outcrop, part of it consisting of a hard, dark tufaceous sandstone and part of a dark, soft shale containing small but well washed pebbles of phthanite. From the hill mentioned south of the ranch there is a steep descent to the Middle Fork, the sedimentary area narrows greatly between two igneous masses and only black slates and sandstones are exposed in the bottom of the canyon. On the north side of Mile Hill there is also a steep descent of 1500 feet to the North Fork; the conglomerate from the top of Mile Hill can be traced down

* Loc. cit., p. 245.

some distance over the slope although the identification is made difficult by sliding rock masses and dense brush. In the bottom of the canyon of the North Fork, however, the sedimentary series is excellently exposed and here the conglomerate may again be found, in particularly fresh condition. Along the river the series mostly consists of dark sandstones and slates; the conglomerate is less developed than on the ridge and the pebbles are somewhat smaller, but otherwise it is identical with that from the former localities. Further east up the river the before-mentioned breccias begin to appear in the series. The conglomerate from the river is a very hard, dark-colored rock composed of small but very smooth and round pebbles (max. diam. 1^{cm}) of gray, white or black phthanite, gray limestone, black slate and white quartz, the latter being least abundant. The cement is black in color and very fine in texture, apparently a consolidated mud. The conglomerate from the summit of the ridge, somewhat softer from weathering, contains pebbles sometimes reaching 4^{cm} in diam.; the quartz pebbles occur in variable quantities, occasionally very abundant. Phthanite and limestone always make the bulk of the pebbles.

This conglomerate has not escaped the sharp eyes of the prospectors of early clays and at three places at least shafts have been sunk in it. Considering the rock identical with the Tertiary, sometimes cemented, gravels found so abundantly higher up on the ridge their object in sinking these shafts was to attain the "bedrock" in the hope of there finding a paying deposit. Their efforts were in vain and abandoned long ago. One shaft south of the United States ranch was sunk 60′ deep about 40 years ago, also one of the shafts to the north of the road. The attempt was renewed about 20 years ago and the total depth attained in the north shaft about 80 feet. None who had been connected with the work could be found and conflicting reports were obtained as to whether any gold had been found in the conglomerate. It is said that the gulches in the vicinity had in early days yielded considerable gold in well worn grains and particles; the character of the gold would indicate that it had come from the conglomerate.

Numerous tests were made on specimens from three localities: first, rock extracted from the shaft south of the road; second, specimens from an outcrop about 300 feet west of that shaft, and third, rock extracted from the deep shaft north of the road on the ground belonging to the United States ranch. In none of these specimens could any seams or veinlets of quartz be seen, nor any indications noted that they had been subjected to the influence of auriferous solutions. A few pounds of each sample were repeatedly crushed in a clean

mortar and washed in a miner's pan; in all instances gold was obtained; the particles—colors—were very fine and flaky but concentrated easily; sometimes only one or two, sometimes a great number of colors were obtained. Beside the gold there was invariably some iron pyrites nearly always found in conglomerates and as well known resulting from the reducing action of organic substance on circulating iron salts. The absence of magnetic and titanic iron ores—black sand—was very noticeable. In order to obtain a better idea of the amount contained Mr. G. F. Deetken kindly made duplicate assays for me of specimens from the two shafts with the result that the conglomerate from the south shaft was found to contain in average 36¢ pr. ton in gold while a distinct trace was obtained from that from the north shaft.

From the general character of the occurrence I believe it represents shore gravels accumulated near the mouth of some river draining the Carboniferous area and emptying into the muddy gulf in which the Mariposa slates were deposited. It is not likely that the deposit will ever be of economic importance though there is a possibility that by thorough prospecting and cross cutting the strata a richer bed might be exposed.

Conclusions:

(1) The Mariposa beds were deposited unconformably upon the rocks of the Calaveras formation, then a land area of considerable extent. From the abundant presence of phthanite pebbles in the conglomerate it is certain that this older series was already at that time considerably altered though the large quantity of limestone also contained makes it probable that the metamorphic action has progressed much further in it since that time. From the absence of igneous rocks in the conglomerate, accentuated by the absence of "black sand" in it, it may be concluded that the numerous basic igneous rocks now contained in the Calaveras formation in this vicinity have principally been intruded after the deposition of the Mariposa beds.

(2) The old land area at that time already contained auriferous quartz veins, the detritus of which enter into the composition of the Mariposa conglomerate.

(3) There are in the Sierra Nevada primary auriferous deposits of very different age. The oldest antedate the Mariposa beds; the greatest number were formed at the close of the eruptive activity following soon after the deposition and upheaval of the Mariposa beds; the most recent, found along the summit and along the eastern slope of the range were formed towards the close of the eruptive activity in late Tertiary time.