CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1909.

PART I. METALS AND NONMETALS EXCEPT FUELS.

C. W. HAYES and WALDEMAR LINDGREN, *Geologists in charge.*

INTRODUCTION.

This volume is the eighth of a series that includes Bulletins 213, 225, 260, 285, 315, 340, and 380, "Contributions to economic geology" for 1902, 1903, 1904, 1905, 1906 (Pt. I), 1907 (Pt. I), and 1908 (Pt. I), respectively. These bulletins are prepared primarily to insure prompt publication of the economic results of investigations made by the United States Geological Survey.

As the subtitle indicates, the papers included are of two classes—(1) preliminary reports on economic investigations the results of which are to be published later in more detailed form; (2) short papers giving comparatively detailed descriptions of occurrences that have economic interest but are not of sufficient importance to warrant a more extended description.

These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded. They have been grouped according to the subjects treated and each group has been issued as an advance chapter as soon as it was ready.

By means of the bibliographies accompanying the several groups of papers these volumes also serve as a guide to the economic publications of the Survey and afford a better idea of the work which the organization is carrying on for the direct advancement of mining interests throughout the country than can readily be obtained from the more voluminous final reports.

The reports on work in Alaska have been printed in a separate series since 1905, the volumes so far issued being Bulletins 259, 284, 314, 345, and 379. Bulletin 442 (in press) covers the work done in Alaska in 1909.

Since 1906 the annual economic bulletin has been printed in two parts, the second part comprising papers on mineral fuels. These volumes for 1906, 1907, and 1908 are Bulletins 316, 341, and 381. Bulletin 431 will form Part II of the "Contributions" for 1909.

Brief abstracts of the publications of the year are given in the annual report of the Director. The complete list of Survey publications affords, by means of finding lists of subjects and of authors, further aid in ascertaining the extent of the Survey's work in economic geology.

GOLD AND SILVER.

NOTES ON THE PLACER DEPOSITS OF GREATERVILLE, ARIZONA.

By J. M. Hill.

INTRODUCTION.

The information contained in this report was obtained by the author in the latter part of March, 1909, while engaged in a mining reconnaissance of the Patagonia and Nogales quadrangles, Arizona, under the direction of Waldemar Lindgren and F. C. Schrader. The writer is under obligations to Mr. P. J. Coyne, of Greaterville, for much valuable information and assistance in the field, and to Messrs. Joseph Anderson, Daniel Johnson, and Hughes for historical data.

Greaterville is 5,280 feet above sea level. It is east of the Santa Rita Mountains, about 3 miles from the summit of Melendreth Pass, whose elevation is 5,850 feet. The Nogales branch of the Southern Pacific Railroad crosses the head of the Cienega drainage basin about 8½ miles southeast of the town. The wagon road from Greaterville to Sonoita, the nearest station on that road, is 13 miles long, running 7 miles a little south of east to Cienega Creek, thence following south up that valley to the station, a distance of 6 miles. A trail of a little over 9 miles connects the two points. Mail is received three times a week, brought on horseback from Helvetia by way of Rosemont, a distance of 14 miles by trail.

In the early part of 1874 the old Yuba mine at the head of Hughes Gulch was operated in a small way. Some cerusite containing silver and gold values is reported to have been rich enough to send to San Francisco and still net $90 per ton. The St. Louis lead mine was located a short time later and produced some ore. In the latter part of 1874 A. Smith found placer gold.[a] The discovery started a rush to this camp, and in 1878 there were 76 American voters regis-

[a] Raymond, R. W., Mines and mining west of the Rocky Mountains, 1875, p. 390.

tered, besides a population of about 400 Mexicans. The Greaterville mining district, according to Mr. Coyne, was organized March 17, 1875, but was never recorded with the county officials.

In 1876 Raymond[a] reported that the gold was coarse and that nuggets worth from $35 to $50 were brought in to Tucson, the average running from $1 to $5. The gold yielded from $16 to $18 an ounce, and it was not difficult for a man to clean up 1 ounce a day. The largest nugget ever reported from the camp weighed 37 ounces.[b]

The gravels were first worked by rocker, as water was scarce. A number of Mexicans made their living by packing water in goatskin bags from Gardner Canyon, 4 miles to the south, charging 25 cents a burro load of 10 to 16 gallons. Mr. Coyne states that by 1881 all the richer stream gravels had been worked over, and men began to leave the camp. Until 1886 the Indians also were to be reckoned with.

At about this same time (1886) the placers were considered worked out, and the rich gravels unquestionably had been greatly depleted. The camp from 1886 to 1900 was practically "dead." In the latter year a slight revival of activity was brought about by the installation of hydraulic mining in Kentucky Gulch by the Stetson Company. After sluicing for a few months, however, work was stopped, and the camp has been idle since.

In 1909 a few Mexicans made a meager living from some gulch diggings, and an American was operating a dry washing machine on a patch of high gravels without much success. From 25 to 30 cents a day at that time was considered good pay.

PRODUCTION.

In 1883[c] the yearly production since the discovery of the camp was estimated to have been about $12,000, and for 1884[b] the total production was $18,000. Mr. J. P. Coyné estimates the total production of a few of the gulches as follows: Louisiana, $40,000; Graham, $100,000; and Sucker, $500,000. He further states that the total production of the camp to date probably amounts to $7,000,000. This estimate, though much higher than Burchard's, was corroborated by several old-time miners, who have been in a position to watch the production of the district. It is possible that the large figure may include the production of the deep mines as well as that of the placers.

The United States Geological Survey obtains information from bankers, storekeepers, and other purchasers of bullion, from which estimates of the production of the various placer camps are made.

[a] Raymond, R. W., Mines and mining west of the Rocky Mountains, 1876, p. 342.
[b] Burchard, H. C., Production of the precious metals in the United States, 1884, p. 46.
[c] Idem, 1883, p. 80.

According to this information the placer-gold production of the Greaterville district for the period from 1902 to 1908, inclusive, is estimated to be $29,500, or an average of $4,218 a year. The production in 1902 was very high and so raised the average, which is usually about $3,000.

DESCRIPTION.

The Greaterville placer area is a rather flat country cut by deep arroyos and marked near its center by two rounded knobs.

From the summit of the Santa Rita Mountains, which opposite this place are rather low, there is a gentle but deeply eroded slope to the Cienega Valley, 9 miles to the east. A number of major gulches trend a little south of east. These are usually intrenched from 20 to 70 feet below the general level. The banks rise steeply, in places precipitously, so that it is difficult to travel either north or south without wide detours. All the arroyos have numerous branches, and the whole area is one of slopes.

There is almost no surface water, except in the rainy season, when it is found in most of the larger gulches. Shallow wells in Empire, Ophir, Kentucky, and Big gulches are used for local needs, but do not give a large enough supply even for rocker washing.

About 4 miles south of Greaterville, in the first canyon south of Gardner Canyon, there is a permanent stream, fed from springs situated under the crest of Old Baldy Peak, 7½ miles southwest of town in an air line.

GEOLOGY.

The areal geology of the Greaterville district, as shown on the sketch map (fig. 1), may be roughly generalized in the statement that there are three north-south belts (1) of granite, (2) of siliceous shales and sandstones, and (3) of wash materials and gravels, covering the area; that the structure dips eastward at relatively low angles; and that this structure is modified by two intrusions, one of granite porphyry as a stock, the other of narrow rhyolite dikes.

A very coarsely granular to porphyritic granite covers the western quarter of the area shown in figure 1, sending out a long, narrow tongue to the southeast at its southern end, along the south side of Fish Canyon. This granite is probably pre-Cambrian. It is intensely weathered to a dull yellow-brown, and its surface is covered with a coarse sand composed of quartz and pink feldspar particles up to one-half inch in diameter. The constituents in order of their abundance are orthoclase, plagioclase (not determined), quartz, biotite, hornblende. No fresh specimens of this rock were found, so little could be learned from thin sections. The general structure of the granite is a series of joints in a north-northwest to south-southeast direction, which cuts a sheeting that dips at flat angles eastward. In this granite there are numerous minor faults; one system strikes approximately east-west and the other parallel to the jointing. Some of these fault fissures are filled with quartz; at other places there is little to show their location. A few small rhyolite dikes were noted, their location being shown on the sketch map (fig. 1).

The southern limit of this granite is a fault that brings the granite against Devonian (?) limestone, though here and there a small crop-

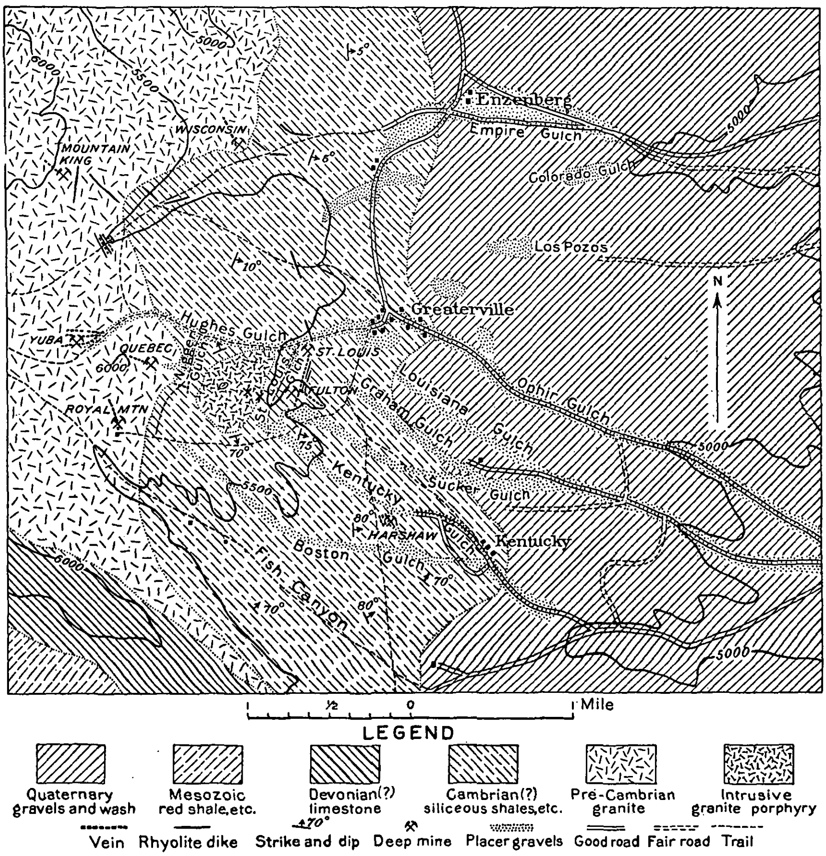

FIGURE 1.—Sketch map of the Greaterville, Ariz., placer camp, showing distribution of dikes, veins, formations, and placer gravels, and the location of deep mines and gulches. Topography enlarged from Patagonia sheet, United States Geological Survey. Contour interval, 500 feet.

ping of what is probably Cambrian quartzite is found between the two. This limestone forms a prominent ridge about a mile south of Fish Canyon (Big Gulch), running southeast for nearly 5 miles, only a small portion of which is shown at the southwest in figure 1. The beds, dark blue-gray, thin and occasionally cherty, dip steeply to the southwest and are not fossiliferous. Their age was suggested by fossils found in similar limestone about one-half mile south of the center of the area shown.

In the extreme southwest corner of the region covered by the sketch map is a small area of red sandstones and shales of Mesozoic, possibly Cretaceous age. These beds are thin and dip steeply to the southwest.

East of the granite belt is a zone about 2 miles in average width underlain by thin-bedded arkose, sandstone, dolomite, and mud stones or shales. At the north end they dip to the east-southeast at angles of 5° to 10°. At the south end, along the granite tongue, the dip is from 70° to 80° NE. In the central part of the area, about the intrusive mass of Granite Mountain, the general structure is very different, the beds everywhere dipping away from the intrusive dome at high angles. The colors in this belt range from almost black, for the dolomites, through dull greens and reds in the quartzites, sandstones, and shales. North of Granite Mountain, where the beds dip at low angles, there is a covering of soil, supporting grass, scrub oak, and a few pines. South of the mountain, where the bedding is almost vertical and there are many gulches, there is comparatively little soil and many exposures of the rock. Small dikes and sills of a dense white porcelain-like rhyolite cut the sedimentary rocks in many places, a few of which are shown on figure 1. The age of these beds is uncertain, but from their lithologic character and their relation to the granite, being deposited on its eroded surface, they have been referred to the Cambrian.

Eastward from the Cambrian belt and covering nearly half of the area of figure 1 is a broad soil-covered area of gravel and wash material of Quaternary age. The contact with the older rocks dips to the east at about 40° in almost all places. Where this contact is exposed in the gulches no conformity is shown, as the shales are thin bedded and dip at high angles to the east, while the younger deposit shows an imperfect bedding, dipping at very low angles in the same direction. It is composed of pebbles and cobbles of all the rocks exposed in the region, partly cemented by lime. It is rather white in appearance, as the constituent bowlders are coated with lime. Mr. Coyne states that a shaft was sunk through this deposit about a mile east of the contact for a depth of over 100 feet without encountering any other formation.

Covering the formations of the eastern half of the area there is a deposit of finer gravel and soil, probably of recent age. It overlaps on the ridges the tilted beds of the Cambrian (?) as well as the lime-cemented Quaternary, but has been carried away from the gulch sides to be deposited in their bottoms.

Besides the rather small rhyolite dikes and sheets there is one intrusive rock of prominence in the area. This forms "Granite

Mountain," a knob that rises to an elevation of 5,500 feet from the general level of 5,000 feet. This hill is about 1¼ miles west-southwest from Greaterville and is a rather conspicuous topographic feature of the region. The granite in hand specimens is white and appears to be made up of feldspar and quartz with a rather large amount of pyrite and a little chalcopyrite widely disseminated through it. It is in some places porphyritic, but more commonly appears granular In most facies a little biotite is present, but in some of the exposures the dark minerals are absent. The weathered surfaces are yellowish brown and contain casts of pyrite surrounded by brown halos. Under the microscope the texture is seen to be granular to slightly porphyritic. Alteration has gone rather far, chlorite and kaolin being common in all the slides. The minerals in order of their abundance are orthoclase, quartz, plagioclase (usually much altered), and biotite. A little magnetite is present as accessory and pyrite is disseminated throughout the rock.

This knob is entirely surrounded by thin-bedded silicified dolomites and hornfels. The contact is not visible at many points, but where seen in some tunnels on the north side of the hill it was sharp. There was, however, a zone of several feet in which the sedimentary rocks were impregnated with quartz, some calcite, pyrite, and chalcopyrite, the latter two minerals giving a dark-brown cropping stained with malachite and azurite.

DISTRIBUTION OF GOLD-BEARING DEPOSITS.

On the sketch map only the location of the placer channels is shown; no indication of their actual width could be made on such a small scale.

SITUATION OF DIGGINGS.

The principal diggings are in the bottoms of the gulches, though channels of older gravels are found crossing the ridges or on the sides of the present valleys. Just south of Greaterville and about 30 feet above the present valley there is a small area of high gravel, and northeast of the town a similar deposit is seen on the crest of the ridge. Westward up Hughes Gulch a few small remnants of the high gravels are seen 15 feet above the bottom on the north side of the gulch, below the mouth of Nigger Gulch. This old channel apparently followed a depression along the present drainage way to a point just west of Greaterville, then possibly swung north parallel to the road between Greaterville and Enzenberg and about 200 feet west of it, supplying the values of the west head of Chispa Gulch. The connection between the gravels of Chispa and Hughes gulches is not apparent, as the upper part of Ophir Gulch, west of Greaterville, is barren and no gravels seem to cross it. The intervening gravels, however, could well have been removed during the erosion of Ophir Gulch, which is one of the larger drainage lines. An east arm of Chispa Gulch, just south of Enzenberg, contains placer gold. This gold was evidently derived from a ledge on the divide between this branch and Los Pozos and Colorado gulches.

PRODUCTIVE GULCHES.

The productive gulches were Boston, Kentucky, Harshaw, Sucker, Graham, Louisiana, Hughes, Ophir below its junction with Hughes, the upper parts of Los Pozos and Colorado, Chispa on the road from Enzenberg camp to Greaterville, and Empire below its junction with Chispa.

Boston Gulch.—Boston Gulch heads in the col south and west of Granite Mountain and trends a little south of east. Gold was found in paying quantities in this valley from its head to a point about one-half mile south of its junction with Kentucky Gulch at the Kentucky camp. In the upper 2 miles of its course the gold was found in a channel 5 feet wide on bed rock, 2 to 4 feet below the surface. Below Harshaw Gulch the values were still confined in a 10-foot channel in the valley bottom, being 5 to 10 feet below the surface. Below the mouth of Kentucky Gulch the valley is wide, and for half a mile below this point the values were distributed on bed rock at a depth of 10 to 16 feet for a width of approximately 50 feet.

Harshaw Gulch.—Harshaw is a short tributary of Boston Gulch. It is very precipitous, heading near Kentucky Gulch. Bed rock is exposed all along and the pay channel was confined to the bottom of the narrow V, rarely over 4 feet wide. In this gulch some very rich gravels were found.

Kentucky Gulch.—Kentucky Gulch heads south-southeast of Granite Mountain and joins Boston Gulch at Kentucky Camp. Values were found on bed rock for its entire length in a 6 to 10 foot channel. At the upper end the auriferous gravels were directly on the surface, becoming deeper down the gulch until at its mouth the pay was 6 feet under the surface.

Sucker Gulch.—Sucker Gulch has three small heads southeast of Granite Mountain. The gravels in this gulch were productive to a point a little below its junction with Ophir Gulch. From its head to the mouth of Graham Gulch the pay channel was 6 to 9 feet wide and 3 to 12 feet below the surface. Between Graham and Louisiana gulches the pay channel averaged from 20 to 50 feet in width and the depth was from 12 feet at the former to 25 feet at the latter gulch. Below the mouth of Louisiana Gulch the values were found distributed through the gravels on bed rock for a breadth of 100 feet. The overburden at the lower end was excessive, so not a great deal of work was done.

About 10 feet above the present channel there are in a few places in the upper part of this gulch small "bars" of pay gravels. These were evidently accumulated by the stream at some time previous to its present period of erosion and are simply remnants of its old channel.

Graham Gulch.—Graham Gulch is a short branch of Sucker heading southwest of the St. Louis mine. The bottom is about 100 feet wide at its lower end, and the pay gravel covered the whole width on bed rock 12 feet below the surface. At its upper end the channel was 10 feet wide and was covered by about 6 inches of soil. Some gravels 15 feet above the present channel on the south side of the gulch were productive.

Louisiana Gulch.—Louisiana Gulch heads about one-fourth mile south of Greaterville, is a little over a mile long, and joins Sucker Gulch. At the head values were found almost at the surface, but near the mouth they were 10 to 12 feet below the surface. The channel in this gulch split and reunited, but was generally about 6 feet wide.

Hughes Gulch.—Hughes Gulch runs north of Granite Mountain, heading just south of the Yuba mine, 2 miles west of Greaterville. A narrow channel, rarely over 6 feet wide from its head to its mouth, was found productive at 2 to 6 feet below the surface.

Nigger and St. Louis gulches.—Nigger and St. Louis gulches are small tributaries of Hughes Gulch. The former is west and the latter east of Granite Mountain. Both of them contain small gold-bearing gravel channels.

Ophir Gulch.—Ophir Gulch heads northeast of the Yuba mine but contains no placer deposits above its junction with Hughes Gulch. Below Greaterville a channel 200 feet wide was found to contain values as far as the junction with Sucker Gulch. The bed rock is rather deep and little work has been done here.

Los Pozos and Colorado gulches.—The upper 3,000 feet of Los Pozos Gulch was found to contain placer values. This gulch heads about a mile northeast of Greaterville. Colorado Gulch, about one-half mile north of Los Pozos, is a short branch of Empire Gulch. For 2,000 feet near its head some gold was found at no great depth below the surface.

Chispa Gulch.—Chispa Gulch is a small branch of Empire Gulch heading southwest of Enzenberg. In the main gulch, about three-fourths of a mile south of Empire Gulch, the highest pay gravels were found. A 5 to 10 foot channel on bed rock, about 10 feet below the surface, was productive and was being worked by Mexicans in the latter part of March, 1909. In an east branch gold was obtained from gravels 3 feet under the surface for a quarter of a mile from Chispa. The western fork of Chispa Gulch is about 1 mile long. At the head pay dirt was directly on the surface. At the mouth a 50-foot channel on bed rock, with 10 feet of overburden, contained values.

Empire Gulch.—Placer gold in Empire Gulch was found only for a mile and a half below the mouth of Chispa Gulch. Near the mouth of the latter gulch the pay gravels were about 300 feet wide, but at the lower end the values were distributed over 1,000 feet. The overburden is 16 feet thick and the pay dirt 2 feet thick on a conglomerate bed rock.

CHARACTER OF GRAVELS AND BED ROCK.

The pay dirt is found on bed rock distributed rather evenly through a 2-foot bed of angular gravels in a fine red-brown, somewhat clayey matrix. Some of the gravels are yellow to gray-brown, but these as a rule were not so rich as the heavily iron-stained beds. The conditions were essentially the same in all the gulches, and the thickness of the pay varied little from place to place.

The constituents of this bed are rather fine, usually less than 1 inch in greatest dimension, though in many places cobbles of 4 to 8 inches are found. In a few places the materials of this bed are roughly stratified and somewhat cemented, usually by lime.

The constituent pebbles are very angular and show almost no water wear. Even the sand consists of angular broken fragments rather than rounded grains. The coarse material is red and yellow sandstone, shales of various colors, pebbles of arkose, a few fragments of dense white rhyolite, and a very minor amount of granite porphyry. In Kentucky and Empire gulches particles of quartz and feldspar showing crystal faces were noted, evidently derived from the granite area where these gulches head. These pebbles are held together by a red-brown clay, not very difficult to handle with water.

The depth of this bed varied in the different localities, being almost at the surface in the heads of the gulches and buried to depths of 10 to 20 feet in the lower eastern ends of the diggings.

The Cambrian (?) sedimentary rocks form a perfect bed rock in the upper parts of the gulches. The beds are standing on edge, and their differences in weathering, due to difference in hardness, have formed natural riffles, behind which the gold has been concentrated. In the lower parts of Kentucky, Sucker, Ophir, and Empire gulches the "cement rock" (the Mesozoic cemented gravels) forms the bed rock and its rough surface has acted as riffles. The bed rock in Colorado, Los Pozos, and Louisiana gulches is entirely "cement rock." This shows that the concentration of the gold has been at least later than early Quaternary.

CHARACTER OF THE GOLD.

Most of the gold from this camp brought from $16 to $19 per ounce, that from Louisiana Gulch being the finest. The gold that was washed in 1909 was in rather small flakes up to 0.1 inch in longest dimension. Some of it is rusty, but the largest part is bright. It is said, however, that in the early days of the camp the gold was very coarse and that pieces whose value was $1 to $5 were commonly found.

Under the microscope the flakes are seen to be very angular, with many projections which would have been worn off if the material had traveled far. One of the large particles contained a small crystal of quartz completely surrounded by gold. Another showed what appeared to be a little galena with the gold. Mr. Coyne states that in the large nuggets it was common to find this association of quartz and galena with gold.

Concentrates from panning consist of about equal parts of magnetite and light-colored minerals that are apparently quartz and a little feldspar. The light-colored grains are somewhat stained with iron. All this material is angular and a few crystal faces (?) of quartz were noted.

ORIGIN OF THE GOLD.

The most productive gulches, Boston, Kentucky, Sucker, Graham, Louisiana, and Hughes, all head about the intrusive mass of Granite Mountain. This intrusion, as already stated, is of granite porphyry containing pyrite and chalcopyrite in appreciable amounts. About its base, in the altered, crumpled sediments of the supposed Cambrian, are found numerous quartz veins carrying galena, pyrite, and chalcopyrite, which are reported to have produced surface ores rich in gold and silver. These veins have been opened at the Yuba, Quebec, and St. Louis mines, as well as in numerous other places. They show very similar characteristics in all exposures. A gangue of quartz, with barite in some places, is banded with argentiferous galena, pyrite, and chalcopyrite. These usually form a stockwork in hornfels, quartzites, sandstones, and shales. The ore is in places wide enough to be called a vein.

The surface ores are much iron-stained quartz with scattered patches of malachite, azurite, or yellow earthy cerusite. It is said that several nuggets of native gold associated with quartz and galena were found in the croppings, particularly in the St. Louis vein.

The weathering of these veins and the attendant transportation of the material by the present streams would adequately account for the concentration of the placer gold in the gulches. The gravels between the gulches, however, contain values which could be accounted for either by sheet wash or by the transportation of the weathered material before the present drainage lines were well established. Concentration by wash from the ridges into the present valleys would further enrich the gold-bearing channels. The complete concentration on bed rock, however, points to frequent movement along the present channels, shaking the gold to the bottom.

The origin of the gold in Los Pozos and Colorado gulches is not so evident, as no ledges have been found on the divide between them and Chispa Gulch. This area is covered by considerable accumulations of wash material, so that prospecting is difficult; and this fact may account for the lack of discoveries of veins in the vicinity. The gold in the west branch of Chispa Gulch may be accounted for either by supposing that the old Hughes drainage turned north at Greaterville to enter the larger drainage of Empire Gulch, or that there are some gold-bearing ledges, not yet discovered, on the divide between this west branch and Ophir Gulch. The validity of the latter supposition is affected by the fact that no values were found in Ophir Gulch above its junction with Hughes Gulch. It is possible, however, that the veins which supplied Chispa Gulch are so far north that none of the branches of Ophir Gulch touch them. The richness of the gravels of Chispa Gulch indicates a rather long period of concentration or very rich primary deposits, and as no veins have been found at its head the former supposition seems the more tenable.

The theory of the origin of the gold from the veins about Granite Mountain is further supported by the fact that in the upper part of Empire Gulch, to the north, and in Fish Canyon (Big Gulch), to the south, no gravels of value have been found. These gulches, the largest in the region, head in the Granite area. There are some few widely scattered prospects in the granite, but the veins apparently carried little gold, except in the Yuba mine.

Furthermore, the fact that the gravels of the placers are largely derived from sedimentary rocks instead of granite shows that the gold did not come from the region west of Granite Mountain.

METHODS OF WORKING THE DEPOSITS.

Water is extremely scarce in the Greaterville placer district, so the means of working the gravels are limited. Dry washing has not proved a great success, as considerable clay is found in the pay dirt. Rocking has been the chief method employed for the recovery of the values.

Small shafts, usually 2½ by 5 feet in cross section, are sunk through the overburden, where it exceeds 3 or 4 feet in depth, to the bed rock. The gravels next to bed rock and for 2 feet above it are gouged out and hoisted to the surface by crude hand windlasses. In some of the pits seen the gravels for a radius of 20 feet were excavated from one small shaft. No lagging was used and there was apparently a constant menace of caving.

When there was a sufficient accumulation of the bed-rock gravels to supply the rockers for a few days, water was purchased and the extraction of the gold commenced. Usually two men worked together, but often one man would break down, hoist, and rock his gravels alone.

Two larger undertakings in the way of placer operations failed, possibly because the concentration of the values on bed rock necessitated the handling of so much valueless overburden. One company installed a 1-ton steam shovel, screens, and conical concentrating tank in Empire Gulch just below Enzenberg. After excavating an area 50 by 100 feet to a depth of 20 feet operations were suspended, as the pay dirt was not rich enough to warrant the removal of the 16 feet or more of overburden. The machinery was left in the pit and is fast being buried by slumping from the sides.

In Kentucky Gulch, at its junction with Boston, the Stetson Company tried hydraulic operations. Water was taken from the first canyon south of Gardner Canyon and carried through an 8-mile pipe line giving a head of 125 feet. The company sluiced 1,000 feet of the creek bed for a width of 30 feet. The gravels in the overburden are rather coarse and the pay is reported to have been too low to warrant further work. The pipe line is still in good repair and the company put up very comfortable quarters at Kentucky camp. It is reported that the 3,000 acres of patented land belonging to this company has lately been acquired by G. B. McAvery, of San Jose, Cal.

FUTURE OF THE CAMP.

The richer gulch gravels of the Greaterville district have been worked over to a considerable extent, but it is possible that some pay channels have not yet been found. The ground that has been washed still contains some gold, as is shown by the production of the few Mexicans who are working in localities known to have been productive. The gravels on the sides of the gulch and covering the ridges also contain small quantities of gold. E. Ezekiel, a mining engineer, of Tucson, who has examined the gravel deposits for a company, states that in the 8 square miles covered by placer gravels there are still probably nearer $100,000,000 than $50,000,000 worth of gold.

The deposits can not be made to pay if worked on a small scale. Hydraulic or dredging in the wider and deeper gulches might possibly pay, but it is a question whether the concentration of the values on bed rock, the considerable overburden to be removed, and the scarcity of water will not greatly retard if not prohibit the future development of the Greaterville placer district.

GOLD MINING IN THE RANDSBURG QUADRANGLE, CALIFORNIA.

By Frank L. Hess.

GENERAL DESCRIPTION OF THE QUADRANGLE.

The Randsburg quadrangle is included between 35° 15′ and 35° 30′ north latitude and 117° 30′ and 117° 45′ east longitude. The town of Johannesburg, consisting of perhaps a score of houses, is almost in the center of the quadrangle, and Randsburg, with possibly 100 houses, lies a mile west. The two towns are separated by a hill between 150 and 200 feet high. Johannesburg is at the end of a branch of the Atchison, Topeka and Santa Fe Railway which joins the main line at Kramer, 28 miles south. The town is about 90 miles north and 30 miles east of Los Angeles, but the distance is 202 miles by the Santa Fe Railway; and to Rand, a station 5 miles north of Randsburg, it is 143 miles by the Southern Pacific Railroad, which has recently built a line across the quadrangle.

The area is part of the Mohave Desert and has an arid climate. The summer is long and hot, with occasional showers, the effects of which are soon lost through the strong winds and heat. The spring and fall months are often pleasant, but during the late fall, winter, and early spring there is much raw wind, which frequently is little less than a gale. Occasional light snows fall, which generally melt within a day or two. On December 20, 1909, 11 inches of snow fell at Randsburg, but in the valley on the north along the Southern Pacific Railroad there was only about 4 inches.

As would be expected from such climatic conditions, the country is dry, vegetation is scanty, and if a water level exists it has been found only in the basins into which the short periodic streams flow.

To judge from the topography of the country, a similar climate has been in existence here through a considerable length of time, for the present erosional forms have probably been shaped largely by weathering agencies similar to those now observed.

TOPOGRAPHY.

GENERAL STATEMENT.

There is much diversity in the topography of the area, owing to mountain-making and volcanic disturbances, faulting, difference in rock textures, and erosion.

The variation in altitude in the quadrangle amounts to about 3,000 feet. The lowest altitude, a little less than 2,300 feet above sea level, is about the middle of the west side. The highest point, Red Mountain, 5,270 feet above the sea, is 2 or 3 miles southeast of the center.

The main features of the topography are three mountain masses, occupying the middle, eastern, and northwestern parts of the quadrangle; a large valley lying in the area between the center and the west side; a long slope to Cuddaback Lake in the southeast; a smooth, rolling area in the south; and a long, gentle slope along the eastern three-quarters of the north side of the quadrangle.

MOUNTAINS.

The three mountain masses are ordinarily referred to as the Rand Mountains, the Lava Mountains, and the El Paso Mountains, from which the Summit Range extends easterly.

The Rand Mountains cross the edge of the quadrangle about 3 miles north of the southwest corner and run northeast 3½ miles beyond Randsburg. They rise with a gentle slope from the southeast almost or quite to the summit; but on the northwest side they drop steeply to the valley, which is 500 to 1,000 feet lower than points on the southeast side that are equally distant from the crest. Along the southwest 2 miles of the range the smooth, gentle slope from the southeast extends all the way to the summit; on the northwest side the declivity is steep and much dissected. Randsburg is situated in a valley in the Rand Mountains, about 3 miles from the northeast end. Johannesburg is located in a cut through the range, 1 mile east and a little north of Randsburg. Beyond Johannesburg the mountains do not stand so high above the surrounding country, and the actual elevation is also less. The main range extends several miles southwest of the quadrangle, gradually sinking to the general level. Nearly all the gold mines of the area, except some small placer mines, are located in this range or in a spur from it.

The Lava Mountains occupy the northern half of the east third of the quadrangle; south of the main body they swing toward the southwest and include the highest peak of the area, Red Mountain. Altogether they cover about 50 square miles, or nearly one-fourth of the quadrangle. In many places they have been sharply eroded, and though there are still some flat tops, in general traveling over them is rough and tiresome. Through much of their extent the mountains are composed of soft sandstone, clay, and tuff, overlain by lava flows and agglomerate. The washing away of the sandstone and clays beneath makes the lava break away, leaving precipitous faces. The arroyos and gulches are of the usual rough, steep forms found in dry lava-covered countries.

The Lava Mountains are connected on the northeast with other volcanic mountains, which extend to the east for many miles and include Pilot Knob, a landmark known all over this part of the desert. On the west lava débris has covered 8 or 10 square miles of country and now forms hills rising 200 to 350 feet above the surrounding valleys. When poured out, the lava ran over a hilly country, filling the valleys and flowing over the tops of the hills.

The El Paso Mountains run across the north end of the quadrangle about N. 80° E. On the west they coalesce with the south end of the Sierra Nevada and the Tehachapi Mountains. The valley along their south face, extending beyond Mohave southward toward Los Angeles, is followed by the Los Angeles aqueduct, now being constructed. The range is not simple but consists of a crooked mass, shaped somewhat like an irregular S, the upper part of which runs north to El Paso Peaks and Laurel Mountain (known to old settlers as Copper Mountain). A smaller range, known as the Summit Range, which at the east side of the quadrangle is partly covered by the lava flows, extends eastward from the lower part of the S. Just west of the quadrangle Goler Wash and an eastern tributary cut through the range.

FAULTS.

A very prominent fault follows along the south face of the mountains and crosses them about the middle of the quadrangle on the Kern-San Bernardino County line. The scarp of the fault can be seen from the south for many miles. It can be readily followed west of the quadrangle for a number of miles, and on the east it can be seen cutting across the end of the Slate Range, 20 or 25 miles away. At Garlock, about 2 miles west of the quadrangle, a large alluvial fan cut through by the fault shows a face 280 feet high (barometric measurement). From its prominence at this point the fault will be referred to as the Garlock fault.

Just within the quadrangle, near its western boundary, are two large depressions formed by the subsidence of the surface along the fault. One is about a quarter of a mile long, 600 feet wide, and 75 feet deep, and the other, half a mile east, is over a mile long, a quarter of a mile wide, and 50 to 125 feet deep. These blocks have dropped in comparatively recent years, though men who were in the country as early as 1863 state that the sinks were there at that time. The principal movement here has been downward on the south or valley side, but the movement along the fault has not been the same in all parts. At a number of places between these sinks and the point at which the fault crosses the summit the latest movement has been upward on the south side.

Smaller faults are innumerable, and on the northwest side of the Rand Mountains they may have had considerable to do with making the topography much rougher than that of the southeast side.

SLOPES AND VALLEYS.

The broad, gentle slope and the sandy valley to which the Rand Mountains sharply descend on the northwest side are striking features of the quadrangle. A surprising fact is that the slope is not everywhere deeply covered with débris. The débris in many places is shallow, and outcrops of solid rock occur here and there.

The large gently rolling area in the southern part of the quadrangle is entirely underlain by granite for several miles from the south side. The mass is somewhat wedge-shaped and in the middle is about 6 miles broad from north to south. Granite crops out in all the small rises and on the slope 2 miles south of Sidney Peak. At the point of the wedge the granite reaches within 2½ miles of Johannesburg. There are no deep watercourses across it, and the covering of débris is gradually finer at points successively farther from the hills. That the flats are very old is shown by the fact that 2 miles or more from the hills the low rounded eminences between the shallow watercourses are nearly covered with white quartz. The other rocks have decomposed and have been carried away by the occasional rain storms. The slope has evidently formed through the weathering of the rocks. On the more exposed surfaces the material has probably been largely removed by the wind, which carries the finer particles into the valleys, while the coarser particles are rolled to the foot of the sharper slopes.

The slope at the north end of the quadrangle is similar, except that it is heavily covered with débris, owing to the shattering of the rocks in the Summit Range adjacent to the Garlock fault and their subsequent conveyance down by water, and to the accumulation of material from a soft sandstone which at one time covered part or all of the area.

The valley north and west of Randsburg, lying between the Rand and El Paso mountains, is a fault valley and is deeply filled with débris. By far the longer slope is on the Rand Mountains side. For a mile or more from the base of the main mountain slope bed rock is exposed here and there, but farther away the rocks are entirely covered by the accumulated débris, which becomes gradually finer toward the middle of the valley. In the western part of the quadrangle south of a line one-half mile south of the Summit Range there is a belt of fine soft sand 2 miles wide. The valley is not symmetrical, owing to the fault on the north, which has let the valley floor down on that side in the western part. The upper part of the valley, above the point where the fault leaves it, shows no extraordinary development.

GEOLOGY.

The rocks of the quadrangle show considerable variety, but though two or three of the igneous rocks have rather exceptional structure there are no remarkably unusual types. Granite occupies the surface of nearly five-tenths of the quadrangle, lava over two-tenths, schists over one-tenth, partly metamorphosed limestones and other sediments less than one-tenth, and sand, with other unconsolidated fragmental covering, less than one-tenth.

GRANITES.

The two main granite areas have already been roughly outlined, one being a broad, wedge-shaped area in the south end of the quadrangle, with the apex about 2½ miles south of Johannesburg, and another extending from the Summit Range northward east of El Paso Peak to the edge of the quadrangle. There is also an intrusive granite which cuts across the Rand Mountains on the south side of Randsburg. It is about 4 miles long and one-half mile wide, forming four of the more prominent peaks. A part of this intrusion is so mixed with schist that it can be mapped only as a complex. This intrusive mass is probably younger than the large mass to the south, for the latter seems to be under and may be older than the schists of the Rand Mountains, whereas the granitic intrusion near Randsburg cuts the schist and probably the granite on the south. It has many phases and in places is basic. There are certain dikes which are orbicular diorites. These dikes have a black and white groundmass of basic feldspar and biotite mica, with round segregations containing a much larger proportion of biotite and small porphyritic feldspars. The segregations or orbicules range from 2 to 18 inches in diameter, but are mostly less than 6 inches. In places the orbicules are round and in other places lens-shaped. Between Caliente and Keene, 40 to 45 miles west of Randsburg, similar dikes, with the orbicules pressed into flat lenticles whose longest diameter is as much as ten times the shortest, appear at numerous places along the road.

The granite at Randsburg was not all intruded at one time, but the periods between the successive intrusions were very short, geologically. During the same period of time in which the granite was intruded many narrow porphyritic dikes of various compositions and textures were intruded. Some of the more acidic ones cut the granites and diabase dikes. In other places they are cut by the granite and by the diabase. At one place on the mountain south of Randsburg porphyritic fragments are cemented by a granitic rock, and on the west side of Red Mountain a granitic dike contains so many large porphyritic fragments that in some places it is difficult to tell which rock forms the dike and which are the inclusions.

Besides the intrusive rocks mentioned, there are near the old Hardcash mine on the northwest side of the Rand Mountains, between 3 and 4 miles southwest of Randsburg, greenstones in masses several hundred feet across. Other greenstones occur on the northwestern edge of the quadrangle, north of Goler. The granites in the northern and northeastern parts of the quadrangle are cut by basic dikes, generally only 2 or 3 feet wide.

SEDIMENTARY ROCKS.

The sedimentary rocks include the schists of the Rand Mountains, the less altered rocks in the northwestern corner of the quadrangle, and a much younger series of poorly consolidated sandstones and clays which crop out from under the lavas and which are also found at Summit Diggings and near the northwest corner of the quadrangle. The rocks of the Rand Mountains are mostly schists with minor interbedded quartzites and greatly altered limestones.

On the southeast side of the mountains and around Randsburg and Johannesburg the schists are thinly fissile and of a dull-gray color. They may be classed as mica-albite schists. The albite is in small knots, generally white and less than one-eighth inch across, but in many places contains so much graphitic matter that it appears black.

On the northwest side of the mountains the schists have, in general, a chloritic appearance, the albite crystals are larger, and the schist is coarser. They are probably lower stratigraphically than the gray mica-albite schists. In places there are beds of amphibolite schist, both light and dark, and some talc schist. The amphibolites are probably altered basic intrusive rocks. In many places the schists have low dips of 5° to 30°, but locally they stand on edge. The schists are so much faulted that an accurate estimate of their thickness can not be made. However, it is probably over 1,000 feet. The schistosity agrees with the bedding.

Interbedded with the schists are strata of pinkish or brown quartzite 6 inches to 6 feet thick, which, in places, show schistosity. In other places the quartzite contains manganese carbonate (on the Cock Robin claim 2½ miles south of Johannesburg) and manganese dioxide (5 miles southwest of Randsburg).

In a small valley 1 mile southwest of Randsburg, on the northeast part of the mountain between Randsburg and the valley, on the north side of the 4,150-foot mountain east of Randsburg and south of Johannesburg, and at other places, limestone 3 to 12 feet thick is found in close connection with the schists. Limestone is present also along the granite contact, under the schist south of the Blackhawk mine, and along the contact south of the Sidney mine. This may be in each place the same limestone, but it is less metamorphosed in most places along the southern border. The limestone is highly crystalline and shows no fossils.

Two miles north of Randsburg are gneissoid rocks, composed largely of white feldspar and chlorite, but not yet examined in detail, between which and the schists no break can be observed. On the other hand, no definite gradation can be observed between them and the more finely schistose rocks of the Rand Mountains, and until more data are at hand they will be considered as a coarser and probably a lower part of the schists.

Little is known of the age of the schists, and no schists similar to those of the Rand Mountains are known within many miles in any direction. So far as present knowledge goes, they form an island in a sea of residual sand. Inquiries were made of numerous prospectors acquainted with other portions of the adjacent desert, but none had seen or at least none had recognized the schists in other places. Prospectors are ordinarily very observant men, and in such a case as this would be sure to notice the fact if similar schists were seen in other localities, owing to the occurrence of gold within the Randsburg area.

The sediments in the northwest part of the quadrangle consist of quartzite, mostly very fine grained, but with a few beds of coarser material; siliceous shales; and limestones, most of which contain a considerable amount of impurities. The limestones contain much chert and in places are so siliceous that little calcium carbonate is to be seen. One bed of limestone is stained red with oxide of iron, so that it is noticeable for a long distance. This particular limestone is thinly bedded and probably about 200 feet thick. Other beds are from a few feet to 100 feet thick. The entire series is probably several thousand feet thick, but owing to folding and faulting it is so difficult to measure that probably no reliable figures could be obtained even in much greater time than was at the writer's disposal. The general strike of the rocks is about northwest, with dips largely to the northeast. A few of the beds are schistose, but they bear little resemblance to the schists around Randsburg.

Only two specimens resembling fossils were found. They were very indistinct, and the better one George H. Girty believes to be possibly a Paleozoic coral or sponge and probably not younger than Carboniferous. These are the only fossils found in the quadrangle.

The sediments of the El Paso Range can probably be connected with other sediments along the Sierra Nevada when the work of correlation is taken up in the field.

A mile and a half southeast of Johannesburg, on the west side of the railroad, is an outcrop of a coarse, very friable yellow sandstone, composed largely of small fragments of quartz, and larger pieces of granite which range up to 3 or 4 inches in diameter. The quartz particles are evidently from granite and are not well rounded. The large pebbles are mostly of pink granite, such as is found in the quadrangle only near the southern edge, a little west of the center, and are only fairly well rounded.

The sandstone has been lifted and then broken through by the lavas of Red Mountain, so that it forms an irregular border around the mountain. Beds of gray, buff, brown, and red unconsolidated clay occur interbedded with the sandstone, and at one place on the northwestern side of the mountain an 8-inch bed of gypsum is included. A mile and a half northeast of Skilling well a bed of gray, impure limestone, which seems to be in lenticular masses reaching 3 to 4 feet in thickness, is interbedded with the sandstone. The limestone has a peculiar nodular structure, like an augen gneiss, as if made up of small lenticles, 3 or 4 inches long by $1\frac{1}{2}$ inches thick. In weathering it leaves nodular pebbles an inch thick. Seven miles northeast of Johannesburg the sandstone forms a sharp yellowish-green peak. At Summit Diggings and in a hill three-fourths of a mile southeast of the Skilling well the sandstone has been changed to a quartzite by intrusive igneous rocks. In some places tuffs form the upper portion of the sandstone.

The sandstone is deposited upon the schists and granite and can be seen in contact with them 3 miles north of Johannesburg. That there was igneous activity during the deposition of the sandstone is shown by the tuff beds at the top. These are made up largely of fragments of pumice, probably rhyolitic, an inch or more in diameter.

The sandstone is probably a brackish-lake deposit and is to be correlated with similar deposits in other parts of the desert which are believed to be Tertiary.

LAVAS.

The lavas are largely andesites, with some basalt, but include more acidic varieties, rhyolite, and probably latite and dacite. There is some obsidian among them. Five miles northeast of Johannesburg fragments of the coarse basal part of the schists are included in the lava, showing that it must have broken through the schists. Fragments of the sandstone also form inclusions. In places there are large masses of broken lava solidly cemented, which, here and there, are colored purple and bright green.

FRAGMENTAL DEPOSITS.

The fragmental deposits, such as sand and gravel, cover considerable areas. As in many arid countries, the lack of streams to grind up and remove them makes the accumulations large, and the valleys are in some places deeply filled with débris. About 2 miles east of St. Elmo a shaft was sunk 250 feet without striking bed rock, though there is a granite outcrop halfway between St. Elmo and the shaft. In a low range of hills 2 miles north of Randsburg, in the small valleys tributary to the large one, shafts have been sunk more than 100 feet deep without striking bed rock, though it shows in the low hills on either side. Small valleys have been entirely filled and the hills on either side covered. At Goler the gravels are at least 800 feet deep, as shown by wells drilled by the Yellow Aster Mining and Milling Company.

On the north side of the valley between Randsburg and Goler there is a very large accumulation of débris, forming hills over 350 feet high. They extend halfway across the quadrangle to Summit Diggings. In them is a great quantity of lava bowlders, remnants of flows from Black Mountain, a few miles west of the north end of the quadrangle. The lava bowlders occur in patches over the summit of the El Paso Range. With the lava is a gravel foreign to the quadrangle, composed of well-rounded quartzite, granite, and intrusive rocks. Its origin has not been traced but seems to have been somewhere in the Sierra Nevada. A group of low hills over 2 miles in diameter north of the northeast end of the Rand Mountains is covered with lava débris from the east side of the quadrangle, and this débris also extends over the low hills 2 miles north of Randsburg. Only a small area of gravels, those located at Summit Diggings, are of economic importance.

HISTORY AND PRESENT CONDITION OF MINING.

Gold was discovered in Goler Wash, 9 miles northwest of Randsburg and a little west of the quadrangle, in the winter of 1893–94. Dry-washing camps soon sprang up there and in Last Chance Canyon, Red Rock Canyon, and Summit Diggings. The site of the last-named camp is in the quadrangle.

In 1895 the Yellow Aster mine was discovered by C. A. Burcham, John Singleton, and Fred Mooers, and other discoveries quickly followed. A railroad was soon constructed from Kramer, on the

Atchison, Topeka and Santa Fe Railway, to Johannesburg, and water was piped from wells 6 and 8 miles east and northwest.

At present there are possibly 700 people in the entire district. The Yellow Aster has been and still is the main mine of the quadrangle. A number of mines, after taking out fair ores near the surface, were unable to follow them downward owing to faulting, pinching of the veins, or impoverishment of the ores, and have been abandoned.

The mines, including the dry placers, have probably produced between $9,000,000 and $10,000,000, of which the Yellow Aster mine has taken out about $6,000,000.

During 1908 the mines of the quadrangle produced $656,560 in gold and $5,321 worth of silver.[a] All the silver was contained in gold bullion. Not counting impurities, these figures indicate a bullion fineness of about 751. The bullion of the Yellow Aster mine averages about 790 fine.[b]

A number of the smaller mines are worked by the leasing system, paying from 10 to 25 per cent royalty, generally after deducting milling charges, but sometimes gross. Twenty-five per cent royalty is probably in each case more than should be paid, and makes mining too hazardous for the lessee. It is usually paid where a lessee has made a fair profit at lower royalty and someone else, desiring to get the same lease, offers a larger one. The owner is then apt to demand a still higher royalty, to the loss of the lessee.

Besides the Yellow Aster's stamp mills, with 100 and 30 stamps, there are the Phoenix, 6 stamps; Red Dog, 10 stamps; Sunshine, 3 stamps; Ostick & Renne, 3 stamps; Blackhawk, 10 stamps; and Little Butte, 2 stamps. The last two are not operated. All of these work on custom ores except the Yellow Aster and Sunshine mills, which work only ores from their own mines. The Atolia Mining Company has a 5-foot Huntingdon mill which is used only upon scheelite ores.

Half a dozen men still work in the placers, making slender "grub money."

In what is known as the Rademacher district, which includes El Paso Peaks, Laurel Mountain, and the adjacent country on the north, considerable prospecting has been done for a number of years and a little is still carried on, but there has been no output.

GOLD DEPOSITS.

DISTRIBUTION.

Most of the gold deposits of the quadrangle lie in the schist area, along the Rand Mountains, reaching their greatest development in the Yellow Aster mine at a place where a granitic intrusion crosses the

[a] Mineral Resources U. S. for 1908, pt. 1, U. S. Geol. Survey, 1909, p. 336.

[b] Burcham, C. A., president Yellow Aster Mining Co., in letter dated April 21, 1910.

axis of the range. Along both sides of the range, southwest from Randsburg, are other gold deposits, but those on the northwest side of the range have so far produced very little ore. Cn the southeast side of the range a number of mines have been and are being profitably worked. There are also a number of mines in the schists within a radius of 1½ miles north and east of Randsburg.

Outside of the schists of the Rand Mountains the St. Elmo mine, located in the granite 5½ miles southeast of Randsburg, has produced some gold. Six miles north by east of Randsburg, at Summit Diggings, a few thousand dollars has been taken from gravels in the sandstones surrounding an intrusive mass of hypersthene-hornblende andesite which has locally metamorphosed the sandstone into quartzite. No veins have been found in the vicinity. Three miles northeast of Summit Diggings, on the north side of the Summit Range, veins an inch or so wide have been discovered which carry gold, silver, and copper, but there has been no production from them.

On the north side of El Paso Peaks and on the north and northeast sides of Laurel Mountain a little gold has been found in narrow veins with copper minerals, but no ore has been produced. Scheelite occurs in small amount with the gold ores in a number of the mines in the Rand Mountains, and a mile north of St. Elmo, at Atolia, are mines which are probably working the largest and purest scheelite deposits known.

YELLOW ASTER MINE.

GENERAL DESCRIPTION.

The Yellow Aster was the first "hard-rock" gold mine discovered in the quadrangle, and for ten years it has been one of the largest gold producers in California. It is at the head of a gulch running northeast from a peak at the northeast end of the main body of the Rand Mountains, a little over one-half mile northeast of Government Peak. A crescent-shaped mass of granite, described on page 27, here cuts across the mountains.

The principal level of the underground workings, known as the Rand level, is about 500 feet below the top of the mountain. The Glory Hole, from which practically all of the ore mined was being taken at the end of 1909, opens from the gulch 105 feet above the Rand level. The granite is intrusive in the schists and occurs in many dikes, which show a close relationship petrographically, though there is a wide difference in their general appearance as casually examined, owing to their varying degrees of decay and alteration. The granite in the mine carries biotite and is rather fine textured. In places the biotite forms irregular segregations from one-fourth inch to 2 inches in diameter. The feldspars are white, buff, and pink, and in some places where the granite is fine grained there are small porphyritic white orthoclase feldspar crystals one-eighth to one-fourth inch in thickness. In places some hornblende has evidently been contained in the granite, its former presence being indicated by aggregations of small particles of magnetite whose general outline corresponds to a cross section of hornblende.

There are also porphyry dikes cutting both granite and schist, but they are older than the ore bodies, which pass through them. Where found in the mine, the granite porphyries are light colored and show little or no mica or hornblende, though it is probable that the lack of biotite is due to its decomposition. The groundmass is of fine-grained orthoclase. The phenocrysts are of microcline and orthoclase with here and there a small quantity of lime feldspar. The phenocrysts are generally not over one-eighth inch in diameter. The granite masses range in thickness from a few inches to several hundred feet. They are evidently branches from a larger body and may come together below.

The prevailing dip of the schists on the top of the mountain is nearly flat, but locally the schists lie at all angles and dip in many directions. Similar variations of dip and strike are seen in the mine. The schist is thinly fissile except near the larger granite masses, where it is locally so compact that it is difficult to distinguish from a dark granite. This appearance has given rise to a belief that the schists are crushed igneous rocks.

At a few places the schists are very siliceous and have probably been formed from quartzose sediments. The schist carries much mica and feldspar, which show that the original sediments contained a considerable quantity of clay.

There is a noticeable absence of visible quartz in the mine. In many places the schists contain large lenses of white quartz, but it is practically barren, and in the few places where massive quartz is found in the mine it does not carry values.

ORE BODIES.

GENERAL TYPES.

The gold deposits found in the Yellow Aster mine are typical of those found in many other mines of the vicinity and will, therefore, be described in some detail.

There are three types of gold-bearing ore bodies in the Yellow Aster mine:

1. Deposits along faults in crushed schist and granite.
2. Stockworks in granite.
3. Fissure veins, with more or less quartz.

In only two or three other mines of the area is there more than one type of gold deposit, and no other has all three types. The three types, though distinct for the most part, in places grade into each other. Very little visible gold is found in the mine, and that little is mostly in small particles. There is a remarkable lack of other metallic minerals. A little pyrite and arsenopyrite, iron oxide derived from them, and some scheelite are the only ones certainly identified, though it is reported that some pannings show a heavy mineral of a light-yellow color which may be wulfenite. Quartz is present in noticeably small quantity. There is some calcite in the veins, which crystallizes in peculiar flattened forms.

FAULT LODES.

The faults were probably caused by the stresses accompanying the intrusion of the granite. They are probably nearly all normal or gravity faults, but the amount of movement is not known in any ore-bearing lode. The movement has been, in each fault, in different directions at different periods, and these directions vary from vertical to horizontal.

On the Rand level the main fault is followed by the Jupiter drift, running N. 80° W., with many minor curves and variations in its course. The fault will hereafter be called the Jupiter fault. The gulch cuts through the fault at the Rand level, where the fault turns and runs about S. 70° E. The dip is from 27° 30′ to 44° to the north and east, but it is less toward the bottom of the workings, 300 feet below the Rand level. The dip is wavy, as is the strike of the fault.

The fault is slickensided in many places on both sides, and accompanied by crushed material from 2 to 80 feet thick. The greatest thickness is in the 100-foot level. The rock is not all crushed fine, but the fault branches with finely crushed material along each part, and the rock between the lesser faults is badly broken. The fault cuts both schist and granite. In both rocks the comminuted material along the fault is so fine and decomposed that in many places it is almost impossible, without much work and careful observation, to tell whether the material is schist or granite.

As would be expected, especially when the diverse movements that have taken place are considered, there is great shattering of the rocks and many minor faults with much slickensiding where the fault turns. Probably the deep gulch at the particular point where the mine is located is due to the shattering caused by the change of direction in the fault.

A great deal of work has been done along the fault. Various levels and stopes follow it to the top of the mountain, and below the Rand level four levels were worked. The amount of ore extracted decreased as the depth increased, and little was done on the Fourth level. Below the Third level the quantity of crushed material along the fault decreases considerably, iron and arsenic pyrites appear, and gold values decrease.

Below the Rand level large chambers were taken out in granite lying in the fault zone. One square-set stope on the first (100-foot) level was over 100 feet long, 50 feet wide, and probably 40 feet high. The gold in this stope is said to have been coarse, in places reaching the size of wheat grains. The ore is thought to have averaged $10 per ton.

Above the stope a sill of granite has been forced between the folia of the schist, which here has a dip of 30° NE., and part of the sill has been taken out for ore. Where the granite is ore bearing it is soft, the biotite is bleached, and the feldspars are sericitized.

Masses of granite have been mined in the Second and Third levels, which are probably part of the same body that was mined in the First level. The workings on the Fourth level were filled with débris and could not be entered, but a small square-set stope is reported to have been taken out of granite.

Near the top, on the northwest side of the hill, several other faults, approximately parallel in strike to the northwest limb of the Jupiter fault but with different dips, have been followed by the workings. Their differing dips cause them to coalesce, and they are probably joined to the Jupiter fault. On the southeast side of the gulch a considerable amount of work has been done along the Jupiter fault. The latter work was done a number of years ago and is now largely caved.

Two other fault zones have also been worked on the southeast side. One, which will be called the K. P. fault, from the name of a stope along it, is about 300 feet southwest from the Jupiter fault. It strikes northwest and dips at various angles. Near its junction on the northwest with a large shattered granite mass the dip is about 30° NE. Toward the southeast the dip steepens nearly to 60°. Some ore has been taken out along its course, but it has not been a large producer.

About 75 feet farther southwest is another fault which will be referred to as the Oriental, from the name of the drift following it on the Rand level. In its general strike the Oriental fault is nearly parallel to the Jupiter fault south of the gulch, and the dip is in the same direction. It has been followed for over 1,000 feet, and at the southern end it is very irregular in direction, is split up, and shows signs of either changing its direction or dissipating into a number of small faults. A stull stope 5 to 18 feet high, reaching nearly to the surface, has been taken out along it.

What the ore has averaged is unknown, but part of it has been of low tenor—less than $2 per ton. It is probable that the ore lies in lenses in the crushed fault zone, as in other mines working similar lodes, and that much of the rock taken out carries practically nothing.

STOCKWORKS IN GRANITE.

The second type of ore deposit in the Yellow Aster mine is made up of comparatively large bodies of granite, which are shattered and impregnated with gold along narrow cracks forming complicated reticulations or stockworks.

The biotite of the granite has been bleached and the feldspar is considerably decayed. Gold is not found in paying quantity where the granite is not largely decomposed, but on the other hand there is no assurance of gold where the granite is decayed. In the lower levels, where oxidation is not so far advanced, there is a considerable amount of arsenopyrite in the rock, and in some drifts the garlic-like odor of oxidizing arsenic is noticeable.

On the Rand level two large square-set stopes, the East sets and the West sets, have been taken out from stockworks. They lie about 500 feet southwest (into the hill) from the point where the Jupiter fault crosses the gulch and almost form a chord to the crescentic fault.

The East sets have a length of about 265 feet and a maximum width of 95 feet and are said to be 50 or 60 feet high. They have a strike between N. 75° W. and N. 80° W. The sets have largely been filled with waste, so that the upper sets are not accessible, and the mine maps show no cross sections.

The West sets are 340 feet long, have a maximum width of 50 feet, and reach upward to the bottom of the Glory Hole, 105 feet, and strike nearly northwest.

The two stopes are in the same mass of granite, 150 feet of which lies between them. It is said to be a low-grade ore.

The West sets are roughly parallel to that part of the Jupiter fault which is southeast of the gulch and the East sets are more nearly parallel to the part northwest of the gulch.

Below the Rand level large square-set stopes which extend to the First level have been taken out in the granite mass. They are not so large as the stopes in the granite on the Rand level.

Strong faults with a stiff clay gouge bound the northeast side of the granite in the West sets and dip 45° to 50° NE. In places the gouge is damp, possibly from leakage of water in the open cut above. The Nero stope, which extends from the Rand level to the First level, follows the fault.

It is not known just what the value of the ore taken from the stopes in the granite has been, but it is believed to have been from $4 to $5 per ton in the East and West sets and probably about the same in the other stopes. There have been places where the values were considerably greater, but the figures given are probably near the average values.

On the Second level only comparatively small stopes have been taken out in the granite, and on this level the stoping is along a fault dipping 50° N. 27° W., the ore lying both above and below the fault. The strike and dip of the fault are probably local, and it seems likely that the general direction of dip is N. 20° to 45° E.

Stopes in the granite have been taken out in the 70-foot and Trilby levels, 53 and 105 feet, respectively, above the Rand level, but they are not so large as the East and West sets. The granite is said to have been worked also in a still higher level, which is now caved and can not be entered. Near the top of the hill some work has been done in shattered granite, but compared with that described it is not extensive.

FISSURE VEINS.

Lying within the curve of the crescent-shaped Jupiter vein, between it and the granite, are two nearly vertical veins known as the Jake Price and the Rand Vertical veins, striking about northwest. On the 100-foot level they are 65 to 110 feet apart, the Jake Price being the nearer to the Jupiter fault, from which it is about 220 feet distant. On the Rand level there is little to be seen of the Jake Price vein. Above the First level the two veins lean toward each other so that they are only a few feet apart at the Rand level.

The Rand Vertical vein runs above the Rand level and joins with the Jupiter fault. At the junction and above it some rich ore has been taken out. The veins have been stoped continuously from a point below the 200-foot level to the Rand level, and the Rand Vertical for perhaps 50 feet above to the Jupiter fault.

Both of the veins are in narrow shear zones that lie mostly in granite dikes but also cut the schist. The cracks of the zone are considerably iron-stained, but no other mineralization is visible. There is some bleaching of biotite through several feet of granite along the vein.

Parts of the veins have been rich, yielding ore reported to be worth over $100 per ton.

The Rand Vertical, below the Second level, follows a granite dike and has been followed downward by a shaft for more than 150 feet. In many places the dike is only 3 or 4 feet thick, and at the depth mentioned it dips into the wall to the north. An attempt to find it by a crosscut 50 feet below was unsuccessful.

Several other fissure veins similar to the Rand Vertical and Jake Price are exposed in the Glory Hole. The richest of these strikes N. 32° W. and is vertical. Others are said to be approximately parallel to this one, but they could not be identified. This vein differs from those described in that it carries up to 3 inches of impure quartz, which in places shows visible gold. The quartz is by no means continuous, even where the vein contains good values in gold. The veins cut both granite and schist.

Another vein that is similar but contains little quartz occurs in a drift running southeast from the Jupiter drift on the Rand level. The vein is in fact merely a series of cracks formed by a shear zone and shows little or no silicification. The cracks cut through a white granite porphyry dike, but the zone is somewhat narrower in the dike, owing to the great resistance of that rock to shattering. No instance of a dike cutting the ore is known in the mine, but in a number of places the ore cuts through dikes, always with much less mineralization, owing to the greater freshness and hardness of the dike matter.

MINING.

There are estimated to be between 12 and 15 miles of drifts, tunnels, and shafts in the Yellow Aster mine, but at present practically all the work is being done in the Glory Hole, and it is the intention to work the mine hereafter entirely by open-cut methods. The grade of the ore mined is thus reduced, but it is estimated that it can be kept high enough to yield a profit. A tremendous amount of overburden must be removed and much nearly barren material must be milled, but the cost of mining is low.

OTHER MINES OF THE FAULT-LODE TYPE.

Across the valley, northeast from the Yellow Aster mine, are four mines located upon a fault that strikes northwest and dips 30° to 75° NE., with many local variations in dip and strike. A diabase dike, from 15 to 40 feet wide and a little more than a mile and a half long, runs along the course followed by the fault. In some places it is cut by the fault; in others sills from the main dike run along the fault, and the fault shows that movement has taken place along it since the intrusion. The diabase both cuts and is cut by granite porphyry dikes. It is, therefore, contemporaneous with the porphyritic intrusions and with the faulting, having been later than the first breaking of the fault, but movement in the fault continued after the intrusion of the diabase.

The gold deposits of the mines along this fault belong to the fault-lode type. From northwest to southeast the mines along the fault are the Little Butte, credited with an output of $35,000, and now unworked; the Kenyon, or "400;" the Butte Wedge, which, in conjunction with the Kenyon, is reported to have produced $500,000; and the Butte, reported to have produced $525,000. Still southwest of the Butte are the Philadelphia Wedge, Jenny Lind fraction, Hector, and Magpie claims. Some ore is said to have been taken from each of these.

There is somewhat more quartz in the fault matter in these mines than in the Yellow Aster. The distribution of values is exceedingly erratic and the ore is ordinarily in lenses, which may be either rich or poor, large or small. One lens in the Kenyon was 10 feet thick and averaged $100 to the ton. It was 40 to 50 feet wide. Other lenses are only a few inches thick and a few feet long. The material on either side, so far as can be told by the eye, may be precisely similar but almost or totally valueless. To show how erratically the ore occurs, Percy C. McMahon stated that although over half a million dollars in gold had been taken out of the Butte in the twelve years he had been connected with the mine he had never seen over $5,000 worth of ore in sight at one time. This was not due to lack of development, for hundreds of feet of drifting and exploratory work had been done, but to the distribution of the values in irregular and almost isolated lenses. At a depth of 520 feet along the incline, or a vertical depth of probably about 300 feet, a good shoot of ore was struck 450 feet northwest of the shaft and was stoped out to the 400-foot level, giving from $35 to $87 in gold to the ton. At this depth the crushed fault material is 1½ to 2 feet thick and carries pyrite and arsenopyrite.

A rich stringer of ore found 300 feet southeast of the shaft cut across the fault and carried $200 to $300 a ton. Only about $1,200 was obtained from it.

It is very probable that there is a similar distribution of the gold in irregularly sized lenses in the Yellow Aster fault lodes, but the system of mining on a large scale and of assaying from the bulk mined does not show it so plainly.

A mile directly north of Randsburg and also 1½ miles north, C. E. and J. Jeffords have mined upon similar faults. On the claim nearer Randsburg, known as the American, the principal workings are on a fault striking N. 20° to 30° W. and dipping about 40° E. The claim farther north and others in the vicinity are in comparatively flat ground known as the Pumpkin Patch and are all along similar faults. They have produced a few thousand dollars in gold, but none are now being worked, as the paying ore near the surface was soon taken out.

At Johannesburg the Phoenix (formerly known as the Val Verde) and the Pinmore or Penimore are working upon fault lodes similar to those of the Butte and Yellow Aster. In the Phoenix both diabase and granite porphyry dikes have been intruded along the fault. The granite porphyry dikes have been greatly squeezed. The diabase dikes are less disturbed and are evidently later.

In the Pinmore the faulting is very complicated. The mine is partly caved, and there are no maps, so that the system of faulting was not solved. Southeast and south of Randsburg the Rattlesnake, Gold Bug (or, as it is generally referred to, the G. B.), Baltic, Blackhawk, Gold Coin, California, Nancy Hanks, Big Horse, Josephine T. G., Golden Link, Hard Cash, and some others are located on similar faults and have produced more or less gold. In the Baltic ores said to carry about $7 a ton were taken out in one stope, which was 24 feet high and 60 to 70 feet broad. Scheelite is said to show in most of the pannings from the mine, and a ton was taken out in one place. It is also found in the G. B. and other claims. The Gold Coin has fissure veins besides fault lodes and will be referred to later. The Hard Cash is on the southwest side of the mountains and unsuccessfully attempted a dry-separation process.

The lode on the Buckboard claim, 2½ miles in a direct line west by south of Randsburg, may be classed with the fault-lode type of deposits, though it shows characteristics of the fissure-vein type. The deposit is along a fault with a dip varying from nearly flat to 35° N. 40° E. The fault is smoothly slickened in places, and the striæ form a downward-opening angle of 15° to 45° southwest of the dip. A fine-grained light-colored dike, with no porphyritic crystals, follows the fault so far as exposed on the upper side of the vein matter. The dike, though somewhat broken, is not much crushed. In places it is 4 feet thick and at other places pinches out. A small, more basic dike shows in a few places.

The vein matter is quartz, and apparently it replaces the schist crushed by the fault. The quartz is everywhere impure and porous, but in general is comparatively white. At one place about 200 feet down the incline from the mouth of the shaft the vein is 15 feet thick. In other places it pinches or degenerates into mere stringers in the schists. There are many small pseudomorphs of hematite after pyrite or arsenopyrite; it is not clear which, but probably both are replaced. The inclined shaft follows the fault about 300 feet. Near the bottom the vein is smaller and less oxidized, and arsenopyrite is sprinkled through the crushed material.

In the ore on the dump a piece from an albite feldspar vein 2 inches thick was picked up. While this was not found in place and it has schist on both sides, it seems to indicate a relation between the lode and the fissure veins of the Stringer district. The albite is totally different from the dikes along the lode or in the vicinity.

A thousand tons of ore from the Buckboard was hauled to Johannesburg for milling tests and is reported to have run $6 a ton.

OTHER GOLD DEPOSITS OF THE STOCKWORK TYPE.

The only gold deposits of the stockwork type in the quadrangle besides those of the Yellow Aster mine are on claims adjoining the Yellow Aster properties on the northwest. So far very little or no ore has been taken from them. The granite is said to carry $4 or $5 per ton. To pay, it would have to be worked on a large scale; and as water would have to be obtained—a very expensive undertaking—

with the present showing it probably would not pay. Some good ore is reported to have been taken, in the early days of the camp, from similar deposits on claims lying about three-fourths of a mile west of the Yellow Aster.

OTHER GOLD DEPOSITS OF THE FISSURE-VEIN TYPE.

The mines of the quadrangle which work fissure veins are located in what is known as the Stringer district, along the southeastern side of the Rand Mountains, from 1½ miles south to 4½ miles southwest of Randsburg. They are comparatively small mines, working veins which, though generally narrow, are in places rich. The district receives its name from the narrowness of the veins.

SUNSHINE–LA CROSSE VEIN.

The vein upon which the Sunshine and La Crosse mines are located is probably the best known and will serve as an example. The mines are 1½ miles south of Randsburg. The Sunshine is on the south side of a shallow valley and the La Crosse is a few hundred feet west, on a small hill. The vein strikes from N. 80° E. to east and west and is practically vertical. It is said to dip 5 feet south of the vertical in a depth of 450 feet. The country rock is gray mica-albite schist, which strikes N. 10° E. and dips 70° to 80° E. The vein is in places as much as 8 or 10 inches thick, but is ordinarily less. From 2 to 6 inches may probably be set down as the average thickness. It is comby; that is, quartz crystals have grown from the sides and the combs have grown together and interlocked until the vein is nearly solid. In only a few places are there vugs in which the quartz crystals retain their individuality. The crystals are in most places very slender, not over one-eighth inch in diameter by an inch or more in length. A very few stout crystals in which the diameter approached the length were seen. Gold is visible in the vein in many places, and is either alone or intergrown with small crystals of arsenopyrite, with intergrowths of arsenopyrite and galena, probably arsenopyrite and zinc blende, arsenopyrite and chalcopyrite, and possibly arsenopyrite and some other mineral. The mineral masses are almost all under one-eighth inch in diameter, and at no place do they form any considerable part of the vein. Each of the minerals occurs alone, as well as intergrown with others. Traces of tellurium were identified in the ore by Chase Palmer, of the United States Geological Survey, but no tellurium mineral has so far been identified. Commercial chemists have also reported tellurium in the ore. Small hairlike crystals of rutile have been found in the vein at one point.

The largest aggregates of gold seen in the quadrangle were taken from the 350-foot level of the Sunshine mine. Two pieces, thought to weigh about 3 ounces each, were made up of small crystals of gold.

The individual crystals were from one thirty-second to one-sixteenth of an inch in diameter. In one piece part of the crystals show one pyramid of an octahedron; others have the edges of the pyramid truncated; others appear to be a cube attached by one corner with the diagonal corner truncated; still others are flattened into plates three-eighths of an inch broad by one thirty-second of an inch thick. All are striated. In the second aggregate the crystals appear round at a casual glance, but are made up of minute plates, much striated.

The minerals enumerated are plainly original in the vein. On the 350-foot level there is a little pyrite which is probably secondary and has been formed from the breaking down of the arsenopyrite. It may also occur on other levels, but none above the 300-foot level could be examined. The vein has been stoped from the 400-foot level (which is said to be really 425 feet) to the surface, though not through its whole length. Some parts of the vein were too poor to work, but they formed the lesser part. Such a barren place was found 175 feet east of the shaft, but it was only 14 feet wide along the vein, and after this was passed the values were found as before.

It is estimated by the lessees that to be profitable the vein must carry $25 in gold per ton and be 6 inches wide. As much of the vein is only 2 or 3 inches wide, it must carry much more than $25 in gold per ton.

The total length of the vein, as shown by the workings in November, 1909, was about 500 feet. At the west end it pinched just east of the La Crosse shaft. On the east end it is cut off by a fault, beyond which it has not been traced.

The vein is crossed by a number of faults which offset it a short distance and by others which, as far as prospecting at that time showed, cut it off completely at both ends. On the west end it is cut off 57 feet from the shaft on the 400-foot level by a fault dipping about 50° SE. The direction of movement could not be ascertained. The vein strikes N. 75° E. at this point. On the east side, 230 feet from the shaft, in the 400-foot level, the vein is crossed by a smaller vein carrying very low values, running north-south, which pinched within 10 feet to the south. The cross vein followed a vertical fault zone. No effort has been made to find the main vein on the opposite side of the fault. The vein was being prospected by deepening the shaft at the time it was visited (the first part of November, 1909) and it was reported that the vein was cut off below the 400-foot level, probably by the same fault that cuts it off on the west. The vein itself crosses a number of faults, which show as much as 6 or 8 inches of crushed materials.

OTHER VEINS IN STRINGER DISTRICT.

Other veins of the same type occur in the Stringer district on the Winnie, Napoleon, Santa Ana, Pearl Wedge, Merced, Royal, Corona, Sidney, Yucca Tree, Bully Boy, Golden Link, and other claims that are not worked.

The Napoleon is reported to have yielded nearly $1,000 per foot from a shaft 100 feet deep, but this seems to have been its richest part and it was not being worked when visited.

The Winnie was the first of the "stringer" claims discovered. At one place the quartz was 2 feet thick and gave $140 a ton on the plates. This was both the thickest and the richest part of the vein. Where worked in November, 1909, the vein was split into four or five branches, from 1½ to 3 inches thick and spread through 3½ to 4 feet of schist. The ore here yielded about $50 per ton on the plates. The quartz is said to show a small amount of scheelite upon panning, but the tungsten mineral is nowhere visible. On the same claim is another vein which carries scheelite and from which several tons have been taken. The characteristics of the veins are considerably different, however, and the scheelite vein carries but little gold. It is thought that the veins carrying the noticeably larger amounts of scheelite are later than the gold veins, for the following reasons: In the Gold Bug claim the scheelite occurs in small lenses in the gold ores—the scheelite itself not carrying gold—and is not so badly crushed as the gold ore. In the Sidney mine scheelite of a bright buffy color occurs in veins with gold, but it was seen only where the vein had been more or less disturbed. Gold occurs in the vein close to the scheelite, and although it has been reported as found in the scheelite, close search by J. C. Walton, the consulting engineer at the mine, and by the writer failed to show such occurrences. Most of the country rock surrounding the Sidney vein is a graphitic schist which contains thin quartz veins between its laminæ. Many assays have been made upon this quartz, but no gold has been found in it. Here and there, however, it contains a small amount of scheelite. It is probable that the scheelite found in the Sidney veins is related more to the veins intercalated with the schist than to the gold-bearing veins, and that the scheelite has been introduced into the latter at points where they had been fractured. The veins which carry the larger amounts of scheelite, such as those occurring on the Winnie and on the Jersey Lily (north of the Blackhawk), have a considerable amount of a green mineral, probably chlorite, in silicified walls, which shows at least that they were deposited by a different ore-bearing solution.

In the Corona claim, 3 miles south of Randsburg, on the 50-foot level, a lens of quartz 5 inches thick contained about an inch of albite feldspar in the midlde. A sample taken from this part of the vein was crushed and panned and gave a good prospect of gold in small "colors," probably equivalent to more than $25 a ton.

The veins in the Stringer district are all more or less disturbed by faults. On the Bully Boy, 2 miles south of Randsburg and three-fourths of a mile west of the Sunshine mine, a vein which was rich at and near the top is cut off 75 feet below the surface and has not been found again. On the Corona, Sunshine Fraction, and Sidney claims the veins are also badly faulted, but the Sidney vein is more continuous than the other two.

The Gold Coin and Stanford claims, three-fourths of a mile east of the Sunshine mine and nearly 2 miles southeast of Randsburg, have a combination of both fissure veins and fault lodes. Along the fault in silicified crushed material there are lenses of rich ore carrying visible gold. Besides the fault lode there are a number of narrow veins, some of which are little wider than a knife blade, but in places they reach a thickness of 8 inches. The veins in some parts carry over $120 a ton in gold. The richest parts are said to be where there is most iron oxide. The oxide is probably derived from the oxidation of arsenopyrite and pyrite.

The main fault runs east-west and dips about 25° N., but with variations. Little ore has been taken out below the 100-foot level (measured along the dip), and below that the crushing is less and oxidation is much less, pyrite and arsenopyrite appearing.

The veins in general strike with the course of the fault, but locally they branch and converge and dip in all possible directions.

VEINS OUTSIDE OF THE STRINGER DISTRICT.

Outside of the Stringer district veins on the St. Elmo claim, 5½ miles southeast of Randsburg, should also be classed as fissure veins. The veins cut granite and the two principal ones strike N. 30° E. and N. 40° E. The former dips 78° N. 60° W. and is 4 to 10 inches thick. The other is practically vertical and reaches 2 feet in thickness. It is reported that $45,000 was taken from a small open cut between 10 and 15 feet deep on the vertical vein. Several shafts were sunk in search of other ore bodies, and some stoping was done on the veins, but apparently no large bodies of ore were found, as the mine has not been operated for three years or more. The ore is quartz carrying visible gold and is said to have been very rich. Scheelite is said to have been found in pannings of the crushed ore, but none was found in a specimen tested by the writer.

The mine is situated in comparatively level ground and no other paying gold ore has been taken out nearer than the Blackhawk mine, about 3 miles northwest, though there is a narrow, short gold-bearing vein a mile north by west on the Murphy claim, in the Atolia scheelite belt. The vein is practically parallel to the scheelite veins. It strikes east-west and is vertical. A shaft 20 feet deep has been dug on it and enough gold was taken out to pay for the labor.

SUMMARY AND THEORY OF ORIGIN OF THE GOLD.

The rocks of the Randsburg quadrangle may be summed up as follows: Granites of different textures and compositions, covering about five-tenths of the quadrangle, occur in the south and north; mica-albite and chlorite-albite schists, of unknown age and believed to be of sedimentary origin, with some interbedded quartzite and limestone, occupy over one-tenth of the area and form the Rand Mountains; somewhat metamorphosed sediments, probably of Paleozoic age, in cluding many beds of limestone, occupy less than one-tenth of the quadrangle; lavas, probably of Tertiary age, composed of rhyolite, andesites, basalts, and others, occupy more than two-tenths of the area; sand and other unconsolidated fragmental coverings hide somewhat less than one-tenth of the rocks of the quadrangle.

A large crescent-shaped granitic intrusion, 4 miles long and one-half mile wide, cuts the schists of the Rand Mountains on the south side of Randsburg. Near this, and probably connected with it, are many porphyry dikes of widely varying composition.

The rocks are extensively faulted, and the faults near the Rand Mountains are believed to have been largely caused by stresses accompanying the intrusion of the granite. Some granite porphyry dikes were intruded along the faults, after the fault lines were established, as there is much crushed material alongside the dikes. There has been some movement in the faults since the intrusion of the dikes, and they have been more or less shattered by it. In other places the strike of the porphyries is across that of the faults, but nowhere are they known to cross the faults without displacement. Most of the faults and fractures due to the intrusion of the granite strike within the northwest and southeast quadrants.

The principal gold deposits lie in the schist area, rather closely connected with the granite. They may be divided into three principal groups:

1. Fault lodes, deposits along faults in crushed schist and granite.
2. Stockworks in granite.
3. Fissure veins, with more or less quartz.

All three types occur in the Yellow Aster mine.

The mines north and east of Randsburg are of the fault-lode type.

Although stockworks form some of the most important deposits in the Yellow Aster mine, no other mine has produced much ore from them.

In the Stringer district, lying south and southwest of Randsburg, the working mines are all upon narrow fissure veins which have a maximum width of 2 feet and a maximum length of 500 feet. All are badly cut by faults.

The ores in the fault lodes and stockworks are greatly oxidized where productive, and all shafts are comparatively shallow.

It seems probable that after the intrusion of the granite and the granite porphyry dikes a large amount of hot water was squeezed from the grânite while it was cooling. The water carried silica, gold, silver, iron, sulphur, arsenic, lime, tungsten, and a little tellurium and titanium in solution and flowed along the faults and shearing planes and through the broken granite. The minerals were deposited wherever chemical reactions or cooling took place. The quantity of silica in the water was evidently not large. It seems possible that the constitution of the watery solutions changed from time to time, as along some veins there is much more alteration of the wall than along others close by in the same rocks. The veins with the more altered walls carry scheelite with very little gold, whereas the gold veins have less altered walls and carry little scheelite.

THE WEAVERVILLE-TRINITY CENTER GOLD GRAVELS, TRINITY COUNTY, CALIFORNIA.

By Donald Francis MacDonald.

INTRODUCTION.

Placer mining has been carried on along upper Trinity River and its tributaries since the early fifties. Of late years, with the exhaustion of the small rich diggings, the sluice box and rocker have given place to the hydraulic plant and the dredge, and these have now opened up great bodies of low-grade gravel. This short report is the result of observations incidentally made while examining placer claims near Minersville, Trinity National Forest, in July and August, 1909. Acknowledgments are due to nearly all the mining men in the district for interest, information, and ready courtesy, but especially to Mr. Bouery, of the La Grange mine, and Mr. MacIlwaine, of the Dorleska. Frequent reference has been made to the interesting articles of O. H. Hershey on the geology of this general region and of D. F. Campbell[a] on the La Grange mine.

LOCATION AND PHYSIOGRAPHY.

GENERAL DESCRIPTION.

Trinity River flows west of south through the northeast part of Trinity County to Douglas City (fig. 2), and from there on until it joins the Klamath its course is northwest. West of the present Trinity Valley and as a southern spur of the main Siskiyou Range, the Sierra Costa[b] rises above the dissected remnants of a peneplain that stand at an elevation of about 4,000 feet. To the east this peneplaned surface is shown in Trinity Ridge and other low level-topped ridges which slope gently southward from the main Siskiyous. Rejuvenation intrenched the drainage in this old peneplain and Trinity River and its tributaries established a new base-level at an elevation of approximately 3,000 feet. This is shown by

[a] Campbell, D. F., Min. and Sci. Press, October 10, 1908.

[b] Described by O. H. Hershey in Am. Geologist, vol. 25, p. 76.

the accordance in summit level of the divides between East Fork and Trinity River and between the following creeks: Rush and Buckeye, Rush and Browns, Oregon Gulch and Weaver. Along the wagon road over the Rush Creek divide washed gravel was observed. This second cycle of erosion was important economically, for it left most of the auriferous gravels of the district which are now being mined. Since the beginning of the third cycle the drainage has been lowered several hundred feet and the bottoms of these new valleys have been considerably widened. This cycle also caused a concentration

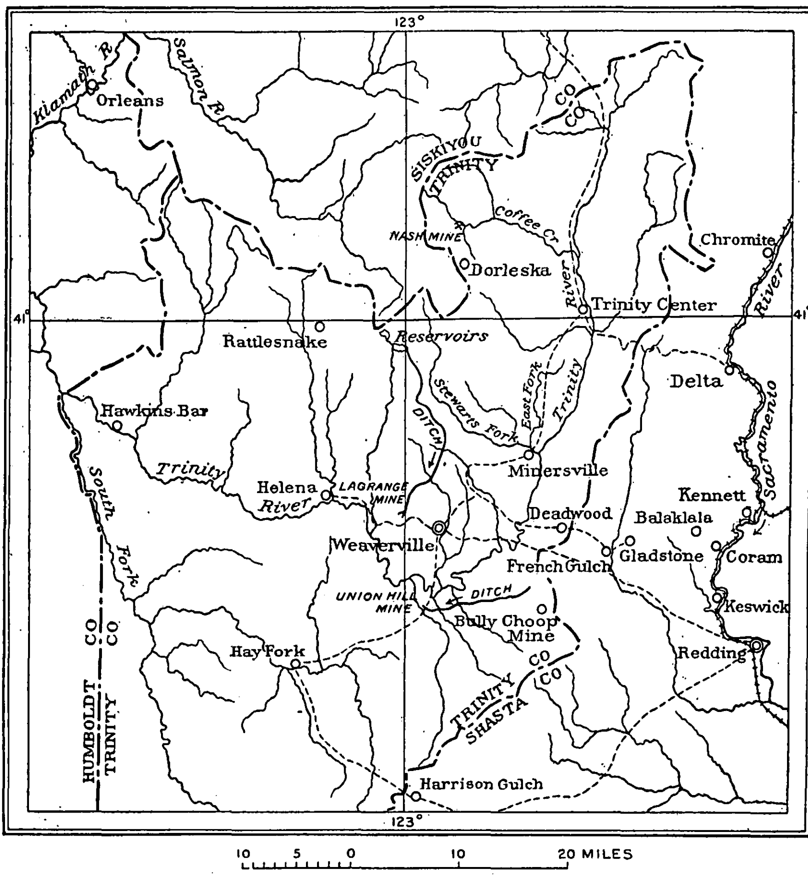

FIGURE 2.—Sketch map of northern part of Trinity County, Cal.

of values in the gravels, especially those near the level of the present Trinity River.

GLACIATION.

Near the beginning of the second cycle of erosion glaciers moved out a few miles from the mountains north and west of Minersville and Trinity Center. They left the western edge of the old peneplain covered with a hundred feet of drift from the complex igneous and metamorphic masses that constitute those mountains. At least two distinct periods of glaciation were recognized. The first deposited the highly oxidized material typically shown on the flat-topped ridges northwest of Minersville; the effects of the second, comparatively recent, are best seen on the headwaters of Coffee Creek and Salmon River. Hershey [a] has called attention to the glaciation of the district and to the capture of upper Coffee Creek by Salmon River, a change in drainage greatly facilitated by the recessional morainal material left in the old Coffee Creek valley 5 miles below its head. This obstruction caused a lake, which soon overflowed into the headward-working Salmon. The upper Salmon now follows the glaciated valley, formerly Coffee Creek valley, to the morainal obstruction and then turns to the left through a V-shaped canyon. The present Coffee Creek rises in this glacial débris and occupies its old U-shaped valley below the drift barrier.

The fresh and unaltered appearance of the till here, and especially of the perched bowlders, is in striking contrast to the highly weathered condition of the older drift on the flat-topped remnants of the 4,000-foot peneplain northwest of Minersville. The upper 6 feet of the latter is weathered into reddish soil. This, together with a growth of brush and timber, masks its glacial character, except where deeply eroded by streams and ditches. Moreover, since deposition Mule and Strope creeks have cut through it and 100 feet into the underlying bed rock. Altogether this material appears to be at least ten times as old as the fresh drift and perched bowlders of upper Coffee Creek. Between these two extremes other periods of glaciation may have occurred.

Around the periphery of a large and irregular granitic batholith, in the mountains from which the ice came, are several gold veins, some of which have been fairly productive. It is believed that the glaciers removed at least the upper portions of veins such as these and left fragments of them in the glacial débris. This is shown by the angular pieces of quartz and sharp-cornered "colors" that occur locally in the drift, especially in the weathered upper portion. This formation was called "dead wash" by the early miners because they found it practically barren. From this glacial till, however, the present auriferous gravels were mostly concentrated. Weathering first disintegrated the bowlders, giving a residual product of clay and gravel and any contained "colors" of gold; stream action then re-sorted this, leaving the auriferous gravels that are mined to-day. Glaciation here, then, has had a direct economic value, for it ground off the mineral veins and carried their fragments to the valley, where weathering and stream action could more rapidly carry on the concentration.

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[a] Jour. Geology, vol. 8, No. 1, p. 46, and Am. Geologist, vol. 31, March, 1903.

PLACER MINING.

In the early fifties prospectors first visited this region, and soon from many gulches came the sound of whipsaw and pick. Busy little camps sprang up and mule trains pioneered their way across the forested mountains, bringing supplies. To-day the old camps are gone, but centrally situated little towns have taken their place. Wagon roads have supplanted the pack trails, and the old sluice box and rocker have largely gone to decay because of the successful exploitation of great bodies of low-grade gravel, which gives brighter promise for the future. The annual yield of placer gold in Trinity County during the last few years has ranged from \$350,000 to \$500,000, according to statistics published by the United States Geological Survey.

LA GRANGE HYDRAULIC MINE.

LOCATION.

The La Grange mine is at the head of Oregon Gulch, 5 miles west of Weaverville and 56 miles northwest of Redding, the nearest railway

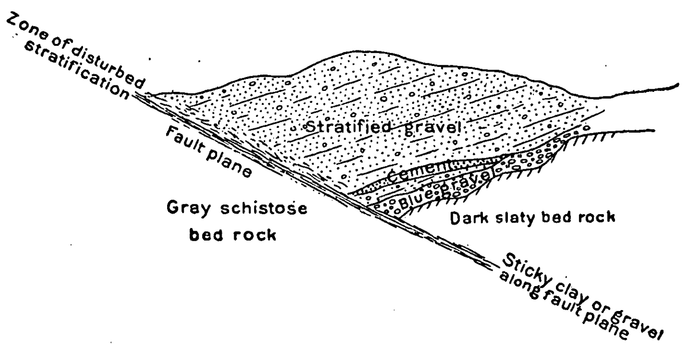

FIGURE 3.—Section across the La Grange channel, west of Weaverville, Cal. The part marked "Stratified gravel" is the tilted gravel bed 600 feet deep and a mile wide, showing a lens of cement gravel near its base.

station. It is owned by the La Grange Hydraulic Gold Mining Company, composed principally of eastern capitalists, and is managed by Pierre Bouery. In equipment and amount of material handled the mine is perhaps second to none in the world.

GEOLOGIC RELATIONS.

The deposit is on an old channel—La Grange Channel—formed by Stewarts Fork or by Trinity River. If it was formed by Stewarts Fork that stream then joined the main Trinity near or below the mouth of Oregon Gulch. The deposit represents a phase of the period when the 3,000-foot base-level was being established and seems to show two mutually unconformable but fairly well stratified gravels. Subsequent faulting and shearing have locally disturbed the stratification and tilted the whole to the southwest, as shown in figure 3. From rim to rim the width of this channel is almost a mile and its greatest depth is 600 feet. Its direction here is determined by its northern rim, which is a great smooth, slickensided fault plane trending N. 70° E. and dipping 22° S., and the striæ on which make a small angle with the horizontal. Along this fault a parting of sticky clay, a few feet thick, separates the gray schistose rock on the north from the dark, slaty, rough-surfaced bed rock on the south side. The stratification of the gravel along this plane is much disturbed, indicating that the throw of the fault must have been considerable. The wash is fairly fresh and contains a great variety of rock; about 12 per cent of it consists of bowlders weighing from 100 pounds to many tons. Near the lower part of this bed is a lens-shaped layer of cement gravel, having a maximum thickness of 50 feet. Below this indurated bed uncemented stratified wash forms the basal part of the younger gravel and rests with apparent unconformity on an older blue gravel.

The so-called blue gravel rests on an uneven surface of slaty bed rock. It presents a much more squeezed and sheared appearance than the upper gravel and shows many stones and bowlders flattened and fractured. Though not a cement gravel it has a much more resistant matrix than the overlying material and shows more small faults, the the principal of which trend N. 40° E. and dip 65° SE. The coloring matter which has given the name to the gravel is probably iron reduced to ferrous compounds by an excess of organic matter.

WATER SUPPLY.

A maximum flow of 3,400 miner's inches of water is conveyed to this mine from Stewarts Fork, 29 miles distant. The headworks consist of a dam giving at present a storage capacity of 13,000 miner's inches, which will next year be increased to 90,000. From this reservoir 8½ miles of flume brings the water to the first inverted siphon, which has a span of 4,800 feet with an 1,100-foot depression and is built of 30-inch steel pipe with lower lengths one-half inch thick. Beyond this siphon there is a 9,000-foot tunnel, two inverted siphons, one with 150 feet difference between head and discharge, the other with 60, and a flume and ditch leading to the reservoirs at the penstock. The flume, 2 feet wide in the bottom, 6 feet wide on top, and 4 feet deep, is built of 4 by 6 inch framework lined with 1½-inch boards. The flume cost $5,000 to $7,000 a mile, the tunnel $10 a running foot.

From the penstocks three main pipe lines carry the water to six giants working under 450 to 650 feet of head, and three of these, together with a smaller one, work at once. The largest pipe is 30 inches, the smallest 15 inches; the gage is No. 4 to No. 7. The mains have 15 to 18 inch inlets and 5 to 9 inch nozzles and are fitted with safety clutches, invented by Mr. Bouery, to prevent accident in case the kingbolt should snap and the top of the giant break loose. These immense giants are fitted with a modified form of "bootleg" deflector and with saddles, so that the piper rides the swinging pipe and has it under perfect control at all times with a minimum amount of exertion and a maximum of safety and efficiency. The reservoir gates are fitted with automatic floaters for regulating the discharge so that the same amount of water a minute will flow whether the reservoir is full and the pressure great or the reservoir nearly empty and the pressure correspondingly low.

MINING AND EQUIPMENT.

In mining, the 600-foot bank is undercut along the bottom and slowly crushes down, breaking even the lens of cement gravel near the base. This undercutting saves the large blasts formerly necessary, and now only the larger bowlders and masses of cement gravel which do not crush small enough are blasted. These are drilled by hammer drills, run by a small water-driven air-compressing plant. This method is much more efficient than "bulldozing" or lifting out with a water-power derrick, as was formerly done. Large masses of clay are encountered along the main fault plane; these are bored with an Ingersoll wood-boring machine, using a seven-eighths inch bit, and blasted. The high-pressure pipes accomplish the cleaning of the bed rock, so that scraping is unnecessary.

The sluice boxes are 4 by 6 feet in cross section and are set into bed-rock cuts blasted out with the aid of water liner No. 6 drills. They have a uniform grade of 8 inches per 12 feet for all except the first 70 boxes, which are set at 7 inches. The sluice is lined with 40-pound steel rails throughout its 3,000 feet of length. The bottom rails are all set crosswise except a few lengths near the upper end laid lengthwise to help give the material a start. Rails set lengthwise and 8 inches apart last two months; lengthwise and 5 inches apart, four months; crosswise and 5 inches apart, six months. The interval of 5 inches has been adopted for the bottom rails; these are held in place and spaced by cast-iron lugs bolted to one rail and having a square depression in the other end, which fits on the head of the bolt holding the lug to the next rail. The rails may thus be readily removed at clean-up time without unscrewing any bolts. They are set on 2 by 6 inch pieces spaced by 4 by 6 wooden end and center blocks, thus forming 10-inch riffles. When the top part is worn off the rails are heated in a special furnace, straightened, and used to line the sides of the boxes. For this lining they are set with the web or stem of the T between thick plank strips and with the flat basal part projecting out over the strips, thus armoring the sides of the sluice. Long bolts passing downward through the strips and rail stems hold them in place. The rails are shipped from San Francisco already drilled and cut into 6-foot lengths. Each length, with lugs attached, costs at the mine, after paying $1.25 for drayage from Redding, about $5. Each of the 140 or more sluice boxes contains 30 transverse rails. About 1,400 feet from the head of the sluice the material can be diverted by means of a steel door to another part of the dumping ground. This exit gives more dump area and facilitates the clean-up of the lower sluice. Through this great iron-clad sluiceway material is washed at the rate of 1,000 cubic yards an hour, even bowlders up to 7 tons in weight being carried through.

Formerly the sluice was lined with wooden blocks 16 by 16 by 13 inches. These wore out so rapidly that a clean-up and relining were necessary every two to three weeks, causing great loss of time and expense. Sanding up, too, often gave trouble, and it was difficult to save the fine gold if the sluice was allowed to carry anywhere near its full capacity. With the present equipment the sluice can be run full day and night, and only three clean-ups a year of the first 40 or 50 boxes are necessary. The lower boxes are cleaned less often. Below the forks of the sluice a clean-up is made about once in two years, and is carried on without interruption of mining by using the other branch of the flume. From a diagram worked out by Mr. Bouery, which shows the curves of settlement of the various sizes of gold in the sluice boxes, the following facts are taken: The largest percentage of the gold recovered is too coarse to go through a 10-mesh screen. The maximum recovery of this size is in the eleventh box, but boxes 5, 12, and 13 have each almost as much. From this point the decline is very rapid to box 22, less rapid to box 48, and thence tails out toward the end. The next size, between 11 and 50 mesh, is less plentiful and reaches a maximum in box 12. From there it declines very rapidly to box 22, then less rapidly to box 48, and gradually to box 136 or beyond. All smaller sizes are much less plentiful than the coarser product. Sizes between 50 and 100 mesh are recovered in quantity in the first boxes, but reach a maximum in box 22. Sizes 101 to 150 mesh are most abundant in box 6, and sizes 150 to 200 in box 13. In spite of the vast amount of material handled and the absence of an undercurrent, gold which will go through a 200-mesh screen is caught in the first box and reaches a maximum somewhere near the twelfth box. Mr. Bouery, in the presence of the writer, poured some of this fine gold, which had been dried, into a glass of water, and much of it floated on the surface film. This great efficiency in catching the values is accounted for by the little whirl of water that forms behind each rail riffle, owing largely to the concavity along the web of the rail between its top and basal projections; also by the absence of sanding and by the pounding action and cross currents from the bowlders as they are carried along. The high efficiency in the saving of gold, the splendid water supply and great depth of gravel, the natural V shape of the bed-rock channel, the dumping facilities, and the efficiency of equipment and management are some of the advantages that result in the low mining cost of this ground, which is estimated at less than 2 cents per cubic yard.

In the sluiceway 1 pint of quicksilver is sprinkled in boxes 1 to 30 every thirty-six hours, 1 quart every two weeks in boxes 31 to 100, and 1 quart every two months in the boxes from 100 to the end of the flume. Most of this is recovered by retorting; the amount actually lost, largely from flouring, is only about 112 pounds per year. The retorts are lined with chalk to prevent adhesion of the gold, and the mercury recovered is refined by heating it with charcoal and some cinnabar. A gasoline furnace and graphite crucibles are used for melting the amalgam, and the slag from it is poured off and run into base bars valued at a few cents an ounce.

The office, boarding house, mine, and ditch line are all connected by telephone, and every ditch tender's cabin is fitted with an electric call bell attached to a float in the flume, so that if the water rises or lowers quickly the alarm is sounded. There is a sawmill at the head of the ditch, and the lumber is floated down to the siphons, where it is shot down the slope of the gulch, trammed up the other side, and again flumed to the place where it is required. An electric-light plant, an electric-heated chamber for thawing powder, a small ice-manufacturing plant, a blacksmith, machine, and pipe shop, and a heating furnace for straightening rails, all run by water power, make the equipment of this mine very complete. The saving of labor by these various devices makes the general running expenses low. Only about 30 men are employed in the mine altogether; 10 of these patrol the ditches, leaving 20, including blacksmiths, machinists, and office force, available for two shifts. The mine men are paid $3 a day of ten hours. The pipers and their helpers work twelve-hour shifts.

HISTORY AND FUTURE PROSPECTS.

Oregon Gulch was first mined in the fifties. In 1872 the Trinity Gold Mining Company installed a small hydraulic plant, which was worked until the La Grange Company took over the property in 1892. This company brought water from Rush Creek with a 14-mile ditch, instead of using the 7-mile system which furnished, for three months each year, 1,500 miner's inches of West Weaver Creek water to the old workings. In 1896 the Rush Creek ditch was extended 14 miles to Stewarts Fork, and soon afterward the present splendid water system was put into use. The annual mining capacity for the first few years after the present company took hold was about 2,000,000 cubic yards. This capacity has gradually been raised until now about 5,000,000 cubic yards of material is sluiced out each year.

No statement of the total production to date is available, but it is estimated to run into the millions of dollars, and the work may be said now to be only well under way. In addition to the enormous quantity of gravel (100,000,000 cubic yards, according to Mr. Bouery) available before the crest of the Oregon Gulch-Weaver Creek divide will be reached by present mining operations, there is some topographic evidence that this same channel passes just north of Weaverville and north of Browns Mountain across to the headwaters of Buckeye Creek. No time was available to trace out the trend of this old channel, but the topographic configuration is suggestive enough to warrant prospecting in this vicinity. Of course these water-laid, low-grade gravels should be carefully distinguished from the barren glacial débris locally known as "dead wash," which is typically shown on the flat-topped ridges at about the 4,000-foot level northwest of Minersville and which may also be expected to occur on the higher ground a considerable distance northwest of Weaverville. It is probable that several decades of mining will be required to exhaust the gravels of the La Grange channel.

OTHER PLACERS NEAR WEAVERVILLE.

Large deposits of placer gravel occur near the town of Weaverville. Of these the most important is owned and has long been operated by Hupp Brothers. These gravels are probably very little younger than the deposits of the La Grange channel, but the concentration seems to have been carried somewhat farther. Rocker and sluice were used for many years on the creeks near Weaverville, and there now seems to be but little gravel left that it would pay to work by hand.

MINERSVILLE AND TRINITY CENTER PLACERS.

At Minersville the principal hydraulic mine is owned and operated by the Trinity Gold and Milling Company, of which Mr. Whipple is general manager. Their gravel deposit is from 100 to 200 feet above East Fork of Stewarts Fork and several hundred feet below the "dead wash." It occurs at an elevation of about 2,500 feet and may be younger than the gravels of the La Grange channel, although such a correlation is not wholly to be relied on because of the faulting of the latter. As no high rim was noticed clearly separating this deposit from the present stream, it is thought to be a bench deposit rather than a true "old channel." Though not of high grade, it is large and will furnish material for many years of mining. This deposit should be carefully differentiated from the "dead wash" which covers the ridge tops a few hundred feet higher up and just northwest of it. The latter is a barren glacial till, entirely distinct, geologically, from any of the gold-bearing gravels of the district.

A few miles farther up East Fork of Stewarts Fork are large and promising benches of gravel, which would probably yield returns if worked with a sufficient head of water. Some of these, especially the property formerly owned by J. C. Van Matre, are said to have paid while worked with a low pressure of water. These properties were idle at the time of visit, owing, it was said, to lack of sufficient capital to replace with a larger system the old flumes which two years earlier had been destroyed by washouts.

At Trinity Center the chief hydraulic property now producing is that owned by the Sykes Gulch Mining Company. Here 150 feet of gravel covered by 50 feet of reddish clay overlies a shale bed rock. Water amounting to 1,300 miner's inches is brought 7 miles by ditch and under 285 feet of head supplies a giant having a 7-inch nozzle. Active mining begins October 1 and continues until the water supply gives out about the middle of July. The gold is smooth and worn and fairly coarse. The values are rather evenly distributed through the gravel, but there is slight concentration as bed rock is approached. The flume is lined with square blocks 10 inches thick and five sets of these are used each season. The bed rock is soft and is cleaned by piping. The estimated cost of mining is about 3 cents per cubic yard. Much mining has been done here, and the gravel seems to be of about the same age as that at Minersville. The deposit is from 200 to perhaps 600 feet above Trinity River.

COFFEE CREEK PLACERS.

Two other active placer mines of importance are the Nash, on West Coffee Creek, near the mouth of Union Creek, and the Holland placer, on East Fork of Coffee Creek. Both are approximately 16 miles north of Trinity Center. Both are worked by sluicing out the creek bottom with large automatic reservoirs, the rim material usually being piped into the main ground sluice. The clean-up consists of diverting the stream from its channel in the sluiced-off area and shoveling the concentrates from the bed rock of the ground sluice into sluice boxes. This method of mining requires that the stream shall have considerable grade, that the bed rock be not too deep, and that the gravel be uncemented and have comparatively few large bowlders. As these two properties are similar and are worked by the same method, but one will be described.

The Nash mine is operated with a reservoir having a capacity of 300,000 miner's inches, built on the creek some distance above the ground now being mined. A 12 by 12 foot gate opens automatically when the reservoir is full, thus sending a vast flood of water down the ground sluice in the stream bed. A ditch 5 miles long supplies 1,000 miner's inches of water under 218 feet head to a giant with a 6-inch nozzle, which is used to pipe the rim material into the ground sluice. The average width of the channel is 40 feet; depth along central axis, 20 feet; grade, 2½ inches per 12 feet; cost of working, about $600 per 100 feet of channel. A flume at the lower end of the bed-rock ground sluice, to catch fine gold, is 72 feet long, 16 feet tapering to 12 feet wide, and 6½ feet deep. Along the bottom it is laid with 18 by 18 by 12 inch blocks, which wear three-fourths of an inch each season of six or seven months' active sluicing. This property is said to have produced about $150,000 since its first development in the early eighties.

FUTURE PROSPECT FOR PLACER MINING IN THE DISTRICT.

There are large deposits of low-grade gravels in the district which are yet untouched, and some of these are workable, though perhaps at considerable expense, by hydraulic methods. Here no antidébris laws hinder the miner, the mountain streams furnish a fair supply of water, timber is abundant, and dumping facilities are in general better than in most hydraulic mining regions.

Along Trinity River are many high bars and low benches which give pan prospects sufficient to invite investigation with a view to dredging. A dredge has been operated near Trinity Center for some time, and it is reported that the extensive diamond-drill prospecting recently carried on there will soon result in the installation of others. The upper Trinity River district is a field which is worthy of examination by dredger men as well as by those interested in hydraulic mining.

PLACER GRAVELS OF THE SUMPTER AND GRANITE DISTRICTS, EASTERN OREGON.

By J. T. Pardee.

INTRODUCTION.

During the summer of 1909 some information was obtained concerning placer mines in an area approximately consisting of the following drainage basins: In Baker County, North Powder River above Red Mountain, Rock Creek, Pine Creek, Goodrich Creek, and Powder River above Sumpter; in Grant County, North Fork of John Day River above Lake Creek, Onion Creek, Crane Creek above Crane Flats, Granite Creek, and Clear Creek.

Placer mining has been carried on in this area since 1863. Practically all the gravels that could be easily attacked have been mined out. Certain deposits, however, that were less favorably situated as regards water supply or dumping facilities remain. The object of this paper is to describe these deposits and briefly discuss the relation of the gravels to the glaciation of the region.

The thanks of the writer are due Mr. F. C. Calkins, of the Survey, for valuable criticism and advice.

The placer gravels of this area (fig. 4) may be separated into two groups. They are, in order of age:

1. High-terrace or intervolcanic [a] gravels. They are highest in relative position and probably of Miocene age.
2. Gulch or valley gravels and some low-terrace gravels closely associated with them. This group occupies the lower relative position and is mainly of Pleistocene age.

HIGH-TERRACE GRAVELS.

GENERAL DESCRIPTION.

The high-terrace gravels are the remnants of the alluvium deposited in the valleys of an ancient river system that was probably the ancestor of the existing one. Although the relations of the two have not yet

[a] Lindgren, W., The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1901, p. 636.

been entirely worked out, enough is known to indicate that these ancient streams were interrupted and their valleys filled in places by volcanic material, and that the streams thus forced to seek new channels have subsequently cut down a few hundred feet beneath their former levels, leaving such portions of the ancient gravels as were not removed in the process "high and dry."

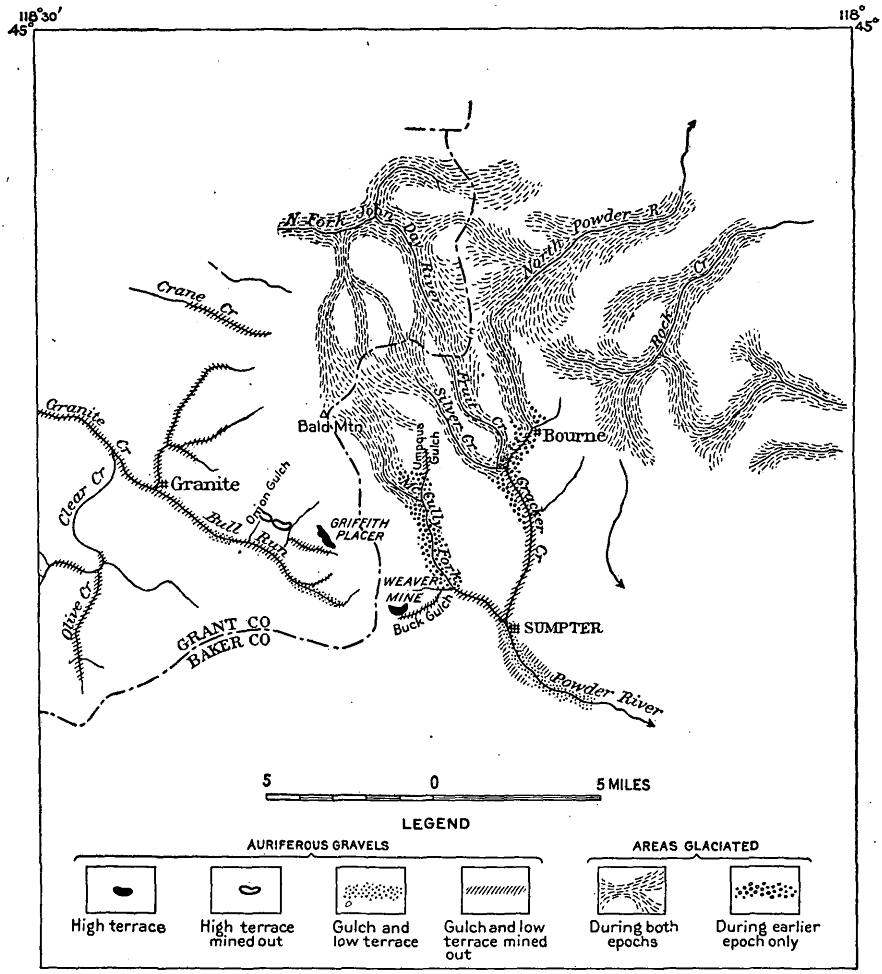

FIGURE 4.—Map of a portion of the Sumpter quadrangle, Oregon, showing distribution of gold-bearing gravels with relation to glaciated areas.

WEAVER MINE.

The Weaver mine is situated near the head of the north prong of Buck Gulch, in a gravel terrace hanging upon the north slope some 200 feet above the bed of the ravine. Its elevation above sea is 5,550 feet. It extends as an ill-defined bench, having a course approximately east and west, 1,000 feet or more, its western termination not being exposed. In its eastern portion pits 50 to 90 feet wide and aggregating 450 feet in length have been made, exposing a bank 40 feet high. These openings have apparently reached not more than halfway across the deposit. In part the gravel rests unconformably upon loosely consolidated fine sands and silt, which in turn rest upon a bed rock of cherty shale and basic igneous intrusive rocks. The gravel consists of smooth rounded cobbles of an average diameter less than 12 inches, in an abundant sandy matrix that is very loosely "cemented." It is thickly bedded, striking N. 75° W. and dipping 6° to 8° N., and together with the bed rock is affected by several normal faults of small throw; one of these, striking N. 70° E. with vertical dip for a short distance, forms the outer boundary of the gravel, which has dropped, relatively, on the north.

Gold is distributed throughout the gravel but is found in greater quantity in the lower layers. It occurs mainly as small half-rounded grains of pin-head size and dust, with occasionally a small nugget. Its fineness is reported as 900 to 940.

It is stated that here the richest gravel lies on the outer rim.[a] This condition the writer has noted as true of many similar gravels elsewhere, and so far true in some instances that only the outer rim was rich enough to pay. The difference is probably due to a secondary concentration during the slow removal of the exposed edge of the gravel by erosion.

The Weaver property is equipped with a small hydraulic plant and supplied with water through a ditch about 6 miles long that diverts the flow of Grays Gulch, a tributary of McCullys Fork. Water in sufficient amount for mining purposes is had only during part of the spring and summer.

This mine has been operated profitably during the past nine years, but a statement of its output and the average yield of the gravel is not available for publication. The sluices here yield a considerable amount of "black sand," a sample of which was examined in the Survey laboratory. A few specks of platinum were detected in it by D. T. Day. It contained in addition a globule of gold amalgam and a few small flattened particles or "colors" of rusty gold.

South and southeast of the Weaver mine, on the opposite slope of Buck Gulch, and on the divide between it and Mosquito Gulch, fragmentary patches of gravels are poorly exposed at elevations of 5,500 to 5,600 feet. They greatly resemble the gravel of the Weaver mine and are thought to belong to the same stream system. On the divide mentioned they are apparently overlain by andesitic tuff.

[a] "Outer rim" among placer miners denotes the rim or bank of an elevated rock channel that lies nearest to or is intersected by the present slope.

GRIFFITH MINE.

The Griffith placers are in a high terrace about 3½ miles northwest of the Weaver mine, at an elevation of approximately 5,500 feet, and on the opposite or west slope of the Blue Mountain divide. The portion of the ridge separating the two places is from 200 to 400 feet higher.

Lindgren[a] has described this deposit and records that in 1900 "a hydraulic pit about 1 acre in extent has been made in the high gravels, and a bank 40 feet high is exposed." The present area of this pit is about the same. Evidently little or no mining has been done since that time. Early in the past season (1909) operations at a point just west of this old pit were commenced, but after a short time they were suspended because of litigation. The gravel here lies unconformably upon fine sediments very similar to those of the Weaver mine and is thickly bedded, striking northwest and dipping 12° NE.

In its general texture this gravel resembles that of the Weaver mine, and it is likewise affected by normal faults, one of which strikes north, with vertical dip and downthrow of 6 feet on the west.

Considerable "black sand" is said to collect in the sluices, and a sample of it was obtained from G. V. Pinson. Platinum was detected in this sample by D. T. Day, in greater quantity than in the sand from the Weaver mine, amounting to about 1½ ounces per ton. (The present market value of refined platinum is $29 per ounce.) In addition, this sample contained a considerable amount of gold amalgam and a few flat particles or "colors" of rusty gold. Both this and the sand from the Weaver mine are by the partial examinations made shown to be well worth saving. These occurrences of platinum are interesting as being from new localities, and the metal's close association there with serpentinized rocks is in line with its general occurrence elsewhere.

The extent of this deposit has not yet been definitely determined by prospecting. It seems, as noted by Lindgren,[a] to extend northwestward for a mile or more, and apparently disappears under a basalt flow.

ONION GULCH.

A considerable deposit of the high-terrace type, lying in a basin at the head of Onion Gulch, has been mined and abandoned. It is about 3 miles northwest of the Griffith mine, at an elevation of 5,100 to 5,200 feet, and is of interest now mainly in its relationship to the deposit at that mine. From a general similarity in the character of the gravels and the elevations and courses of their channels it appears possible that they are remnants of the same deposit. Deep

[a] Op. cit., p. 688.

Creek, whose course is transverse to this ancient channel and whose stream bed at the crossing is now some 300 feet lower, affords a measure of the canyon cutting since that time.

The gold of this group was no doubt derived from the bed rock within the drainage basins of these ancient streams, but apparently not from the immediate vicinity of the existing gravel remnants.

LOW-TERRACE AND GULCH GRAVELS.

Included in low-terrace and gulch gravels are the bench gravels or "bars" found along either side of the present streams, usually lying 20 to 50 feet above them. They record a temporary halt in the Pleistocene downcutting of the streams, the specific cause for which has not yet been determined. The subsequent excavation of the valleys to the present level has left remnants of these deposits. They are found mainly along McCully Fork above Sumpter and along Granite Creek below Granite and Lawton. Their gold content appears to have been derived not alone from the erosion of the bed rock but largely from the high-terrace gravels. When Lindgren saw these deposits in 1900 some mining was still in progress.[a] Since then they have been practically worked out and abandoned. Near Sumpter, on the benches bordering Cracker Creek and McCully Fork, there still remain some patches of gravel aggregating 2 or 3 acres; and the lower layers of gravel in the southern portion of the Ellis mine have been left, apparently because they were situated too low for sluicing.

Somewhat younger, but closely related in history to the low-terrace deposits, are the accumulations along the beds of the present streams. They were the first to be exploited and have been mined to exhaustion where value sufficient for ordinary mining methods is found. The gold of these deposits was derived not only from the bed rock but in some instances at least in greater part from the high-terrace gravels. This is notably true of Buck Gulch and the upper course of Bull Run.

The low-terrace and gulch gravels may be classed according to richness into three minor groups, which are given below with the streams in which each is found:

1. Comparatively rich gravels, in Buck Gulch, Bull Run, Granite Creek, Crane Créek, Olive Creek, and Umpqua Gulch. So far as evidence can be obtained the gravels of these streams have produced the greater part of the gold credited to the area under consideration.
2. Comparatively lean gravels, in Cracker Creek, from Bourne to Sumpter, and McCully Fork, from Sumpter upstream 3 or 4 miles.
3. Practically barren gravels, in Fruit Creek, Silver Creek, Rock Creek, upper course of North Powder River, upper course of North

[a] Op. cit., p. 656.

John Day River, Cracker Creek above Bourne, and upper course of McCully Fork, excepting Umpqua Gulch.

The leanness of the last two groups is apparently not due to the poverty of the bed rock eroded, but is to be explained mainly as a result of glaciation, which has affected all these valleys more or less but has been entirely absent from those containing the rich gravels. The glacial history of this region is briefly as follows:

(*a*) An earlier glacial epoch in which ice extended down Cracker Creek to a point within 2 or 3 miles of Sumpter and down McCully Fork somewhat below the Granite stage-road crossing. All the valleys of the third or barren group were more extensively glaciated. The effect of this invasion upon the gravels, rich and poor, was to mix them, dilute with other débris, and shift the whole mass downstream.

(*b*) An epoch in which the ice disappeared and the streams to a great extent reconcentrated the jumbled mass left by the glacier. The lean gravels of Cracker Creek are a product of this epoch, as are in great part the low-terrace gravels of McCully Fork.

(*c*) A reinvasion of the ice that affected Cracker Creek as far down as Bourne and McCully Fork, within 2 or 3 miles of the glacier's former extension, and again glaciated the valleys of the third group. The effect of this invasion was, within its restricted area, similar to that of the earlier one. The more or less re-sorted stream gravels were again removed and left as unsorted worthless morainal material.

(*d*) Disappearance of this later ice and resumption of stream erosion and reconcentration, continuing to the present time. This is the Recent period of geologic history, which has been relatively so brief that the streams have had time to accomplish little in the way of reconcentrating the moraines and practically no erosion of the bed rock.

The relations of the placer gravels of this area to its glacial history thus impressively bring out the vast length of time required for the concentration of gold by the sluicing action of streams.

EXTENT OF REMAINING GRAVELS.

HIGH-TERRACE GRAVELS.

At the Weaver and Griffith mines a rather indefinitely known but considerable body of the high-terrace gravels remains, which may be expected to produce moderately for several years.

LOW-TERRACE AND GULCH GRAVELS.

In addition to those noted on page 63, the remaining low-terrace and gulch gravels are those of Bull Run and Powder River. Along Bull Run there remains a considerable amount of gravel upon a bed rock of too slight grade to permit the application of ordinary mining methods. The largest area of this description lies a short distance below Gold Center. It is a mile or more in length, of irregular width, averaging perhaps 200 feet, and about 10 to 15 feet deep. A dredge, under the management of Captain Wetherall, is being installed to work this deposit and is expected to be ready for operation in the spring of 1910.

Below the junction of McCully Fork and Cracker Creek, at Sumpter, is a deposit of alluvium in the main stream. It is about 1,000 feet in average width, extends at least 2 miles below Sumpter, and appears to merge with the more extensive alluvium of the main Sumpter Valley.

Prospecting by means of drilling has been in progress on this deposit during the past two seasons, presumably with a view of determining its suitability for dredging. The results so far obtained are not known.

There is a heavy deposit of alluvium, containing large bowlders, in the bed of Clear Creek from Lawton up to the mouth of Lightning Creek and thence up that stream. This gravel, from available evidence, appears to be gold bearing but is of little commercial value at present, owing mainly to the expense incurred in mining such coarse material where the grade is insufficient.

FUTURE PRODUCTION.

A moderate annual output may be expected from the high-terrace gravels for some years to come, and in addition a probable further yield from the dredged deposits.

It is perhaps needless to observe that as a rule placer deposits are not to be expected in a recently glaciated region, and that the absence of placer gold does not necessarily signify that gold quartz is lacking; this fact is illustrated by Cracker Creek, whose tributaries have eroded a great part of the rich "mother lode." On the other hand, the gold of rich alluvium has not necessarily a source within the limits of the particular drainage basin in which it is found; this is illustrated by Buck Gulch, where there is no gold quartz in the bed rock. The disregarding of this principle has in several instances led to considerable expenditures for the development of worthless quartz claims, on the strength of their being situated at the upper limit of rich placer deposits.

SURVEY PUBLICATIONS ON GOLD AND SILVER.

The following list includes the more important publications by the United States Geological Survey, exclusive of those on Alaska, on precious metals and mining districts. Certain mining camps, while principally copper or lead producers, yield also smaller amounts of gold and silver. Publications on such districts are listed in the bibliographies for copper and for lead and zinc. When two metals are of importance in a particular district, references may be duplicated. For names of recent geologic folios in which gold and silver deposits are mapped and described, reference should be made to the table in the "Introduction" to this volume.

These publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.; the monographs from either the Director or the Superintendent of Documents.

ARNOLD, RALPH. Gold placers of the coast of Washington. In Bulletin 260, pp. 154–157. 1905. 40c.

BAIN, H. F. Reported gold deposits of the Wichita Mountains [Okla.]. In Bulletin 225, pp. 120–122. 1904. 35c.

BALL, S. H. Geological reconnaissance in southwestern Nevada and eastern California. In Bulletin 285, pp. 53–73. 1906. 60c. Also Bulletin 308. 218 pp. 1907.

BARRELL, JOSEPH. Geology of the Marysville mining district, Montana. Professional Paper 57. 178 pp. 1907.

BECKER, G. F. Geology of the Comstock lode and the Washoe district; with atlas. Monograph III. 422 pp. 1882. $11.

——— Gold fields of the southern Appalachians. In Sixteenth Ann. Rept., pt. 3, pp. 251–331. 1895.

——— Witwatersrand banket, with notes on other gold-bearing pudding stones. In Eighteenth Ann. Rept., pt. 5, pp. 153–184. 1897.

——— Brief memorandum on the geology of the Philippine Islands. In Twentieth Ann. Rept., pt. 2, pp. 3–7. 1900.

BOUTWELL, J. M. Economic geology of the Bingham mining district, Utah. Professional Paper 38, pp. 73–385. 1905.

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CALKINS, F. C., and MACDONALD, D. F. A geologic reconnaissance in northern Idaho and northwestern Montana. Bulletin 384. 112 pp. 1909.

COLLIER, A. J. Gold-bearing river sands of northeastern Washington. In Bulletin 315, pp. 56–70. 1907.

CROSS, WHITMAN. General geology of the Cripple Creek district, Colorado. In Sixteenth Ann. Rept., pt. 2, pp. 13–109. 1895. $1.25.

——— Geology of Silver Cliff and the Rosita Hills, Colorado. In Seventeenth Ann. Rept., pt. 2, pp. 269–403. 1896.

CROSS, WHITMAN, and SPENCER, A. C. Geology of the Rico Mountains, Colorado. In Twenty-first Ann. Rept., pt. 2, pp. 15–165. 1900.

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DILLER, J. S. The Bohemia mining region of western Oregon, with notes on the Blue River mining region. In Twentieth Ann. Rept., pt. 3, pp. 7–36. 1900. $1.50.

——— Mineral resources of the Indian Valley region, California. In Bulletin 260, pp. 45–49. 1905. 40c.

——— Geology of the Taylorsville region, California. Bulletin 353. 128 pp. 1908.

DILLER, J. S., and KAY, G. F. Mines of the Riddles quadrangle, Oregon. In Bulletin 340, pp. 134–151. 1908.

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ECKEL, E. C. Gold and pyrite deposits of the Dahlonega district, Georgia. In Bulletin 213, pp. 57–63. 1903. 25c.

EMMONS, S. F. Geology and mining industry of Leadville, Colo.; with atlas. Monograph XII. 870 pp. 1886. $8.40.

——— Progress of the precious-metal industry in the United States since 1880. In Mineral Resources U. S. for 1891, pp. 46–94. 1892. 50c.

——— Economic geology of the Mercur mining district, Utah. In Sixteenth Ann. Rept., pt. 2, pp. 349–369. 1895. $1.25.

——— The mines of Custer County, Colo. In Seventeenth Ann. Rept., pt. 2, pp. 411–472. 1896. $2.35.

EMMONS, S. F., and IRVING, J. D. Downtown district of Leadville, Colo. Bulletin 320. 72 pp. 1907.

EMMONS, W. H. The Neglected mine and near-by properties, Colorado. In Bulletin 260, pp. 121–127. 1905. 40c.

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GRATON, L. C. Reconnaissance of some gold and tin deposits of the southern Appalachians; with notes on the Dahlonega mines, by Waldemar Lindgren. Bulletin 293. 134 pp. 1906.

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HILL, J. M. Notes on the economic geology of southeastern Gunnison County, Colo. In Bulletin 380, pp. 21–40. 1909.

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