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RECONNAISSANCE

OF THE

ORE DEPOSITS IN NORTHERN YUMA COUNTY, ARIZONA

BY

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RECONNAISSANCE OF THE ORE DEPOSITS IN NORTHERN YUMA COUNTY, ARIZONA.

By HOWLAND BANCROFT.

INTRODUCTION.

AREA EXAMINED.

The area examined in the reconnaissance here reported is shown on the accompanying general geologic and topographic map (Pl. I). It lies between meridians 113° 16′ and 114° 30′ west longitude and between parallels 33° 30′ and 34° 30′ north latitude, including parts of Yavapai, Maricopa, Mohave, and Yuma counties, Ariz., by far the largest part of the area lying in Yuma County. (See fig. 1.) The investigation therefore covered principally the economic geology of northern Yuma County. Brief mention is also made of the geology and ore deposits of the extreme southeastern part of San Bernardino County, Cal.

PURPOSE AND CHARACTER OF RECONNAISSANCE.

The field work in this area was begun by the writer early in March and completed late in May, 1909. The investigation was a reconnaissance of a large area concerning which little information was available. The object of the work was to get as accurate an understanding of the economic geology of the principal ore deposits of the region as was obtainable in the short time allotted. In the course of the work a few of the most prominent properties were studied in some detail and a great many others were visited. The fact that one property is treated at length and another is apparently hurried over is not necessarily a reflection on the one which received less time and study. The presence or absence of supplies influenced or determined the amount of time which could be spent at some of the camps.

The size of the area examined (approximately 5,000 square miles) and the brief period spent in the field were not the only features adverse to thorough work. The country is very sparsely settled; the lack of development work on many of the properties restricted observation to the surficial phase of the ore deposits; at a great number of the deposits no one was found from whom reliable data could be obtained; and the neglected conditions which exist in many of the camps, where only annual assessment work is done to hold the claims, also interfered seriously with the investigation.

ACCESS TO THE AREA.

A branch line of the Santa Fe system, the Arizona and California Railroad, runs through the center of this area, connecting Wickenburg on the Santa Fe, Prescott and Phoenix Railway with Parker, where the Arizona and California Railroad [a] crosses Colorado River to tap the main Santa Fe line at Cadiz, Cal. At the time of this investiga-

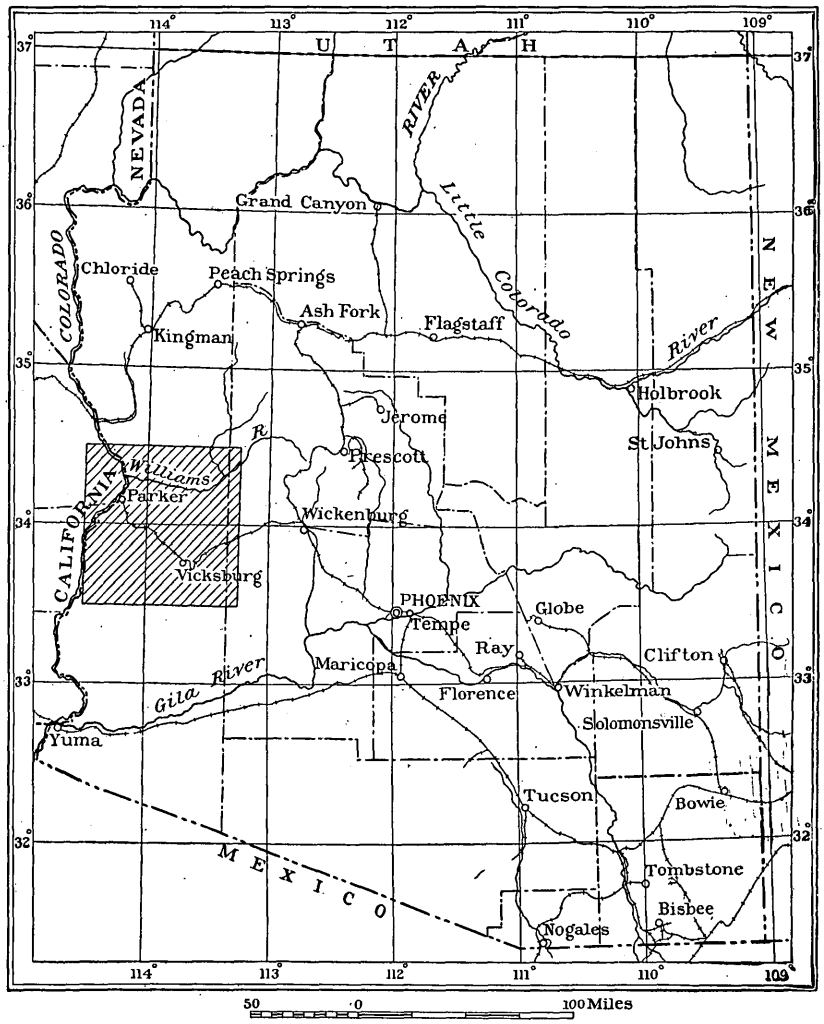

FIGURE 1.—Index map of Arizona showing location of area described.

tion this railroad was running passenger trains daily and three freight trains weekly between Parker and Prescott. To reach most of the mines rather long trips must be taken from the railroad stations, and these journeys are most frequently made in wagons along stage

[a] This road is now (October, 1910) known as a part of the Santa Fe, Prescott and Phoenix Railway. Daily passenger and freight trains run over this line between Phoenix, Ariz., and Los Angeles, Cal.

routes, although on some routes automobiles have been installed.[a] A schedule of these stage lines can be obtained from any agent of the Santa Fe system. Most of the wagon roads are fairly good and there are enough watering places to make travel over almost any part of the region possible, although in some places not at all convenient.

EXPLANATION OF THE GENERAL MAP.

The accompanying general map (Pl. I, in pocket) was originally drawn in the field as a means of locating the mountain ranges and some of the principal prospects and mountain peaks. At first only the boundaries of the several isolated ranges were drawn, the elevations of some prominent peaks were determined by vertical angles, and the locations of the properties visited were noted. The original scale was 4 miles to the inch, the Arizona and California Railroad maps having been utilized as a base and tied in by the latitude and longitude of Monument Peak, furnished by the topographic branch of the United States Geological Survey. After the writer returned from the field, as the Parker sheet was finished, it was decided to reduce parts of the Parker map to the scale of the reconnaissance sheet and to project contours which would extend over the rest of the area examined. The result is a crude topographic map of the district, with 500-foot contours. It is hoped that these contours do not go very far astray in representing the general topography of this part of the territory, and at the same time the users are warned not to expect too much detail in a map prepared in this way and on a scale so small.

The geologic boundaries have not been definitely represented, for they are in few places known to the writer. General conceptions of the geology, however, can be obtained from the map, which admittedly has many faults, most of them due to the reconnaissance nature of the investigation. Rocks supposed to be pre-Cambrian are all represented by one color, regardless of the complex to which they belong. The granite intrusion in the southwestern part of the Harquahala and Harcuvar ranges is mapped in places, although no doubt there are many other exposures of the rock in the area. The lava flows and some of the material supposed to have accompanied them are represented by one color. Valley filling and various detrital deposits are mapped as one formation.

ACKNOWLEDGMENTS.

During the investigation the writer was visited in the field by Mr. Waldemar Lindgren, who spent several days with him examining the geology and ore deposits in parts of the district, and whose conception of the general geologic conditions existing in this region, combined

[a] The Arizona and Swansea Railroad is now (October, 1910) in operation and runs a mixed train between Bouse and Swansea three times a week.

with a great deal of cheerful and generous assistance in the office, has greatly aided in the preparation of this report.

The writer takes this opportunity to express his gratitude to all the mining men of the district, who gave him most hearty cooperation, and especially to Mr. Louis B. Carr, of Wendendale, Ariz., who very kindly offered material assistance and even his own personal services to further the work. To Mr. W. A. Drake and others of the Santa Fe, Prescott and Phoenix Railway Company cordial thanks are due for the use of their maps and for many courtesies.

PREVIOUS INVESTIGATIONS.

With the exception of areas surveyed in a hurried reconnaissance trip made by Lee[a] in 1903, in an investigation of the water resources of a part of western Arizona, only a very small part of the region considered in this report had been examined by the United States Geological Survey prior to this investigation. A part of the northeastern portion of the area was covered by the Wheeler Survey in the early seventies, and the topographic survey of the Parker quadrangle, forming the northwestern portion of the region covered by this reconnaissance, has been completed very recently.

Sundry localities have been examined in a more or less cursory manner by many mining engineers and geologists, and a few of the properties have been carefully studied by competent men, but as the work has been done for mining companies with a view to sale or purchase, the geologic results of the investigations have seldom been made public.

Numerous articles on the general activity, mineral production, and mining interests of this region and its vicinity were published during the years 1869 to 1876 in R. W. Raymond's reports on mining statistics west of the Rocky Mountains, and these reports afford a fund of data on the early history of the region.

Until very recently this region has lain quite out of the ordinary routes of travel and has been without any kind of railroad facilities, so that little information has been published concerning its mines and mining industries. E. A. Haggott, in 1909, prepared a map of the district which shows in a general way the location of the different properties and the principal physical features in the area. The following is a chronological bibliography of papers or reports which deal with parts of this area.

[a] Lee, W. T., Bull. U. S. Geol. Survey No. 352, 1908.

BIBLIOGRAPHY.

1865. Blake, W. P., Iron regions of Arizona: Am. Jour. Sci., 2d ser., vol. 40, 1865, p. 388.
Describes the geology and iron deposits near Williams River.

1868. Browne, J. Ross, Mineral resources of the States and Territories west of the Rocky Mountains.
Various notes on several mining districts within the area, with brief accounts of the Cunningham, Planet, and La Paz deposits.

1871-2-3. Wheeler Atlas, sheet No. 75.
Shows part of the geology in the extreme northeast of the area investigated.

1871. Raymond, R. W., Mining statistics west of the Rocky Mountains, pp. 267–269.
Contains several notes on various properties in the district.

1872. Raymond, R. W., Mining statistics west of the Rocky Mountains, p. 336.
Contains very brief mention of La Paz district.

1873. Raymond, R. W., Mining statistics west of the Rocky Mountains, p. 312.
Mentions briefly Planet and Constancia properties.

1874. Raymond, R. W., Mining statistics west of the Rocky Mountains, p. 344.
Contains very brief mention of La Paz and Williams Fork districts.

1875. Raymond, R. W., Mining statistics west of the Rocky Mountains, p. 395.
Mentions the McCracken mine.

1875. Wheeler Survey, vol. 3.
Contains a few general notes applicable to parts of the region under investigation.

1876. Raymond, R. W., Mining statistics west of the Rocky Mountains, pp. 351, 353.
Contains notes on the McCracken and Ehrenberg districts.

1877. Hodge, H. C., Arizona as it is.
Describes the Planet and McCracken mines at some length and gives various notes on other districts.

1884. Hamilton, Patrick, The resources of Arizona.
Notes on several of the mining districts.

1893. Blandy, J. F., Some notes on the geology of Arizona: Eng. and Min. Jour., vol. 56, 1893, pp. 473–474.
Geology in the vicinity of the junction of Santa Maria and Williams Rivers.

1899. Blake, W. P., in Report of the Governor of Arizona to the Secretary of the Interior.
Gives notes on the mining districts, climate, and vegetation in the area.

1901. Comstock, T. B., The geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 1038–1101.
Describes the general geology and vein formations of parts of Arizona, and gives a few brief general notes on properties covered by this investigation.

1902. Pratt, J. H., Gold deposits of Arizona: Eng. and Min. Jour., vol. 73, 1902, pp. 795–796.
Describes the geology and ore deposits of the Socorro gold mine, near Harrisburg.

1903. Austin W. L., Discussion of a paper by W. H. Weed, Ore deposits near igneous contacts, in Trans. Am. Inst. Min. Eng., vol. 33, 1903, pp. 1070–1077.
Brief reference to Planet mine.

1903. Blake, W. P., in Report of the Governor of Arizona to the Secretary of the Interior.
Gives information pertaining to the geology, ore deposits, and localities of several of the more prominent mining districts in the area.

1904. McCarn, H. L., The Planet copper mines: Eng. and Min. Jour., vol. 78, 1904, pp. 26–27.
Describes the geology, ore deposits, and workings of the Planet mine.

1907 · Smith, F. C., The cyanidation of raw pyritic concentrates: Trans. Am. Inst. Min. Eng., vol. 37 (for 1906), 1907, pp. 570–575.
Describes the methods of the Socorro gold company, near Harrisburg.
1907. Hately, George, Copper mining on the Colorado River: Min. World, vol. 26, p. 809.
Gives a few notes on the geology, ores, and locations of properties in Arizona and California in the vicinity of the town of Parker, Ariz.
1908. Lee, W. T., Geologic reconnaissance of a part of western Arizona: Bull. U. S. Geol. Survey No. 352, 1908.
Notes on the geology of a part of the region here discussed.
1909. Blake, W. P., A report to Hon. J. H. Kibbey, Governor of Arizona.
Brief description of several minerals from localities within this region.
1910. Stevens, H. J., The copper handbook for 1909.
Various descriptions of copper properties located within the area examined.
1910. Higgins, Edwin, Copper deposits of northern Yuma County, Ariz.: Min. World, vol. 33, pp. 855, 903.
Describes several copper deposits within the area.

Besides these articles there are many notes and references to the district contained in the Engineering and Mining Journal, the Mining and Scientific Press, the Mining World, the Arizona Mining Journal, and other journals, a complete list of which it is impracticable to give, for the articles usually appeared as "special correspondence" or "mining news," the author's name not being given.

HISTORY.

The earliest settlers and prospectors in the region seemed to be on friendly terms with the natives. Later, for various causes, the white man was looked upon as an intruder and had to defend himself constantly against the attacks of the Indians. Hence the early settlement of this part of the region was rather slow, and only a few properties now active were opened in the early days.

Placer gold in paying quantities was discovered [a] in the neighborhood of La Paz as early as 1862, and within a year 2,000 men were searching for the precious metal in this vicinity. From the Planet mine, discovered in 1863, ore was shipped as early as 1868, or perhaps earlier. Ore was smelted and bullion produced in the early eighties, and the slag dump resulting from these operations is said to assay 5 per cent copper. In 1874 the hostile Apaches were placed on Indian reserves and the settlers and prospectors were thus able to carry on their explorations more safely.

The McCracken property, in southern Mohave County, discovered August 17, 1874, by McCracken and Owens,[b] had its best days in the seventies and is reported to have shipped a great deal of ore, The Bonanza, at Harquahala, a short distance from Harrisburg. was located in 1888 and has been the largest producer in this region.

[a] Hamilton, Patrick, Resources of Arizona, 1884. [b] Hodge, H. C., Arizona as it is, 1877, p. 70.

The old Los Angeles trail ran right through this area from Ehrenberg to Wickenburg. The Southern Pacific Railroad, completed in 1879, and the Atlantic and Pacific, completed in 1882, no doubt helped to develop the central western Arizona region. However, the former railroad is a little too far south and the latter too far north to assist very materially a country in whose growth transportation is the dominant factor. With the completion of the Arizona and California Railroad from Wickenburg to Parker in 1907 an impetus was given to mining activity throughout the district. Many old claims were relocated and new ones were staked out. The Clara Consolidated Mining Company has built a railroad from Bouse to Swansea, called the Arizona and Swansea Railroad. Other proposed roads have been surveyed and may be completed in the future.

The towns along the Arizona and California Railroad have all been recently built and have attracted some of the inhabitants from the smaller places more remote from the railroad. At the present time (January, 1910) Parker, though containing only a few hundred persons, is probably the largest town in the area. The population of such places is constantly changing, however, so that it is not possible to give authentic data concerning the population of the area or of the settlements within it.

CLIMATE.

Unlike the greater part of Arizona, which is over 3,000 feet in elevation, the portion covered in this reconnaissance and that south of it is practically all under 2,000 feet. This low elevation, combined with the southern latitude and the desert conditions which prevail throughout the region, tends to produce intense heat in summer, which makes life, to one not acclimated, almost unbearable. During the months between November and May, however, the climate in central-western Arizona is most enjoyable because of the continuous mild, even temperature with almost perpetual sunshine and the lack of the intense desert glare which is so trying during the summer months.

The United States Weather Bureau at Phoenix publishes some very interesting statistics regarding average monthly precipitation, snowfall, temperature, frost, humidity, and wind direction for several of the stations included in this reconnaissance. The maximum temperature recorded at Parker, Ariz., near the western border of the area covered by this reconnaissance, occurred in July, when the thermometer reached 127° Fahrenheit. The minimum occurred in January, when the mercury dropped to 16°. The mean annual temperature for a period of 12 years is 70.9° Fahrenheit. At Signal station located at an elevation of 1,652 feet in the northeastern part of the area examined, the maximum temperature

recorded is 121°, the minimum is 10°, and the mean 67.4°. There is little or no snowfall in the area, but occasionally a slight covering is noted on top of the peaks of the Harquahala and the Harcuvar Mountains. The prevailing wind direction at both Parker and Congress is southwest. The mean annual precipitation recorded at Parker during a period of 8 years is 4.27 inches, and records at Signal station during a period of 15 years show a mean annual precipitation of 7.37 inches.

VEGETATION.

Cacti of many different varieties form the most abundant vegetation in the area. These can not be utilized to any great extent in an economic way and are interesting mainly because of their prodigious growth. Cholla (*Opuntia fulgida*) of several different varieties, prickly pear (any cactus of the genus *Opuntia*), nigger head (*Echinocactus*), greasewood (*Sarcobatus maximiliana*), and palo verde (*Cercidium torreyanum*) abound in the low country; and ocotillo (*Fouquiera splendens*), yucca, and sahuaro (*Cereus giganteus*) are very common in the hills and mountains. Mesquite and ironwood are fairly abundant on some of the mountain slopes and are used principally for fuel. A certain variety of oak is also found, but is not very common.

Along Williams and Colorado rivers, the only two running streams in the area, there is an abundant growth of cottonwood and palo verde—a most acceptable sight to the traveler who has crossed miles and miles of desert waste. Most of the washes in the district contain palo verde and greasewood, and the latter is common throughout the desert. Sagebrush, gietta, and other coarse grasses are plentiful in the valleys and low country. Mesquite beans, a product of the mesquite tree, contain a large percentage of grape sugar, and are supposed by the natives to afford a very nutritious food.

TIMBER.

As ironwood is unfit for use in the mines and as no other large trees grow here in sufficient number to afford timber, it becomes necessary to ship in all the timber from outside districts. Oregon pine is shipped down the coast in boats and freighted by rail to points in central-western Arizona at a total cost of $24 to $28 a thousand feet delivered at any Arizona and California Railroad station. Some timber is also obtained from nothern Arizona at a cost about equal to that of Oregon pine. The freight rate (January, 1910) on lumber from southern California to Arizona and California Railroad stations is $8 a ton in carload lots. The freight rate to these stations from Flagstaff and Williams is $6.40 a ton, and the freight on stulls and lagging from these same points is $5 a ton.

MINING AND METALLURGY.

CONDITIONS AND COST OF MINING.

General conditions in the region.—In central-western Arizona mining is not carried on under the most favorable conditions. Wood, timber, and water are scarce, and most of the properties are far from the railroad, so that a long haul is necessary in order to ship out the ores and bring in supplies. Fuel, whether gasoline, crude oil, distillate, or coal, must be hauled from the railroad to the mines, and at some mines water must be pumped from distant places or hauled by wagons. Wood also must be hauled, some of it for long distances. All these items increase the expense of mining, and as the region is undeveloped, few data are available to show the cost of these operations.

Freight costs.—The property of the Cunningham Pass Copper Mining Company is about 11 miles by wagon road from Wenden, the nearest railroad station. The ascent from the railroad to the property is gradual, the road crossing only one small divide. Freight to Wenden is $4 a ton, the back freight being $3. The cost of hauling freight to the Bonanza mine from Salome, a distance of 10 or 11 miles by wagon road, was given by the management as $4 a ton on small shipments and $3.50 a ton on large consignments. Hauling freight 28 miles to the Planet property is reported to have cost from $10 to $18 a ton, and the superintendent of the San Marcos reported a cost of $4 a ton for freight haul between their property and Wenden, a distance of only 5 miles.

The railroad freight rates from all points on the Arizona and California Railroad to certain smelters are uniform for ore of the same grade. For example, the rate (March, 1909) to the Arizona Smelting Company at Humboldt on ores not exceeding $15 a ton was $2; not exceeding $25, $2.50; not exceeding $35, $3; not exceeding $50, $3.50; not exceeding $100, $5, and not exceeding $300, $6.50. Probably the freight charge on most of the ore shipped from the district would be less than $5 a ton.

The freight rate from all Arizona and California Railroad points to El Paso, Tex. (March, 1909), on ores not exceeding $35 is $6; to Sasco, Ariz., on ore not exceeding $30, $4.95; to Denver, Colo., on ore not exceeding $50, $11; and to San Francisco, Cal., on same class of ore, $10.50.

Most of the ore from the Arizona and California district has been shipped to Humboldt, Ariz., but since the closing down of the smelter at that place [a] the ore has been shipped to smelters at Sasco, Ariz.,[b] and El Paso, Tex., and to other points in the Southwest.

[a] This smelter is now (February, 1911) in operation. [b] This smelter is now (February, 1911) closed.

The freight rate on coal from Gallup, N. Mex., whence most of the coal used in the region is shipped, is $4.15 a ton in carload lots to any point on the Arizona and California Railroad. The freight on distillate from Los Angeles is $17 a ton, and the freight on crude oil from Bakersfield, Cal., is $6 a ton.

Smelter charges.—The treatment charges of the smelters naturally vary considerably, according to the class of ore to be smelted. On copper ore from the Cunningham Pass property, which averaged about 12 per cent copper, 0.7 ounce gold, 12 per cent iron, and 54 per cent insoluble matter, the smelting charges of both the Humboldt and the El Paso smelters averaged approximately $8 a ton. This high rate is due to the large percentage of silica, a penalty of 10 cents per unit excess silica over iron being charged by the smelters.

On gold ore shipped from the Pittsburg Harqua Hala property (San Marcos) to the Humboldt smelter the treatment charges were $10 a ton for ore of the following analysis: Gold, 1.56 ounces; silver, 0.34 ounce; insoluble, 88 per cent; iron, 5.4 per cent. The dominant factor in smelting charges for most of the ores in this region is naturally their content of iron and silica. The silica content of many ores is high and increases the smelter charges proportionally.

Cost of mining.—The actual cost of mining the ore differs so much according to location of properties, scale of operations, and other factors that it is hardly possible to give figures that are even suggestive. The lowest prices given were $2.50 and the highest $9 a ton. The cost of mining at some properties in this district no doubt exceeds $9 a ton. Under present conditions, therefore, in order to determine the average complete cost of production (including shipment to smelters) it is well to figure on railroad freight charges of $4; hauling charges, $4 to $20; treatment charges, $6 to $10; mining costs, $2.50 to $9—an average minimum total of $16.50 and an average maximum total of $43 per ton of ore mined and shipped. These figures, of course, apply only to ore which is not concentrated and which is shipped directly to the smelters.

Smelters.—Most of the ores from this district are shipped to custom smelters outside of the area, but there are several smelters of very small capacity and other reduction works of various kinds in the region. At present (January, 1910) there is in progress of erection a 700-ton smelter at Swansea, Ariz., where the Clara Consolidated properties are located. This smelter will probably do custom work, as it is located in the center of large deposits of hematite in limestone, which form the main part of the Signal ore deposits, and which will be an excellent flux for siliceous ores shipped in from the outside. On the completion of the Arizona and Swansea Railroad this smelter will be as easy of access to the properties in the district as are the custom smelters outside of the area and will be nearer.

Two small copper smelters (neither of them active at present) are located at the Planet and the Valensuella properties, and a quicksilver smelter is located at the Cinnabar workings in the southwestern part of the area. Various adobe furnaces have been operated in this region in the past with some success, but this method of smelting is now obsolete.

Mills.—Mills of various types and sizes have been constructed in the area. The Socorro mill and the process of ore separation there employed have already been fully described.[a]

Probably the largest mill in the area is that at the Bonanza (Harqua Hala) mine. This mill has 40 stamps, and when it is running at full capacity the company can mine and mill ore for $2.50 a ton. The plan of the mill is very simple, the ore passing over grizzlies into the rock crushers, from them into feeders, and thence into the batteries. Quicksilver is used in the mortars and on the plates. The water used in the mill comes from the mine, which furnishes about 3,000 gallons a day. This water, used over and over, will suffice for 20 stamps. Other water is piped from the pumping station at Harrisburg, about 5 miles distant.

Numerous small stamp mills have been erected in various parts of the area, nearly every mining district having one or more within its boundaries. These have been more or less successful, and one or two still remain in good repair; most of them, however, have become worthless, mainly because of partial dismantlement and lack of use.

Labor.—Labor conditions are apparently adjusted to the progress of the mining activity of the country, there being plenty of miners wherever there is ample work for them. Wages are about the same as those paid in other mining districts of the Western States.

METHODS OF MINING.

Most of the mining in the area is carried on by inclined shafts, but there are a few vertical shafts, some crosscut adits, and drifts on the veins. The presence of so many inclined shafts is probably due to the fact that most of the veins have a fairly gentle dip (30°–60°), and the easiest and safest way of exploration seems to be to follow the vein. Fairbanks-Morse hoists are used almost universally, the average size being 9 to 15 horsepower. Distillate is used for fuel and costs approximately 15 cents a gallon in carload lots delivered at any Arizona and California Railroad point. In smaller lots, by the tank, it costs about 17½ cents a gallon. Some of the larger properties use steam hoists, generating steam by crude oil that is shipped from Bakersfield, Cal. The oil costs $1.75 a barrel (40 gallons) at Arizona and California Railroad points. One wire-rope tramway has been

[a] Smith, F C., The cyanidation of raw pyritic concentrates: Trans. Am. Inst. Min. Eng., vol. 37, 1907.

used, connecting the Golden Eagle property with the Bonanza mill, about a mile distant. The country is not developed enough to require a lengthy description of the methods of mining, all the mines being more or less in the prospecting stage.

PROPERTIES EXAMINED.

The properties in the region which are supposed to be, in some particulars at least, the more prominent are listed in the following table. The table also includes, however, some obscure prospects that were examined because of their proximity to well-known deposits which were studied with more or less detail. For lack of time, some locally well-known properties could not be examined.

List of properties examined.

No.	Name of operator, owner, locality, or mining company.	Property ordinarily called the—	Mining district.[a]	Active (x) or inactive (v) at time of examination.
1	Planet Copper Mining Co.	Planet mine	1	v
2	Mineral Hill	Norma	1	v
		Mohave Chief	1	v
		Copper King	1	v
3	Clara Consolidated Gold and Copper Mining Co.	Clara	1	x
		Moro	1	x
		Signal	1	x
4	Quartz King Gold Mining Co.	Quartz King	1	x
5	William Mack	Billy Mack's mine	1	v
6	Mr. Watson	Carnation group	1	v
7	Mr. Osbourne	W. & O	1	v
8	Mr. Osbourne et al	Dome City	1	v
		Mineral Zone	1	v
		Mail Pouch	1	v
		Pride	1	v
9	Corona Copper Co.	Chicago	1	x
		Mammoth	1	v
		Also others	1	v
10	Valensuella Copper Co.	Valensuella	2	x
11	Julia Travis	Mariquita	3	v
12	Colonial Mining Co.	Cinnabar	3	v
13	French-American Mining Co.	French-American	3	v
14	New York-Plomosa Gold Mining Co.	New York-Plomosa	3	v
15	Guadalupe	Guadalupe (Moreno)	3	v
16	Ibex Mountain	Lead Camp	3	v
17	Mr. Mudersbach	Mudersbach Copper Camp	3	v
18	Forepaw	Iron Mine	3	v
19	Little Butte Consolidated Mines Co.	Little Butte	3	x
20	Yuma Copper Co.	Yuma	4	v
21	Yellow Bird	Yellow Bird	4	v
22	Alvin Griffith et al	Arizona Northern	4	v
22	Mr. Winchester	Desert Prospect	4	v
24	Calcite Mining Co.	Calcite	4	x
25	Tank Pass Consolidated Mining Co.	Cobralla	4	v
26	Bonanza-Golden Eagle Mining Co.	Bonanza	4	x
27	Hercules Gold Mining Co.	Hercules	4	v
28	Socorro Gold Mining Co.	Socorro	4	v
29	Pittsburg Harqua Hala Gold Mining Co.	San Marcos	4	v
30	Cunningham Pass Copper Mining Co.	Critic	4	x
		Boone	4	v
31	Mr. Bullard	Bullard's	4	v
32	McCracken Mountain	McCracken	Owens	v
33	Viata Mining Co.	Bennett's	Monumental, Cal.	v
34	Copper Basin	Copper Basin	do	v
35	Bowman & Thompson	Bowman's	do	x

[a] For map of mining districts, see figure 4 (p. 45).

OTHER PROPERTIES.

On a recent map published by E. A. Haggott many other properties are also noted, but the author is unaware of the development or the exact location of most of them. Few of them were being actively developed at the time the field work for this report was done. Their names and the regions in which they are located are given below.

In the Harquahala Range—the Boneroff, Sunset, Mountain Chief, Yuma, Del Monte, Big Four, Shawnee, Cholla, Evergreen, Shamrock, Martin, Genung, Geer's, Sayer, Golden, Dushay, and Armstrong properties.

In the Harcuvar Range—the Ford, Ewar, Lind-Griffin, Dolan's, Beekman, Hughes, Quinn & Scales, McDonald, Lester, Torres, Bell Crown, Akers, Oro Cobre, Robinson's, Lessens, Harcuvar Copper Company, Josephi's, Agard's, C. & O., Auditorium, and Burson & Wallace properties.

In the Williams Mountains south of Williams River—the Red Bird, Midnight, Montana-Arizona, Blanco, Wentworth, Revenue, Blanchard's, Continental, Juanita, Gier, Black Diamond, White Eagle, Mavis, Richmond, Gray Eagle, Belcher, and Cyclone properties.

In the Williams Mountains north of Williams River—the DeWitt, Rawhide, New Clara, Bryan, McCuen, Casteneta Copper Company, McWright, and Profetto properties.

In the Plomosa Mountains—the Moore, Success, King Verde, River, Smith, Zero, Vulcan, Edna, Quinn & Gaynor, Ibex, Old Maid, Manipulator, and Bellows properties.

In the Dome Rock Mountains—the Bowyer, Harris, Virgin Queen, Copper Bottom, and Ida May properties, the latter, however, being located in the isolated hills south of Parker some 10 or 15 miles, which hills may be taken as a northern remnant of the Dome Rock Mountains.

In the Whipple Mountains (California)—the Dunn, Hinaman, Martin, Black Metal, Manning, Dunkirk, Dickson, Copper Chief, Lily, St. Clair, Lucky Boy, Raney, Friday 13th, Mount Whipple, Honn, Brazle, Wareham, Garrett, Young, Klondyke, White, Dunbar, Wilson, Confidence, Grand Central, Hawn, Baltimore, Copper, Roths, Blue Bird, Cat Claw, National, American Eagle, A. C. Group, D. & W., Atkinson, Nicolite, Copper Basin,[a] Bowman's,[a] and Viati properties.[a]

[a] Described in the text of this report.

TOPOGRAPHY.

RELIEF.

GENERAL FEATURES.

The country investigated in this reconnaissance shows typical desert topography. The area covered by the mountain ranges is exceedingly small as compared with that of the valleys. Most of these ranges rise abruptly out of the desert, and the intervening valleys, which slope with decreasing declivity down to the washes leading to Colorado River, are filled with detrital material resulting from the erosion of the mountains. In places the slopes of the ranges are almost covered with this erosional débris, so that the most impressive feature seen by an observer looking toward the upper end of a valley is the broad gentle slope to the deserts that lie between the mountain ranges. In the northern part of the area lava flows have tended to make the topography somewhat rolling. The foothills of the Williams Mountains are composed of such lava flows, and the Whipple and the Plomosa Mountains owe part of their prominence to lava flows that cap the older eroded rocks and in places surround their bases. No deeply dissected stream valleys are present in the area except in the washes near Williams and Colorado rivers, where fairly steep, though short, precipitous canyons have been formed. The axes of the mountain ranges extend in two separate lines, one northeast and southwest, the other north and south. It is possible that this latter direction may have resulted from erosion in the original stream course of Colorado River, which possibly at one time flowed down the valley in which Quartzsite is located.

The lowest elevations in the area occur along the present stream bed of Colorado River, which is below 500 feet. The highest peak, Harquahala, attains an elevation of over 5,500 feet, the valley just north having a general elevation of 2,200 feet. The average difference in height between the mountain tops and the valleys, however, is about 1,500 or 2,000 feet.

In the main, the mountains are carved from old crystalline and metamorphic rocks, and the ridges and slopes are therefore fairly regular and lack the abrupt cliffs and terraces characteristic of ranges in which the sedimentary rocks participate largely in the structure. In detail, however, the landscape bears the imprint of desert erosion, of which small but steep scarps, jagged outcrops, and sharply cut ravines are typical.

Because of the almost total lack of vegetation in the region little or no soil covers the mountains, the result being that their contours and natural colors stand out with very marked prominence.

MOUNTAIN RANGES.

Principal features.—This area includes six distinct mountain ranges, of which the Harquahala and the Harcuvar are the most prominent and well defined. The others are the Plomosa, the Williams, the Whipple, and the Dome Rock mountains. The hills commonly called Granite Wash Mountains are really a continuation of the Harcuvar Range, and to set them apart in a separate division is not only unnecessary but incorrect and misleading.

Harquahala Range.—The Harquahala Range is separated from the Harcuvar Mountains by Granite Wash Pass. The southwest end of the Harquahala Mountains is composed of low but prominent peaks, which rise several hundred feet above the surrounding flat desert. Centennial Wash practically cuts the Harquahala Mountains in two. Northeast of Harrisburg the range is less dissected by erosion, and Harquahala Mountain caps the range, at an elevation of 5,669 feet. This range is distinguished from the others by the compact form of the main mountain mass. In the rest of the area there are many prominent peaks, but few, if any, individual mountains which are nearly as large as Harquahala. In fact, the character and conspicuousness of the range seems to depend largely on this one mountain.

Harcuvar Range.—Of all the ranges in the area, the Harcuvar is probably the most continuous and uniform in general contour. Many prominent peaks project a few hundred feet above the average elevation of the range, and when observed from a great distance these seem, with the exception of Harcuvar Peak, like very small knobs projecting from a high plateau. The general trend of the mountains is northeast-southwest, the southwestern extremity turning abruptly to the south, where it practically joins the Harquahala Range. Harcuvar Peak is the most prominent in this range and is second only to Harquahala Mountain in being the most conspicuous landmark in the area.

Other mountain ranges.—North and south of Williams River the country for several miles is built up by low foothills which gradually rise to the base of a few prominent peaks, among which Planet is by far the most noteworthy, and these constitute the Williams Mountains. They are so decidedly different from the other ranges in the area that the presence of foothills is worthy of remark.

Of the remaining Arizona mountain ranges to be discussed, the Plomosa Mountains[a] (distinguished by the Black Mesa) are probably more prominent and certainly cover a greater area than the Dome Rock Mountains. Both ranges are in the southwestern part of the area and are separated from each other and from the remaining

[a] These are called the "Palomas" by Lee; Bull. U. S. Geol. Survey No. 352, 1908.

mountain groups by broad valleys. The trend of the mountains is north-south in both instances.

The Whipple Mountains, located in California and culminating in the well-known landmark, Monument Peak, show characteristic topographic forms which may be accounted for by the geology of the range. There is a difference of over 3,000 feet between the top of the highest mountain in the Whipple Range and the Colorado Valley, which is some 10 miles distant.

DRAINAGE.

Colorado River and its tributaries drain the whole area. Williams River, tributary to the Colorado, has running water throughout the year in its lower course. Part of the year Big Sandy and the Santa Maria have a regular flow, and during this period the Williams has running water continuously. In the rainy season the various washes frequently have a large flow of water, but this is only of temporary duration, seldom lasting over two days and frequently only several hours. Some peculiarities in drainage may be seen by referring to the general map (Pl. I) which accompanies this paper. South of Salome there is a very low divide, which forms a prominent watershed. Also, on the road from the Guadalupe to Vicksburg a divide is passed, southeast of which all water is drained in that direction, while to the northwest the drainage is in the opposite direction.

Bouse Wash probably drains more country than any other wash in the area.

GROUND-WATER LEVEL.

In this part of Arizona the ground-water level fluctuates with the seasons and is different at different localities, and no definite distance below the surface can be given as the present water-table level. In general this conforms to the topography of the mountain ranges, although there are many exceptions, and erratic underground channels are found in parts of the area. Near Harrisburg, in Centennial Wash, there is an extensive flow a few feet below the surface, and a company is now building a dam across the channel of this stream, hoping thereby to conserve the water for use in the valley. In the Bonanza, Cunningham Pass, and Little Butte properties the water level is about 170, 320, and 200 feet, respectively, below the collar of the shaft.

GEOLOGY.

GENERAL GEOLOGIC FEATURES.

The rocks of the region as represented on the geologic map (Pl. I) have been divided into pre-Cambrian, Mesozoic (?), Tertiary, and Quaternary.

Pre-Cambrian.—Pre-Cambrian rocks compose practically all the mountain ranges except those near the mouth of Williams River and

some scattered mountains in other parts of the area which are capped by lava flows. Nearly all of the ore deposits are found in the pre-Cambrian rocks, so that these will necessarily receive more attention than the others.

Granites, gneisses, schists, quartzites, limestones, dolomites, and argillites constitute the pre-Cambrian rocks, all of which are at many places cut by intrusive rocks of different kinds and ages. Diabase, pegmatite, and aplite are the most common dike rocks in the pre-Cambrian, but other types also are present.

Mesozoic (?).—The age of the large and massive granite intrusion in the Harcuvar Range is not known. Certainly it is younger than the pre-Cambrian strata through which it cuts. Because of the fact that so many granite intrusions have taken place in the Pacific States in Mesozoic time, this one is assigned temporarily to that era, no fossils having been found in the area either to substantiate or disprove the correctness of the assignment.

Tertiary.—The lava flows, with the exception of some of the basalts which are interbedded in and rest on top of Temple Bar conglomerate,[a] have been assigned to the Tertiary system. Several of the ranges are capped by volcanic rocks, and many prominent peaks in the area are composed entirely of igneous flows.

Quaternary.—The broad valleys between mountain ranges, the river banks, and the thick gravels which occur north of Williams River cover by far the largest part of the map. All of these, including most of the basalts, belong in the Quaternary system.

PRE-CAMBRIAN ROCKS.

GRANITE-GNEISS-SCHIST COMPLEX.

The oldest rocks in the area are probably of Archean age. They are granitic; many are gneissic and some are decidedly schistose in structure. The major part of the Harcuvar Mountains north of Harcuvar Peak is composed of this type of rock, as is the Harquahala Range north of Centennial Wash. Material belonging to this complex makes up much of the Williams Range and also forms the basal portion of the Whipple Mountains in California, and no doubt underlies and forms part of the Dome Rock and the Plomosa mountains. In some places, as at Socorro and Little Butte, the granite is of normal structure; at the Signal, the Cunningham Pass, and the Planet workings the basal rock is decidedly gneissic. At the San Marcos and elsewhere the granite is in part normal, but often changes very abruptly to gneiss, there seeming to be no regularity in the change from normal granite to gneiss and schist.

[a] Lee, W. T., Bull. U. S. Geol. Survey No. 352, 1908, p. 18.

These rocks occur in many colors, white, pink, and gray predominating, the color in many places depending on the presence and alignment of the ferromagnesian minerals and the degree of alteration of any or all of the constituents of the rock. Some of the schists have a blackish cast. The Harcuvar Range as a whole looks decidedly gray, the tone probably resulting from the white feldspar and black mica constituents of the rocks. The gneiss just south of the Signal and north of the Planet is of a pinkish cast.

Basic rocks of dioritic composition were intruded into the granites before the metamorphism of the area, and have been metamorphosed along with the rest of the series.

Pegmatite and aplite dikes are common throughout the granite gneiss schist area. Some of these intrusions are of large proportions, being several hundred feet wide and perhaps several thousand feet long. Generally the pegmatite dikes are of smaller dimensions.

Thin sections of granitic gneiss examined under the microscope show holocrystalline structure and a composition of microcline and orthoclase feldspar, with perhaps a little albite, associated with considerable quartz and a noticeable amount of biotite. Some augite is present in the rocks and a very small amount of calcite. Each mineral is remarkably fresh, even the feldspars showing hardly any signs of sericitization.

The basic dioritic gneiss has a structure similar to that of the granitic gneiss and is composed almost entirely of hornblende with andesine or labradorite feldspar with here and there a few crystals of quartz.

The schists have in general the same composition as the gneisses, the difference between the rocks being merely textural. Most of the schists in the area, however, not belonging to this granite gneiss schist complex are of quite different origin, being for the most part recrystallized sediments.

Granitic aplites (fine-grained muscovite granites) are composed of quartz, orthoclase, and muscovite.

Pegmatite represents another phase of granite, being composed of very large crystals of orthoclase, quartz, and mica.

METAMORPHOSED SEDIMENTS AND SEDIMENTARY SCHISTS.

POSITION AND CHARACTER.

Resting on and younger than the granite gneiss complex are metamorphosed sediments, not schistose, and sedimentary schists. Of the former only a thickness of a few hundred feet now remains, while of the latter several thousand feet can still be seen in the area. The first type is composed of quartzites, limestones, and dolomites, and the second of argillites and arenaceous shales, metamorphosed into

fine-grained quartz-mica schists, both of which types are believed to be of pre-Cambrian age. To the writer's knowledge neither of the groups can be correlated with any known division in Arizona. Because of their lithologic and structural characters they are not comparable to the Pinal schist of Ransome, the Arizonian of Blake, or the Yavapai schist of Jaggar and Palache. Nor are they considered analogous to the little-altered, nearly horizontal sandstones and shales (Unkar and Chuar groups) of the Algonkian in the Grand Canyon section. The Pinal and Yavapai schists are fine-grained quartz muscovite sedimentary rocks, which are entirely free from limestones and quartzites, the whole being intruded by innumerable granitic rocks of pre-Cambrian age.

In this area these metamorphosed sediments and sedimentary schists contain limestones, dolomites, quartzites, amphibolites, and quartz-mica schists, and in no places noted were they intruded by granitic rocks which appeared to be of pre-Cambrian age. Hence it is impossible at the present writing to correlate the rocks found in this regionally metamorphosed area with any known formation outside.

Sheets of basic rocks have been intruded into and poured out over the various sediments at many different periods, so that the complex has intercalated basic rocks (now amphibolites) which have been metamorphosed along with the rest of the series, the result being a very intimate association of the two.

QUARTZ-MICA SCHIST GROUP.

The rocks which appeared to be the oldest in this complex of metamorphosed sediments and sedimentary schists are the medium-grained to coarse-grained quartz-mica schists in the vicinity of the Valensuella workings. These dip northwest away from the gneissic micaceous granite found south of Tyson Wash, which is probably the oldest rock in the vicinity and is perhaps comparable to the granite gneiss complex of the Harcuvar Range. The schists attain a thickness of several hundred feet, vary in color from gray to black, and seem to be derived from the erosion of a quartz-mica diorite. Under the microscope the thin sections show the presence of much labradorite and nearly an equal amount of orthoclase feldspar, associated with quartz and a noticeable amount of white mica. Pyroxenes in small quantities are present in some of the schists, and chlorite is rather abundant. Rocks of similar composition and texture were noted in many other parts of the area and in general seem to underlie the quartzites, dolomites, limestones, fine-grained quartz-mica schists, and argillites.

Near the Calcite workings a section was observed in which the basal rock was a coarse-grained quartz-mica schist similar to that in the vicinity of the Valensuella. Over this occurs a few feet of

very much altered, fine-grained quartz-mica schist, which is in turn overlain by a few feet of quartzite capped by several feet of quartz-mica schist with another thin layer of quartzite on top, the whole section being perhaps 100 feet thick. The canyon between the Calcite property and the Desert prospect, known as Desert Canyon, is cut in a series composed mainly of arenaceous shales and argillites, the total thickness of which is several thousand feet.

QUARTZITE-DOLOMITE-LIMESTONE GROUP.

In the vicinity of the Bonanza (Harqua Hala) mine the series resembles greatly that found near the Socorro workings. South of the Bonanza mine a thin stratum of quartzite overlays coarse-grained crystalline rocks of granitic composition and is in turn capped by a few feet of dolomite and by 200 or 300 feet of schists, limestone, and shale. On top of the ridge just south of the Bonanza mine a massive layer of gray limestone is found, which is 50 to 100 feet in thickness. This limestone appears to be younger than that seen in the vicinity of Planet and the Clara Consolidated and elsewhere, but it is nevertheless believed by the author to be of pre-Cambrian age. This is similar in many respects to a limestone noted near the Mudersbach copper camp.

In the vicinity of the Socorro mine a similar series is observed, where 100 to 200 feet of quartzite rest upon a granitic base, and on top of the quartzite occurs several hundred feet of yellowish crystalline limestone, near the upper portion of which intercalated argillites and fine-grained quartz-mica schists occur. It is possible that these argillites are comparable in age to those found in the vicinity of the Desert prospect, where medium to fine grained quartz-mica schists also form a part of the series, but the whole series has a somewhat less altered aspect. No fossils could be discovered.

The quartzites vary in color from white to pinkish gray, and in general seem to be rather pure. They are in most places very compact and highly silicified, most of those seen being fine-grained, although coarse-grained quartzites are present in the area, some having been noted at the Bonanza mine. In no place where quartzites were noted did the thickness exceed 200 feet, and generally it was much less.

The only dolomite definitely recognized as such was found near the Bonanza mine, where it is only of nominal thickness. This is of a dark-gray color and contains many vugs and transverse fissures filled with iron-stained calcite. The rock is exceedingly fine grained and has a glistening surface. A partial analysis showed the presence of 20.59 per cent magnesia.

Limestones of various sorts were found in beds ranging in thickness from a few inches to several hundred feet. Some are pure white

coarsely crystalline marble, and the majority are fine to medium grained yellow, brown or dark-brown crystalline limestones. Analyses of three typical specimens of the fine-grained variety gave the following results:

Analyses of limestones from northern Yuma County, Ariz.

[Chase Palmer, analyst, U. S. Geol. Survey.]

Locality.	CaO.	MgO.	Loss on ignition.
Battleship Mountain	52.57	0.23	41.75
Planet, dump of vertical shaft	44.63	2.11	36.98
Planet, limestone used as flux in smelter	34.15	2.99	30.00

ARGILLITES AND ARENACEOUS SHALE GROUP.

The remaining group of metamorphosed sediments, composed of argillites and arenaceous shales, the latter having been metamorphosed into fine-grained quartz-mica schists, is of wide distribution.

The argillites are found in a typical exposure in the vicinity of the Desert prospect, 2 miles north of Vicksburg, where the formation attains a thickness of several thousand feet. The series alternates with arenaceous strata and calcareous beds and a great number of amphibolitic layers of varying thickness. Clay shales of the same general type were also observed at Mineral Hill and intercalated in the limestones near the Socorro workings. The rocks in the vicinity of Cinnabar appear to be mainly of the fine-grained quartz-mica schist type and are prominent in the Dome Rock Mountains. The argillites are greenish to dark gray or almost black in color, resembling in many respects roofing slates. They seem to be composed largely of carbonaceous matter, with which is associated approximately equal amounts of feldspar and quartz, the former having largely changed to white mica. Chlorite is present in some of the argillites and in places to such an extent that the rock has a decided greenish tone.

The arenaceous shales which have been metamorphosed into fine-grained quartz-mica schists have every conceivable color, ranging from silvery white to gray, brown, yellow, red, and a color which approaches black. The principal constituents of the rock are, as its name implies, quartz and mica, the latter usually being in the form of sericite, presumably resulting from the decomposition of feldspars. The colors are due in general to the kind of mica and the amount of epidote and chlorite present, and in part to the degree of oxidation of the contained iron. Some specimens of the rocks feel greasy and are readily scratched with a knife blade, showing characteristics due to the presence of a large percentage of mica.

INTRUSIVE ROCKS.

Basic rocks.—Throughout the area diabase and the derivatives of other basic rocks are almost universally present in large exposures of pre-Cambrian rocks. In places they appear to have been intruded prior to the development of schistose structure in the region; in others they occur as sills occupying bedding planes between strata; and here and there the diabase cuts across all formations, this evidently being the youngest phase of these intrusive rocks. Part of the basic rocks are schistose, some are massive, and most of them have undergone metamorphism so great that they now form amphibolitic rock.

Where these rocks have intruded formations other than limestone they seem to have either cut the formation entirely or else to have formed sills or sheets between the various strata. With the limestone, however, conditions are locally quite different, and frequently great thicknesses of the material can be seen in which the metamorphic amphibolite plays an important part. In the vicinity of Battleship Mountain, Limestone Mountain, Planet, and elsewhere, the limestone seems to have been partly absorbed by and literally saturated with the basic rock, so that the result is like that produced by immersing a fractured brick in hot slag, or, better, like bricks after long service in mercury condensers. Perhaps the basic rock was introduced under the weight of former overlying sediments and filled all of the open spaces, besides replacing parts of the limestone.

In other localities, as at Billy Mack's, there seem to have been alternate periods of deposition of sediments and of basic flows, one on top of another, the whole being later metamorphosed and tilted to its present position.

Many of the dark-colored intrusives in the area resemble megascopically the diabases and other related rocks. As microscopic study has shown these to be connected with the Mesozoic (?) granite intrusion, they will be discussed in that connection.

The diabases have a general greenish tone and are phanerocrystalline, having a medium to fine grained texture. Thin sections of the younger phase of the diabases examined under the microscope show ophitic structure, the chief constituents being augite and labradorite, with which is associated a considerable amount of epidote and calcite.

The amphibolites found in this area were probably formed through the alteration of basic rocks like diabase, diorite, or gabbro. These amphibolite masses are of various shades of green and are usually rather soft, being composed largely of some amphibole mineral, associated with a little quartz and much chlorite and talc.

Dikes.—True pegmatites seem to be conspicuously absent in the metamorphosed sedimentary complex, but it is the writer's belief

that much of the so-called vein and "bull" quartz found throughout the series is of pegmatitic origin and is probably connected with later intrusions in the area, which will be discussed under post-Cambrian rocks.

Aplite of texture different from that observed in the granite gneiss schist complex occurs at many places in these metamorphosed sediments. This is no doubt likewise connected with the intrusion of granite in the southwestern part of the Harcuvar and the Harquahala ranges and will be discussed under Mesozoic rocks.

Other intrusives.—As the occurrence of other intrusives has only local significance, they will be discussed under the detailed description of mineral deposits.

POST-CAMBRIAN ROCKS.

MESOZOIC (?) INTRUSIVE ROCKS.

GRANITE.

Of the various post-Cambrian intrusives found within the area, the granite occurring in the Harcuvar Range and forming parts of its southwest extremity is probably the most prominent.

Two large masses of this granite were seen, one of which forms Harcuvar Peak and the other forms the range from a little west of Harcuvar Peak to a point just southwest of Salome Peak. Numerous other occurrences of smaller dimensions were noted. The intruding magma may have sent out stringers which outcrop at various distances from the parent mass, and which have no surface connection with the main intrusion. Branching masses of this granite are exposed in Granite Wash Pass and also near the Calcite workings. In places the intruding magma has suffered more severe metamorphism than the surrounding rock. On the other hand, some of the sedimentary schists have practically absorbed the granite and its accompanying solutions. Apparently the degree of absorption and alteration of the granitic magma depended upon the composition of the intruded rocks. Limestone, for example, was profoundly altered, but the schists seem to have been only slightly changed. Where later granitic dikes cut the granite, large contact minerals were developed, such as hornblende crystals more than an inch in length and biotite crystals more than one-half inch in diameter. The rock shows to the unaided eye large feldspar, quartz, and biotite crystals, and is apparently epidotized to some extent. Examination of thin sections reveals the presence of microcline and orthoclase feldspars with a little albite, much quartz, biotite, and hornblende, and a very small amount of augite. Epidote is fairly conspicuous.

In the vicinity of Quartzsite a small hill 1 mile due south of the town is composed entirely of a medium-grained, greenish-colored

augite andesite porphyry, and another mountain, 2 miles southwest of Quartzsite, is composed of a medium-grained aplite, both of which rocks are probably late intrusives and are no doubt present in many places in the area. Granitic intrusives were noted in the vicinity of the Mariquita prospect, and quartz monzonite porphyry was seen at the Mudersbach copper camp.

INTRUSIVE DIKES CONNECTED WITH THE GRANITE.

Aplite.—Several types of intrusive dikes which commonly accompany granitic intrusion were observed. Of these the most common have aplitic composition, and are of both fine and coarse-grained texture with large exposed surface dimensions, some of them being over a mile in length. These aplites differ from those mentioned under pre-Cambrian dikes in that they are not so jointed and are in general fine grained and massive. In the immediate vicinity of the granite area aplite dikes are extremely numerous, and form a noticeable part of Salome Peak. They also seem to have been more widely distributed through the area than the granite proper, and rocks of similar aplitic composition and texture are found as far away as the Mudersbach copper property. It seems probable that they are connected with the main granitic intrusion.

Vogesite and minette.—Vogesite dikes were observed in several places in the vicinity of Salome and Harcuvar peaks, and minette dikes were noted in the Socorro and Valensuella localities. The former porphyritic rock is characterized by the number of hornblende or augite phenocrysts it contains. These are lath-shaped and stand out prominently on a weathered surface of the rock. Under the microscope thin sections show a predominance of hornblende or augite crystals and some orthoclase feldspar. Apatite is also a noticeable feature of the rocks.

Minette dikes are also porphyritic and are composed of biotite and orthoclase feldspar. Apatite is a conspicuous feature of the rock when viewed in thin section under the microscope, this mineral and the feldspar constituents not being visible upon megascopic examination.

TERTIARY ROCKS.

General character.—On the map accompanying this report (Pl. I) all of the lava flows are represented by one color. A few of the effusives are of Tertiary age; the area occupied by them, however, forms only a small portion of that covered by volcanic flows, the majority of which are believed to be Quaternary basalts.

Volcanic plugs are present in several places in the area, and apparently are more numerous near the lower portion of Williams River than elsewhere. Between Swansea and Planet a plug was noted on the south of the road, some 3½ miles from the former place. Here

the limestones appear reddish in color and cellular in structure in the vicinity of the intrusion. Scoria, ash, and chaotic breccia of quartz, rhyolite, and andesite form the principal part of the plug. No flow remains in the vicinity. Elsewhere presumable remnants of plugs were noted at some little distance from the road, but there was no opportunity for a close study of any.

Lava flows.—Volcanic rocks, presumably of Tertiary age, occur a short distance northeast of Bouse, where low hills, extending in the same general direction, are composed of andesitic breccia and lava flows. South of the Little Butte property there is a small remnant of rhyolitic breccia which probably represents a former lava flow. A large part of the Plomosa Mountains is composed of material of igneous origin, the lower portions of which are probably Tertiary andesites. In the vicinity of the main Quartzsite-Vicksburg stage route these mountains are capped by basalts presumably of Quaternary age, the whole series of rocks being about 1,500 feet thick in Black Mesa, 18 miles southwest of Vicksburg. Bullard Peak, about 10 miles a little east of north of Golden, is composed of very basic andesitic material which rests on the pre-Cambrian granite gneiss schist complex—a conglomerate about 100 feet in thickness is overlain by some 100 feet of volcanic ash, on top of which rests a thin layer of andesite, the whole constituting Bullard Peak. Although only 300 feet above the desert at the point of contact with the older gneiss, it is nevertheless a very conspicuous landmark in the area, and probably represents the remnant of a formerly existing flow of wide distribution. The occurrence of copper ore in this formation is a notable feature, and will be more fully discussed under detailed descriptions of ore deposits.

Breccia.—From the general description of Greggs breccia by Lee [a] and from personal conversation with him upon the subject, it seems highly probable to the writer that there is present in this area at least the basal portion of a breccia similar to the so-called Greggs breccia. The actual age of this formation is unknown, although it seems certainly to be late Tertiary.[b] This breccia is composed mainly of coarse fragments of crystalline rock poorly stratified and roughly cemented by calcareous and siliceous solutions.

The Mammoth workings of the Corona Copper Co. are located on the contact of a breccia with the underlying pre-Cambrian granite-gneiss-schist complex. The character of the breccia will be described under detailed description of ore deposits. For the present it is well to keep in mind the fact that if this is Greggs breccia there is evidence here of mineralization during Tertiary times, and this in conjunction with the mineralization at Bullard's (which is also supposed

[a] Lee, W. T., Geologic reconnaissance of a part of western Arizona: Bull. U. S. Geol. Survey No. 352, 1908, pp. 17, 32.

[b] Idem, p. 60.

to be in Tertiary rocks) offers substantial proof of at least one definite period of Tertiary mineralization. Just southeast of Castaneta Well there is a small hill rising some 200 feet above the desert, which is composed of a breccia of rhyolite fragments which may be comparable to parts of the Greggs breccia of Lee,[a] and on top of Battleship Mountain a very thin breccia was noted. No doubt there are many other occurrences of the same rock within the area, but these were the only ones seen by the writer. In all occurrences noted the breccia rests on the old pre-Cambrian rocks and is only of nominal thickness, representing perhaps the oldest and basal phase of the formation, which is described by Lee as being 1,400 feet thick in the vicinity of Greggs Ferry.

QUATERNARY DEPOSITS.

Basalt flows.—In the southwest many of the basalts are commonly called măl'-a-pī—a mispronunciation of the Spanish *mal país* (măl pah-ees'), meaning bad country [b]—a term which is also used to describe the broken character of the country caused by the cubical weathering of the basalts and the subsequent formation of steep cliffs.

According to Lee [c] most of the basalts of central western Arizona belong in the Quaternary system, although he says "Some of the older basalt sheets of the region may also belong to the Tertiary, but this is not definitely known." Schrader [d] gives the age of the olivine basalts found in Mohave County as Quaternary and notes the fact that they cut gravels of this age and occur as a covering to them and to the older rocks.

In the area included in this reconnaissance the basalt flows are numerous and form a large part of some of the mountain ranges. The Williams Mountains, south of the lower part of Williams River, are composed mainly of basalt; volcanic ash or river silt and gravels have filled up the erosional depressions; and the basaltic flows form broad, flat plateaus in places sloping gently down to deserts and elsewhere forming steep sharp cliffs. The section in Lee's bulletin (No. 352, p. 54) is a typical illustration of the mode of occurrence of the basalt flows. North of Williams River, en route to Yucca, about 2 miles south of Castaneta Well, occasional volcanic hills were seen some little distance to the west, and a fairly consistent flow was noted just east of the road. Castle Dome Mountain, observed from a distance of 5 miles, seemed to be made up of volcanic flows, part or all of which may belong to the Quaternary. Ash and basalt were observed on the west side of a small isolated range some 14 miles a

[a] Lee, W. T., Geologic reconnaissance of a part of Western Arizona: Bull. U. S. Geol. Survey No. 352, 1908, p. 17.

[b] Ransome, F. L., Prof. Paper U. S. Geol. Survey No. 66, 1909, p. 26.

[c] Lee, W. T., op. cit., pp. 16, 18.

[d] Schrader, F. C., Bull. U. S. Geol. Survey No. 397, 1909, p. 42.

little west of south of Parker, where, as in the Williams Mountains, the old drainage valleys and washes have been filled up with ash and erosional débris and the basalt poured out in flat layers. The Plomosa Range south of Ibex Mountain is probably largely composed of volcanic material, of which the upper portions are no doubt Quaternary. On the California side numerous basaltic bowlders were noted on the way to Copper Basin, and it is probable that Quaternary basalts constitute the upper portion of the Whipple Mountains, Monument Peak apparently having been formed from this material.

Conglomerate.—North of Williams River, east of the road to Yucca, great masses of reddish conglomerate occupy large areas and occasionally form high mountains. This conglomerate may be comparable to the Temple Bar conglomerate of Lee,[a] which has been described by him as being very similar to the Gila conglomerate of Gilbert,[b] Ransome,[c] and Lindgren[d] from different parts of southern Arizona.

The conglomerate as exposed north of Williams River rests on an older granite base and is composed mainly of round bowlders of granite and schist, which in places attain large dimensions, and is cemented by sandy material. Quartz pebbles are prominent, and the whole hill seemed to be very well consolidated. Potts Mountain, some distance away from the route traveled, appeared to be composed mainly of the same sort of material, although the rocks may be similar to those which form McCracken Mountain. The origin of siliceous cement in the conglomerate can be accounted for when the volcanic plugs in the area are considered. In conjunction with these, hot springs no doubt issued from the ground and locally silicified the gravels and breccia, the remnants of which are now visible in the area.

Gravels and detrital deposits.—Along Colorado River, opposite Parker, on the California side, a formation called by Lee[e] Chemehuevis gravel was noted. Here the gravels are 100 to 500 feet thick and form benches extending several miles west. The formation according to Lee is found from the mouth of the Grand Canyon to the Gulf of California. The valleys between the mountain ranges are filled with various kinds of detrital material, and the map of this part of the region is colored as belonging to the Quaternary system. The Temple Bar conglomerate of Lee extends several miles north of Planet along the road to Yucca and fills a great basin termed by him Detrital Sacramento Valley.[f]

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[a] Lee, W. T., op. cit., pp. 17, 18.

[b] Gilbert, G. K., U. S. Geog. Survey W. 100th Mer., vol. 3, pt. 5, 1875, p. 540.

[c] Ransome, F. L., Geology of Globe copper district, Arizona: Prof. Paper U. S. Geol. Survey No. 12, 1903, pp. 47–51.

[d] Lindgren, Waldemar, The copper deposits of the Clifton-Morenci district, Arizona: Prof. Paper U. S. Geol. Survey No. 43, 1905, pp. 75–77.

[e] Lee, W. T., op. cit., pp. 44–45.

[f] For description of this valley by Lee see Bull. U. S. Geol. Survey No. 352, 1908, pp. 52, 53.

GEOLOGIC HISTORY.

PRE-CAMBRIAN CONDITIONS.

Granite-gneiss-schist complex.—The oldest and basal rocks throughout the area mapped are derived from granites and quartz diorites which were metamorphosed in pre-Cambrian time into gneisses and schists. The original relation of these rock magmas must, for the present at least, remain unexplained. The field evidence seems to indicate an intimate association of various granitic and dioritic magmas, the primary relations of which subsequent metamorphic processes have so completely changed that a correct solution of the many complexities would involve untold time and detailed study, with only a suggestion of ultimate success.

Sedimentation.—After the crystalline granites, gneisses, and schists had been severely eroded and partly base leveled, the area was submerged, and several thousand feet of sediments that formed limestone, sandstone, clay, and arenaceous shales were deposited. Basic rocks were intruded or flowed out over these sediments, the results of which are now present in the area as amphibolites. The less resistant of this series were made schistose by regional dynamometamorphism, which is supposed to have taken place during pre-Cambrian time, with resulting argillites and quartz-mica schists. The sandstones were changed to quartzites, and in one or two localities the limestone became dolomite, although in the majority of cases it was simply changed into a crystalline condition.

MESOZOIC (?) CONDITIONS.

Granite intrusion.—At the time of the granite intrusion, which is provisionally treated as of Mesozoic age, the pre-Cambrian rocks had been elevated and erosional processes had been at work during a large part of Mesozoic time, whatever sediments were deposited during former periods having been stripped off, with the result that great valleys were excavated and then filled with detritus and mountain ranges were carved out with bold relief. The intrusion of the granite seems to have affected in only a slight and very local way the physical history of the rocks, the intrusion being confined to the southwestern part of the Harcuvar and the Harquahala ranges and apparently having taken place with only a slight overlying pressure. The results of contact metamorphism caused by the injection of this magma will be discussed in another place.

TERTIARY AND QUATERNARY CONDITIONS.

Volcanic activity and extensive erosion, accompanied by the deposition of much detrital material, mark the Cenozoic history of the region. Flows of andesite and rhyolite, of which only remnants of the older phases now remain, were followed by extensive erosion and

subsequent flows of andesite and olivine basalt, the last probably being of Quaternary age. During Tertiary and Quaternary time thick deposits of breccia and conglomerate were laid down and frequently directly on top of pre-Cambrian rocks, showing the tremendous erosion which had taken place during preceding periods. Willis T. Lee [a] gives an account of the geologic events which occurred during Cenozoic times and which the present writer will not dwell upon because of their lack of connection with the ore deposits of the region.

EFFECTS OF METAMORPHISM.

REGIONAL DYNAMOMETAMORPHISM.

All of the pre-Cambrian rocks in the area have been subjected to dynamometamorphism, with the result that the gneisses, schists, amphibolites, and argillites show very pronounced foliation, and that the limestones, quartzites, and amphibolites evince considerable chemical alteration attendant upon this process. With the former change which has occurred in the rocks the main interest of the economic geologist is centered in the possibility of the connection of this metamorphism with the formation, in the argillites and the intercalated amphibolites, of receptacles for the minute auriferous quartz-siderite veins. These veins are common in the southwestern part of the Harcuvar Range, in the locality of the Arizona Northern, the Yellow Bird, the Desert, and other deposits. The sandstones have been silicified and quartzite has resulted, and in one or two localities limestone has been changed to dolomite.

The effects of dynamometamorphism upon the limestones and the intercalated amphibolites are believed by the writer (whose views on this subject are in accord with those of Waldemar Lindgren) to have been far-reaching and to have played a very important part in the formation of the replacement deposits of copper and iron in limestone. As this subject will be treated at greater length elsewhere in this report, it is only necessary to state here that it is believed that during the regional dynamometamorphism of the area the primary metallic constituents of the diabase, diorite, or gabbro which now forms amphibolite were removed, either by segregation or by the action of solutions, and were subsequently deposited in the intercalated limestones with which such deposits are invariably associated in this area.

CONTACT METAMORPHISM.

The principal results of contact metamorphism are seen in connection with the intrusion of the granite which forms a prominent part of the southwestern extension of the Harcuvar Range. Here epidote, augite,

[a] Op. cit., pp. 57–67.

hornblende, albite, actinolite, magnetite, garnet, vesuvianite, chalcopyrite, pyrite, and bornite have been developed by contact metamorphism, and a thick stratum of limestone completely changed to wollastonite was noted. Contact metamorphic minerals have been developed at some distance from this central mass, and it is thought that fingers, perhaps showing differentiation phases of the parent magma, extend for some distance under the surrounding country. The mines of the Cobralla, the Calcite, and the Yuma copper companies' and the deposits of the Mudersbach copper camp all show decided evidence of contact metamorphic phenomena, and it is highly probable that many of the gold quartz veins in the region owe their origin to the solutions accompanying this granite intrusion. Thus far the true contact metamorphic deposits which have been prospected have not been shown to be very extensive.

PHYSIOGRAPHIC PROBLEMS.

The region contains many exceedingly interesting physiographic problems such as the Colorado River drainage, which has been worked out by Lee,[a] and other equally interesting features which are still unsolved. Especially worthy of study are the relations between the Tertiary and the Quaternary rocks and deposits. Because of the fact that this area was investigated with a view to determining the character of the ore deposits, little or no time was spent on the solution of physiographic problems.

THE MINERAL DEPOSITS.

PERIODS OF MINERALIZATION.

Tertiary.—One period of mineralization is definitely known, namely the Tertiary. The deposit in augite andesite at Bullard Peak is undoubtedly of this age. The mineralization in the Mammoth deposit of the Corona Copper Company probably took place during Tertiary time, although this is not positively known. The Clara[b] and Moro deposits, near Swansea, occurring in tuff and sandstone, are probably of Tertiary age and may represent secondary deposition of material derived from the older underlying pre-Cambrian rocks in which the hematite-copper deposits are located. Perhaps the Blue Slate deposit near the Little Butte represents the same general period of mineralization. The fissure veins of the McCracken, Lead Camp, and Guadalupe type are undoubtedly of comparatively recent origin, but it is not possible to fix their age definitely.

[a] Lee, W. T., Bull. U. S. Geol. Survey No. 352, 1908.

[b] This deposit is located near Clara Peak and is quite unlike the Signal deposit, which is frequently called the "Clara" because it is owned by the Clara Consolidated Gold and Copper Mining Company.

Mesozoic.—The granite intrusion which is so conspicuous in the southwestern part of the Harcuvar Range is provisionally considered as of Mesozoic age. Connected with this intrusion are contact-metamorphic deposits of the Calcite, the Cobralla, and the Yuma copper companies, which deposits are believed to have been formed during Mesozoic times. The quartz monzonite porphyry which has caused the mineralization at the Mudersbach copper camp may be connected with the intrusion of the same granite, and, if so, this deposit is also probably Mesozoic.

The numerous quartz veins found throughout the area and especially those in the San Marcos, Socorro, Hercules, and Bonanza deposits are likewise believed to have resulted from siliceous ore-bearing solutions accompanying this intrusion of granite, and hence may be provisionally classed as Mesozoic.

Pre-Cambrian.—The deposits considered as belonging to the pre-Cambrian era are believed to have been formed at separate periods, and they represent several different types. The hematite-copper deposits, occurring in limestone with intercalated amphibolite or tuffaceous material, like those at Planet, Swansea, Little Butte, Pride, Mineral Hill, and other places are believed to represent the younger phase of the pre-Cambrian deposits. The copper deposits occurring in shear zones in schist, such as the Wardwell & Osbourne, the Carnation, and the Quartz King, are at present considered as of pre-Cambrian age, although there is no actual proof to substantiate this conclusion. The quartz veins in granite and gneiss similar to the Sunshine in the vicinity of the Little Butte are considered as the oldest type of deposit in the area.

Kinds of deposits.—Because of the diversity of the deposits in this area it has been thought advisable in discussing the different types to separate them into groups according to the ore which is most sought for in the respective workings. Hence divisions have been made of the gold, copper, iron, lead, and quicksilver deposits, and a brief sketch of the genesis of the veins of each group will be given.

GOLD DEPOSITS.

QUARTZ VEINS AND SHEAR ZONES IN GRANITE, GNEISS, SCHIST, AND METAMORPHOSED SEDIMENTS.

In this type are included such veins as occur in the Hercules, the San Marcos, the Socorro, and in the Bonanza workings. The last two are somewhat similar in that they lie near the contact of the crystalline rocks and the sedimentary series; the Socorro, however, starts in coarse-grained granite and runs out into sedimentary rocks, while the Bonanza starts in sediments and runs into a crushed granitic rock. The Hercules and the San Marcos resemble each

other to a marked degree, and both veins, so far as explored, lie entirely in crystalline gneissic rocks. There is no uniformity in the dip and the strike of these veins, the former varying from 26° to 60°, and the latter from east-west in the Sorocco to north-south in the Bonanza.

The vein filling is primarily quartz and brecciated country rock, and the chief valuable ore has, in the past, been free milling gold. The pyrite of the deposits is oxidized above ground-water level (in general within 200 feet of the surface), and the free gold values are there concentrated. In this connection it is interesting to note the advantage a flatly dipping vein has over one with a steep pitch. For example, in figure 2, A′–B′ represents a vein dipping 63° and shows the lineal extent downward in the zone of surficial oxidation and concentration of gold values as compared with the vein A–B,

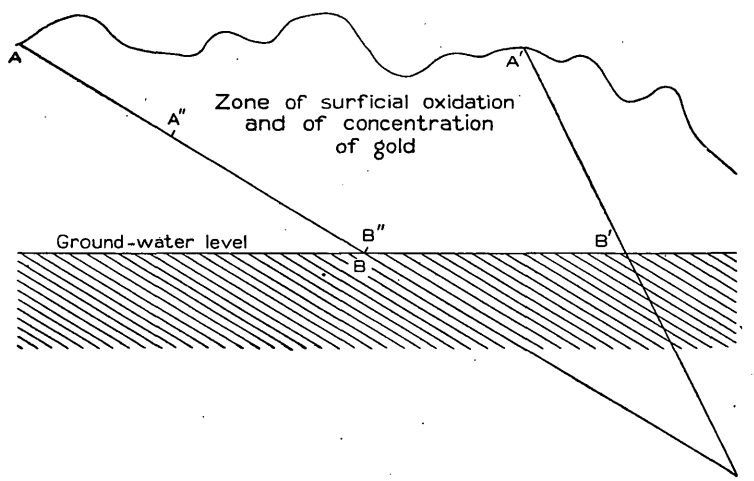

FIGURE 2.—Diagram showing one advantage of a low dip to a superficially oxidized gold quartz vein of the Bonanza type.

the same vertical distance above ground-water level, but dipping only 30°. A″–B″ is the length of the vein A′–B′ laid off on the vein A–B.

The larger the shear zone the more porous the vein, and hence the greater the opportunity for the deposition of pyrite, and also the larger the quantity available for concentration by surficial oxidation. The Bonanza mine affords a good example of large shear zones. The fact that in the past the principal values have been found in the zone of oxidation has led to the supposition that all of the rich parts of the vein would be above the present ground-water level, pyrite being found below. It should be remembered, however, that the present ground-water level may differ from that of earlier times; it may be lower or it may be higher. Therefore there is always the possibility,

not necessarily the probability, of finding below the present ground-water level ore that has in the past been concentrated at the lower stand of this level.

In general the higher values in these veins occur in pockets, and even the quartz veins are frequently lenticular. It is believed that the veins were formed by mineralizing solutions accompanying the intrusion of the granite mass in the southwestern part of the Harquahala and the Harcuvar Ranges.

There are a few true fissure veins in gneiss, carrying gold as the principal ore. The Mail Pouch and the Mineral Zone No. 1 were the only ones examined by the writer and these have been described very briefly in another part of the report. The Guadalupe is reported

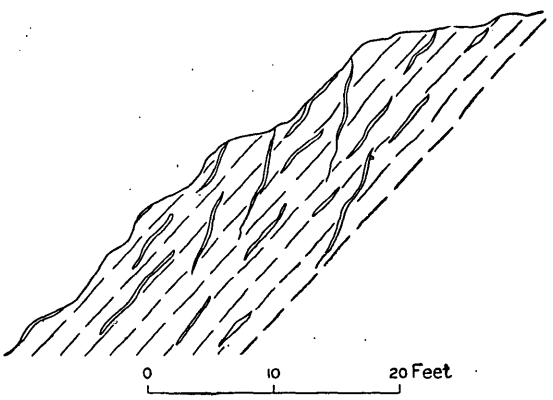

FIGURE 3.—Ideal cross section of a few feet of strata in the vicinity of the Arizona Northern prospect. Shows small quartz-siderite stringers in amphibolite and metamorphosed sediments.

to have been worked for its gold values; surface indications, however, would throw it into the class of lead deposits in fissure veins.

QUARTZ-SIDERITE STRINGERS IN AMPHIBOLITE, SHALE, AND LIMESTONE.

The deposits of this type are found mainly in the southwestern part of the Harcuvar Range and represent irregular masses or gash veins of quartz which are frequently auriferous. The gold values which are so often found in these veins may in part have resulted from superficial oxidation of the pyrite and concentration in place. As these veins are exposed by the erosion gold is concentrated in the placer deposits in the gulches which have been more or less successfully dry washed in the past. Figure 3 shows an ideal cross section of a few feet of strata in the Arizona Northern vicinity, where metamorphosed sediments contain intercalated amphibolite. Here the veins exposed on the surface are generally very small and lenticular and are easily picked out. In a short crosscut in the formation other

lenses were exposed, and from this evidence and the general character of the formation the figure is drawn.

These veins contain also some galena and chalcopyrite. Galena has been found in the Harquahala vicinity, and it is possible that the Guadalupe vein is comparable in age to these deposits. It is thought that solutions accompanying the granite intrusion brought in the silica, the carbonates, and the metals, and because of the kind of fissures here present for their deposition formed small gash veins rather than any other type.

THIN FILMS OF GOLD DEPOSITED IN JOINT PLANES IN SHALE.

In several prospects within the area thin films of gold deposited in joint planes in shale were noted. The best-known local examples of this are probably in the Moro prospect, owned by the Clara Consolidated Company, and in the Blue Slate prospect, near the Little Butte. Evidently these deposits are the result of secondary deposition of gold, the original source of which is probably in the near vicinity. In general, deposits of this sort are apt to be of very low grade because of the extreme thinness of the gold flakes; and the saving of the gold is difficult.

COPPER DEPOSITS.

DEPOSITS IN THE PRE-CAMBRIAN SEDIMENTARY SERIES.

The most extensive deposits of iron and copper in this region occur in the series of sedimentary beds and associated amphibolites and chloritic schists which overlie the oldest pre-Cambrian complex of granites and gneisses. The majority of the important examples described in the detailed part of this report are of this character and prominent among them are the deposits at Planet, Signal, various points on Colorado River, and at the Little Butte. These deposits deserve particular mention because of their belonging to a somewhat rare type, the genesis of which is still more or less in doubt. The deposits are generally in two forms. They occur in shear zones in the amphibolitic and chloritic rocks as irregular veins, and in the limestone as replacement deposits, the latter usually appearing at or close to the contact with the underlying older gneisses. Owing to the deep and thorough oxidation which all the deposits in this region have suffered it is often difficult to ascertain the primary constitution of the ore, but it is probable that in all cases the important minerals were specularite, pyrite, and chalcopyrite, containing very small quantities of precious metals. The gangue minerals are quartz, calcite, and, in places, a small amount of siderite. Epidote, chlorite, and amphibole are sometimes present in small quantities. The copper sulphides have been thoroughly oxidized, and the metal now

appears mainly in the form of chrysocolla, malachite, and allied oxidized ores. It is believed that the deposits were originally poor in copper and that oxidation has caused their concentration. The concentration of gold noted in a few places is probably also the result of oxidation. In general these deposits contain little gold and silver.

As a rule there are no intrusive rocks in the vicinity with which the deposits could be genetically connected. The association of the copper ores with specularite and their frequent occurrence between limestone and gneiss have often led mining engineers to consider them as of contact metamorphic origin, but there is no valid ground for such classification. A characteristic feature is the association with amphibolitic and chloritic rocks. As these are known to contain copper throughout the world, it is suggested that the metals have in some way been derived by concentration from these rocks. The formation of the deposits probably occurred in pre-Cambrian time and apparently during or after the regional metamorphism which the sedimentary series has suffered. The mineral association described is not one ordinarily occurring in regionally metamorphosed rocks, but, nevertheless, it is believed that they were formed as suggested by a concentration from the amphibolitic rocks during the period of dynamometamorphism. The association of beautifully crystallized specularite with sulphides would indicate deposition at elevated temperature and high pressure. It is also to be noted that the usual position of the deposits is in the basal limestone which generally is covered by the amphibolitic rocks.[a]

REPLACEMENT DEPOSITS IN LIMESTONE.

The Planet, the Signal, and the Little Butte properties represent the principal replacement deposits in limestone. In all of them the gangue minerals are chiefly specularite and quartz with some calcite, and the principal ore minerals are chrysocolla and malachite, which are intimately mixed with the specularite. Occasional specks of chalcopyrite, pyrite, and bornite were noted in these deposits, but they form at present a small portion of the developed ore bodies.

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[a] In discussing the genesis of these ores with Mr. A. C. Spencer the rôle of "water of dehydration as a factor in segregating metallic ores during dynamometamorphism" was considered.

The well-established fact that large quantities of water are set free during dynamometamorphism as the result of crystallization and concomitant dehydration warrants the suggestion that waters of this origin may become a controlling factor in the segregation of metallic ores. In the present case the original crystallization of the diabase or related rock has been destroyed and recrystallization of the constituent minerals has taken place, absorbing some of the water of dehydration by the formation of the micas, epidotes, etc. The rest of the water liberated in this recrystallization could have dissolved and segregated the metallic contents of the original diabase. By circulation through the intimately associated limestone strata, these waters may have been the first agent in depositing the minerals, which, through subsequent oxidation by meteoric waters have been still further concentrated into workable deposits.

Van Hise (Mon. U. S. Geol. Survey, vol. 47, 1904, gives considerable information on the subject of dehydration, but fails to point out the availability of the waters set free by recrystallization for segregating and depositing ores. A. C. Spencer, in discussing the copper deposits of the Encampment district, Wyoming, Prof. Paper U. S. Geol. Survey No. 25, 1907, Chapter III), attributes the origin of certain copper ores to segregation during dynamometamorphism but does not discuss the source of the water involved.

The occurrence of primary specularite intimately associated with quartz and calcite, also believed to be primary, was noted in limestone near the Little Butte property. These minerals follow roughly the stratification planes of the limestone. Specularite having the same general appearance as that noted at the Little Butte was observed in the vicinity of Limestone Mountain between Swansea and Planet. As this iron mineral is more resistant to weathering than limestone large masses of black lustrous specularite are found strewn over the surface of the ground. Associated with the specularite are small crystals of pyrite, which have almost completely altered to limonite. The specularite itself is very fresh and shows little or no decomposition.

One of the most interesting features in connection with the minerals found in this area is the omnipresence of hematite in gossans on top of the veins, in many of the limestone strata replaced by specularite, and generally throughout the region in joints, small cracks, and fissures in the pre-Cambrian granite gneiss schist complex. Especially noticeable are the hematite seams which line all of the openings in the older aplite. In general, this hematite is a hard compact variety, having a dark-red to black color; in places, however, the hematite is soft and earthy and, as exposed in some of the deposits, seems to have assumed this texture along slipping planes where it has been severely crushed.

In any but arid and hot regions this oxidation product of pyrite would be limonite. Here, however, limonite seems to be derived from the oxidation of siderite. The vast quantity of hematite present in the region and its universal distribution as an alteration of pyrite in the older series of rocks is indicative of very extensive oxidation.

SHEAR ZONES IN AMPHIBOLITE AND CHLORITIC SCHISTS.

Among the deposits of this type may be mentioned the Wardwell and Osbourne, the Carnation, and the Quartz King. In general there is a similar geologic section in the vicinity of these deposits. The gangue is principally sheared country rock cemented by quartz, hematite, calcite, and a little siderite. Variable amounts of chrysocolla and malachite form the ore minerals. The shear zones vary from a few inches up to several feet and the ore course is just as irregular.

SHEAR ZONES AND FISSURE VEINS IN GNEISS.

Several different copper deposits in the area are contained in shear zones in gneiss and schist, among which the Viati Mining Company property and the Copper Basin prospects probably afford the best examples. Here the gangue is principally brecciated country rock cemented by quartz and hematite with which is associated a little

chalcocite, some cuprite and malachite, and an occasional speck of native copper. The ores are reported to carry also a little gold. These deposits are probably of pre-Cambrian age and may be accounted for by the secondary concentration of very lean primary ores, which may have taken place during the dynamometamorphism of the area.

The principal deposit of typical fissure veins examined belongs to the Cunningham Pass Copper Mining Company and cuts directly across the planes of lamination of the gneiss and schist. The width of the vein varies from a few inches up to 3 or 4 feet and the ore-bearing streak is variable, changing abruptly in places from a barren vein into several inches of ore. The gangue is principally brecciated country and soft red hematite, with some specularite and limonite. Quartz is present in large quantities and occurs in vugs. Occasional veinlets of calcite and barite are present and seem to occupy post-mineral fractures. Above ground-water level the chief ore minerals are chrysocolla and chalcopyrite with some malachite, cuprite, and a little chalcocite. Below water level the chief ore consists of chalcocite associated with much quartz. Chalcopyrite and pyrite are also found in this part of the vein.

The ores have apparently resulted from the leaching and subsequent concentration of values contained in primary pyrite and chalcopyrite.

FISSURE VEINS IN ANDESITE.

The deposit at Bullard Peak is the only one of this type which was examined. It occupies a simple fissure in augite andesite. The vein varies in width from a few inches to 4 feet. The ore is chrysocolla, with which occurs some malachite, a little copper glance, and a small amount of cuprite. Quartz and calcite form the gangue. Some hematite was noted. The deposit is of Tertiary age.

CONTACT-METAMORPHIC DEPOSITS.

Copper deposits originating by contact metamorphism are found chiefly in the vicinity of the granite intrusion which forms a large part of the southwestern extension of the Harquahala and the Harcuvar ranges. Another deposit, located some little distance farther west, seems to owe its origin to the intrusion of quartz monzonite porphyry, which may have some connection with the granite magma already referred to.

Chalcopyrite, pyrite, and bornite have been developed to some extent by contact metamorphism, and deposits resulting from these minerals have been prospected with more or less success. In general the mineralization by copper ore seems to have been exceedingly slight. In the vicinity of the Calcite deposit contact metamorphic minerals are scarce, which fact leads to the supposition that this part of the sedimentary series was intruded when not overlain by a very

heavy overburden. About 6 or 8 miles farther north many different contact minerals are present, indicating that this part of the area was under greater pressure than that in the vicinity of Calcite.

IRON DEPOSITS.

Replacement deposits in limestone have already been described under the heading "Copper deposits" (p. 41), and the reader is referred to that description for the genesis of these replacements.

Another type of replacement in limestone exists in the Iron mine south of Bouse. Here, however, the character of the ore is decidedly different from that found in connection with the intercalated amphibolite. The limestones are only partly replaced and appear to form very impure hematite containing much calcareous and siliceous material, which shows practically all of the sedimentary characteristics of the rock which it replaces. Jasper is found in large quantities in the vicinity, and the Tertiary acidic intrusives which cut through the limestones may be responsible for the mineralization.

LEAD DEPOSITS.

Several deposits carrying lead ore were examined, among which the McCracken was by far the most prominent. The veins are probably comparatively recent and may belong to the Tertiary period of formation.

The gangue in the McCracken veins consists principally of carbonates and sulphates with some silicates cementing the fragments of schist and quartz. The carbonates are principally calcite and siderite, with which is associated some dolomite, the former being stained by iron and manganese in such a way that many colors result, the pink-stained calcite closely resembling rhodocrosite. Barite is the principal sulphate present and occurs in large quantities. The most conspicuous ore mineral is galena, which is reported to be argentiferous. Cerusite and anglesite are probably present in substantial amounts.

South of Bouse, in a deposit commonly called the Lead Camp, the vein has a gangue of quartz which contains some galena and is also slightly mineralized with chrysocolla and malachite.

The Guadalupe vein consists of pure white quartz containing many veinlets of siderite, which are said to be auriferous. Galena is found in places in the vein and appears to occur mainly in pockets.

QUICKSILVER DEPOSITS.

Only one deposit containing cinnabar was examined, and this belongs to the Colonial Mining Company at Cinnabar. Here a shear zone, varying in width from a few inches up to several feet, cuts across a sedimentary series of fine-grained quartz-mica schists. This zone

is sparsely mineralized with cinnabar. The gangue is highly siliceous and is cut by small stringers of calcite and siderite. The ore in places is conspicuously marked by green carbonate of copper, and gold and silver also are reported from the deposit. Magnetite is a prominent feature in one type of the schists in the vicinity. It has been suggested [a] that the cinnabar has been derived from mercurial tetrahedrite.

DESCRIPTIONS OF MINERAL DEPOSITS.

GENERAL STATEMENT.

Deposits of gold, copper, lead, iron, and quicksilver are found within the area. The mining districts in the region, as shown by the official

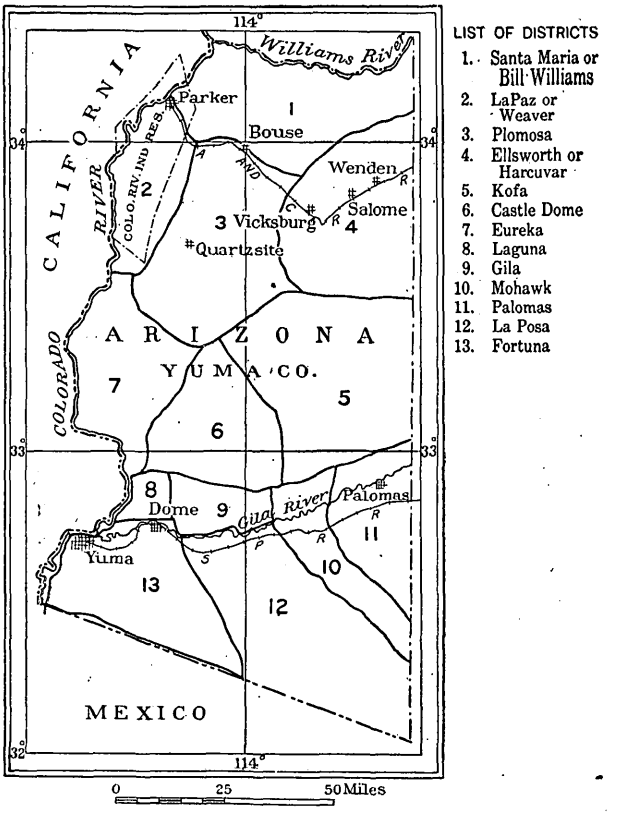

FIGURE 4.—Map of Yuma County, Ariz., showing mining districts, as outlined by the county clerk.

records of the county clerk of Yuma County, are outlined in figure 4. For the convenience of those most interested in the mineral deposits of this part of Arizona, properties in contiguous localities will be

[a] Bancroft, H., Notes on the occurrence of cinnabar in central western Arizona: Bull. U. S. Geol. Survey No. 430, 1910, pp. 151–153.

described together. The geographic divisions which seem most natural are as follows:

A. Deposits in the vicinity of Williams River:
   1. Planet.
   2. Mineral Hill.
   3. Clara Consolidated.

B. Deposits along Colorado River:
   On the California side—
   1. Viati Mining Company.
   2. Copper Basin.
   3. Bowman's.
   On the Arizona side—
   4. Quartz King.
   5. Billy Macks.
   6. Carnation.
   7. Wardwell & Osbourne (W. & O.).

C. Deposits in the Dome Rock Mountains:
   1. Valensuella.
   2. Mariquita.
   3. Colonial Mining Company (Cinnabar).
   4. French American.
   5. Placer deposits.

D. Deposits in the Plomosa Mountains:
   1. New York Plomosa.
   2. Guadalupe.
   3. Lead Camp.
   4. Mudersbach Copper Camp.
   5. Iron Mine.
   6. Little Butte and vicinity.

E. Deposits in the southwest end of Harcuvar Range:
   1. Yuma Copper Company (I. & A.).
   2. Yellow Bird.
   3. Arizona Northern.
   4. Desert.
   5. Calcite.
   6. Cobralla.

F. Deposits in the southwest end of Harquahala Range:
   1. Bonanza (Harqua Hala).
   2. Golden Eagle.
   3. Hercules.
   4. Socorro.
   5. San Marcos.

G. Miscellaneous deposits:
   1. Cunningham Pass vicinity.
   2. Bullard Peak vicinity.
   3. Corona vicinity.
   4. Planet Peak vicinity on the southwest.
   5. McCracken vicinity.

DEPOSITS IN THE VICINITY OF WILLIAMS RIVER.

The deposits which are to be described under this heading form a natural group by proximity and lithologic similarity. The Planet and the Mineral Hill deposits are separated from each other by a distance of only 2 or 3 miles and from the Clara Consolidated properties at Swansea by a distance of 9 or 10 miles in an air line. They are located in the Santa Maria [a] (or Bill Williams) mining district, in the Williams Mountains a little south of Williams River.

The rocks in the vicinity of all of the deposits are mainly of the pre-Cambrian granite gneiss schist complex overlain by metamorphosed sediments with intercalated amphibolite, all of which are in places covered by volcanic material of a much later age.

[a] See map of mining districts compiled from official records by the county clerk, Yuma County, figure 4 of this report.

PLANET COPPER MINE.

GENERAL DESCRIPTION OF THE MINE.

Location and means of access.—From the viewpoint of natural surroundings most conducive to mining operations the deposits worked by the Planet Copper Company are situated in one of the most favorable parts of central western Arizona. Williams River, less than a quarter of a mile from the company's office, affords a plentiful supply of water, and the large trees growing upon the banks of this stream will furnish the necessary mine timber for some time to come. The 700-ton smelter at Swansea is only 9 or 10 miles distant in an air line and may afford fairly convenient smelting facilities. The wagon haul between the two places over the present roads is, however, of the most difficult nature.

Planet is situated on the north bank of Williams River, 21½ miles north of Bouse, the distance by wagon road being considerably greater (28 miles). At present the transportation facilities between the two places are of the crudest kind, a stage making the trip to Planet three times a week, coming one day and returning to Bouse the next. It is hoped that the Arizona and Swansea Railroad will make the problem of transportation a simpler and cheaper one than it has been in the past.

History.—The workings at Planet have been referred to by various authors who have written on the mineral wealth of Arizona, and these deposits seem to have been among the best known in the early days of mining in this territory. According to Patrick Hamilton [a] the Planet mine was discovered in 1863, and by the year 1884 had shipped over 6,000 tons [b] of high-grade copper ore to San Francisco. This ore was hauled to Aubrey on Colorado River and was then shipped down that stream to its mouth, most of the ore being sent from there to San Francisco, Cal., although some of it was transported to Swansea, Wales.

One of the oldest smelters in Arizona is located at Planet, having been erected in 1884. Previous to this an adobe furnace had been used to some extent in smelting the ores. The slag dumps from both furnaces are reported to contain upward of 5 per cent copper.

Claims.—Thirty-one lode claims, 3 placers, and 2 mill sites constitute the land holdings of the Planet Company. Survey for patent was being carried on in April, 1909.

Development.—The principal development work on the Planet properties consists of an inclined shaft, No. 1, the first 40 feet of which pitches 45° and the remainder about 15°. This shaft has an

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[a] The resources of Arizona, 1884, p. 240.

[b] According to H. C. Hodge the shipments to San Francisco up to 1877 amounted to 8,000 tons of copper ore. See Arizona as it is, p. 69.

elevation of 750 feet at the collar, and is 700 feet long, with short drifts north and south of it, one drift 465 feet long southwest, and crosscuts and stopes, making up a total of about 2,500 feet. Shaft No. 2, started at an elevation of 950 feet, is a double compartment vertical shaft 9 feet by 4½ feet in the clear, and has been sunk to a depth of 350 feet from the top of the ridge into which the inclined shaft penetrates, connection affording good ventilation being made with the inclined shaft workings by an upraise from one of the south drifts (No. 7) near the end of the incline.

Numerous other shafts and inclines have been sunk, drifts and crosscuts run, and a great many open cuts made.[a] These are a valuable aid to the study of the geology of the region, but they do not show very much of the ore bodies which they have been started to develop.

Equipment.—The machinery consists of two gasoline hoists (one 22 horsepower and the other 12 horsepower), a diamond drilling plant, and a 5-drill air compressor and engine. The 36-inch blast furnace, which was erected in 1884, has not been operated for some time nor has it been dismantled, and it appears to be in fairly good condition. A photograph of this smelter is shown on Plate II, *A*.

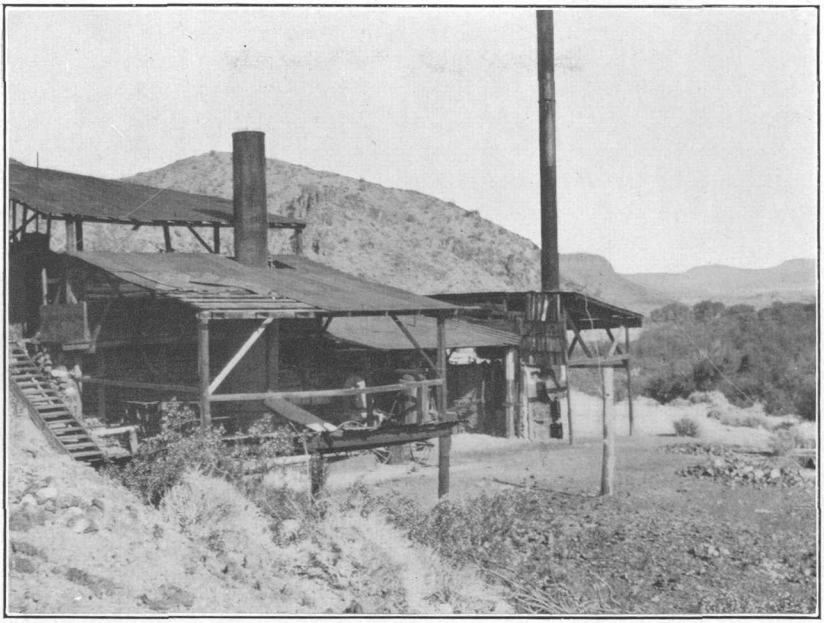
TOPOGRAPHY.

Viewed southward from a point a short distance north of Williams River, the hills in the vicinity of the Planet workings are seen to form a series of three long, narrow ridges all pointing northwestward and separated from each other by steep-sided canyons draining in the same direction. The ridges increase in height from the most northeasterly, which is low and rises only 100 feet or so above the river, to the last ridge on the southwest, which culminates in Jones Peak, the top of which has an elevation of 1,200 feet, or 600 feet above Williams River. The steep sides of these ridges afford admirable exposures of the geological relationships existing in the locality, and are also valuable as an aid in the exploration of the ore bodies, although in the erosion of the area large parts of the deposits have no doubt been destroyed.

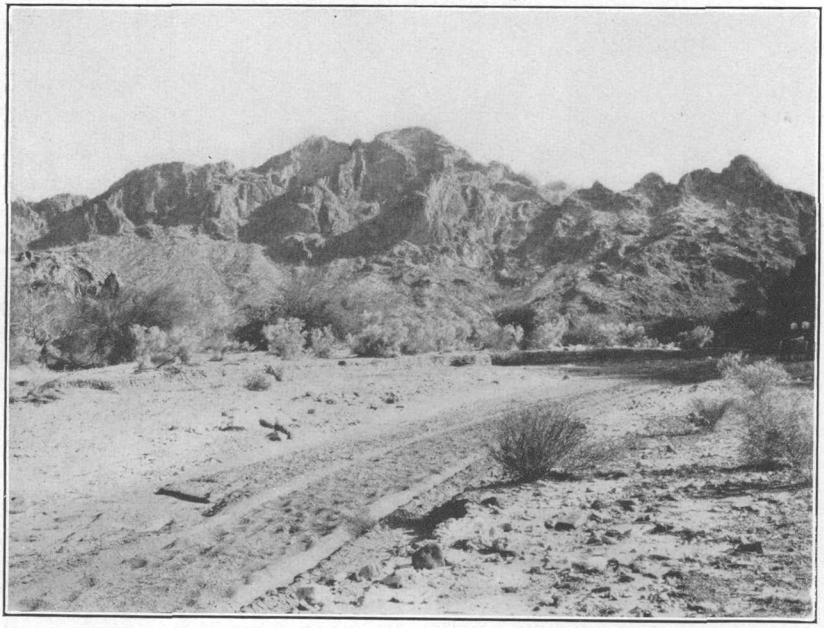
GEOLOGY.

Rocks.—The rocks in the vicinity of Planet are considered to be pre-Cambrian. The lowest formation is granite gneiss, which is overlain by thin bands of limestone intercalated with amphibolite, on top of which rest massive limestone and a series of arenaceous shales, metamorphosed into fine-grained quartz-mica schists. The general lithologic similarity in the sections near Signal and Planet is a feature worthy of remark. A geologic and topographic map and a cross section in the Planet locality are given in figures 5 and 6.

[a] In the prospectus issued by the company 6,000 feet of underground development work are claimed.



A. SMELTER AT PLANET, ARIZ.



B. MOUNTAIN OF GNEISS AND SCHIST ON WILLIAMS RIVER 1 MILE WEST OF PLANET.

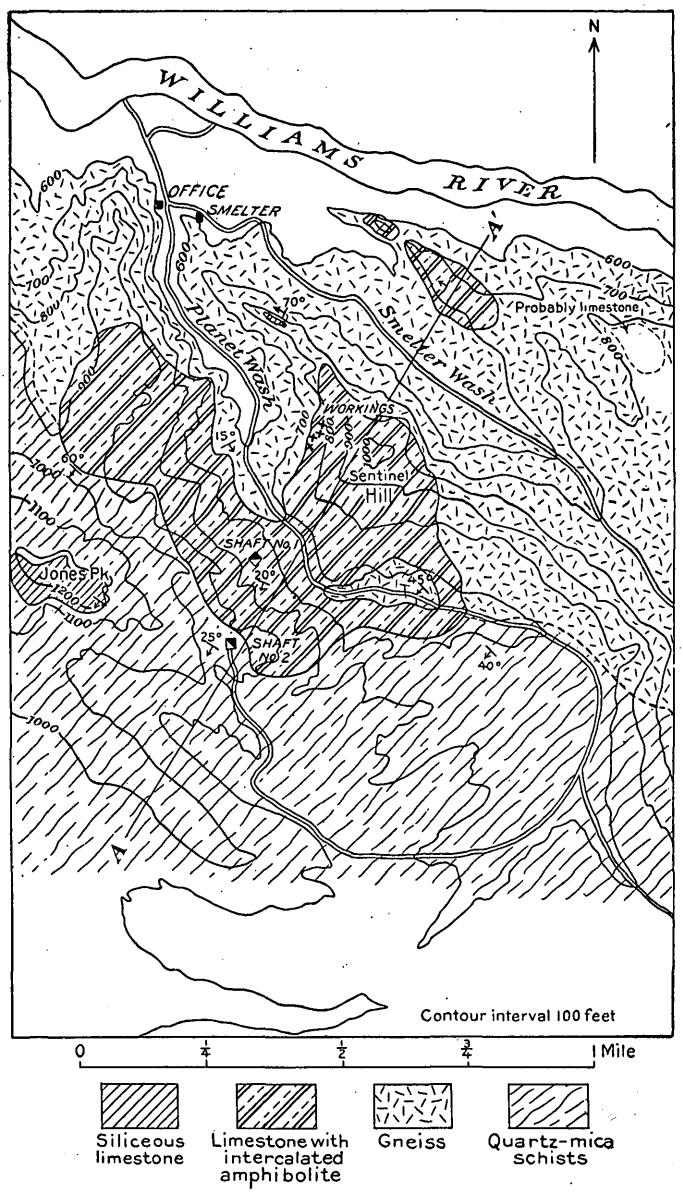


FIGURE 5.—Topographic and geologic sketch map of the vicinity of Planet.

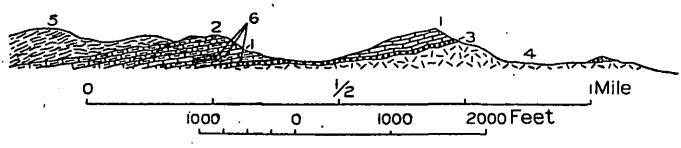


FIGURE 6.—Cross section of the hills in the vicinity of Planet along the section line A–A′ of figure 5: 1, Limestone; 2, limestone with intercalated amphibolite; 3, conglomerate: 4, gneiss; 5, quartz-mica schists; 6, known ore bodies in this section, extent undetermined.

Gneiss.—Reference to the same figures will show the distribution of gneiss in the immediate vicinity of the Planet deposits, where it extends south from the river for a distance of several miles and is the basal rock throughout this section; in places it forms prominent mountains, as may be seen by reference to Plate II, *B*. Here the foliated structure is very pronounced in places and the general dip of the lamination planes is between 15° and 30°. SE. The rocks are locally both fine grained and extremely coarse grained, the gradations from one type to the other being imperceptible. Chloritization seems to have been extensive in some of the gneisses and epidote is present in large amounts. Quartz and feldspar crystals form the main part of the rock, and the color of the gneiss seems to be due in large part to the kind and amount of the latter mineral present. Some coarse-grained pink gneisses are very prominent in this locality, although the whitish fine-grained rock is the more prevalent. Some faulting has taken place in these rocks, but not nearly as much as would be supposed from a cursory examination of the relation of the overlying sediments to the older gneisses. Before the limestone and the arenaceous shales were deposited on top of the gneiss erosion had trenched the crystalline rock, and contact between the two formations is therefore decidedly irregular and when viewed in a section along the strike of the sediments shows apparent but deceptive evidence of faulting. In general these are simply unconformable contacts, although at one place on the Ella Belle claim there may be some displacement in the series. When the land was submerged, the sediments deposited filled up these depressions in the surface of the gneiss, and subsequent stream erosion has exposed many of the irregularities of the old surface, so that now it is possible to see in places the irregular contact between the two formations. Erosion has been so active, however, that much of the sedimentary series is entirely removed, and with it the evidence of its former continuity and presence in the old dissected lines of drainage.

Aplite and diabase dikes are universally present in the gneiss series.

Limestone with intercalated amphibolite and fine-grained quartz-mica schist.—A series of metamorphosed sediments with intercalated amphibolite rests unconformably on top of the eroded surface of the older granite gneiss. The whole sedimentary complex strikes northwest, dips 15° to 60° SW., and occupies in this vicinity all of the area southwest of the Planet workings, where the total thickness of the series is approximately 900 feet. The lower 200 feet of this complex is composed of thin bands of limestone with intercalated amphibolite resting upon a limestone conglomerate 20 or 30 feet thick, which is locally silicified and composed mainly of bowlders of limestone, quartz, and gneiss. Resting unconformably on top of this series is about 100 feet of a more massive limestone which seems to be free

from amphibolite and in which no ore values were noted. Above the massive limestone is a series of fine-grained quartz-mica schists about 600 feet thick, which dips 60° SW. near the base of Jones Peak, but gradually flattens near the top of this peak and southeast along the strike, so that the dip is approximately 20° to 25° SW. in the vicinity above the workings. These schists are likewise slightly unconformable upon the underlying rock, which in the center of the area near the workings is the massive limestone; to the northwest and the southeast the basal gneiss lies directly below the schists.

The limestones are brownish in color, are of fine texture, and the massive variety contains 44.63 per cent lime (CaO) and 2.11 per cent magnesia (MgO). The schists are all fine grained, vary in color from silvery white to gray, red, brown, and green, and are composed chiefly of quartz and white mica, much of the latter presumably having been developed by the alteration of the feldspars. Much chlorite is present in some of the schists, giving them a decidedly greenish tone; some of them might possibly be classed as chlorite schists. Iron oxide has stained other schists in various ways, so that the series presents a variegated appearance. The amphibolite has varying green colors and is usually rather soft, being composed largely of some amphibole mineral associated with a little quartz and much chlorite and talc. Small quartz veins are present in all of the rocks, and an iron cap of hematite is found in many places associated with the limestones. These show only partial replacement by iron and frequently almost entire replacement by silica.

Other geologic features.—Quartzite is found west of Planet Wash, three-fourths of a mile southeast of the inclined shaft No. 1, at an elevation of 700 feet, where it dips southwest at an angle of 40°. Gold is reported as having been found in this formation in values as high as $5 per ton, this presumably occurring along the joints of the quartzite, where occasional copper stains are visible. The rocks in this area dip approximately 40° S. 40° W., and the sequence is as follows: Amphibolitic schists rest on top of the gneiss. These are covered by massive limestone free from amphibolite, over which is found siliceous limestone. Upon this is a conglomerate of quartzite and siliceous schist fragments, over which occurs the quartzite. The section varies considerably along the strike, and parts of it are lacking in places, probably due to deposition upon old erosional surfaces, and, locally, under shallow water conditions.

ORE DEPOSITS.

General statement.—The main developed ore bodies occur just above the contact of the underlying gneiss with limestone, the latter being replaced by hematite, which carries uncertain amounts of copper. In thickness the deposits vary from a few inches to several

feet, depending upon the amount of replacement which has taken place in the limestone.

Vertical shaft (on Bill Williams claim).—According to the log of the new vertical shaft on the Bill Williams claim three distinct ore bodies were cut in sinking 350 feet through the metamorphosed sediments, which dip 20° to 25° SW., all of them being above the contact with the crystalline gneiss. As the shaft was timbered, an examination of these ore bodies was impossible, and so the information on distances, vertical extent of ore bodies, and assays has been taken from the prospectus issued by the company.

The first body of ore was encountered 170 feet below the collar of the shaft, where about 5 feet of "iron lime" is recorded. This is probably partly replaced limestone. Below this the company took a sample from the interval between 175 feet and 180 feet, which they record as containing 5.56 per cent copper and 48 per cent iron. From the distance 180 feet below the collar to 185 feet the ore body is reported as containing 3.4 per cent copper. Specimens found on the dump from this shaft showed that this first ore body is composed almost entirely of highly replaced limestone, containing hematite in large quantities and a little chrysocolla associated with limonite deposited in the fractures of the ore. Malachite is present in small quantities.

The second ore body cut in the vertical shaft was penetrated at a depth of 230 feet below the collar. At this place the management report 7 feet of ore, averaging 4.77 per cent copper and $1 in gold per ton, and from 237 feet to 254 feet the assay is given as 8 to 9 per cent copper and gold ranging from a minimum of 40 cents to a maximum of $3.30 per ton. A sample of this ore from the dump shows almost massive hematite partly altered to limonite, with copper stains on slickensided surfaces; the remnant of the replaced rock is highly siliceous, and a little quartz is present in the ore.

At a depth of 290 feet the log of the shaft shows a massive body of iron ore, which is 20 feet thick and which caps a 15-foot body of ore running from 5 to 8 per cent copper. This last body has the same relation to the underlying gneiss as have the rest of the developed ore deposits of the Planet group. Specimens of this ore show massive hematite with a scattering of malachite, and also a very siliceous breccia cemented by the various oxides of iron, with a small amount of copper carbonate.

Although these ore bodies were cut in sinking the shaft, no development has been done on them, and therefore the principal consideration will be devoted to parts of the Planet group which have been more or less thoroughly prospected.

Inclined shaft No. 1 (on Planet claim).—The inclined shaft started on the Planet and run through the Mark Hanna and the Bill Williams claims represents the most continuous development done on any of the Planet deposits. As already stated, this shaft has, with the various laterals, 2,500 feet of underground workings. For the first 40 feet the incline pitches 45°, and then the dip changes rather abruptly to 15° SW., which is the grade for the rest of the 700 feet to the end of the shaft. Throughout the present incline the main values occur in a limestone conglomerate, locally silicified and containing bowlders of limestone, quartz, and gneiss, and resting on top of the old eroded gneiss, the surface of which apparently dips about 15° S. or SW. The sediments rest on top of this gneiss and dip 20° to 25° SW., and the incline follows the general line of contact between the two formations. Hematite is prominent and seems to contain considerable copper, the latter being present both as carbonate and sulphate. Occasional crystals of pyrite ranging in size from $\frac{1}{32}$-inch up to $\frac{1}{2}$-inch cubes, and the omnipresence of the sulphate of copper form very noticeable features of the deposit. The ore body ranges in thickness from a few inches up to 6 or 7 feet, as shown by the various upraises and winzes cut from the short laterals of the incline, and extends for a known distance of 700 feet southwest of the shaft collar and presumably continues along the contact to a greater distance. Ore from the dump of this incline shows principally hematite, with considerable malachite, some azurite and chrysocolla, and the black oxide of manganese being prominent on some specimens.

Mr. H. A. Keller sampled these workings in 1907, and the results have been published by the Planet Company. These show that the average copper content of the ore body varies from 2 to 6 per cent with occasional values of 11 per cent.

Two general samples from the ore dump of the inclined shaft, according to Mr. Keller, gave the following analyses:

Analyses of ore from inclined shaft No. 1, Planet copper mine, Yuma County, Ariz.

	1.	2.	Average.
Copper (Cu)	6.29	5.30	5.8
Silica (SiO_2)	39.91	38.81	39.36
Iron (Fe)	32.00	30.62	31.31
Alumina (Al_2O_3)	.....	.....	1.83
Lime (CaO)	.56	.20	.38
Sulphur (S)	4.07	3.85	3.96
			82.64

Mr. Keller gives the average width of the ore body as 4 feet 3 inches and its average copper content as 5.90 per cent. The accuracy of this statement seems well supported by an examination of the property.

Two analyses of the clear slag from the old dump are reported as follows:

Analyses of slag from inclined shaft No. 1, Planet copper mine, Yuma County, Ariz.

	1.	2.
Silica	34.5	38.0
Iron oxide (FeO)	48.8	45.2
Copper	5.2	5.7
Alumina	10.0	10.6
Lime (CaO)	1.2	1.5
Magnesia	None.	None.

A level started at the base of the steep 40-foot incline and driven almost due south for a distance of 160 feet is, beyond the 120-foot station, where a short incline is sunk, entirely in hematite. Apparently this ore body is a short distance above the basal gneiss and represents a complete replacement of the limestone strata which lie on the gently southward dipping surface of the gneiss. Some 60 feet west this level is prolonged from the west branch and extends for a distance of 480 feet southwest, the whole of the drift being in hematite, analyses of which have been made by the Colorado Fuel and Iron Company and the results published in a report to the Planet Company by H. A. Keller. Two of their analyses are as follows:

Analyses of hematite from inclined shaft No. 1, Planet copper mine, Yuma County, Ariz.

[H. A. Keller, analyst.]

		1.		2.
Iron (Fe)	65.48		60.42	
Iron (Fe_2O_3)		93.54		86.31
Silica (SiO_2)		7.00		12.87
Phosphorus		.031		.018
		100.571		99.198

Other workings.—More or less development exists on numerous other claims, all of which show the deposits to be of a very similar nature, being replacements in limestone by iron and copper minerals. The latter, however, are more siliceous in the workings on Sentinel Hill and farther east than those found in the ore body opened by shaft No. 1, chrysocolla forming the principal copper ore in the Blue Bird, the Palmetto, and the Sentinel Hill deposits. Specularite is present in large amounts, with malachite and the black oxide of manganese forming an important part of some of the surface exposures. A mineral was noted in a specimen from the dump of the Palmetto prospect which very closely resembles the description of morencite, a mineral discovered by Lindgren in the Clifton-Morenci district.[a]

Origin of the ores.—The chief ores in these deposits consist of aggregates of foils of specularite (part of which is probably primary), a little limonite, some malachite, and an occasional speck of pyrite.

[a] Lindgren, Waldemar, Prof. Paper U. S. Geol. Survey No. 43, 1905, pp. 115–116, 178.

With the exception of the minute quantity of pyrite and the still smaller quantity of bornite and chalcopyrite seen in a few of the specimens, the deposits are formed of oxidized material, a large part of which has presumably resulted from the alteration of pyrite and chalcopyrite. This theory is upheld by the omnipresence of crystals of soluble sulphates found scattered throughout the ore body and probably resulting from the action of the sulphuric acid (liberated from pyrite in its decomposition) upon limestone, which is itself in places almost completely replaced by ore minerals. There is a total lack of contact metamorphic silicate minerals, as well as an absence of any intrusive (other than the rock which now forms amphibolite) of later date than the limestones, and it seems highly improbable that these deposits are of contact metamorphic origin.

The deposits seem to follow the bedding planes of the limestone and the general line of contact between this formation and the underlying gneiss. It is possible that during the long-continued alteration which these ancient rocks have undergone the iron and copper values, which occur in normal diabases and associated basic rocks, were concentrated or at least taken into solution and subsequently replaced the limestone with which the amphibolite is so intimately associated in this as well as in similar deposits within the area. The occurrence of fairly large bodies of hematite, almost invariably associated with the silicates and carbonates of copper in rocks which are essentially limestones with intercalated amphibolite, and the total absence of any intrusives (other than the rock which now forms amphibolite) of later date than the limestones, are all indicative of a local origin for the ores.[a] Although the extent of the ore deposits varies considerably in geologic sections of this sort, similar relations were observed in the following places: Planet, Swansea, Carnation, Battleship Mountain, Limestone Mountain, and Pride prospect.

MINERAL HILL DEPOSITS.

GENERAL DESCRIPTION.

These deposits are situated on the slope just west of Mineral Wash, 2½ miles from Planet and over a mile up the wash from Williams River. The group of claims comprising the Mineral Hill deposits which are to be discussed have been prospected in a general way, although there is no permanent camp located at the place, and no active development was going on at the time of the writer's visit. The upper workings are admirably situated for tunneling, and shafting would not be a necessary feature of the operations above the wash level. Water has to be hauled from Williams River, timber is practically absent in the immediate vicinity, and fuel would have to be hauled for large operations.

[a] For a discussion of the genesis of these ores see page 41.

The Continental prospects, which are in this vicinity, were not examined for lack of time.

Means of access.—The Mineral Hill deposits are almost as difficult of approach as the Planet. Bouse and Parker are nearly equidistant from Mineral Hill in an air line, the former being 21½ miles due south and the latter 17½ miles southwest. By wagon road, however, the distance to both places is increased at least 4 or 5 miles. The completion of the Arizona and Swansea Railroad makes it possible to shorten the wagon haul considerably, and, in the future, should the property become productive, no doubt a route to this railroad will be chosen for transportation.

TOPOGRAPHY.

Near the deposits Mineral Wash has an elevation of a little over 500 feet. On the west of the wash, hills rise somewhat steeply to an

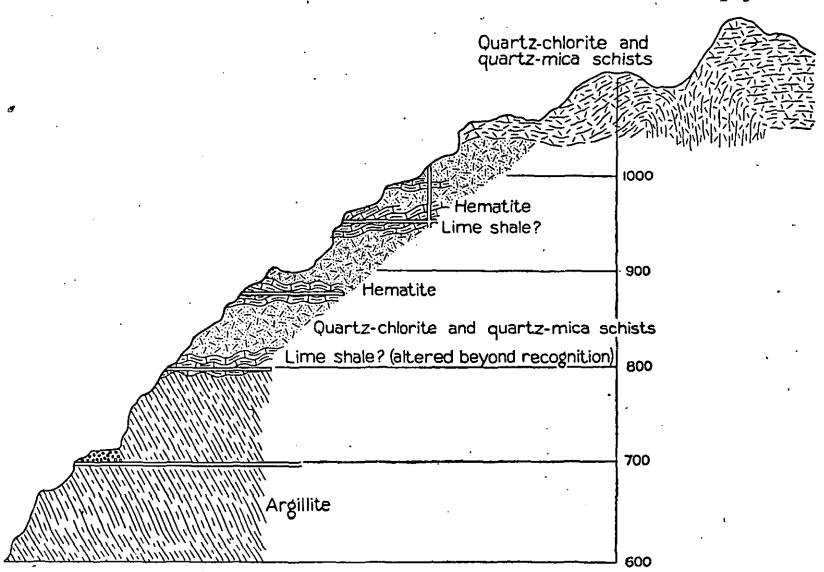


FIGURE 7.—Ideal section of Mineral Hill.

elevation of 1,100 feet, and in one of these hills the deposits occur. The topography in the vicinity is characterized by steep-sided but shallow canyons and isolated hills. A short distance farther west at an elevation of 1,500 feet a basalt-covered plateau extends toward Colorado River.

GEOLOGY.

The rocks at Mineral Hill (see fig. 7) are a basal series of argillite having a thickness of several hundred feet, upon whose eroded surface rests a series, 300 feet thick, of arenaceous shales, metamorphosed into fine-grained, quartz-mica schists of various colors, interlaminated with a small amount of very impure limestone. Intimately associated with these schists is a metamorphic rock which resembles a quartz chlorite

schist, the field relations suggesting intrusion of the rock into the series. Microscopic examination of thin sections shows, however, that the chloritic rock is of unquestionable clastic origin, so that its intrusive appearance is manifestly deceptive. A satisfactory explanation of the relations existing here is difficult. This metamorphic rock occupies about four-fifths of that portion of Mineral Hill which is above the elevation of 700 feet.

It is possible that during the period of regional metamorphism when the schists were folded and faulted, the pressure upon them was so great that they assumed locally, before recrystallization, the relation to the quartz chlorite schist which makes the latter rock appear as an intrusion into them. It seems scarcely possible for the quartz chlorite rock to have become so plastic that it could have been squeezed into fractures formed in the quartz-mica schists.

The strata which form Mineral Hill are undoubtedly continuous with those resting on the gneiss in the vicinity of Planet, and both series were probably lifted and deformed at the same time. Figure 7 represents an ideal section of the geology of this vicinity.

In general the dip varies from 30° to 50° SW., although above the elevation of 800 feet where the quartz chlorite and quartz-mica schists overlie the eroded argillites the dip is comparatively flat and remains so up to an elevation of 1,050 feet, where the most extreme twisting and contorting of the schists is seen and where the dip changes every few feet.

ORE DEPOSITS.

Workings.—Although only a small amount of development has been done on the ore bodies in this hill, and this of a very scattered nature, there exist nevertheless enough workings to exhibit in a general way the relationship between the geology and the ore deposits in the vicinity.

On the north slope of Mineral Hill there are four short adits, 200 feet or less in length, separated from one another by vertical distances of 100 feet or more. From the upper adit a 40-foot upraise to the surface has been driven. The Mohave Chief and the Norma workings on the southeast slope of the hill were examined in a cursory way, the time being very limited and the developments meager.

Ore bodies exposed by workings on the north slope of Mineral Hill.—An adit started at the elevation of 700 feet and driven 200 feet S. 45° W. passes through surface conglomerate for a short distance; the remainder of the adit cuts fine-grained schists, which dip rather steeply southwest. At right angles to the dip of the schists occur several minor slips which are mineralized to a small extent by chrysocolla.

The second adit in this series is driven 100 feet higher up on the hillside and is 100 feet long. The floor of this working seems to be

just above an eroded surface of the schists, and the roof is composed of material which in the field greatly resembles a very much altered and silicified locally brecciated limestone.

A third adit is located at an elevation of 875 feet, and the 100 feet of tunneling exposes a small deposit of hematite in a conglomerate of exceedingly impure lime shale and quartz chlorite schist fragments. So much alteration has taken place that the fragments referred to as lime shale may represent other rocks, the original character of which it is impossible to determine. The ore body here is intimately associated with the conglomerate, and hence of an impure nature. About 25 feet above this level there is another thin band of hematite which occurs between walls of quartz chlorite schist.

At an elevation of 950 feet is found the most promising of the deposits on the north slope of the hill. Here the drift is run about 100 feet, having specularite for a roof and a much-altered, iron-stained rock resembling shale for a floor. An upraise of 40 feet to the surface cuts, above the hematite, quartz chlorite schist which contains a thin layer of lime shale about 25 feet above the level. The specularite and the much-altered shaly rock both contain chrysocolla and malachite in fairly large proportions; in both instances, however, the copper minerals fill fractures which have cut across the iron ore and the altered rock.

A short distance above the highest workings described the schists are greatly contorted, twisted, and buckled. In many places within the area small folds were seen, but not in any other locality were similar results noted on such a large scale. Quartz veins are developed on a small scale throughout the whole series. These are in part lenticular, lying in the planes of lamination, although they generally cut the formation.

Ore bodies exposed by workings on the Mohave Chief and the Norma claims.—A short distance south and west of the openings on the north slope of the hill occurs the deposit opened on the Mohave Chief claim. One of the workings here is a small open cut, the top of which is at an elevation of 950 feet. The work at this point has been done just over the contact of the lime shale with the quartz chlorite schist, and no regularity exists in the deposit. The mineralization occurs in scattered patches. Chrysocolla intimately mixed with brochantite is associated with a jaspery gangue. Just west of the open cut and 25 feet lower there are several small workings which have been started in lime shale or limestone, which is more massive than the greater part of that seen in the vicinity and which is intimately associated with the green quartz chlorite schist rock.

On the Norma claim an adit started in lime shale at an elevation of 800 feet shows a little mineralization in fissures which cut across the country rock in the general direction of N. 20° W. These fissures are

only a few inches wide and not many of them are present in that portion of the rock exposed by the adit.

Paragenesis of the ores.—As at the Planet mine the sulphides have been almost wholly oxidized, and it is difficult to say what the original condition may have been. Here too, probably, some of the specularite is primary, and it is believed that it was associated with pyrite and chalcopyrite. At Mineral Hill the oxidized copper ores appear to be later than the specularite and were in large part deposited in fractures in this iron ore; at the Planet they occur distributed throughout the specularite.

CLARA CONSOLIDATED MINING COMPANY'S PROPERTIES.

PROPERTIES AND LOCATION.

The properties examined belonging to the Clara Consolidated Mining Company are the Signal, the Moro, and the Clara. The last two represent deposits of nature different from that of the Signal, and they are located some little distance to the southeast in a different geologic formation.

Swansea, the name of the locality in which the Signal deposits occur, is the center of the mining and smelting activity of the Clara Consolidated Mining Company. Here the company has recently erected a 700-ton smelter; it has also built railroad connections with its near-by properties and with the town of Bouse, situated on the Arizona and California Railroad about 23 miles a little west of south of Swansea. At the time of the writer's first visit to the properties a few bunk houses, offices, and a store constituted the town. No doubt at the time of writing (March, 1910) Swansea is a more substantial place, for the railroad from Bouse and the smelter have been completed since the prospects were examined in April, 1909. Water is pumped to the property from Williams River, 4 or 5 miles distant, through a 6-inch and a 3-inch main, and timber is shipped in from the outside.

TOPOGRAPHY.

The road from Bouse to Swansea ascends the gentle slopes of the foothills of Williams Mountains, which are so thoroughly covered by débris that only low, gently sloping ridges project above the detrital masses. About 3 miles south of Swansea the country breaks off toward Williams River and the descent of 500 feet to the Signal property is through a rough country, where the rocks are well exposed. In the immediate vicinity south of the Signal deposit a hill of gneiss capped by limestone rises to an elevation of 1,800 feet. Several similarly formed hills are a noticeable feature about 1 mile west, where they attain an elevation of 200 to 400 feet above the surrounding desert, which slopes gradually in the direction of Williams River.

Sharp prominent ridges of gneiss form the mountains south and east, and Clara Peak, a little over a mile to the east and composed of much younger material, rises to an elevation of 2,400 feet, or about 1,000 feet above the general elevation of this part of Williams Mountains.

SIGNAL PROPERTY.

HISTORY.

Prior to July, 1908, the properties, which were at that time united as the Clara Consolidated Gold and Copper Mining Company, belonged to several individuals and companies. Of these the Signal Mining Company had probably done by far the greatest amount of development work, although as a matter of fact this was of very meager extent. According to a legend current in the district Germans worked this deposit many years ago, and in proof of this tale it is said that a German ore car was found in one of the old workings. The writer talked on this subject with Mr. J. W. Johnson, of Mineral Hill, who said that he had left an old wooden car in the workings of the Signal some twenty or thirty years ago, and that this was probably the much talked of "find."

PRESENT CONDITION.

Development.—On the Signal property there are six shafts (see fig. 8 for locations), two inclined and four vertical. Nos. 1, 4, 5, and 6 are vertical, the first having been used as the principal development shaft at the time of the writer's first visits to the property, in the spring of 1909. Shaft No. 1 is down some 400 feet, and levels have been driven at 100-foot intervals, with drifts, crosscuts, raises, etc., aggregating several hundred feet of workings. In September, 1910, this shaft was filled with water and waste up to the 200-foot level, so that it was not accessible for examination below that level. No. 4 shaft was sunk with a view to making it the future working shaft of the property. An examination of figure 8 will show that No. 4 shaft was sunk outside of the ore zone, at a place where all of the ore would have to be trammed back to the shaft in a direction away from the smelter, thereby increasing the cost of handling the ore. This shaft was abandoned at the time of the writer's last visit to the property (September, 1910), and shafts 5 and 6 were being sunk and the underground developments pushed in their direction. Shafts No. 2 and No. 3 are inclined, the former about 45° to 50° N. 22° W. and the latter 65° to 75° N. 45° W. Shaft No. 3 is not now used—this and shaft No. 2 representing older workings on the property. Shaft No. 3 is approximately 200 feet and shaft No. 2 a little over 300 feet deep, the latter being connected with all the main workings of the mine. The development work done to September, 1910,

including shafts, crosscuts, drifts, winzes, etc., would amount to approximately 6,000 feet.

Equipment.[a]—Small gasoline hoists for two of the shafts have been installed for some time. A 125-horsepower geared steam hoist is reported to have been ordered for the new working shaft. A 6-drill air compressor furnishes power for the drills operated in the workings from shaft No. 1. Two electric locomotives are used for hauling ore from the shafts to the ore bins.

The smelting plant consists of a 700-ton copper furnace, 44 by 280 inches, opening at the top into a Mitchell steel hood, 10 by 26 feet,

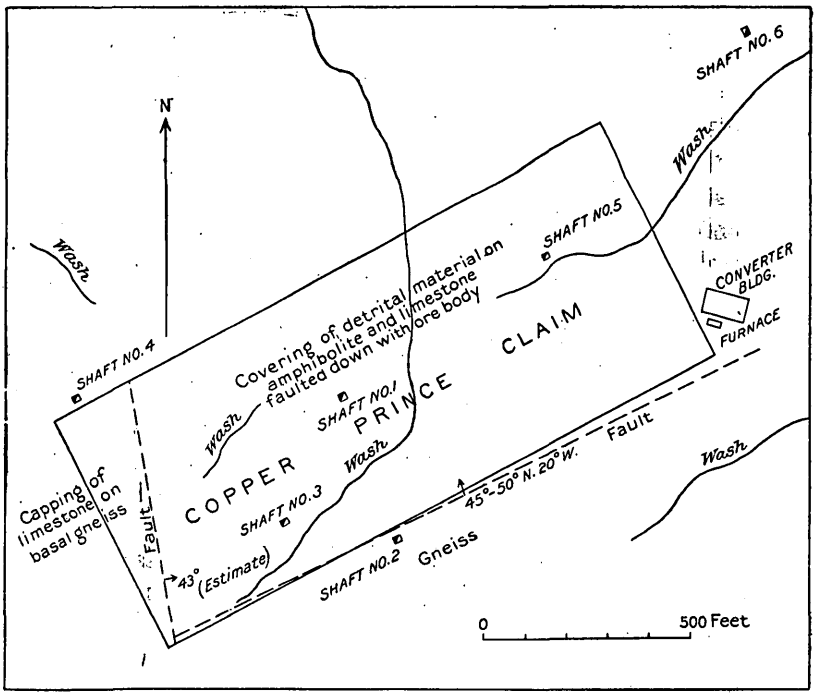


FIGURE 8.—Diagram showing location of shafts and possible surface location of two main faults on the claim containing the Signal ore deposit.

which opens into a main flue 8 feet in diameter leading into two balloon flues, each 5 by 7 feet. The brick and concrete dust chamber, 20 feet wide, 12 feet high, and 90 feet long, opens into the steel stack, 150 feet high. The floor of the dust chamber is of concrete, having hoppers for discharging the flue dust into cars underneath. Two blowers to supply the blast for the furnace have been set in place. The foundations are in for the steel converter building, which is to contain a 50-ton electric crane and two stands of copper converters. The blast for these will be supplied by a low-pressure air compressor.

[a] The information pertaining to the equipment is taken directly from the Mining and Scientific Press, Feb. 19, 1910, p. 299.

A steam electric generator will operate the electric crane and supply power for the trolley lines of ore and slag cars. The converters will be operated by electric power. A crusher, a set of rolls, and a mud mill are being installed for preparing the siliceous ore for converter lining. The charging cars to be used will have automatic weighing attachments for weighing the ore and coke before they are dumped directly into the furnaces.

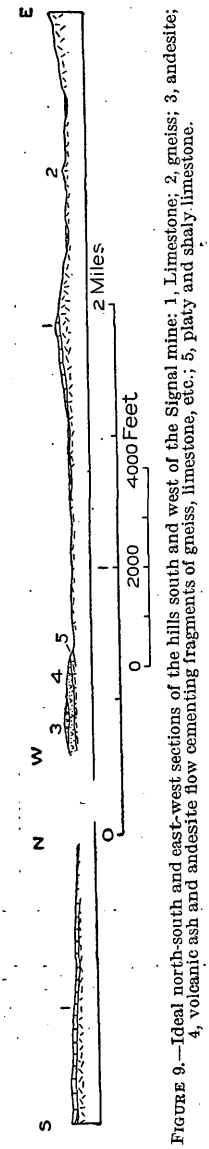


FIGURE 9.—Ideal north-south and east-west sections of the hills south and west of the Signal mine: 1, Limestone; 2, gneiss; 3, andesite; 4, volcanic ash and andesite flow cementing fragments of gneiss, limestone, etc.; 5, platy and shaly limestone.

Production.—At present (March, 1910), there has been no output from the Signal mine by the Clara Consolidated Company. If there was any production previous to July, 1908, it was only nominal.

GEOLOGY.

The country rock at the Signal mine (see fig. 9) is a coarse-grained, rather light colored granitic gneiss, showing some chlorite and epidote along the lines of foliation. In places this rock is compact and fine grained and somewhat resembles quartzite. Locally this phase of the rock has been called quartz porphyry. The schistosity of the rock is nearly flat, though locally it is not at all regular in direction of dip. In the canyon south of the office the general dip of the planes of lamination is 10° to 20° NW., and the strike varies from 35° to 85° NE. The hills south and east of this canyon are composed of gneiss; the pressed feldspars and lenticular quartz aggregates show clearly the igneous origin of the rocks. The low ridge west of the gulch consists of a heavy bench of dark-brown limestone dipping 35° to 40° W. or NW., and resting unconformably on the gneiss. (See fig. 9.) Near the north end of this low ridge there is a small amount of highly siliceous material, which apparently underlies the limestone and overlies the gneiss. This rock is only a few feet thick and has been exposed by the erosion of the overlying limestone. In places this erosion has occurred in such a manner that the siliceous rock appears to have cut through the limestone, although the relations seem rather doubtful. The siliceous rock is a pinkish gray and seems to be composed entirely of silica, vugs or cavities in it being filled with quartz crystals. It is impossible to determine the original character of the rock, but it now appears to be a quartzite, and may here represent the remnant of the basal part of the sedimentary

series. The rock just west of the mine and south of the office contains schistose layers of a chloritic amphibolite, conformable with the limestone. The limestone is probably not over 100 feet thick. Farther west and northwest other small hills of limestone and intercalated amphibolite can be seen. Here diabase intrusives cut the formation, and along the contact of the dikes quartz-siderite veins have been formed. One hill a little farther to the southwest than the ones just referred to, and about 1½ miles due west of the Signal office, is composed of quite different rocks. Above a coarse-grained pink granitic rock, which is cut by diabase dikes, comes a series (50 feet or more) of platy and shaly limestone, dipping about 20° a little south of west. Upon this rests a series of deposits, 200 feet thick, composed of volcanic ash and an andesitic flow cementing fragments of limestone, granite, schist, and other rock mostly angular, although some are rounded. The remaining 50 feet of the hill is composed of an andesite flow, which also covers the tops of a few of the hills in the immediate vicinity of the one just described. The tuff and andesite are much later than the underlying rock and are probably of Tertiary age.

At the base of the limestone in the wash lies the ore deposit. As exposed on the surface this represents an irregular replacement in the limestone which extends a short distance along the gulch as a zone about 30 feet wide, containing much hematite, partly crystallized as specularite, and some copper stains, but with no other visible minerals. Here, as elsewhere, the limestone overlies the gneiss and is intimately associated with the amphibolitic schist, which is barren of any mineralization on the surface. The surface of the gneiss as eroded here dips approximately 52° N. Elsewhere this eroded surface changes its plane considerably, the unconformable relation of the sediments and the gneiss making this all the more apparent.

THE ORE DEPOSIT.

Figures 10 and 11 illustrate features of the ore deposit and of its development. The Copper Prince claim is shown in figure 8, which gives approximately the locations of the various shafts, washes, etc. The true position of the two faults is rather uncertain, and their exact surface locations are unknown to the writer. For the sake of reference, however, their approximate position has been outlined. The major part of this claim, it will be seen, occupies a faulted block of country rock whose original position was to the southwest and considerably higher than it is at present. Figure 10 is a tentative cross section of the deposit as developed in September, 1910. Figure 11 represents a hypothetical stereogram of the ore deposit as it would probably appear if it could be viewed from the northeast corner of the claim.

The ore deposit lies in the faulted block of country rock. It is an irregular replacement of the limestone by specularite, with here and there a scattering of chalcopyrite and a small amount of pyrite, associated with some quartz and epidote, the whole being similar in many respects to the Planet ore bodies. The main body of ore

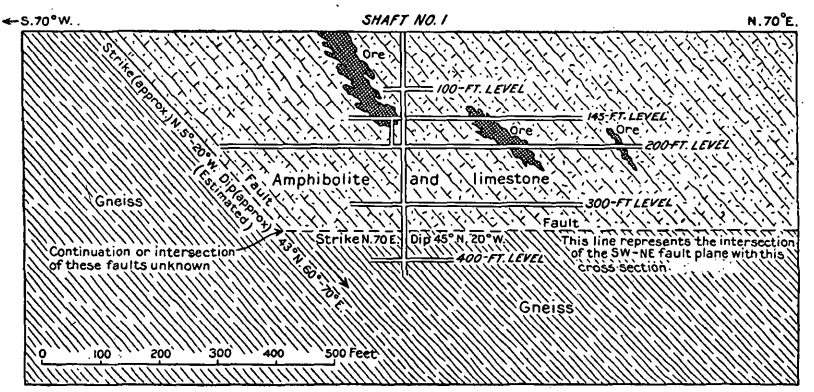


FIGURE 10.—Tentative cross section of the Signal ore deposit as developed in September, 1910.

is about 90 feet long, and presumably extends above the 145-foot level to the surface. The width of the ore body varies considerably according to the amount of replacement which has taken place in the country rock, perhaps a fair average being from 20 to 30 feet. The western side of this ore body seems to lie along a fault which

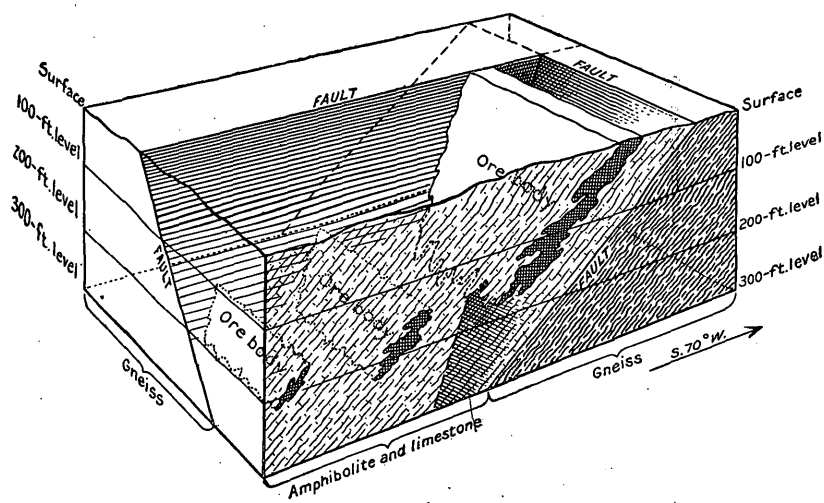


FIGURE 11.—Hypothetical stereogram of the Signal deposit.

dips approximately 35° N. 70° E. On all sides of the ore body amphibolite and limestone are found, amphibolite greatly predominating, although in places limestone is conspicuously present. Large limestone bowlders, which are apparently nearly pure calcium carbonate, are found in this ore body. These are covered in part with

hematite crystals, which are intimately associated with amphibolite. Pyrite and chalcopyrite are also present. Specimens from the dump show also some black oxide of manganese. An average assay of the deposit as exposed on the 145-foot level, in drift D 2, would perhaps run 2.5 per cent copper.

Evidences of extreme movement are noticeable, great slickensided surfaces and severe contortion having been observed in most of the underground workings. Viewed underground this movement appears more recent than pre-Cambrian.

Gneiss was found in crosscut No. 205, which is located 70 feet S. 70° W. of shaft No. 3 on level No. 2 and driven in a southeasterly direction, and amphibole was noted in drift No. 203, which is located 150 feet N. 70° E. of shaft No. 3 and driven in a northwesterly direction. This exposes the fault plane or contact of gneiss and the metamorphic series in a remarkably good manner.

As exposed on the surface and in the workings of the Signal mine the ore zone seems to be rather narrow and to be composed almost entirely of specularite, replacing the limestone, with here and there a scattering of chalcopyrite and a very small amount of pyrite. The shear zone, which is so prominent in the workings, is by no means thoroughly mineralized, and there is little probability that it will be found so at depth.

Other ore bodies, similar to those found on the 200-foot level, may be encountered as drifting in a northeast direction progresses. Concentration of ore along slipping planes of the amphibolite was noted in many places, and it is possible that future developments may expose other ore bodies which will prove extensive enough to mine.

ORIGIN OF THE ORES.

Doubtless the origin of the Signal ore body may be attributed to the same causes as those that formed the Planet deposits. In the Signal property later faulting and fracturing is evident, and chalcopyrite, pyrite, and hematite have been introduced in small quantities into the crushed zones of the country rock and in small cross fissures in the gangue and ore.

MORO PROPERTY.

RELATIONSHIPS AND LOCATION.

The property of this name is one of the group owned by the Clara Consolidated Company and its general geologic relationships and similarity of ore deposits are quite analogous to those of the Clara situated only 2 miles northeast. The workings of the Moro are situated in a small oblong hill about one-fourth of a mile wide and three-fourths of a mile long, the base of which is along a rising

contact between underlying pre-Cambrian granite gneiss and overlying probably Tertiary sandstone and volcanic tuff. Moro No. 1 tunnel is some 2½ miles southeast of Signal shaft No. 1 and 2 miles a little east of south of Clara Peak. This adit is on the southeast side of the small hill, and is at an altitude of about 1,650 feet.

No. 2 tunnel is a short distance farther up the hill at an elevation of 1,700 feet, and this, as are the others, is located near the contact of the gneiss with the tuff.

No. 3 tunnel is on the west side just below the northwest end of the hill at an elevation of 1,750 feet.

Development.—In April, 1909, the following development work had been done on the Moro group:

Moro No. 1. Adit about 200 feet long and a very short crosscut on a small transverse fissure cutting across the adit.
Moro No. 2. Inclined shaft 50 feet deep, dipping 20° SE.
Moro No. 3. Adit 200 feet long with drifts at right angles to end, one 20 and the other 50 feet long.

No production from the property is known.

GEOLOGY.

As already stated, these deposits occur near the contact of granite gneiss and beds of tuff and sandstone. The relation between the two is unconformable, and they are separated by wide geologic epochs, the gneiss being pre-Cambrian and the sediments no doubt being late Tertiary or Quaternary. Between Moro No. 2 and the divide near the top of the hill, a thin band of probably pre-Cambrian limestone was observed, which is analogous to the covering of limestone on top of the granite gneiss back of the Signal office. At the Moro workings the plane of the eroded surface of gneiss dips southeast, but this dip is only local and was caused by former drainage. At an elevation of 1,900 feet, at the base of the sedimentary series which forms Clara Peak, another band of limestone (probably pre-Cambrian also) was seen overlying the granite gneiss.

ORE DEPOSITS.

The ore occurs above the gneiss in and above the conglomerate which marks the base of the tuff and the sandstone sediments. Scant deposits of the silicate and carbonate of copper, with here and there a little leaf gold, have been made along the joints and small fissures in the sediments. Calcite is abundant in the openings in the rocks and quartz is present in small quantities. A little copper glance was noted in Moro No. 2 and besides the calcite some gypsum. Specularite was not seen, although the red oxide of iron (hematite) is present in many places. The deposits are small, and mineralization is limited.

CLARA PROSPECTS.

The Clara deposits are very similar to the Moro deposits. They are located 2 miles southeast of Clara Peak at an elevation of about 1,450 feet, just west of one of the main washes in the vicinity draining into Williams River. A section from Clara workings to Clara Peak and thence to the limestone hills south of Signal office is given in figure 12. The workings consist of a short adit tunnel at an elevation of 1,450 feet, a shaft some 90 feet deep at an elevation of 1,475 feet, and an adit about 100 feet long with a 10-foot winze at the end, located at an elevation of about 1,500 feet. These developments are all located within a short distance of each other on the east side of a hill about 1 mile wide and two-thirds of a mile long, near the contact of volcanic tuff and sandstone with the older underlying granite gneiss. The first opening shows several parallel joints which form small fissures running north-south and dipping about 80° W., with little or no mineralization. The shaft passes through 20 feet of sedimentaries, dipping slightly northeast, and the remaining 70 or 80 feet is in hard granite gneiss showing no mineralization whatever.

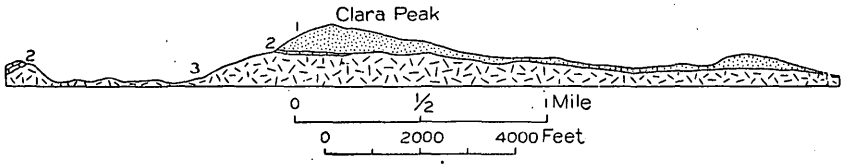


FIGURE 12.—Ideal section from Clara workings to Clara Peak and thence to the limestone hills just south of the Signal office. 1, Volcanic ash and sandstone; 2, pre-Cambrian limestone; 3, gneiss.

The third opening is practically on the contact between the two formations and shows jasper with a little silicate of copper, some minute particles of chalcocite, and iron stains fairly prominent at the breast of the adit. Specularite was not observed in the workings. Here the sediments dip 15° SW. Leaf gold has been reported from these properties; none was in evidence, however, at the time of the writer's visit.

Probably both the Moro and the Clara deposits have resulted from a secondary deposition of material derived from the older underlying rocks which contain the hematite-copper deposits worked in the Signal mine and elsewhere.

DEPOSITS ALONG COLORADO RIVER.

The deposits which are to be described under this heading are more or less scattered and are not of one type, although some similarity exists in the geological sections of the different localities. Of these properties three are on the California and four are on the Arizona side of the Colorado.

PROPERTIES ON THE CALIFORNIA SIDE OF THE COLORADO.

PROPERTIES EXAMINED.

The Viati Mining Company, the Copper Basin prospects, and the deposits worked by Mr. Bowman are all located in the Monumental mining district of San Bernardino County, Cal., on the southeastern side of the Whipple Mountains, some 10 or 15 miles north of Parker, Ariz. A means of transportation for the ores is furnished by the Arizona and California Railroad, its nearest point being just across the river from Parker. At the time of the writer's visit to the district no large production had been reported from the various workings, although some ore was said to have been shipped from a prospect in Copper Basin.

VIATI MINING COMPANY'S PROPERTY.

GENERAL DESCRIPTION.

The properties worked by this company are situated near the head of Bennett Wash, 7 miles due north of Parker. The camp is located at an elevation of 1,350 feet, and a fair wagon road to the California side of the Arizona and California Railroad bridge over the Colorado, which is approximately 400 feet above sea level, is perhaps 3 miles longer than a straight line between the two places. Parker, Ariz., is the present base of supplies, although in the near future, with the completion of the Arizona and California Railroad, no doubt a town will be built on the west bank of the Colorado.

Timber is very scarce in the vicinity and has to be shipped in here, as to almost every other place in the area. Water for domestic use was being pumped from the mine at the time of the writer's visit to the property. Distillate is used in operating the machinery, and, according to a statement by the superintendent, costs 27 cents a gallon in tank lots delivered to the California side of the Colorado and 3 cents to freight it to the camp, a total of 30 cents a gallon at the mine. The best grade of distillate is used, and the consumption is given by Mr. Bennett as three-fourths of a gallon per hour on the 15-horsepower Fairbanks-Morse hoist. No shipments have been made from this property.

Equipment.—The principal equipment consists of a 15-horsepower hoist, a 9-horsepower vertical engine, a 7½-kilowatt dynamo, and an electric pump run by a motor.

Development.—The development work done on these claims consists of the Pasadena vertical shaft about 150 feet deep, from which 2 very short levels have been run separated from each other by a vertical distance of 75 feet, and of the Horseshoe Tunnel, a crosscut, approximately 80 feet long, southeast of which several rather shallow open cuts have been made upon quartz ledges which run northwest-southeast for some distance on the properties.

TOPOGRAPHY.

The deposits are located in a part of the Whipple Mountains, which marks the dividing line between the gradually sloping desert southeast and the high precipitous spurs of the mountains northwest. In the immediate vicinity of the deposits the ridges are steep but not very high, rising only about 200 feet above the washes. Farther northwest the acclivity is very much more pronounced, the ridges there attaining an altitude of several hundred feet above the bottom of the valleys.

GEOLOGY.

Gneisses and schists, presumably of pre-Cambrian age and probably resulting from the metamorphism of granites and basic diorites, form the hills in this vicinity. The schistose structure of all the rocks is very pronounced, and in general the lamination planes dip northeastward, although there are many local changes, and frequently the lines of foliation are almost flat. These rocks are presumably a part of the granite gneiss schist complex which has been so often referred to in the discussion of the Arizona ore deposits, and their mineral constituents are not dissimilar enough to warrant a separate petrographic description. Aplite dikes of large dimensions, locally called "white spar," are found throughout the gneisses. These are severely fractured, the small fissures in many places being completely filled with hematite, which by its slickensided surfaces shows postmineral movement. Near the outcrop of the quartz ledges which have been prospected on this property, the most prevalent rock is a metamorphosed diorite, the lamination planes of which are parallel to those of the granitic gneiss and which was intruded into the granite prior to its metamorphism.

ORE DEPOSITS.

Pasadena shaft.—The Pasadena shaft, at an elevation of 1,350 feet, which has been sunk to a vertical depth of 150 feet, was started with the intention of crosscutting to the west from the 200-foot level, and so, perhaps, cutting at this depth the possible continuation of quartz ledges, which outcrop on the surface some little distance away in the same direction. As only a small amount of mineralization is in evidence in the workings of the shaft the following description will deal mainly with the occurrence of the ledges as viewed along the surface outcrops.

On the 70-foot level a short crosscut has been driven northeastward, which intersects a small vein about 12 inches wide, occupying a fault plane in the granite gneiss and dipping 45° N. 65° E. Slickensided surfaces of the country rock are noticeable and gouge is present

in large amounts. A thin stringer of copper glance 2 or 3 inches wide occurs in the vein, and pyrite, hematite, and quartz are also present. The ore is reported to contain, besides the copper values, a small amount of gold. Slickensided surfaces of the ore show post-mineral movement on a small scale.

At the bottom of the shaft, 150 feet from the collar, a crosscut has been driven northeast for a distance of 100 feet. Seventy-five feet along the crosscut a vein has been cut which dips 45° N. 65° E., and which is probably in a continuation of the fault plane found on the 70-foot level. On the 150-foot level, however, the fault zone is 4 feet wide and shows evidence of intense movement; slickensided surfaces are prominent and great quantities of gouge and brecciated gneiss form the vein. Here mineralization seems to be very scanty, no chalcocite being seen and only a small amount of pyrite with a very little chalcopyrite and some native copper scattered through the vein. In a small secondary fracture found cutting the fresh gneiss only a few feet beyond the vein, pyrite, hematite, and quartz are found.

This level has to be drained by a pump and may be under the ground-water level for the immediate vicinity.

Horseshoe tunnel.—The Horseshoe tunnel is located at an elevation of 1,400 feet about one-half mile above the Pasadena shaft in the wash which comes down to the camp of the Viati Mining Company from the northwest. The crosscut was driven to intersect two quartz ledges which show very prominently on the surface, one of which is probably encountered in the 80 feet of tunneling which constitutes the development in this working. This ledge is about 5 feet wide, strikes S. 25° E., and dips approximately 60° to 70° N. 65° E., here apparently cutting across the schistosity of the gneisses which at this particular place is very flat. Mineralization, except by the oxides of iron, is scanty, the silicate and carbonate of copper being very sparsely distributed. According to a statement made by Mr. Bennett of this company the ledge cut in this working carries some values in gold, the average being higher than on the outcrop.

Quartz ledge outcrops.—The outcrops of the ledges just above the crosscut are found at an elevation of 1,450 feet, and as there exposed vary from 5 to 8 feet in width and are separated from each other by 15 to 20 feet of gneiss. The croppings show a brecciated form of quartz which is heavily stained with the oxides of iron and a little manganese. The ledges contain many vugs, most of them filled with quartz crystals, associated with some calcite. Mr. Bennett is the authority for the statement that the croppings do not carry high values in gold. These croppings can be traced continuously for 1 mile in a southeasterly direction, the width varying between 1 and 8 feet.

On the way from the Horseshoe tunnel to the second opening on the croppings, which is about 3,000 feet southeast of the Horseshoe tunnel, gneiss was found to be continuous across the strike of the quartz ledges, apparently cutting them off. This is evidence in favor of the pre-Cambrian age of the quartz, showing that during regional dynamometamorphism the quartz veins were displaced and that in places their continuity was entirely cut off. Above the Horseshoe tunnel two ledges were in evidence. These continued parallel for some little distance, one of them not being present at the second opening, however, nor was it seen to the southeast of this opening. In places the ledge appeared to lie in the planes of schistosity of the gneiss and elsewhere to cut directly across them. A very basic schistose diorite or gabbro dike was noticed in the vicinity of the second open cut, which appeared to cut across the strike of the vein, although no contact between the two was visible.

Southeast of this opening the ledge appears to be faulted in a great many places and varies greatly in width, in general the croppings being narrower than those to the northwest.

Origin of the ores.—The exact nature of the origin of the deposits is rather doubtful. They are probably of pre-Cambrian age, and the quartz seems to have been introduced prior to the recrystallization of the granites and diorites into gneisses, evidence of this being found in the continuity of the gneiss across the main ledges whose outcrops are persistent in a northwest-southeast direction for over 1 mile. The partly brecciated condition of the quartz constituting the ledges is indicative of later movements in the vein or else of the introduction of the quartz just prior to the recrystallization of the granites. Very lean primary disseminated ores are sufficient to account for the mineralization in this region, which may have taken place during the dynamometamorphism of the area.

COPPER BASIN PROSPECTS.

GENERAL DESCRIPTION.

These properties are located just northwest of Monument Peak, about 15 miles by wagon road and 11 miles in an air line north of Parker. Not much development has taken place, nor has a permanent camp been built, and only small shipments of ore have been made from these prospects.[a]

TOPOGRAPHY.

After crossing a divide, which has an elevation of 1,450 feet, and is 2 miles southwest of the deposits, the road drops down into Copper Basin, which is in a small valley circling Monument Peak on the north and east and draining into a wash, which empties into the Colorado, a

[a] Shipments are reported to have been made to Swansea, Wales, from Prospect No. 2.

mile or so north of Eagle Landing. Monument Peak, which is just southeast of the prospects, rises abruptly to an elevation of 2,750 feet, and a small projecting finger on the southeast of the main peak is used as one of the corners in the Colorado River Indian Reservation.

GEOLOGY.

The deposits are in pre-Cambrian granite and granite gneiss which contain irregular dark patches, some of which are schistose and amphibolitic. In places there are small areas of distinctly gneissic rocks, aplites, and granitic rocks, surrounded by the massive granite. Monument Peak, to the southwest, is made up of lava flows, which are probably of basaltic composition. Plate III, *A*, shows Monument Peak in the distance.

ORE DEPOSITS.

Prospect No. 3.—This opening is the one nearest to Monument Peak and is a shallow shaft (80 feet deep) sunk on a fairly well-defined shear zone, 2 or 3 feet wide, which strikes N. 18° W. and dips 85° S. 70° W. The country rock is imperfect schistose granite and diorite, one wall of which appears to be of diabasic origin. The gangue appears to be mainly an iron-stained gouge of brecciated country rock containing some oxidized copper ores with a little chalcopyrite and chalcocite.

Prospect No. 2.—About 1,000 feet north of No. 3 and separated from it by imperfect amphibolite schist, striking N. 70° E., with massive granite near by, is located Copper Basin prospect No. 2. Here a short adit has been run near the vein and a shallow shaft has been sunk. This deposit looks like an irregular chimney in hornblendic schist striking N. 35° E., the ore-bearing streak appearing to course N. 55° W. and to dip 75° N. 35° E. On the surface the vein appears to be about 3 feet wide and is all slightly mineralized by the oxides of iron and copper. Native copper, chalcocite, cuprite, malachite, hematite, and quartz are present in the vein, which is reported to carry some gold.

Summary.—These deposits are probably of pre-Cambrian age and are all contained in granite and schist, one of them being clearly connected with amphibolitic schist. They may be accounted for by the secondary concentration of very lean disseminated primary ores. No strongly defined fissures show in the workings, and there is probably little hope of extensive deposits.

BOWMAN PROSPECTS.

The deposits owned and worked by Messrs. Bowman Bros. & Humphries are located a short distance south of Monument Peak and a little east of the main Copper Basin road. Developments on the properties are in an early prospecting state, little work having been

done. The two short adits and the open cuts show the contact between the old underlying massive granite, in which oxidized copper ores occur, and the capping of sandstone and tuff. The veins are small and look uncertain, with scanty mineralization, and only oxidized products were in evidence at the time of the writer's visit to the camp.

PROPERTIES ON THE ARIZONA SIDE OF THE COLORADO.

PROPERTIES EXAMINED.

Under this heading will be described the Quartz King, the Billy Mack, the Carnation, and the Wardwell & Osbourne properties, which are all located in the Williams Mountains in the northwestern part of the Santa Maria (or Bill Williams) mining district.[a] The first three properties are perhaps more properly classed in this group than in the last, for they are not far from Colorado River, whereas the Wardwell & Osbourne prospect is some distance southwest. Parker, on the Arizona and California Railroad, is the base of supplies, and is also the present shipping point for these properties.

QUARTZ KING PROPERTY.

GENERAL DESCRIPTION.

The Quartz King workings are located 5 miles northeast of Parker in an air line, and are made accessible by a good wagon road some 7 miles long between the two places. A store located on the main Colorado River road is kept up by the management, and telephone connections with Parker are maintained. There are several houses near the new workings on the property, and these with a shaft house constitute the surface improvements. The following machinery is installed in the shaft house: One 60-horsepower hoist, one 60-horsepower compressor, and one small blower. In the crosscut from the bottom of the new shaft one drill was in operation on May 1, 1909. Distillate is used for fuel, and about 50 gallons are reported to be consumed daily in operating the machinery. The property is being worked for gold and copper.

TOPOGRAPHY.

The deposits are located about 1½ miles from Colorado River and about 250 feet above it on the southwestern slope of a long narrow ridge which extends almost down to the river. The camp is located near the head of a small ravine at an elevation of 550 feet and about 150 feet below the older and upper workings on the property. The hills are not very precipitous and the peculiar topography in the vicinity is entirely dependent upon the geological relationships.

[a] See figure 4 (p. 45) for map showing boundaries of mining districts.

GEOLOGY.

The rocks in the vicinity are amphibolitic and chloritic schists which are nearly vertical and strike northwest-southeast. Upon the eroded surface of these older rocks rest basalt and a clastic rock composed entirely of brecciated microline feldspar and quartz fragments. The ore deposit occurs in a shear zone or fault plane in the amphibolitic and chloritic schists, which resemble in a very general way the schists seen in the vicinity of Billy Mack's, Osbourne's, and many other places; it has probably resulted from the metamorphism of arenaceous shales intruded by diabase or other basic rocks. Joint planes are common in the clastic rock found resting on the amphibolite near the upper workings, and the basalt seems to be very platy and to have been jointed in a more or less local fashion. The irregularity of the contact between the underlying amphibolite and the later sediments and igneous flows forms the most noticeable feature in both the topography and the geology of the vicinity.

THE ORE DEPOSIT AS EXPOSED BY WORKINGS.

Upper workings.—The upper workings are located at an elevation of 700 feet. The vein, as observed at this place, appears to occupy a fault plane or a shear zone in the schists which strikes S. 20° to 30° E. in places and north-south in general. The dip is almost perpendicular, the inclination noted on the surface being to the southwest. Because of the nature of the deposit the gangue is principally sheared country rock which has been cemented in part by later deposition of quartz, showing brecciation due to subsequent movement. The ore minerals occurring with the quartz are malachite and chrysocolla with hematite. The deposit is not very extensive in width though quite persistent in length. The shaft here is reported to be 300 feet deep and to have 900 feet of laterals.

New shaft.—Some 300 feet below the upper workings a new vertical shaft has been started. This penetrates the clastic rock throughout the 100 feet in depth which had been attained at the time the property was visited. At this level a crosscut had at that time been driven toward the supposed continuation of the vein and had cut 70 feet of the same sort of clastic material.

BILLY MACK PROPERTY.

LOCATION AND DEVELOPMENT.

The property belonging to Mr. Mack which is commonly referred to as Billy Mack's Ruby mine is perhaps one of the best known deposits in the area. This is no doubt due to the fact that free gold occurs here in appreciable quantities and has in the past been mined in a way peculiar to the owner.

In an air line it is just 6 miles in a northeasterly direction from Parker to the Billy Mack adit on the Ruby property. By wagon road this distance is increased to 7 or 8 miles, and the difference in elevation between the two places is approximately 400 feet, the acclivity being mainly in the vicinity of the prospect. Little is known to the writer of the early history of this property. According to rumor the gold extracted from the vein has been the means of subsistence of its owner for a great many years, and it is said that the property has never been consistently worked. Surely the small amount of underground development testifies to the accuracy of this last statement. The production has been variously estimated, the highest estimate amounting to $65,000, and the tailings from a small 5-stamp mill are said to contain several thousand dollars' worth of gold which has not been extracted by stamping.

The work on the prospect has been done by hand drilling, and there is no machinery on the ground. The mill is located a short distance north of the Quartz King store and is just off the main Colorado River road, about 2 miles from the prospect. Water has not been encountered in any of the workings so far, the deepest of which are 165 feet below the level of the main opening. Some timber could be obtained in the locality along the banks of the Colorado.

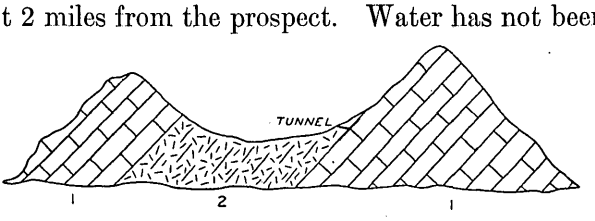


FIGURE 13.—Ideal section in the vicinity of Billy Mack property. 1, Limestone; 2, chloritic micaceous schist.

GEOLOGY.

The rocks in the immediate vicinity are limestones and chloritic schists, the latter being contained between conformable beds of the former, and the whole series strikes northeast and dips 45° NW. Figure 13 shows the geological relations existing in this locality.

The limestones rise on each side of the gulch to heights of 200 or 300 feet and are in rudely bedded benches, the weathered surface of which is dark brown. The texture of the fresh rock is fine grained and the color is a dark gray. Veinlets of siderite are found in abundance throughout the limestones. The ridge on the northwest probably represents a thickness of 200 feet. The width of the lower bench exceeds this dimension, but it is impossible to say by what amount, as the ridges northeast are composed of this material, and these may represent a thickness of between 200 and 700 feet, perhaps more.

The valley between these two horizons of limestone is about 800 feet wide, and has been excavated in soft chloritic micaceous schist,

the thickness of which is probably not less than 500 feet. As seen in the creek bed the schist is slightly contorted and is of light greenish-gray color, containing small and likewise contorted quartz veins. This schist probably represents tuffaceous deposits or an old flow of diabase or related rock (perhaps the remnant of a quartz diorite or dacite) on top of the lower bench of limestone. Above this the sediments on the northwest were deposited. A thin section of the chlorite schist shows much talc and white mica, together with an abundance of chlorite, quartz, and a little feldspar. Amphiboles were probably present in the original rock, although none are now recognizable in the schist.

The whole series has been subjected to pressure, and, as the schistosity developed far more easily in the basic rock than in the limestones, the basic rock shows contortion, while the limestones are only crushed and brecciated in places.

ORE DEPOSIT.

As shown by the workings and the surface croppings of the vein, which are about 80 feet above the wash level, the deposit occupies the contact plane between the underlying limestone and the micaceous chlorite schist. Quartz is the prevalent vein material, and much of it is cellular, as if carbonates had been dissolved from it. A little amphibolite, epidote, and some chlorite were noted as associated with the deposit. The ore minerals are chiefly malachite and chrysocolla, with some native gold. Specularite, probably of secondary origin, is abundant in the workings. The deposit is not very regular, mineralization being in scattered bunches, with a noticeable lack of continuity between the various ore pockets. These in general have been only a few inches in width and not of great length, having been explored by individual workings.

The association of minerals found in this deposit is characteristic of copper deposits connected in origin with basic flows. Possibly the deposit was formed by concentration of the original metallic contents in the basic rock during the metamorphism of the region. The primary ore is probably poor in gold values.

CARNATION PROPERTY.

LOCATION AND DEVELOPMENT.

This property is located about 9 miles in an air line northeast of Parker, the wagon road between the two places being about 13 miles long. The camp, which consists of several tents, is situated at an elevation of 880 feet. The deposit is a very short distance to the east of the camp, and the workings are 100 and 200 feet higher on the west side of a bluff which has been eroded in such a manner that the remaining hills and ridges form a crescent-shaped background.

Water has to be hauled and is stored in tanks at the camp. The developments are in an early prospecting stage, and at the time of the writer's visit the property was idle.

GEOLOGY.

Massive limestones interbedded with amphibolitic and quartz-mica schists form prominent ridges on the north, and the same rocks are capped by tuff and nearly level olivine basalt flows on the east. The deposit occurs in the amphibolitic schists, and is prospected by a shallow inclined shaft just below the contact with the overlying basalt. In general the schists strike northeast-southwest and dip about 45° SE., although there are many local disturbances in the vicinity of the deposit and elsewhere, so that the directions of strike and dip are by no means constant. The presence of the medium-grained quartz-mica schist in this series is about the only thing which mars the similarity between this section and that at the Billy Mack locality.

The fractures in the basalt are filled with calcite, and no evidence of metallic mineralization exists in the younger rocks into which a short vertical shaft has been sunk.

ORE DEPOSITS.

The deposit here, as at the Quartz King, seems to occupy a shear zone or fault plane in the amphibolite schists. Ten or twelve feet above the vein occurs a thin layer of limestone, the top of which is partly replaced by hematite. Over this is a narrow band of medium-grained quartz-mica schist which is capped by tuff and a succession of basaltic flows. The vein, which is 2 or 3 feet wide, consists mainly of brecciated country gangue showing some mineralization by the silicate and carbonate of copper. Postmineral fracturing has occurred, followed by a recementing of material by siderite, calcite, and quartz, the latter forming jasper in places. Secondary specularite was noted in a specimen on the dump.

Origin of the ores.—It is possible but hardly probable that the quartz-mica schist may have been of igneous origin and intrusive in the limestone, thereby causing the mineralization. The more plausible supposition is that the ore deposit was formed by concentration of the original copper content of a basic flow or of tuffaceous rocks from which the amphibolite has resulted by the metamorphism of the region.

WARDWELL & OSBOURNE PROPERTY.

LOCATION AND DEVELOPMENT.

The property called by this name is situated some distance southeast of the rest of the Colorado River group, and is made accessible by a circuitous road from Parker, which is about 15 miles long and extends in a general easterly direction from that place. The prospect may

also be reached by a branch from another road which is not so commonly used, the location of which can be seen by referring to Plate I.

As the property was idle and the workings were closed at the time of the writer's visit only a brief description of the ore occurrence as shown on the surface can be given. The principal underground developments consist of an adit tunnel located at an elevation of 950 feet and an inclined shaft, the collar of which is some 100 feet lower than the main adit. Besides these, three other small workings were noted, and, judged by the various dumps, the total developments are not very extensive. Probably no large shipments have been made from the property.

GEOLOGY.

In the vicinity of the Wardwell & Osbourne camp fine-grained quartz-mica and amphibolitic schists underlie tuff and olivine basalt, the younger rocks being barren of mineralization and covering for the most part the older rocks throughout this section. Erosion has cut through this series a short distance into the schists, which are exposed for about one-half mile farther west, where basalt again hides them from view. The uneven contact of the two formations is due to the irregularity of the old erosional surface which is now occupied by tuff associated with basalt flows. In general the schists dip southwest and strike northwest, the dip varying from 10° to 90°. Plate III, *A*, shows the basalt bowlders in the vicinity of the divide between Billy Mack's and the Wardwell & Osbourne property. Monument Peak is shown in the distance.

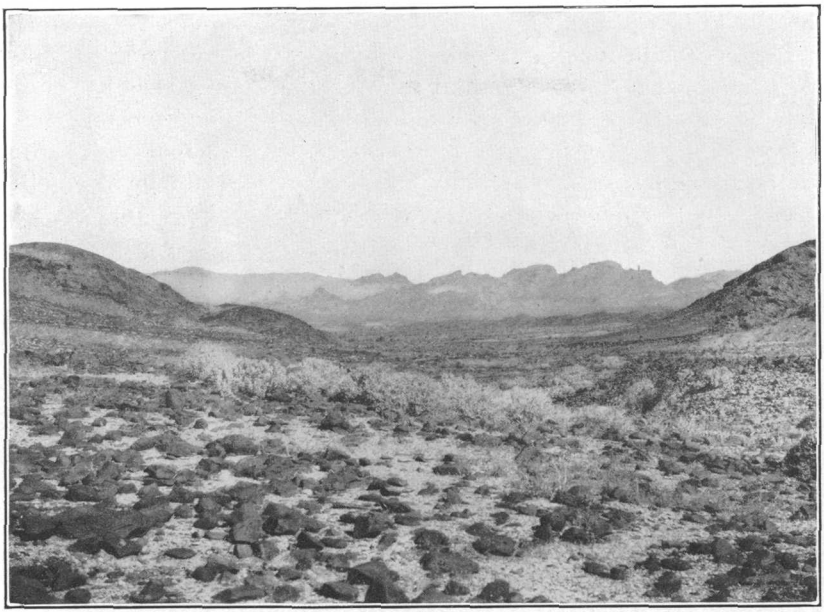
ORE DEPOSIT.

Judged by the surface exposures the mineralization seems to have taken place along a nearly vertical fault plane in the schists which strikes S. 30° W., and which is filled mainly with brecciated country rock cemented by siliceous material. The vein does not follow the planes of schistosity, but cuts directly across them. The shear zone is only a few feet in width and the ore-bearing streak, as viewed on the surface outcrop, is irregular and relatively narrow when present. A specimen of ore from one of the dumps shows a breccia of siliceous fragments cemented by hematite, with a little chrysocolla and malachite, the copper solutions apparently having been later than the others.

DEPOSITS IN THE DOME ROCK MOUNTAINS.

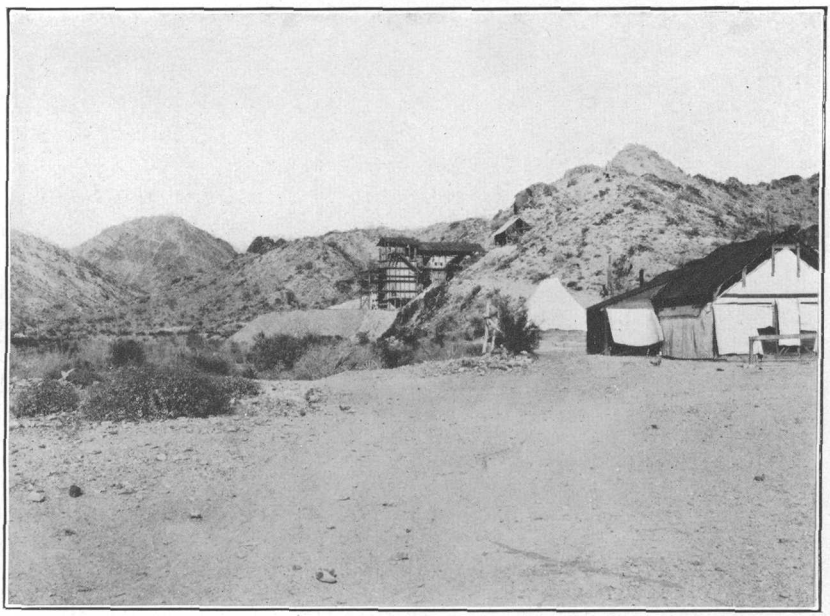
LOCATION AND CHARACTERISTICS.

The Dome Rock Mountains were among the first to be earnestly prospected for lodes because of the early discovery of gold placer deposits on their western slope. The results have not been as gratifying as anticipated; nevertheless, several veins carrying free gold have been located. Because of lack of time the only free gold property examined was the Mariquita.



A. BASALT BOWLDERS ON DIVIDE BETWEEN BILLY MACK'S AND WARDWELL & OSBOURNE PROPERTIES.

Monument Peak in the distance.



B. SMELTER AT CINNABAR, ARIZ.

Copper is also found in the range, the Valensuella deposit being the only one visited. Locally the Copper Bottom deposits seem to be well and favorably known, and the writer regrets that circumstances prohibited an examination of these prospects.

The Dome Rock Mountains have several individual characteristics, among which the occurrence of cinnabar in the southern part of the range is especially worthy of note. The deposit worked by the Colonial Mining Company was inspected, and a hurried visit was paid to the property of the French American Mining Company, a short distance west of Cinnabar.

With the exception of the Valensuella prospect all of the deposits examined in the Dome Rock Mountains are located in the southwestern part of the Plomosa mining district, the Valensuella probably being in the La Paz (or Weaver) district.[a]

Transportation facilities are not of the best for any of the properties in this vicinity. Bouse and Vicksburg, the nearest railroad points, are distant from Cinnabar in an air line 31 and 35 miles, respectively; and from the Valensuella camp, Bouse is distant 22 miles in a direct line. The wagon roads are necessarily longer, and transportation becomes a very expensive factor in the mining industry of the area. In the past some ore has been shipped down the Colorado.

VALENSUELLA COPPER COMPANY'S PROPERTY.

LOCATION AND DEVELOPMENT.

The deposit worked by the Valensuella Copper Company is located in the northern part of the Dome Rock Mountains near the Colorado River Indian Reservation line, the exact location of which seems to be an unsettled question. The location of the property on the reconnaissance map (Pl. I) is only approximate.

The nearest railroad point is at the town of Bouse, distant 22 miles in a direct line north of east of the camp; the distance by wagon road is not known to the writer. As no ore has been shipped from the property, costs of transportation can not be given.

Timber is lacking in the vicinity, and water is obtained from a well near the collar of the shaft, in which it stands 450 feet below the surface.

Equipment.—An 18-horsepower hoist and a 25-ton smelter, which has not seen much active service, constitute the company's principal equipment on the ground. The other surface improvements consist of several buildings and a smithy.

Underground development.—An inclined shaft the slope of which varies in dip from horizontal to 35° has been sunk to a total depth of 900 feet on the incline. From this shaft various short levels have

[a] For boundaries of mining districts see figure 4, compiled by county clerk of Yuma County from official records.

been driven, making a total of about 1,600 feet of workings. The bottom of this shaft is probably 450 feet in a vertical distance below the surface, which is also the approximate ground-water level.

TOPOGRAPHY.

The camp and workings are located in the northern part of the range at an elevation of 600 feet, and are at the base of a steep mountain slope just above the desert, which stretches away to the east for 12 miles or more. The drainage of the vicinity is into Tyson Wash, about 4 miles south of the Valensuella. On the west a narrow canyon with precipitous walls extends for three-fourths of a mile, and its course appears to have been determined by a fault. The canyon has nearly cut in two this northern projection of the Dome Rock Mountains, thereby revealing a good geologic section. The portion of the range as represented in this vicinity rises only about 500 feet above the desert, and is characterized by sharp peaks which terminate a narrow and uneven ridge.

GEOLOGY.

In the vicinity of the Valensuella camp the geologic section is unlike that seen in other localities which were examined during the reconnaissance of the area. The prevailing rocks are coarse-grained schists, and most of them appear to be metamorphosed sediments deposited from the erosion of granitic and dioritic rocks. One lens of cream-colored, coarse, crystalline limestone, about 12 feet thick, occurs in the schists in the section exposed south of the road and a short distance west of the camp. Limestone is reported to have been cut at a depth of 125 feet in workings on the north side of the road, about one-half mile west of camp.

The schists range in color from almost black to gray, pink, and silvery white, depending upon the kind and amount of mica present in the rocks. The very dark rocks carry much biotite and augite; the lighter ones contain more quartz, feldspar, and white mica. Intruded into the series, prior to their metamorphism, occur typical quartz porphyry and aplite, in which schistose structure is well developed. Later intrusives of pegmatite (garnetiferous), diabase (pyritiferous), and minette dikes are present in the vicinity. Of the first a great many were seen in the hills on the south side of the road. The diabase is fairly common in the vicinity; the minette seems rather scantily distributed, having been noted only in the workings of the prospect, where it occurs in the 100-foot level above the vein.

The schists in general dip northwest away from a gneissic micaceous granite found south of Tyson Wash, which granite is probably the oldest rock in the vicinity and is perhaps comparable to the granite gneiss complex of the Harcuvar Range.

ORE DEPOSIT.

The ore deposit occurs along a shear zone in the schists. The plane of movement varies from almost horizontal to a dip of 35° and has pinches and swells which tend to make a decidedly irregular deposit. In general, the strike of the vein is east-west and the dip is north. The vein varies greatly in width. In some places it is several feet wide; in others it pinches out. The ore course is even more capricious, occurring in irregular pockets and stringers and disappearing entirely between the 300-foot and the 400-foot level.

The gangue is composed of brecciated country rock, some quartz, and much calcite, the latter forming in bunches several inches in diameter throughout the upper 400 feet of workings.

Chrysocolla, some malachite, a little pyrite, and considerable hematite constitute the ore minerals.

As viewed at the 100-foot level, where drifts have been run 100 feet each side of the shaft and some stoping done, the parts of the vein exposed showed a little good ore. Most of the best material has been extracted, however, and little except the caved workings were visible. The ore is reported by the manager to contain 10 per cent copper and $1.50 in gold per ton. Above the vein occurs a minette dike.

On the 300-foot level drifts 200 feet in length have been driven on both sides of the shaft. These show scanty mineralization and not much continuity in the deposit. Between the 300-foot and the 400-foot levels the vein was lost. The manager of the property reports (May 6, 1910) that a crosscut back from the bottom of the shaft 150 feet has revealed a vein in place. The ores seem to be leached, however, and sulphides are not conspicuous.

Origin of ores.—At this deposit also oxidation veils the original character of the ore. The abundant calcite in the gangue suggests deposition nearer to the surface and perhaps at more recent time than in most of the mines previously described. The mineralization appears to be later than the development of schistosity, and it is possible that the ore deposition had some connection with the intrusions of diabase and minette noted in the vicinity

MARIQUITA PROSPECT.

The Mariquita prospect is located about 6 miles west of Quartzsite, the road leading to it branching from the Ehrenberg stage line some 4 miles out of Quartzsite. It is situated 2 miles north of the stage road at an elevation of 1,100 feet on the southeastern side of a saddle which occurs midway in the Dome Rock Mountains.

Medium to fine grained quartz-mica schists apparently intruded by much younger fine to medium-grained granites or quartz monzonites are the rocks in the immediate vicinity. The schists strike northwest-southeast and dip 20° NE., and they contain, besides the quartz and mica, much epidote and chlorite with a large percentage of orthoclase feldspar and some unaltered but contorted biotite crystals.

A fairly large vein of quartz carrying a little copper and gold, which has been roughly prospected, is the source of the ore extracted from this property. The vein strikes S. 20° E. and dips 20° NE., and lies in a slip or fault between parallel schist strata. In width the vein varies from a few inches to several feet, is fairly persistent in length, and apparently is lenticular. As the workings on the property are old and not very extensive, little accurate data on the size of the ore body were obtained.

COLONIAL MINING COMPANY'S PROPERTY.

LOCATION AND DEVELOPMENT.

The following sketch is simply a rearrangement of the material which was published by the writer in "Contributions to economic geology for 1909, part 1," [a] under the heading "Notes on the occurrence of cinnabar in central western Arizona."

The property worked by this company has been known for a number of years [b] and is located at Cinnabar, which is in the southern part of the Dome Rock Mountains, some 8 miles due southwest of Quartzsite. Vicksburg, the most accessible railroad station, is in an air line just 28 miles a little north of west of Quartzsite. The stage road between the places is a few miles longer. The road between Quartzsite and the prospects is about 20 miles long and is a very poor one after branching off from the main Yuma road. Timber for use as fuel in the smelter and water for domestic purposes are obtained somewhere in the vicinity, although neither are found in great abundance.

The surface equipment consists of a good shaft house with adequate machinery for carrying on operations, several dwellings, and a 30-ton Scott tile furnace with six condensers. Plate III, *B* (p. 78), shows a view of the smelter and camp.

A vertical shaft 300 feet deep and four short levels running from it make a total of several hundred feet of underground development.

During parts of 1908 the furnace was operated on the property, a small quantity of mercury being recovered. High absorption of the metal by the bricks of local manufacture used in the condensers is

[a] Bull. U. S. Geol. Survey No. 430, 1910, pp. 151–153.

[b] These deposits, according to Turner, have been known for over thirty years. See Turner, H. W., Quicksilver: Mineral Industry during 1908, p. 743.

reported by the management to have so lowered the percentage extracted that metallurgical operations have not proved profitable.

TOPOGRAPHY.

The topography is characterized by broad sloping valleys with mountain ranges rising abruptly from the deserts. The Dome Rock Mountains have an average elevation of 1,500 feet, being approximately 1,000 feet above the surrounding country. The spur in which the cinnabar occurs forms the highest branch of the mountains, one of its peaks rising to an elevation of over 2,700 feet.

GEOLOGY.

The rocks in this locality are arenaceous shales, presumably of pre-Cambrian age, which have been metamorphosed into quartz-mica schists. The dip of the strata in the vicinity of the deposits is in general between 15° and 45° NE., and the strike is northwest, with many pronounced local changes in both. To the unaided eye most of the rocks appear to be fine grained, with a satiny sheen, ranging in color from light silver white through gray, brown, and red to a dark, almost black tone. The colors are due in general to the kind of mica and the amount of chlorite and epidote present, and in part to the degree of oxidation of the contained iron. Mica is prominent, and although the crystals are not large, they are conspicuous enough to be recognized without the use of a strong lens, and because of their abundance the rocks are fairly soft, feel greasy, and are readily scratched with a knife blade. Upon microscopic examination of thin sections it is found that the general composition of the schists is the same, all of them containing much quartz, orthoclase with some andesine feldspar, and mica, part of the latter probably resulting from the decomposition of the feldspars. Epidote is present in almost all of the schists, some of which are highly chloritized. Near the veins the wall rocks show calcite and epidote in abundance, with some zoisite.

The country rock in which the deposit worked by the Colonial Mining Company occurs is unlike the majority of the schists in the vicinity in that it contains scattered throughout the rock in large quantities small crystals of magnetite.

ORE DEPOSIT.

The vein worked by the Colonial Mining Company strikes S. 55° E., is practically perpendicular, and occupies a fault zone which shows intense brecciation of the country rock.

The gangue is highly siliceous and is cut by small stringers of calcite and siderite, the former occurring in places in conspicuous quantities but being entirely absent in the croppings of the vein where silica with a little black oxide of manganese forms the ledge. In width the vein varies from a few inches to several feet; parallel breccia planes of

small magnitude, which accompany the main fault, in places tend to widen the deposit. The ore shoot in the property is said to pitch southeast.

Cinnabar is sparsely distributed throughout the gangue and is supposed to be found mainly on the northeast side of a very plastic, iron-stained gouge which has resulted from movement in the fault zone. The ore in places is conspicuously marked by the green carbonate of copper, and Turner [a] has reported gold and silver in ores from this deposit. The presence of magnetite near the vein is a feature worthy of note, the alteration of which has probably formed the red and yellow stains so common in the brecciated vein material and gouge.

Origin of the cinnabar.—Considering the facts that late eruptives are absent in the vicinity, that the deposit is entirely oxidized, and that copper stains are prominent, with values of gold and silver occurring in the vein, it seems highly probable that the cinnabar has been derived from mercurial tetrahedrite. Waldemar Lindgren has noted the occurrence of this mineral in gold quartz veins of the Granite district, Blue Mountains, Oregon, where pyrite, chalcopyrite, and arsenopyrite are also found.[b]

FRENCH AMERICAN PROSPECTS.

About 1½ miles west of the Colonial Mining Company's property up a steep and narrow gulch at an elevation of about 1,600 feet are located prospects owned by the French American Company. The present name is probably the result of a tradition that formerly the vicinity had been prospected and worked by Frenchmen.

A few open cuts show the character of the ledge and of the country rocks. The latter are mainly fine-grained quartz-mica schists with two prominent layers of impure limestone in the vicinity of the quartz ledge which is several feet thick and has a fairly continuous outcrop.

There are found associated with the pure white quartz a noticeable amount of tourmaline, a little free gold, and some copper glance, all except the last apparently of primary origin. Siderite associated with gold and tourmaline was noted, and cinnabar is said to occur with the tourmaline in the quartz, although none was in evidence at the time of the writer's visit to the property. The vein strikes N. 55° W. and dips about 15° SE., cutting directly across the schists, which have a dip of 20° to 30° N. 60° E. A variety of schist next to the vein is highly impregnated with tourmaline, while another schist in the vicinity is extremely silicified.

The association in this vein of primary quartz, tourmaline, and gold is thought to indicate deposition under rather high temperature and pressure.

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[a] Turner, H. W., Quicksilver: Mineral Industry during 1908, p. 743.
[b] Twenty-second Ann. Rept. U. S. Geol. Survey, 1901, p. 663.

PLACER DEPOSITS NEAR THE DOME ROCK MOUNTAINS.

LOCATION AND HISTORY.

The placer deposits near the Dome Rock Mountains were among the earliest discoveries in central western Arizona, and they have been worked with more or less success in an intermittent fashion ever since 1862. As no work was in progress at the time of the writer's visit and as it was impossible to examine the famous La Paz district, it has been thought advisable to incorporate in this description extracts from the report of J. Ross Browne on the mineral resources of the States and Territories west of the Rocky Mountains, published in 1868. Mr. A. McKey, one time member of the Territorial legislature from La Paz, is the authority for the following information on the La Paz district:

Captain Pauline Weaver and others, in the month of January, 1862, were trapping on the Colorado River, and at times would stray off into the mountains for the purpose of prospecting for gold. They had discovered what was then named and is still called "El Arroyo de la Tenaja," which is about 2 miles north from El Campo Ferrá, and about 7 miles east from La Paz. In this gulch they had discovered gold in small quantities and had taken out $2 or $3 worth, which Captain Weaver kept in a goose quill.

Soon after this discovery Weaver visited Fort Yuma and exhibited what gold he had. This evidence of the existence of a commodity so much sought for in this country convinced others that gold might be found in quantities by hunting for it. Don José M. Redondo, having heard of the discovery, at once set out to visit the newly found "El Dorado" in company with several others. He arrived a few days afterwards at the camp of Captain Weaver, who pointed out to him and his party the particular gulch from which he had taken the gold. After a short examination of this place the party set out in different directions to discover, if possible, something which would pay to work, and the extent of the placers. Within less than a mile from Weaver's camp, south, Redondo took a pan of dirt to prospect, and when he had dry washed it, to the astonishment of himself and the party with him, he found that he had one "chispa," which weighed 2 ounces and $1, besides other small pieces. Others of his party found good prospects, but none of the company had come for anything more than to ascertain the truth or falsity of the reported glad tidings, and therefore were not prepared to remain and work for want of the necessary provisions and tools, but were compelled to return to La Laguna, a settlement some 20 miles above Fort Yuma, on the Arizona side of the Colorado. * * * Very soon the knowledge of these discoveries spread to Sonora and California, and people began to pour in from all points, and continued to come until they probably numbered 1,500. This population was maintained to a greater or less extent until the spring of 1864, when the apparent exhaustion of the placers and the extreme high prices for provisions caused large numbers to leave. The discovery of the Weaver and Walker's diggings in the year 1863 drew away many of the miners from these placers.

Of the yield of these placers, anything like an approximation to the average daily amount of what was taken out per man would only be guesswork. Hundreds of dollars per day to the man was common, and now and again a thousand or more per day. Don Juan Ferrá took one nugget from his claim which weighed 47 ounces and $6. Another party found a "chispa" weighing 27 ounces, and another one of 26 ounces.

Many others found pieces of from one to two ounces up to 20, and yet it is contended that the greater proportion of the larger nuggets were never shown for fear of some evil spirits who infested the mines at the time. It is the opinion of those most conversant with the first working of these placers that much the greater proportion of the gold taken out was in nuggets weighing from $1 up to the size of the "chispas" above named. I have often heard it said of those days that "not even a Papago Indian would work for less than $10 per day."

As has been seen from the above, the gold was large and generally clear of foreign substances. The largest piece (above mentioned) did not contain an apparent atom of quartz or any other base matter. The gold from the different camps varied a trifle in its worth at the mint in San Francisco, and brought from $17.50 to $19.50 per ounce. But all that was sold or taken here went for from $16 to $17 per ounce. Since the year 1864 until the present there have been at various times many men at work in these placers, numbering hundreds in the winter months, but in the summer months not exceeding 75 or 100; and all seem to do sufficiently well not to be willing to work for the wages of the country, which are and have been for some time from $30 to $65 per month and found. No inconsiderable amount of gold comes in from these placers now weekly, and only a few days ago I saw, myself, a nugget which weighed $40, clear and pure from any foreign substance.

Some parties have lately come into these diggings with what is called concentrators or dry washers, which they have been working for a few weeks, and in conversation with Mr. Finkler (an owner of one of these machines) he told me that he could make $20 per day where he was at work, and pay $3 per day for his hands, and that he only required four to work the machines. Should these machines prove a success, these placers will soon be peopled again with industrious, prosperous miners. Of the total amount of gold taken from these mines, I am as much at a loss to say what it has been as I was to name the average daily wages of the first years, and as I might greatly differ from those who were among the first in these mines, I do not feel justified in setting up an opinion as against them; I shall, therefore, give the substance of the several opinions which I have obtained from those who were the pioneers of these placers. I have failed to find any one of them whose opinion is that less than $1,000,000 were taken from these diggings within the first year, and in all probability as much was taken out within the following years.

In the desert which extends between the Dome Rock and the Plomosa mountains and is traversed by Tyson Wash, placer mining by dry washing has been carried on intermittently for a great many years. Innumerable short shafts have been sunk in the detrital deposits, and these openings are in many instances connected by underground tunnels. At the present time placer mining is not receiving much attention in this district, and, as the dry washers save only the large flakes of gold, water is an essential feature in thoroughly prospecting these deposits.

ORIGIN OF THE PLACERS.

When the age of the rocks and the ore deposits contained therein is considered in conjunction with the tremendous amount of erosion which has taken place in the area and the omnipresence of minute auriferous quartz gash veins, it does not seem unreasonable to suppose that the placers owe their origin to the veins located in the adjacent mountains.

DEPOSITS IN THE PLOMOSA MOUNTAINS.

LOCATION AND PROPERTIES.

Among the prospects examined in the Plomosa Mountains, which properties are in the southwestern part of the area and extend north to the Arizona and California Railroad, are included deposits of gold (placer), lead, copper, and iron. Vicksburg is the nearest railroad point for the New York-Plomosa and the Guadalupe, and Bouse is the most convenient station for the Lead Camp, the Mudersbach, the Iron Mine, and the Little Butte properties. All of the properties are located in the Plomosa mining district,[a] and are near the base of the range just above the contact with the surrounding desert. Only one of the properties, namely, the Little Butte, was actively operated at the time of the visit to the district; hence the information obtained on these deposits was principally of a geological nature. The writer regrets that circumstances prevented him from visiting the Success property, located about 3 miles south of the Guadalupe. Two carloads of ore shipped from this deposit are reported to have netted $105 each, and a third to have returned a slightly smaller amount, the values being in gold and copper.

NEW YORK–PLOMOSA.

LOCATION AND DEVELOPMENT.

Various placer deposits in the area have been worked intermittently for a number of years, but none of them, so far as the writer is aware, have been prospected on a large scale, nor have they been attacked in a manner similar to that employed by the New York-Plomosa Company, dry washing having been the usual method of procedure. This company, however, in the last few years has installed large machinery, laid a 7-mile water pipe line without any expansion joints, and has got all ready to work the placers. For some reason only one run had been made prior to May, 1909, the results of which were not available.

The deposits worked by this company are located near the southwestern end of the Plomosa Mountains in the western slope and are, in an air line, 24 miles a little south of west of Vicksburg. By wagon road, however, the distance is increased considerably, the property usually being approached from Quartzsite.

There has been installed on the property the following machinery: Three 100-horsepower boilers, one 300-horsepower Corliss engine, two Williams mills, two Huntington mills, and various accessories. The pipe line which furnishes the water used on the property is approximately

[a] For location of mining districts see figure 4 (p. 45), compiled from official records by county clerk, Yuma County, Ariz.

7 miles long and is about 5 inches in diameter, the difference in elevation between the two terminals of the line being approximately 400 feet.

The ground has been prospected by a great many small tunnels with frequent openings to the surface, and an occasional larger adit tunnel run along the bed rock. The vicinity had previously been prospected by "dry washers," and consequently the underground work resembles a network of small burrowings, some of which a man can scarcely drag himself through. An accurate idea of the explored territory could not be obtained, as many of the workings were inaccessible.

GEOLOGY.

The bedrock in the vicinity of the deposits is a grayish-green partially schistose rock composed essentially of quartz and andesine feldspar, with some epidote and noticeable amounts of chlorite; the texture is fine grained and weathered surfaces show an imperfect schistose structure. Overlying this bedrock in places is a dark-colored greenish rock which is locally decidedly schistose; it is composed of quartz, andesine, or labradorite feldspar, and hypersthene, with a large amount of white mica and chlorite, and is presumably of igneous origin. This rock is exposed on the surface of the foothills east of the workings, where the lamination planes dip west and northwest at a comparatively flat angle. Quartz veins of small magnitude occur in both of these formations. A ridge of medium to coarse-grained quartz-biotite schist was observed a short distance northeast of the property, and a mile away in the same direction a coarse-grained gneissic rock was seen. This last type also contains quartz lenses and is cut by aplite dikes, which were not observed in the immediate vicinity of the New York-Plomosa.

ORE DEPOSITS.

In certain old drainage channels which led away from the southwestern part of the Plomosa Mountains is found an auriferous conglomerate of granite, schist, and quartz fragments cemented by lime carbonate. In thickness this conglomerate or "cement rock" varies from a few inches to a great many feet, the depth depending largely on the shape and size of the formerly existing channels. It is certain that placer gold occurs in this cement rock, but no data of the average tenor or the probable cost of working could be obtained. It was evidently the intention of the company to work the cemented material in mills. The quartz veins in the mountains close at hand are thought to be a reasonable source of origin for the gold found in the placers.

GUADALUPE (MORENO).

The Guadalupe prospect is located at an elevation of 1,800 feet on the western side of the southern part of the Plomosa Mountains, and is just west of the divide over which is built the stage road between Quartzsite and Vicksburg, which places are respectively 11 and 21 miles by wagon road from the Guadalupe. As the property was not worked at the time of the writer's visit only a superficial examination was possible, the underground developments being inaccessible. Apparently the deposit has been prospected by a short vertical shaft in addition to several surface cuts. Abandoned buildings and a shaft house constitute the surface improvements. Small shipments are reported[a] to have been made to San Francisco and to the smelter at Needles, Cal.

Geology.—As one approaches the Guadalupe from Quartzsite all of the rocks forming the cliffs are of volcanic origin up to within a short distance of the property. On the west these are mainly hornblende andesites and are probably of Tertiary age. In the immediate vicinity of the prospect south of the road are found more ancient rocks, probably of pre-Cambrian age. The basal member appears to be a coarse-grained silicified sandstone or arkose, and although it is impossible to state positively whether the rock is of sedimentary or igneous origin, evidence seems to favor the view that it is a recrystallized quartzose sediment, and it is in this formation that the Guadalupe vein outcrops. Lying on top of this is found a slightly schistose basic rock which appears to be of dioritic origin and which apparently represents an old flow upon the surface of the underlying quartzose rock.

Over these a few hundred feet north lies a limestone conglomerate of variable thickness, above which come about 300 feet of bluish, reddish, and yellowish limestone of unknown age. These dip about 10° SE. and strike N. 60° E., and form a prominent peak which is capped by olivine basalt.

On the south the andesites probably cover the older rocks and these are no doubt also capped by basalt.

Ore deposit.—As shown by the surface cuts the deposit is in the form of a true fissure vein cutting the quartzitic rock. The trend of the ledge is S. 25° E. and it stands almost perpendicularly. The width varies from a few inches to several feet, the ledge seeming to be quite persistent along its outcrop. Numerous stringers of the main vein were noted which did not show marked continuity or definition, and these dipped at all angles. The filling of the vein consists almost wholly of pure white quartz in which occur many veinlets of siderite, said[a] to be auriferous, which mineral is also

[a] Personal communication from Mr. W. J. Stoneham.

prominent in the fractures and joints of the quartzose rock. Galena, reported[a] to be argentiferous and very slightly auriferous, was found in places in the vein, inclosing quartz, and from the ore dump good-sized specimens of this lead sulphide were examined. The carbonate and sulphate of lead were seen on some of the specimens, and a small amount of malachite was observed. Some hematite is present in the ore. The writer regrets his inability to give details of the continuation of the vein in depth.

LEAD CAMP.

This property is about 9 miles almost due south of Bouse, and is in the northern part of the Plomosa Range, 1 mile northeast of Ibex Mountain, at an elevation of 1,400 feet, being somewhat higher than the town of Bouse, with which place it is connected by a fair wagon road. The property has not been productive recently, the last shipment having been made several years ago. This is reported to have been of 3,700 pounds, which carried $10 in gold to the ton and 45 per cent lead, mainly in the form of the carbonate. The developments on the property are only of a prospecting nature, and consist mainly of superficial exploration with open cuts and a shallow shaft.

The rock in which the vein occurs resembles a silicified rhyolite which has the appearance of antedating the Tertiary lavas found in other parts of the area, and is composed of the main constituents—silica and feldspar. This rock is reddish or pinkish in color and felsitic in texture, the altered feldspars being the only distinct phenocrysts visible, and it is possibly a recrystallized sediment. Intruded into the siliceous formation are diabase dikes of uncertain relation to the ore body, it being impossible to determine whether they cut the vein or not. West of the camp limestone caps the older basal gneiss formations and is probably older than the rock which resembles a rhyolite. The limestone apparently is continuous with that seen in the vicinity of the Iron Mine, and perhaps is persistent throughout the lower part of the Plomosa Mountains. The limestone noted on the north of the road between the Guadalupe and Vicksburg might well be a part of the same formation. Just west of camp the limestone seems to be intimately associated with a white, fine-grained quartz-feldspar rock, and the general appearance of the two points to the conclusion that the limestone has been intruded by this rock. Microscopic study of thin sections shows that the rock in all probability is of clastic origin and has resulted from the erosion of a granite, contemporaneous deposition of this material and of limestone having probably taken place. A short distance southwest of the old workings the vein cuts across the limestone, and elsewhere is in the silicified type of rock.

[a] Personal communication from Mr. W. J. Stoneham.

The deposit seems to be a true fissure vein and, as exposed on the surface near the lower opening, strikes N. 80° E., and stands almost vertically. It is about 12 inches wide and is filled with a gangue of quartz, which is slightly mineralized by chrysocolla, malachite, and iron oxides. A short distance away in the upper workings and in a shallow shaft a vein apparently strikes S. 15° E. and dips a little northeast, standing almost perpendicularly. Farther southwest galena is found along the outcrop of the vein.

MUDERSBACH COPPER CAMP.

The deposits of the Mudersbach copper camp differ from all previously described in this paper in that they represent true contact metamorphic deposits formed at the contact of an intrusive cooling magma. The other deposits examined in this area which show strong evidence of contact metamorphism are the Cobralla, the Yuma Copper Company (I. & A.), and the Calcite.

The Mudersbach copper prospect is located 2 miles northwest of the Lead Camp at an elevation of 1,400 feet, and is just 8 miles in an air line a little west of south of Bouse. The road between the railroad station and the copper prospect is only moderately good, being sandy in places with some steep grades in the vicinity of the camp. The development work done on the prospect is small, consisting of a few surface cuts with two shallow shafts. One carload of ore has been shipped, which the owner reports averaged 10.4 per cent copper and $1 in gold per ton.

GEOLOGY AND ORE DEPOSIT.

The northern part of the Plomosa Mountains slopes gradually down to the level of the desert, and the rocks which form this portion of the range appear to be for the most part granites and schists with some limestones, all of probable pre-Cambrian age. These formations have been cut by later intrusives at different periods, one type of which is especially interesting in connection with the Mudersbach copper property. The oldest rocks were observed a short distance north of the property and consist of schists and partially schistose granite, the latter being similar in general appearance to the granite found in the Little Butte vicinity. These older rocks are cut by dikes of aplite and diabase, which intrusives are seldom absent in the pre-Cambrian granite gneiss schist complex of this area. On top of this series is found a thin band of fine-grained white quartzite and then about 100 feet of variously colored crystalline limestones, brown predominating, but yellow and blue noticeable. These limestones are metamorphosed to some extent, and show local silicification and some fracturing with calcite filling the fissures. One stratum of gypsum was noted which was several feet wide

and several hundred feet long. This gypsum has probably resulted from the alteration of limestone in place, the alteration being carried on by the sulphuric acid liberated in the oxidation of pyrite, which is found in all stages of decomposition in the deposit. The limestones dip south in general, although with no regularity, other directions being prominent. A light-colored, medium-grained quartz monzonite porphyry has intruded the series, and judging from the exposures has stopped near the base of the sediments. Phenocrysts of biotite are prominent, and in thin sections micropegmatitic structure is plainly visible in the quartz and feldspar crystals. In general the limestones do not show much alteration, but at their base near the contact with the quartzite and the intruded magma a narrow band of garnet, associated with specularite, calcite, and other contact metamorphic minerals, has been formed.

Here also occurs the ore deposit, apparently replacing to a limited extent the limestone and a thin conglomerate at its base. The replacement has been in an irregular, pockety manner, as is shown in the outcrop and in the surface cuts, and the amount of replacement varies from a few inches to several feet. The ore is principally hematite with some copper in the form of carbonates. A specimen taken from the dump, however, shows primary pyrite, chalcopyrite, and specularite in a gangue of quartz and calcite with a secondary chlorite mineral. A coating of bornite is present on some of the sulphide crystals, and secondary iron oxides are also conspicuous.

IRON MINE.

This property is located 6 miles in a direct line southwest of Bouse at an elevation of 1,150 feet and is in the extreme northern part of the main mass of the Plomosa Mountains. Small surface cuts constitute the development work done on the property, which has not been operated for some time. No production from this place is reported.

The rocks in the vicinity are limestones, presumably pre-Cambrian, which have been rather severely cut up by eruptions of probable Tertiary acidic lavas. The limestones rest on normal biotite granite and where observed vary in dip from 50° S. 40° W. to almost vertical. Tuffs containing jasper and a rather thick conglomerate form noticeable geologic features a short distance north of the property.

The limestones are partly replaced locally by hematite in an irregular fashion, these beds still retaining their sedimentary characteristics, and the replaced strata in places being separated by beds of barren limestone. The hematite is very impure, containing much calcareous and siliceous material. The width of continuous replacement of the limestone by hematite ranges up to several feet. Siderite is present in notable quantities.

LITTLE BUTTE AND VICINITY.

LOCATION AND DEVELOPMENT.

This locality takes its name from a topographic feature in the vicinity, a small butte one-fourth mile from the shaft, which forms the extreme northern part of the Plomosa Mountains. The Little Butte prospect is situated 4 miles northwest of Bouse and approximately 1 mile south of the railroad, where the lowest foothills of the range merge into the gravel plain sloping down to Parker. The property has been prospected by different owners and several shipments have been made. At the time of the writer's visit, although a good camp had been established, developments were just being started, the incline shaft was only down a short distance,[a] and only a small amount of machinery had been installed on the property.

GEOLOGY.

The area just west of Little Butte, including the small hill known by the same name, is composed mainly of a medium-grained crumbling granite which shows slight schistosity and whose principal mineral constituents are biotite, orthoclase feldspar, and quartz. The rock is not very fresh; the feldspars show kaolinization, and the whole is stained a reddish-pink by iron oxides. Small irregular masses and veins of quartz and pegmatite are found in this granite, which is also intruded by dikes of diabase which take all kinds of forms and shapes. The diabase is schistose in places and is evidently a later instrusion than the pegmatites, these being cut by it.

At the Little Butte property an area of sedimentary, probably pre-Cambrian, rocks begins. These take the form of a broad crescent striking east-west and dipping about 20° S. The basal member of the series is a rough brown limestone, which is similar in many respects to that noted in various other parts of the area. Here, however, the rock is more shaly, and a large part of it consists of dark-gray and dark-green lime shale. This type of rock is continuous for about 1,000 feet southwest of the shaft, where the limestone borders against granite and is evidently on top of it. Near the Little Butte shaft the outcrops of the limestone show partial and complete replacement by specularite carrying in places some copper oxide ores. Granite prevails for three-fourths mile farther southwest where there is a prominent ridge of very cherty brown to yellowish-brown limestone. Here the sediments strike N. 54° W. and dip 30° SW., and these continue to the northwest, forming a low ridge in which are located the Blue Slate prospect and others. This belt of brown limestone is probably not over 1,500 feet wide and is overlain on the south by rough hills of a partly brecciated flow rock which possibly represents an old rhyolite and occupies a strip of country at least 1 mile wide.

[a] The incline shaft is now (March, 1910) reported to be down 385 feet.

ORE DEPOSITS.

There are at least two kinds of deposits in this vicinity—those in the sedimentary area and those in granite. The latter type is represented by a considerable number of steep northeast trending quartz veins which are often irregular and frequently faulted, and some of which are reported to carry gold values in appreciable quantities. A shipment is said to have been made from the Sunshine lode which brought very good returns. These quartz veins probably represent an epoch of vein formation earlier than the sedimentary series.

The Little Butte and the Blue Slate are representatives of later deposits in the sedimentary series, and these typify two distinct classes of mineralization. The Blue Slate is a fissure striking N. 60° W. and standing nearly vertically in dark-green flat-lying shales. The gangue is crushed shale; specularite and oxidized copper ores are present; and thin films of gold occur in places as a coating to the lime shale. This occurrence of gold is similar to that noted in the Moro prospect of the Clara Consolidated Company.

The Little Butte deposit represents a partial replacement of limestone by hematite, with which is associated a little oxidized copper ore and a secondary concentration of these oxides along the contact of the granite and overlying limestone. As viewed in the underground workings exposed in March, 1909 (all above the 200-foot level), the ore occurred in irregular lenticular bunches just below the contact with the overlying rock. These shoots were not very persistent and showed more in the nature of pockets than otherwise. The general strike of the contact of the two formations as exposed underground is S. 18° E., and the dip varies from 30° to 40° E. R. P. Sharpe, the superintendent of the Little Butte Consolidated Mines Company, reports [a] that the inclined shaft is down to a depth of 385 feet and that the amount of water coming in has been so great that developments below the 300-foot level have been suspended pending the arrival of heavier pumping machinery. He says that from the point where water was first encountered at 210 feet depth, the granite foot wall became highly leached and correspondingly soft, and that rich bunches of oxidized copper ores were encountered at a depth of 350 feet on the incline in the granite some 25 or 30 feet away from the contact. These ores are said to carry good values in gold, as also are those developed on the 200-foot and 300-foot levels, where copper ores are practically absent. From the 200-foot level to the surface 22 cars of ore were stoped and shipped. These, Mr. Sharpe reports, averaged 7.6 per cent copper, 28.9 per cent iron, 32.4 per cent insoluble, with 2.4 ounces of silver and $6.65 in gold to the ton. Sulphides had not been found in the workings up to the date of Mr. Sharpe's letter, March 6, 1910. Gold is reported to occur also in

[a] Personal communication by letter under date March 6, 1910.

the hanging wall and is said to be found at distances of 20 to 30 feet away from the contact.

Specularite and quartz with a little chlorite were the principal gangue minerals noted. The ores show an intimate association of specularite, chrysocolla, and malachite, the last occurring in radial bunches scattered throughout the chrysocolla, with quartz crystals lining some of the open spaces in the ore. Thin sections of the ores show a breccia of chrysocolla and malachite, cemented by specularite. One thin section of a piece of rock taken from an outcrop of limestone about 800 feet south of the Little Butte shaft shows in banded structure the apparent contemporaneous deposition of primary specularite, quartz, and calcite or dolomite. A stratum of rock in this same locality shows beside the replacement of the limestone by hematite, small fissures in the rock filled by hematite, the mineralization appearing to have taken place at one period. The carbonate rock presents a highly chloritized appearance, but it is thought that the color is due principally to staining by iron oxides.

DEPOSITS AT THE SOUTHWEST END OF HARCUVAR RANGE.

GENERAL DESCRIPTION.

The southwestern extension of the Harcuvar Range contains some interesting free-gold prospects and a few copper prospects. Among the former type may be mentioned the Yellow Bird and the Arizona Northern, the last being locally famous in 1909 as the "Salome Strike." The I. & A., or Yuma Copper Company, and the Calcite are both being prospected for possible copper deposits. There were also a number of prospects which the writer desired to visit, but which had to be neglected because of limited time. Among these should be mentioned the Ultimatum of the Tank Pass Consolidated Mining Company.

All of these deposits are located in the Ellsworth mining district,[a] which district is sometimes known as the Harcuvar, and they are, with the exception of the Arizona Northern, situated near the base of the mountain range, being easily accessible by wagon roads. Vicksburg is the most convenient railroad point for all except the Calcite and the Cobralla, Salome being the natural station for these properties.

YUMA COPPER PROPERTY (FORMERLY I. & A.).

LOCATION AND DEVELOPMENT.

The property of the Yuma Copper Company is 7 miles due north of Vicksburg and has been prospected by shallow surface cuts and short shafts, the deepest of which was inaccessible when the property

[a] See figure 4 (p. 45) for map of mining districts prepared from official records by the clerk of Yuma County.

was visited.[a] At that time a new inclined shaft was being sunk a short distance northeast of the so-called iron dike which is a prominent feature in the vicinity of the camp. Water is obtained from a well on the property.

GEOLOGY.

In the immediate vicinity of the various prospects there is a marked similarity in the general geologic section, although there is a distinct difference in the type of rock found at each of the three workings visited. Just east of the camp a steep mountain rises to an altitude of 3,200 feet, which is 1,400 feet above the camp of the Yuma Copper Company. The geologic section exposed here is composed almost entirely of rocks belonging in the general series of pre-Cambrian metamorphosed sediments which are found throughout the southwestern part of the Harcuvar Range and elsewhere in the vicinity. These are medium to fine-grained quartz-mica schists and arenaceous shales, intruded in an irregular manner by acidic and basic dikes which usually follow but occasionally cut directly across the planes of schistosity. Some of these are vogesite dikes presumably connected with the intrusion of the granite which forms Salome Peak only 1½ miles northeast of this mountain, and the rest are comparable to those already described as present in the sedimentary schist series. A thin band of rock, composed entirely of epidote, augite, hornblende, and albite, their relative abundance being in the order named, was observed near the base of the steep rise. This rock probably represents the result of contact metamorphism, which has accompanied the intrusion of the granite, the main mass of which is only a short distance northeast and branches of which are present in almost every part of the southwestern end of the Harcuvar Range. Small stringers of quartz occur throughout the section, and in many instances occupy joint planes in the rocks.

The partial replacement of a ledge of yellow crystalline limestone by magnetite in the vicinity of the camp is the most conspicuous part of the section exposed on the property. This replacement, though not entirely regular, is several feet thick and of considerable length. Thin layers of actinolite are present in the magnetite and quartz is also fairly conspicuous, all three constituents, as shown in a thin section, appearing to have crystallized contemporaneously. Calcite is also a prominent component of the ledge. The replacement of the limestone by magnetite may be one of the results of the metamorphic action produced by the intrusion of the granite in this general vicinity.

The new inclined shaft which was being sunk a short distance northeast of this magnetite ledge had for walls a very highly chloritized and

[a] In a report issued by the company, March 16, 1910, the total development up to January 1, 1910, is claimed to be 1,022 feet, of which 543 feet is in shaft sinking and the rest in drifts, crosscuts, and surface trenching.

epidotized, fine-grained schist, which showed some copper and manganese oxide stains in the joints and lamination planes and was underlain by a very impure limestone in which occur many pseudomorphs of hematite after pyrite and numerous vugs lined with calcite.

The dump of the vertical shaft showed two distinct types of rock—one a very much metamorphosed, fine-grained quartz-mica schist highly chloritized and carrying noticeable quantities of pyrite, and the other pure white gypsum. The schist was fractured and the crevices filled with calcium sulphate, the latter occurring in such quantities on the dump as to indicate large deposits of this material below. As the shaft workings were inaccessible, nothing can be said about them.

The dump showed no promising looking ore, and the rocks thereon have been described.

YELLOW BIRD AND VICINITY.

GENERAL DESCRIPTION.

This is one of the interesting free-gold localities in the area which has been intermittently prospected for a number of years. It is situated just 5 miles north of Vicksburg. There are no extensive developments in the vicinity, and it is now interesting mainly to the geologist and mineralogist.

GEOLOGY.

The prevailing rocks are fine-grained slates and quartz-mica schists, with thin layers of intercalated limestone. In general the schists south of the Yellow Bird camp dip 10° to 40° SE., although locally they are severely contorted and folded and in places show evidence of faulting. The slates are grayish blue in color, are very fine grained, and appear to be metamorphosed calcareous shales traversed by minute stringers of calcite. The schists are in general similar to those already described in other localities where quartz-mica schists are prominent. Here they are fine grained, have a dull satiny luster, and are composed essentially of quartz and white mica. Chlorite and iron oxide have so stained the rocks that various colors have resulted. Diabase intrusives are common in the vicinity, and these are evidently of later age than the schists. Amphibolite layers between the schists may represent the remnants of former flows or intrusions of a basic magma. The rocks are similar in a general way to those in the vicinity of the Arizona Northern.

ORE DEPOSITS.

A fair exposure of the quartz veinlets is afforded by an opening on the south side of a ridge just south of the camp. Here is exposed a series of several parallel veins separated by schist. This series is about 25 feet in width, the largest single quartz vein being 4 feet wide,

and it can be traced in a vertical distance 50 feet down the north side of the ridge where it disappears from view. These veins strike about S. 20° E. and stand quite straight, being slightly faulted, however, both horizontally and vertically. The quartz is pure white in places and bluish black elsewhere, containing invariably a considerable amount of siderite, a little specularite and pyrite, with calcite filling vugs and cross fissures in the veins. The quartz and siderite appear to have crystallized contemporaneously.

On the north side and below the top of the ridge, which is just south of the camp, occurs a true fissure vein about 10 inches wide. This strikes north-south and, although nearly vertical, dips a trifle east. The vein filling is composed almost entirely of quartz with a little iron oxide scattered throughout, and the vein is tightly frozen to its walls. Just below this opening, about 15 feet, as exposed in another open cut, the fissure is found to thin down to 1 inch.

In general the veins occupy the lamination planes in the rocks and occur in much the same manner as those in the vicinity of the Arizona Northern.

In the second wash south of the Yellow Bird camp and a short distance west of the Arizona Northern prospect are some diggings locally known as Dutch Henry's, which are reported to have produced several thousand dollars worth of gold. Here quartz veins occur in a schist series similar in many respects to that present in the vicinity of the Yellow Bird camp. One prominent vein dips due west, cutting the schists which dip southeast. In general, however, the ledges occupy the lamination planes of the schists and occur in several instances along the contact of diabase and slates.

Origin of the deposits.—It is possible that waters accompanying the intrusion of the granite which forms Salome Peak are responsible for the numerous quartz lenses found throughout this part of the Harcuvar Range. Although no free gold was seen at either locality just described, there has been, no doubt, a considerable amount extracted from the veins as well as from placer deposits below them, and it is highly probable that there are other places in the vicinity which will warrant prospecting.[a]

ARIZONA NORTHERN (SALOME STRIKE) VICINITY.

DEVELOPMENT AND LOCATION.

The finding of free gold in considerable quantities in small gash veins in this vicinity caused a small boom in the spring of 1909. Many people visited the prospect, and some staked out claims in the vicinity, although little actual assessment work had been done before the writer left the field. The developments on the strike itself are of

a See discussion on future prospects in Arizona Northern vicinity, p. 101.

the most meager nature, consisting only of a small surface cut in the mountain side. Because of the possibility of finding other gash veins in the vicinity a brief description will be given of the general conditions and geological relationships existing in this locality.

The Arizona Northern is in an air line just 5 miles a little east of north of Vicksburg, which station is not only the nearest but by far the most convenient to the property. Near the old Desert prospect, under the management of Josiah Winchester, a town of tents sprang up, bearing, while the boom lasted, the name of the promoter. This is just a trifle over 2 miles northeast of Vicksburg and was utilized as a stopping place by many of the people who visited the new strike. From the Desert property there are two ways of approaching the Arizona Northern vicinity. One is northeast up the canyon by a rough wagon road, which leads to within a mile or less of the strike, a trail having been built from this point to the prospect. The other way is by a good wagon road to the Yellow Bird prospect and then by trail from this place to the Arizona Northern. The nearest known water supply is at the Desert property.

TOPOGRAPHY.

Reference to figure 14 will show the type of country in the vicinity of the Arizona Northern, and Plate IV shows two views taken from the top of the mountain above the prospect. Rather prominent ridges are separated by deeply dissected valleys, which merge abruptly into the desert and there become obliterated. The sketch map was drawn from a point a short distance east of the prospect shown thereon, and the ridges north of this place were not examined. The difference in elevation between the top of the ridges and the valleys is approximately 800 feet, and the exposures of rock here, as elsewhere in the area, are very distinct. The opposite direction of dip of the schists on either side of the wash in the vicinity of the prospect suggests that the direction of the gulch may have been determined by faulting.

GEOLOGY.

The portion of the Harcuvar Range exposed to view in going from the Desert prospect to the Arizona Northern by way of Desert Canyon is essentially a sedimentary series of dark clay slates alternating with calcareous beds and arenaceous strata and including numerous amphibolitic beds of varying thickness. This series is intruded by later dikes, of which the principal types are aplite and minette.

The clay slates and allied rocks, some of which have been metamorphosed into fine-grained quartz-mica schists, are not greatly altered and where observed showed no evidence of contact metamorphism. The schistosity is well defined in the slates, and those of the pure clay variety are in part almost fissile enough for roofing materials. The more massive calcareous beds seem to have been less

susceptible to the development of lamination planes than the slates, and in several places phenomena were seen indicating that the schistosity was not entirely coincident with the stratification. This was evidenced by the oblique angle between bedding planes in the massive strata and the schistose laminæ in the slates. The predominant colors are black, gray, and green, and the rocks, except the quartz-mica schists, are extremely fine grained.

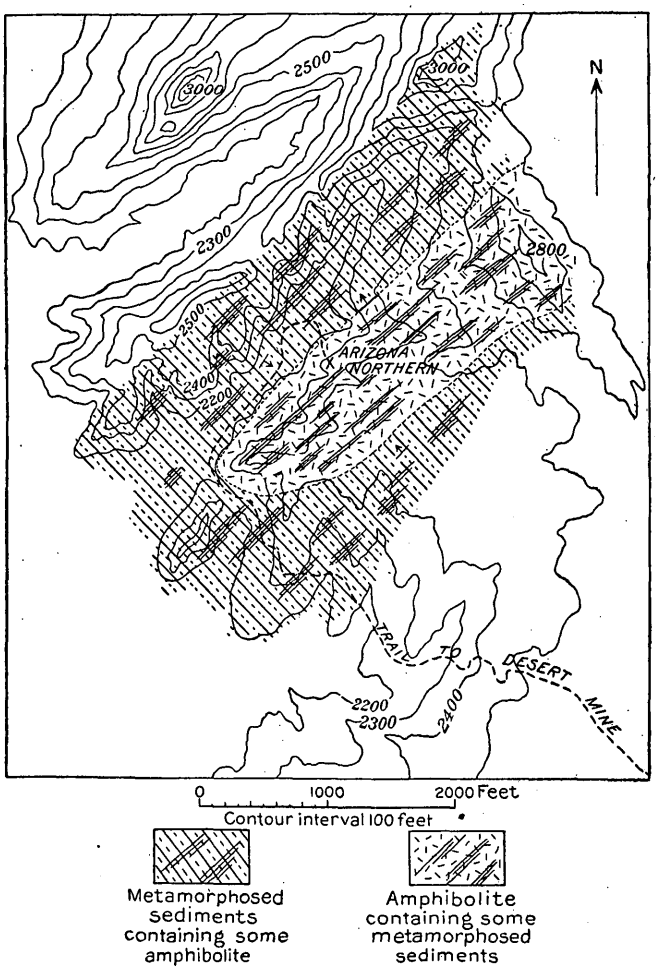
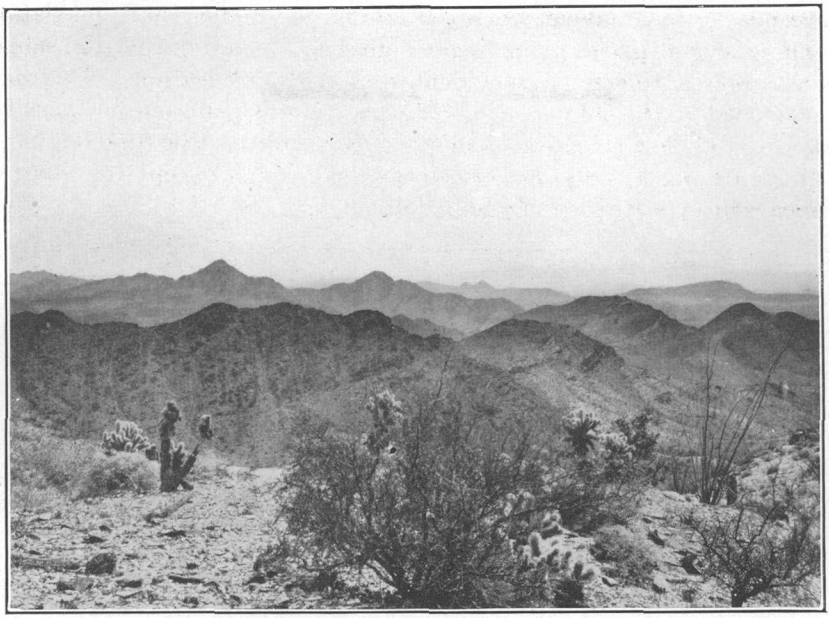
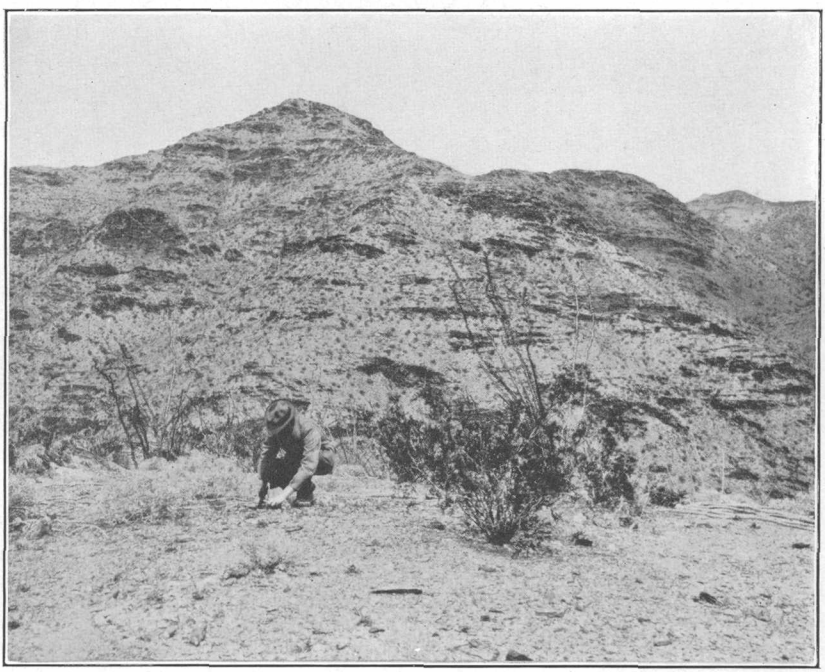


FIGURE 14.—Topographic and geologic sketch map of the vicinity of the Arizona Northern prospect.

Many of the amphibolite layers are only a foot or two in thickness, while some are massive, resembling fine-grained diabase, and these are schistose at the contact with slates. In general the amphibolite is greenish in color, is schistose, conforms to the strike and dip of the sedimentary series, and represents, perhaps, a succession of flows or intrusives into the complex before its schistosity had been developed. Reference to figure 14 will show the Arizona Northern as



A. RIDGES IN VICINITY OF ARIZONA NORTHERN PROPERTY.



B. PEAK JUST EAST OF ARIZONA NORTHERN PROPERTY.

located in amphibolite of the massive type near its contact with slates, which are more or less continuous throughout the area mapped as amphibolite. Doubtless other localities in the vicinity contain massive amphibolite and probably have associated with it numerous veins similar to those found here. As only a very small part of the area was studied in detail, it is impossible to give information on this point, and the sketch map of this vicinity is complete only in so far as it deals with the immediate surroundings of the Arizona Northern prospect.

ORE-BEARING VEINS.

Included in this complex and in many places following the planes of schistosity are a great many quartz veins, generally irregular and often contorted. (See fig. 3, p. 39.) As a rule they are small and not continuous, although in places where it probably is nearly barren of gold values the quartz occurs in large masses. The small veins nearly always contain some siderite or allied carbonate, and occasionally chalcopyrite and galena are present. It was from small gash veins of this type that the Arizona Northern pocket was taken. Here free gold occurred in considerable quantities and in some of the best specimens seen by the writer constituted one-half of the ore. In general the free gold is rather sparingly distributed in the veins, and in several places where the writer knocked off pieces of ledge matter some distance away from the "Glory Hole" the free gold was only discovered after dissolving the iron oxide and carbonate present, which formed an effective covering for the gold. Specimens from an apparently barren ledge, which had not been prospected at all up to the time of the writer's last visit to the camp, showed some beautiful free gold after treatment with acid. This ledge is located about 50 feet in a vertical distance above the "Glory Hole," and apparently it cuts across the schistosity of the rocks. The gangue is composed principally of siderite and limonite, with a subordinate amount of quartz. The rock in which the ledge occurs is very calcareous, resembling a dolomite. This is apparently intercalated with amphibolite, as is the rest of the sedimentary series.

Origin of ores.—The gold in these veins may have been derived in part by the oxidation of pyrite, but most of it is probably primary. The veins are believed to have been formed after the probably Mesozoic intrusion of the large granite mass of Salome Peak, the nearest granite noted being about 1 mile distant.

Future prospects.—While the irregular character of the veins militates against deep mining, their frequent occurrence is conducive to mining to shallow depths and over large areas. Some of the gash veins might be profitably worked in a small stamp mill, provided the initial outlay of money were small. After the ground is proved, if it warrants the expenditure of large sums of money for machinery, then the vicinity could be worked on a larger scale.

DESERT PROSPECT.

The Desert prospect, operated by Josiah Winchester, is located 350 feet above and about 2 miles northeast of Vicksburg and has been well known for a number of years as situated near an old well, which has been the source of water supply for many of the properties in this locality. The gulches here, as elsewhere in the vicinity, have been prospected to some extent by dry washing, and it is no doubt due to the fact that some fairly good placers had been worked in these gulches that the adit tunnel on the property was driven, presumably in the hope of cutting gold-bearing ledges in place. Thus far this has not been accomplished.

The camp became known as "Winchester" shortly after the discovery of the Arizona Northern. A small, partly dismantled stamp mill is located near the mouth of the adit tunnel.

Arenaceous shales and argillites are the principal rocks in the vicinity. These contain intercalated amphibolite to a less degree than those in the vicinity of the Arizona Northern, and the series here is more calcareous, being traversed in places by veinlets of calcite. A very persistent dike of aplite cuts through the rocks just above the workings on the east and can be seen for several thousand feet to the north. It is probably connected in origin with the granite intrusion to the east. A number of basic dikes are seen in the vicinity.

Small stringers of quartz occupy openings in the sedimentary series, and in general follow the planes of schistosity. These show some mineralization, chiefly by limonite, although some chrysocolla and malachite, with a very small amount of cuprite are present, and a little chalcocite was noted. The placers which have been worked in this vicinity probably originated from the concentration of gold derived from these small quartz lenses. A short distance above the adit opening below the top of the small hill just back of the camp there is a large lens of quartz stained by malachite and limonite.

CALCITE PROSPECT.

In an air line the Calcite prospect is just 5 miles due west of Salome, the distance by wagon road being a little greater. The workings are located in a wash known as Desert Canyon and are a short distance west of the base of the range in the lower hills which form this part of the Harcuvar Range. At the time of the writer's visit (May, 1909) the vertical shaft had been sunk 150 feet and a level 40 feet long had been driven.

The geology is exceedingly interesting because of the late granitic intrusives, which have cut up through the metamorphosed sedimentary complex and still further changed its character. The granite which has so promiscuously invaded the southwestern part of the

Harcuvar Range is here present in various places, and has worked a decided change in the calcareous strata which are intercalated with the quartz-mica schists and the quartzites. Basic intrusives are also present, but these do not appear to have caused much alteration in the series. The calcareous rocks in places have been entirely silicified, and subsequently formed fissures have been filled by gypsum; and one stratum of this rock, 40 feet wide, highly impregnated with iron pyrite, is being explored for copper deposits by the Calcite Company. The pyrite is tarnished and stained in places so that it resembles bornite and chalcopyrite.

The lack of contact metamorphic minerals is indicative of a shallow depth or slight overlying weight at the time of the intrusion of the granite magma.

COBRALLA VICINITY.

The Cobralla is one of several properties located in the Tank Pass vicinity, and the writer regrets to state that it was the only one he had time to visit. With the exception of some drilling, which was being carried on at the Ultimatum, all of the prospects in the locality were idle. At the present writing (May, 1910) the principal development in the area seems to be in the vicinity of the Ultimatum, the work being carried on by the Tank Pass Consolidated Mines Company, which has taken over[a] the Cobralla and various other properties in the vicinity.

It is about 10 miles in a northwest direction from Salome to the Cobralla, the distance by wagon road being longer. Tank Pass, traversed in going to and from this property, is some 550 feet above the prospect and about 1,000 feet above Salome, and necessitates a steep haul in either direction. No large shipments have been made from this locality so far as the writer is aware.

The Cobralla is located in the end of a long, narrow ridge, which projects northward from the main mass of Salome Peak, and in traversing which granitic rocks are seen intruding a sedimentary series comparable in many respects to that seen in the vicinity of the Calcite. Here the intrusion appears to have taken place at a greater depth or under more pressure, contact metamorphic minerals having been developed on a large scale and limestone strata in places completely changed to wollastonite. Minette dikes were noted in the area where granite, later than the main mass which forms Salome Peak, has been intruded, and pegmatite and aplite dikes were seen which cut all formations. Along the contacts of granite with granite large hornblende and albite crystals have been developed. These are associated with some epidote and a little calcite.

[a] Los Angeles Mining Review for November 24, 1909, Arizona correspondence; and various recent articles in the Arizona Mining Journal.

Medium-grained quartz-mica schists appear to underlie intercalated quartzite, limestone, and amphibolite strata which have been variously silicified. The directions of strike and dip are not constant over large areas, these changing from a strike of N. 70° W. and a dip of 30° SW., some 2,000 feet south of the Cobralla, to an east-west strike and a 30° N. dip about 1,000 feet south of the prospect, and to a 15° to 20° NE. dip and a northwest-southeast strike at one of the openings just northwest of the Cobralla house. In the immediate vicinity of the prospect holes the directions of dip and strike vary continuously and local folding and faulting are pronounced.

The Cobralla property has been prospected by a shallow shaft and several small surface cuts. In the shaft a zone of intense movement is shown, and the resulting brecciated schist fragments form the main part of the fracture filling. Here the fissure cuts directly across the schistosity of the rocks, and various contact metamorphic minerals are exposed. Epidote is the most prominent, and actinolite has been developed on a large scale. Magnetite is present in the limestone, and pseudomorphs of hematite after pyrite are noted in places. Vesuvianite is present in very small amounts, and garnet was seen in some of the specimens. The small amounts present of malachite, and the copper sulphide, chalcocite, are presumably derivatives of chalcopyrite and bornite of contact metamorphic origin, and these minerals seem to occur in larger amounts in the limestone than in the schists. Secondary quartz and calcite are abundant, filling small fractures and occurring in vugs; and the black oxide of manganese was noted on some of the specimens. Wollastonite occurs, overlying the schists in the open cut northwest of the Cobralla house.

Metalliferous ores are not abundant along this contact metamorphic zone, but possibly future developments in this and contiguous localities may prove more successful in uncovering copper ores.

DEPOSITS AT THE SOUTHWEST END OF THE HARQUAHALA MOUNTAINS.

PROPERTIES EXAMINED.

This part of the range is locally well known in that it contains the famous Bonanza mine, known for a time as the Harqua Hala. This property and the Golden Eagle, the Hercules, the Socorro, the San Marcos, and others have been worked for the gold values occurring in the deposits, and some remarkably rich ore has been extracted from the various workings. There are numerous other deposits in the Harquahala Mountains, but the five mentioned above were reported to have received the most prospecting, and they were, therefore, the only ones examined. Wenden and Salome are the railroad stations most accessible to these deposits, which are all located in the central

part of the Ellsworth [a] or Harcuvar mining district. This part of the Harquahala Mountains is characterized by the presence of sedimentary strata, which constitute a large portion of the southwestern extension of the range.

BONANZA MINE (HARQUA HALA).

HISTORY, LOCATION, AND DEVELOPMENT.

History.—According to report the original prospect was located on November 14, 1888, by Messrs. Harry Wharton, Robert Stein, and Mike Sullivan. The property is said to have been sold in part to Messrs. Gray, Kirkland, and Corcoran, and in part to Mr. Hubbard, who bought out the other owners within a year. After taking a large sum from the mine, Mr. Hubbard is said to have sold it to an English company in 1893. According to report Mr. Hubbard bid in the property at auction in 1898, and later sold it to the Bonanza and Golden Eagle Mining Company. The property was then leased to the Harqua Hala Mining Company. Later the property reverted to the Bonanza and Golden Eagle Mining Company, which now controls it. Lessees are said to have produced considerable gold between the time Mr. Hubbard first worked the property and its sale to the English company. The total production of ore from the mine reaches $3,631,000.

Location.—The Bonanza mine is located at a place known as "Harqua Hala," in the extreme southwestern part of the Harquahala Mountains, near the base of Martin Peak, at an elevation of approximately 1,800 feet, and is, in an air line, 8 miles almost due south of Salome. A fair wagon road connects the mine with Salome, from which point supplies are shipped in.

General economic considerations.—Crude oil is used for fuel in the generation of power and costs $1.75 per barrel at Salome, the freight to the mine adding about 50 cents to this price. Timber costs $33 per thousand at the property. Mining costs naturally vary considerably. The Harqua Hala Company, when operating, reported a cost of $3 per ton for mining and milling. Water is obtained by a pipe line from Harrisburg.

Equipment.—The company owns two 20-horsepower hoists, one air compressor capable of running six drills, a 40-stamp mill,[b] (see Pl. V, *B*), an 80-horsepower engine, four 100-horsepower double boilers, two Blake crushers, and a 5,050-foot tramway, present capacity 10 tons per hour, connecting the Bonanza mill with the Golden Eagle mine (owned by the same company and located 1 mile north). Several dwellings and houses are located in the vicinity. The 30,000-

[a] For map of mining districts see figure 4 (p. 45), prepared from official records by the county clerk of Yuma County.

[b] For partial description of mill see this report, p. 17.

foot pipe line from Harrisburg supplies the camp with all the necessary water, and for milling purposes much of the water from the mine has been utilized in the past.

Development.—A shaft inclined at an angle of approximately 60° and attaining the vertical depth of 205 feet below the collar, together with about 7,000 feet of levels, drifts, crosscuts, and winzes, constitute the principal development of the Bonanza mine. Plate VI shows a plan of the property. The main stoped area is reached from levels 3, 4, and 5, and below this the remaining levels 6 and 7 consist of long crosscuts. A large "glory hole," shown in Plate V, *A*, is the result of the caving of one of the big stopes. Numerous other workings, which are mainly shallow shafts, have been started at different places on the property.

TOPOGRAPHY.

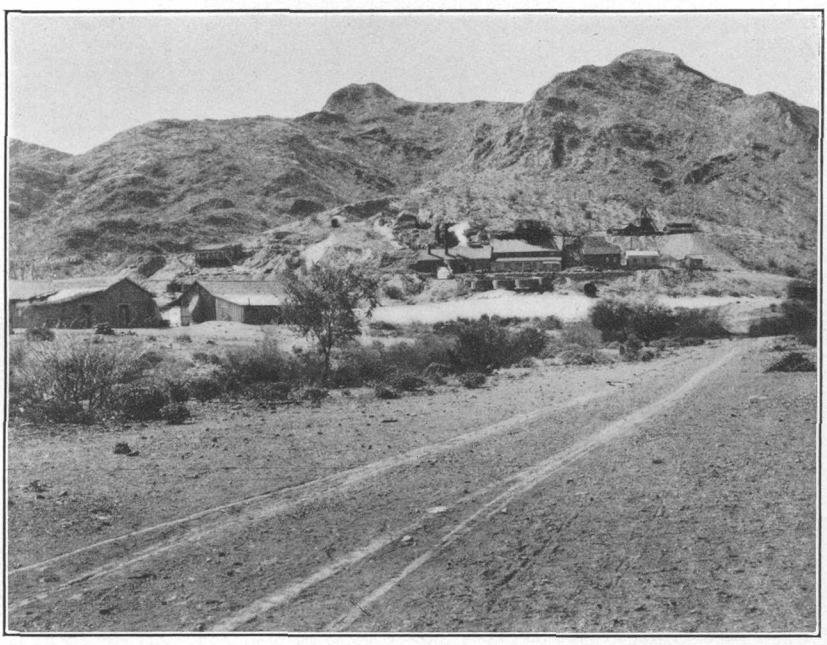
The Bonanza mine is located near the base of Martin Peak (shown in Pl. V, *B*) on its northeast side, and is a few feet above a wash, which drains south and east. The drainage is confined between two rather prominent ridges capped by peaks rising 600 feet or more above the wash, the ridges being separated from each other by about 2 miles. These peaks form the most prominent feature of the southwestern extension of the Harquahala Range and effectually conceal the workings of the Bonanza mine from any but a northern view.

GEOLOGY.

The basal rock in the vicinity, which is not exposed on the surface near the mine, is rather coarse grained and has the composition of a granite. It is highly impregnated with pyrite. Just north of the Golden Eagle, which is 1 mile a little east of north of the Bonanza, the contact between the sedimentary series and this granitic base rock may be seen. The contact apparently runs in a general northerly direction and probably could be found a short distance northwest of the Bonanza. The eroded surface of this granite rock appears to dip southeast.

The sedimentary rocks in which the deposit occurs have a few feet of reddish quartzitic grits for a base. Over this lie 100 feet or more of intercalated limestone and argillaceous shale, above which is a thin conglomerate, capped by several hundred feet of schists and gray limestone, including a small thickness of dark-gray dolomite and thin beds of conglomerate. The whole series has been tilted in various directions and the dip near the top of the section appears to vary from 20° to 60° a little west of north. Marked divergences from this general direction were seen, and strata which dip southeast were noted near the base of the series. The presence of dolomite in this section is worthy of remark, little having been seen elsewhere in the area. A partial analysis by Chase Palmer, of the United States

A. CAVED STOPE IN BONANZA MINE.



B. PART OF HARQUAHALA, ARIZ., INCLUDING BUILDINGS OF THE BONANZA MINE.

Geological Survey, of a specimen taken near the base of Martin Peak gave 29.94 per cent CaO, 20.59 per cent MgO, and a loss of 47.03 per cent on ignition. Many of the dark-brown limestones throughout the area, especially those in the vicinity of the Planet and Signal properties, resemble dolomites. Analysis, however, shows that they contain hardly any magnesia.

The whole series is intruded by dark-colored basic dikes, and veinlets of quartz and calcite are found throughout the section.

ORE DEPOSIT.

At the present time there is not a great deal to see of the Bonanza ore deposit. Below the fifth level (see Pl. VI for plan of workings), which is under water level (that being 170 feet below the collar of the shaft), most of the work has been of an exploratory nature, and above

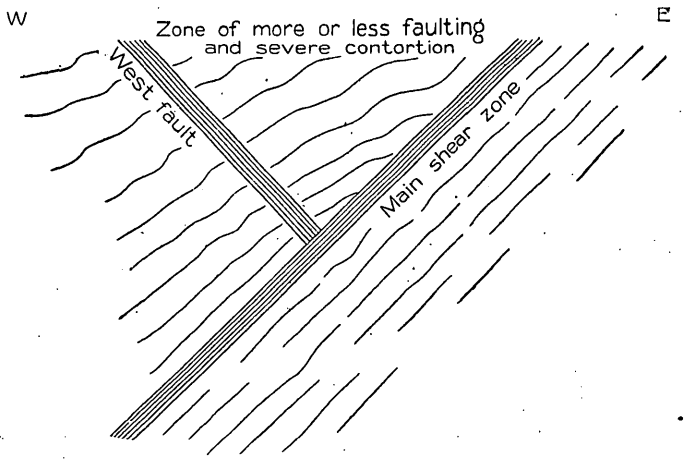


FIGURE 15.—Ideal section of part of the two principal veins exposed in the Castle Garden stope, Bonanza mine.

this the stopes, drifts, and other workings have all been in the oxidized zone. Consequently only the skeleton remains of the pay portions of the deposit, which has been largely worked out. As viewed underground the ore shoots seem to have occupied zones of shearing extending through the sedimentary series of intercalated limestone, shale, and quartzite into the basal granitic formation. This is exposed in places in the lower workings on levels No. 6 and No. 7 and is a very coarse grained granitic looking rock, which has been severely crushed and fractured, and pyrite has been deposited along the brecciated zones, which are now filled with sericite, the latter presumably resulting from the decomposition of formerly existing feldspars. Figure 15 shows the relation of the fault planes as exposed in the "Castle Garden stope." The two main ore shoots represent a continuous shear zone on the east, striking approximately north-south and dipping at an angle of about 45° W., into which runs a lesser

fault from the west, the strike being parallel to that of the others, while the dip is 45° E. The ore shoot on the west, however, has been more productive. These two main veins vary in width from a few inches up to many feet, and it is in the zone of movement that the gold values have been concentrated. Soft hematite of a deep-red color is omnipresent in the workings above water level, and this, with quartz, calcite, brecciated crushed country rock, and a little gypsum form the gangue minerals present in the croppings of the veins. Very rich pockets of gold are reported to have been found in various parts of the mine, and the writer was shown a good part of a large nugget, the original specimen having been reported to be worth $10,000. This particular piece showed large bunches of gold intimately associated with quartz. The quantity of silver found in the ore is remarkably small, and there is hardly any evidence of copper in the oxidized zone. Small quantities of galena have been found replacing dolomite in a shallow shaft located 500 feet southwest of the mine.

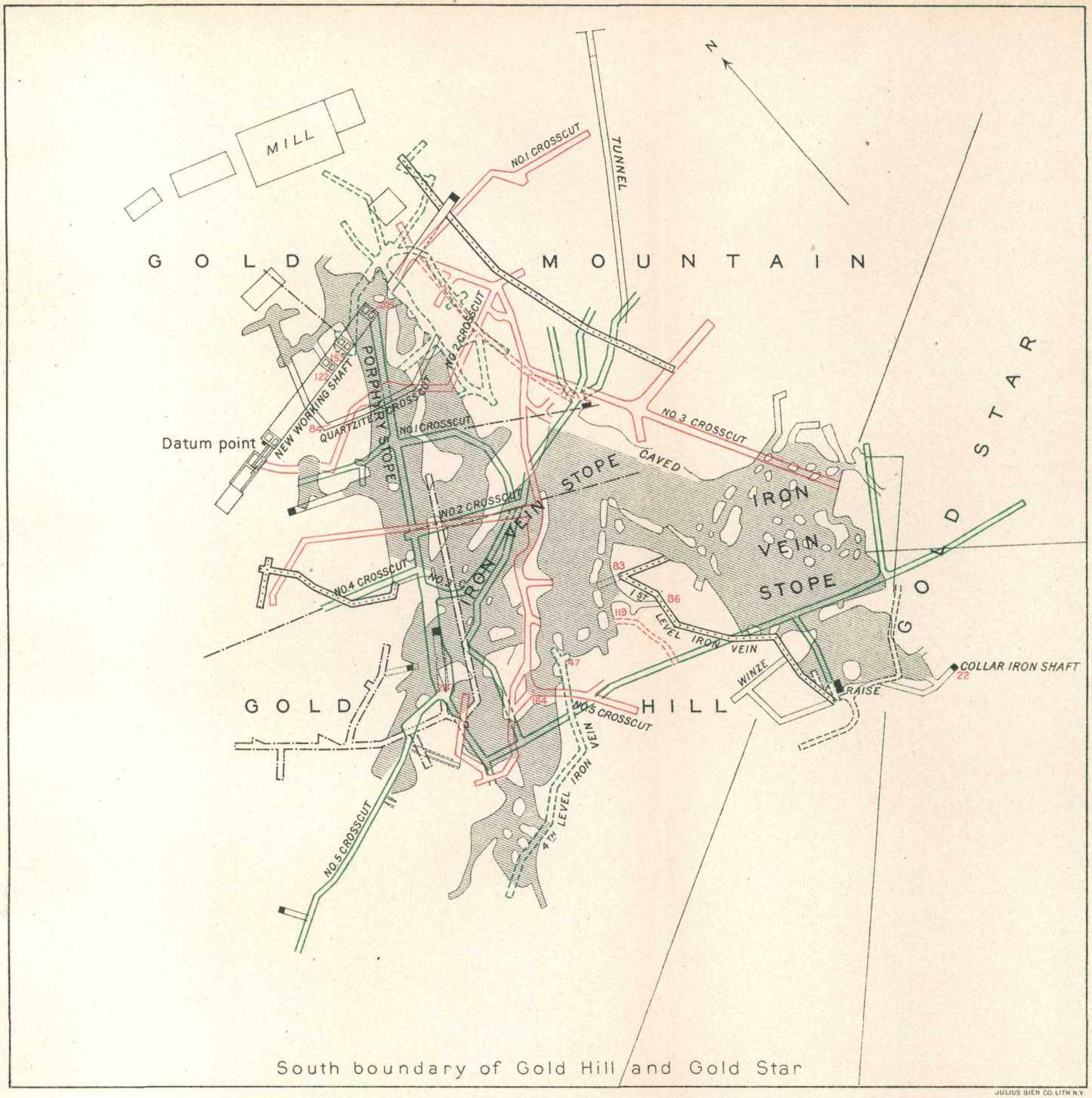
Future of the deposit.—On considering the fact that such a large production has been derived from the levels above the vertical depth of 170 feet together with the complete change of character of the veins below this depth, it seems reasonable to suppose that if there are any large ore shoots or pockets found in the future they will probably be above ground-water level along the strike of the shear zones rather than in those portions of the planes of movement which are now below the zone of oxidation. It may, however, be found possible to work profitably the pyrite which occurs in the shear zones in the granitic rock below the sediments.

Origin of the ores.—The gold values found in the workings above water level have probably resulted from concentration in the zone of oxidation of the gold content of the pyrite, which seems to have been introduced into the granitic rock after its brecciation, and was no doubt likewise present in the shear zones crossing the sedimentary series.

GOLDEN EAGLE PROPERTY.

There was no opportunity to visit the Golden Eagle property, and the following information has been taken from correspondence with the president of the Bonanza-Golden Eagle Mining Company:

The Golden Eagle is opened by an inclined shaft 400 feet long, dipping at an angle of 45°, and there are about 450 feet of drifts and crosscuts on the lower level where a body of ore carrying pyrite, chalcopyrite, and very small amounts of other copper sulphides has been encountered. Two assays of this ore made by John A. Hunter of the Congress Gold Mining Company and transmitted to the writer by Mr. Martin, president of the company owning the Golden Eagle,



LEGEND

- First level
- Third level
- Fourth level
- Fifth level
- Sixth level
- Seventh level
- 114 feet above sixth level

Figures in red represent number of feet below datum point at collar of shaft

JULIUS BIEN CO. LITH N.Y.

PLAN OF WORKINGS OF BONANZA AND GOLDEN EAGLE GOLD MINING CO.

0 100 200 Feet

show the following results: Copper, 0.25 and 4.84 per cent; silver, 1.32 and 2.88 ounces per ton; gold, 0.48 and 1.12 ounces per ton. Mr. Martin states that the ore above the 300-foot level was free milling and that it has been stoped out.

HERCULES PROPERTY.

LOCATION AND DEVELOPMENT.

This property is nearly equidistant from Salome and Wenden, being in a direct line about one-half mile nearer the latter place, and 3½ miles almost due south of it. Salome is just 4 miles in an air line a little north of due west of the Hercules property, and good wagon roads connect the property with both stations, the length of these roads being approximately 5 miles. The prospect is located at an elevation of about 2,100 feet and is near the end of the extreme northwestern projection of the Harquahala Range east of Centennial Wash.

The property has been developed by two shallow inclined shafts, one located several hundred feet east of the other, and these are connected underground by one level. The shafts dip about 60° N. and presumably have been started with a view to following down the vein.

The total production of the Hercules Company is said to be about $10,000. Good dwellings have been erected on the ground, some machinery is installed, and water is pumped through a pipe line to the camp.

GEOLOGY.

Coarse-grained quartz diorite gneiss contains the veins which have been worked on the property. This rock is present in various phases for some little distance to the west, the Prince claim having been located and prospected about one-fourth mile west of the Hercules in a finer grained phase of the same formation. This quartz diorite was intruded by a fine to medium grained quartz-mica rock of granitic or dioritic composition, and both are overlain by fine-grained calcareous quartz-mica schists and quartzites. Figure 16, sketched from the top of the quartzite knoll, shows the geologic relations in a general way, and Plate VII, *A*, illustrates the manner in which the metamorphosed sediments overlie the quartz diorite gneiss and medium-grained quartz-mica schist. Schistose structure has been induced in all of these rocks except the quartzites and the later diabase intrusives. Some of the strata included in the quartz-mica schists are so calcareous that they resemble limestones. Examination of these so-called limestones under the microscope reveals the presence of much quartz and mica with only a subordinate amount of calcium carbonate.

ORE BODY.

Lenticular veins of quartz occur in the quartz diorite gneiss. As exposed in the eastern shaft, the quartz vein varies in width from 8 to 24 inches and appears to occupy a shear zone in the country rock. The strike of the vein here is S. 75° W. and the dip is about 60° N. The vein filling is brecciated to some extent and shows banded structure of quartz and jasper with fragments of both ce-

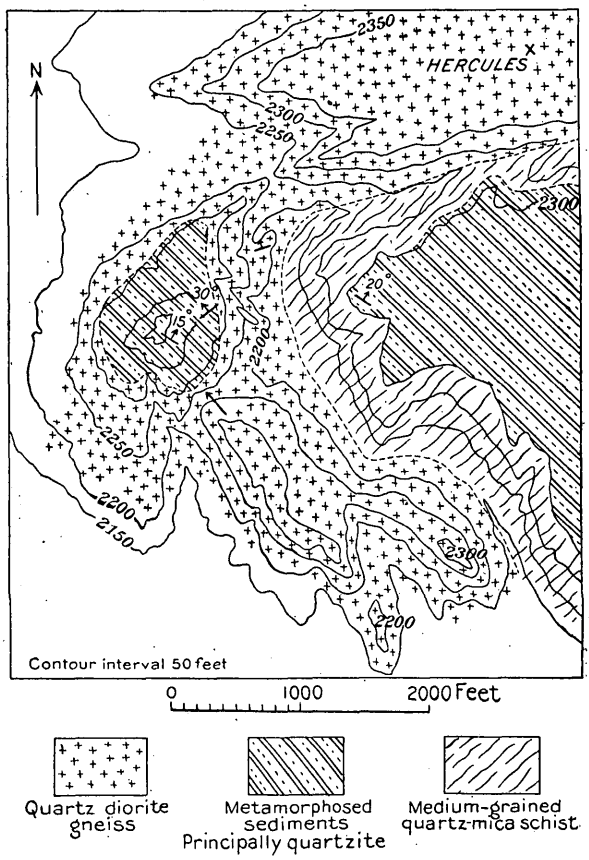
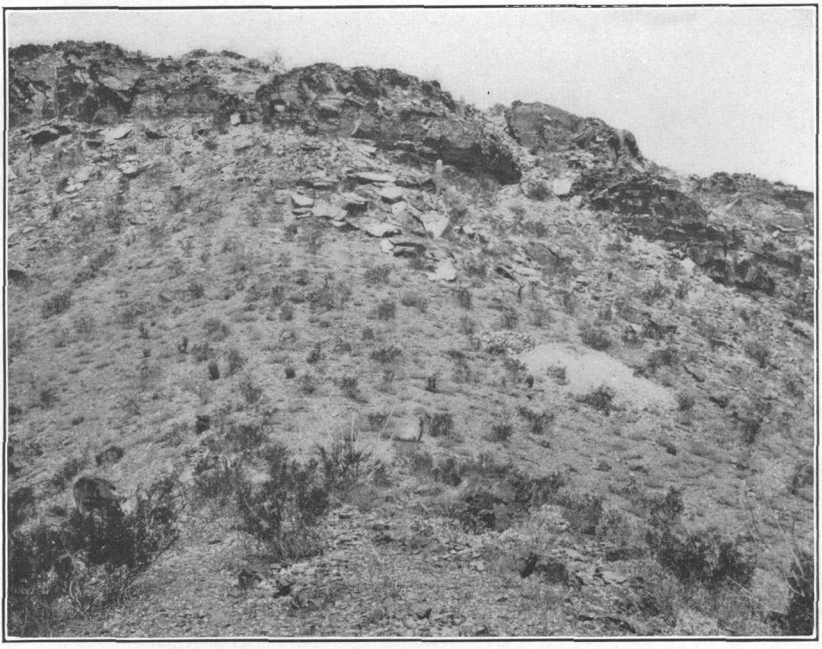


FIGURE 16.—Topographic and geologic sketch map of the area just south of the Hercules property.

mented by limonite. The gold values are obtained from the highly iron-stained quartz masses and are probably derived by oxidation of auriferous pyrite.

Reference to figure 17, which represents one wall of a stope in the Prince claim about one-fourth mile west of the Hercules, will help in understanding the character of these deposits. There is little continuity to the quartz lenses, postmineral faulting having taken place along both the dip and the strike of the veins.



A. VIEW NEAR HERCULES MINE, SHOWING CONTACT OF METAMORPHOSED ROCKS WITH UNDERLYING QUARTZ DIORITE GNEISS.

B. VIEW NEAR CUNNINGHAM PASS MINE, SHOWING INTRUSIVE DIABASE IN GNEISS.

SOCORRO PROPERTY.

LOCATION AND DEVELOPMENT.

This property is located on the southern side of the Harquahala Mountains at an elevation of about 2,000 feet, and, in an air line, is just 10 miles southeast of Salome, with which place it is connected by wagon road. A mill [a] has been erected upon the property and this, with an assay office, shaft house, power plant, and several dwellings constitutes the surface improvements.

The deposit has been developed by a shaft over 325 feet deep, inclined at an angle of 26° N., in which water was standing near the 250-foot level when the property was examined by the writer. This

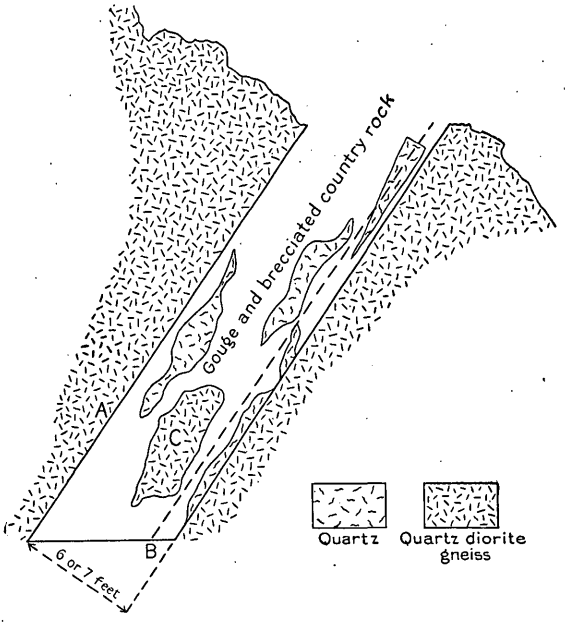


FIGURE 17.—Diagram showing character of the ore body in the Prince claim. A, Faulting along here formed vein; B, postmineral plane of movement at right angle to dip of vein—that is, along the strike; C, horse of country rock.

is about 110 feet in a vertical distance below the collar of the shaft. From the shaft several short levels have been run about 300 feet, and some stoping has been done.

GEOLOGY.

Coarse-grained granite which shows some schistosity is the basal rock in this locality and is similar to the pre-Cambrian granite so universally present in this area. Resting unconformably upon the granitic rock is a series of slightly metamorphosed sediments of which about 150 feet of fine-grained grayish-red quartzite forms the base.

[a] For description of mill and cyanide process see Trans. Am. Inst. Min. Eng., vol. 37, 1907, p. 570, article by F. C. Smith on the cyanidation of raw pyritic concentrates.

This is overlain by several hundred feet of yellowish-brown limestone, the upper portion of which contains intercalated argillites and quartz-mica schists. Strata of schistose shaly limestone and a rock very closely resembling a dolomite (containing, however, fragments of quartz) were noticed near the contact of the quartzite and the overlying limestone. A great number of pseudomorphs of hematite after pyrite were noted in parts of the basal granite in the vicinity and also in a rock near the contact between limestone and quartzite in the ridge just south of the shaft house. One specimen of quartz-mica schist taken from the dump and reported to have come from the 325-foot level about 350 feet south of the shaft shows abundant amounts of tourmaline and pyrite scattered through it. The whole sedimentary series has been tilted so that it now occupies diverse positions. The prevalent direction of dip, however, is east or southeast, the amount varying from 30° to 80°. Faulting has also taken place on a large scale. Small quartz veins are present in all of the formations, and calcite veins are not uncommon in the fractured limestone. A minette dike similar to that seen in the Valensuella workings was noted cutting the limestone on the ridge projecting southward from the mine, and this is possibly an accompaniment of the main granite intrusion found several miles farther west.

ORE DEPOSIT.

A large quartz vein occupying a fissure, which starts in the basal granite and extends out into the sedimentary series underground, forms the ore deposit. This vein strikes in an east-west direction and dips at a rather flat angle, about 26° N. The width varies from practically nothing up to several feet, the horizontal extent as defined in the workings is probably not over 300 feet, and the depth to which the vein has been followed is uncertain, as the lower workings were inaccessible. Above the 250-foot level, practically all of the quartz is highly iron-stained and oxidized ores which were free milling have been worked. Below this level pyrite containing gold forms the principal ore, and this in the past has been cyanided. In places massive pockets of pyrite are encountered, although this is exceptional, as the distribution of this mineral is rather scattered; the country rock here and there is highly impregnated with it.

The vein material shows considerable brecciation and recementation by siliceous solutions, pure white quartz being the predominant gangue, with some jasper. A little limonite was noted in this quartz. Vugs and drusy cavities lined with quartz are common, and free gold was noted in some of the cavities. The ores contain also some silver [a] and a minute amount of copper from covellite. A little galena was observed in slips in the limestone exposed by a short adit tunnel in the ridge south of the shaft.

[a] See Trans. Am. Inst. Min. Eng., vol. 37, 1907, p. 570.

Origin of ores.—Siliceous solutions carrying pyrite were probably introduced under severe pressure into this series of rocks following the intrusion of granite, which took place some little distance farther west and fingers of which no doubt extend for long distances under the surrounding country. The presence of the minette dike, the numerous quartz veins, the intimate association of tourmaline in the schists, and the abundant quantities of pyrite occurring in the rocks in the vicinity are all indicative of the results of solutions accompanying granitic intrusion. Superficial oxidation has concentrated above ground-water level the values in the pyrite in this zone, below which level unaltered pyrite will probably be the future gold ore here as elsewhere in similar deposits in the southwestern part of the Harquahala Range.

SAN MARCOS DEPOSIT.

LOCATION AND DEVELOPMENT.

The San Marcos property, owned by the Pittsburg Harqua Hala Gold Mining Company, is, as regards transportation, one of the most accessible in the area. Wenden, the nearest railroad station, is just 4.1 miles in an air line northwest of the San Marcos, the distance by a good wagon road between the two places being approximately 5 miles, with an easy grade, and the camp is about 450 feet above the station. The total production up to May, 1909, is reported as about $10,000,[a] the majority of this having been prior to 1906.

A shaft inclined at an angle of about 30° NW., between 450 and 500 feet long, and 4 levels 100 feet apart on the incline, constituting in all some 1,700 feet of workings, make up the underground development on the San Marcos property. Figure 18 represents a plan of the shaft and levels.

A small but substantial camp has been built on the property, and these buildings, including a shaft house and a 12-horsepower hoist, constitute the present equipment of the camp.

GEOLOGY.

The rocks in the vicinity of the San Marcos are granites, probably of pre-Cambrian age, which have been intruded by basic dikes; parts of the series have been subsequently sheared, so that the granites are partially schistose and in places are massive. Coarse-grained rocks of aplitic composition have apparently intruded the older granites, and in these no schistose structure is observable. The basic amphibolites are sheared beyond recognition in places and are there represented by a soft earthy material quite unlike the original rock.

[a] Superintendent Carr reports that 300 tons of ore were milled in October, 1909, which returned $8 per ton on the plates.

Faulting is pronounced, as in other prospects of this type in this locality.

ORE DEPOSIT.

Because of the very gentle dip to the shear zone in which the deposit occurs, the oxidized zone will have a greater linear extent downward, and, as the higher values occur in the zone of surficial oxidation in deposits of this type, the gentle dip is a favorable feature. As shown in the shaft between the collar and a point a few feet above No. 1 level the vein varies from 18 to 24 inches in width and has in the past

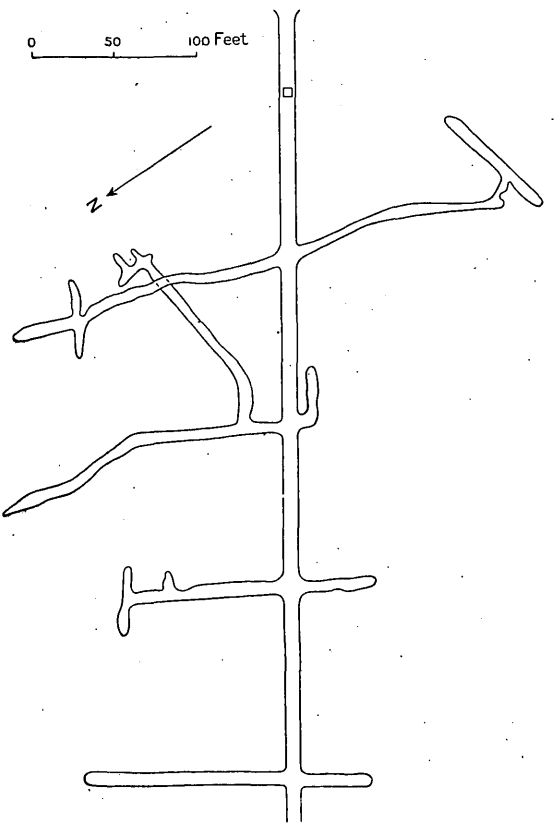


FIGURE 18.—Plan of workings of San Marcos property.

yielded some exceptionally high grade ore. The gangue is principally quartz and brecciated country rock with a great deal of iron oxide mixed with it, and an occasional flake of specularite. The values are almost entirely in gold, which carries only a very small quantity of silver. No sulphides were seen in the property, everything above the bottom level being oxidized. When the property was visited the fourth and lowest level was under water. Just before reaching the first level the vein apparently disappears in the roof and, as this has

not been explored to any extent, it is impossible to say whether it has pinched out or simply flattened.

Below No. 1 level several small lenses of quartz have been discovered which carry values, but they are not continuous and are probably analogous to the lenses found in the Prince claim, west of the Hercules, a diagram of which appears on page 111 of this report.

MISCELLANEOUS DEPOSITS.

Under this heading deposits in the Cunningham Pass, Bullard Peak, Corona, McCracken, and Planet Peak vicinities will be discussed. These are here grouped together, not because of any similarity in mode of occurrence, but rather because of their geographic location, which prohibited their incorporation in any of the six groups which have just been described. All have been prospected as copper deposits except the McCracken, that having been in the past a silver-lead deposit of some note.

CUNNINGHAM PASS VICINITY.

GENERAL GEOLOGIC FEATURES.

There are numerous prospects in this locality, but the only one that was actively shipping at the time of the writer's visit was the Critic, of the Cunningham Pass Copper Company. This immediate vicinity was therefore studied in some detail, deposits on several claims belonging to the company being examined in a cursory manner. Hence the following description deals principally with the properties belonging to the Cunningham Pass Copper Company.

The rocks exposed in this vicinity typify the pre-Cambrian granite gneiss schist complex referred to in a preceding chapter on the geology of the region. Here a vast thickness of the series represents normal mica orthoclase granite, changing abruptly into gneiss and including between the layers of gneiss the resulting schistose phases of former basic intrusives. The whole series, which is composed principally of gneiss and schist, is cut by innumerable dikes of pegmatite and aplite, with here and there prominent diabase intrusives. Plate VII, *B* (p. 110), shows the relation of the later intrusive diabase in the gneiss, and Plate VIII, *A* (p. 118), shows in the foreground the head frame and dump on the Critic workings, in the background the portion of the Harcuvar Range just northeast of Cunningham Pass. In the ridge in which the Critic and Boone workings are located the planes of schistosity dip at a flat angle approximately 15° NW. In the hills northeast across the wash the dip is northeast, and there seems to be no marked regularity in small areas, although in general the lamination planes in the whole range northeast of Cunningham Pass dip slightly southeast.

CUNNINGHAM PASS MINE.

LOCATION AND DEVELOPMENT.

The property of the Cunningham Pass Copper Mining Company is in the Ellsworth [a] or Harcuvar mining district and is located, as the name implies, near Cunningham Pass, the Critic shaft being just 5,000 feet N. 70° W. of it. In an air line, Wenden, the nearest and most accessible railroad station, is just 8¼ miles almost due south of the Critic shaft, the distance by wagon road being approximately

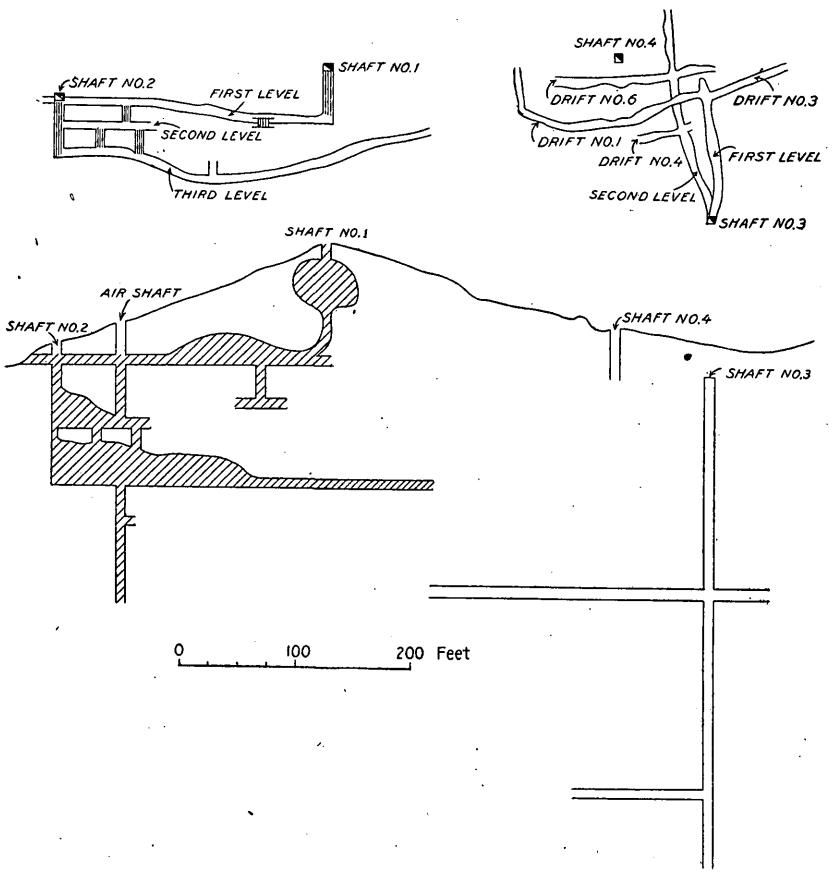


FIGURE 19.—Plan and section of the workings on the Critic claim, Cunningham Pass Copper Mining Company.

11 miles. This road involves a steep rise of 400 feet over the pass going to Wenden and a rise of about 700 feet in returning.

Freight on ore from the property to Wenden costs $4 per ton; the back haul is $3 per ton. Distillate is used for motive power in driving the hoist, compressor, and small blower, and the cost of this, including freight to the property, is 15 cents a gallon when bought in

[a] For map of mining districts see figure 4 (p. 45), compiled from official records by the clerk of Yuma County, Ariz.

carload lots. Lumber costs $32 per thousand at the mine. Water for domestic use is obtained from two surface wells in the locality, and considerable water for other purposes is obtained from the shaft. The general manager of the company states that ore can be mined for $2.50 per ton. The company holds 13 claims, one of which, the Critic, is patented. Several buildings of a substantial nature constitute the surface improvements at the property. The machinery installed consists of a 12-horsepower hoist, a compressor capable of running four 2¼-inch drills, driven by a 40-horsepower engine, and a small blower driven by a 2-horsepower engine.

Shallow shafts have been sunk on all of the claims held by the company; the main development, however, has been carried on in prospecting the Critic claim. Here the Boone and Critic workings are located, the former representing the original prospect and the latter a more extensive development of what the management considers an extension of the northeast Boone vein. Figure 19 shows a plan and section of the underground development which totals 2,000 feet on this claim. The new vertical shaft is down nearly 400 feet, and the two main levels and accompanying drifts total 1,050 feet, of which 330 [a] feet represent drifts on the Critic vein. Not much stoping has been done from these drifts. The Boone workings represent a total of 950 feet of development work, including two inclined shafts pitching at a very steep angle, three levels, winzes, etc. A large part of the ore shipped from this property has been taken from the Boone workings. The total production of the Cunningham Pass Copper Company up to April, 1909, has been between 600 and 700 tons of ore, which averaged about 12 per cent copper and carried from one-half to 1 ounce of gold per ton.

ORE DEPOSIT.

As shown in the Boone and Critic workings the ore deposit occupies a true fissure cutting directly across the schistosity of the country rocks. The width of the vein varies from a few inches up to 3 or 4 feet and the ore-bearing streak is likewise as inconstant in its dimensions, changing abruptly in places from a barren vein into several inches of ore and again pinching out as suddenly. This is probably due to post-mineral longitudinal faulting, both horizontal and vertical, which is very much in evidence in the property, with the result that the deposits are pinched in several places. In figure 20, *A* is a sketch of the breast of No. 9 drift from No. 2 level, drawn in March, 1909; *B* shows the vein in a stope a few feet above No. 6 drift from No. 2 level; and *C* represents the breast of the drift a short distance beyond. After this drift had been advanced a few feet, a good showing of chalcocite was exposed, which with a little further drifting

[a] In May, 1910, probably 100 feet more of drifting has been done on drifts Nos. 6 and 9 since the property was examined in March, 1909.

shortly dwindled down to a very lean streak. The country rock on both sides of the vein is fresh, although in a few places where faulting has been pronounced the schists are mineralized, principally by pyrite and hematite, the latter seeming to occupy every conceivable fracture in the rocks. Some of the pegmatites in the rock show mineralization, chiefly by stains of copper and iron, and the fractures of the aplite dikes are filled with hematite.

The strike of the Critic vein is N. 50° to 60° W. and the dip is fairly steep, pitching 70° to 80° SW.

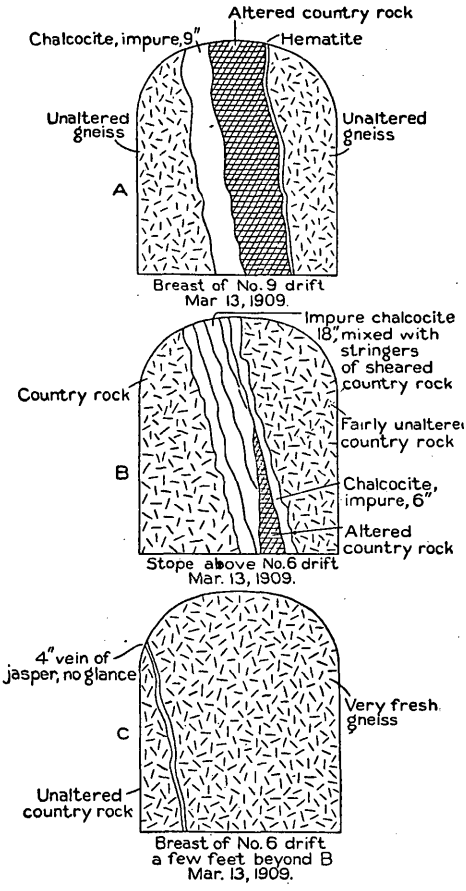
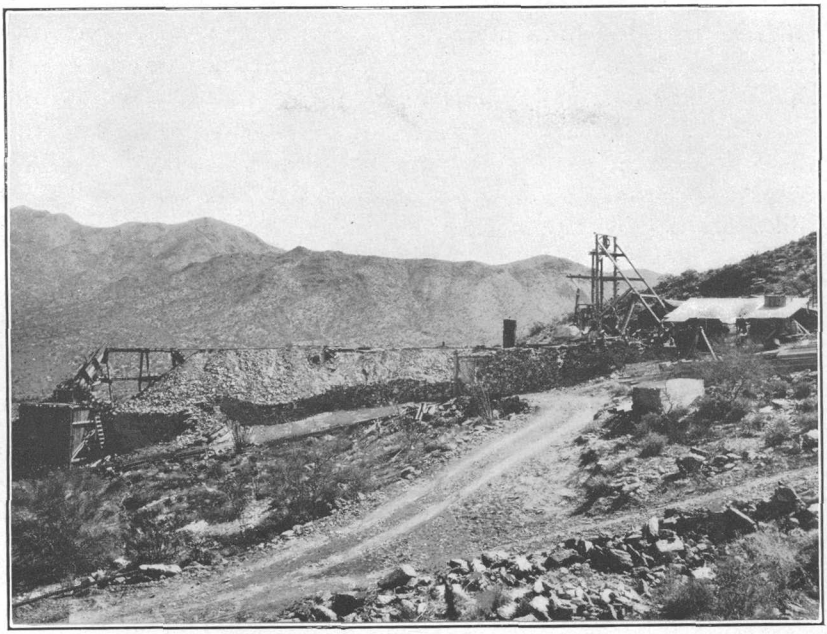
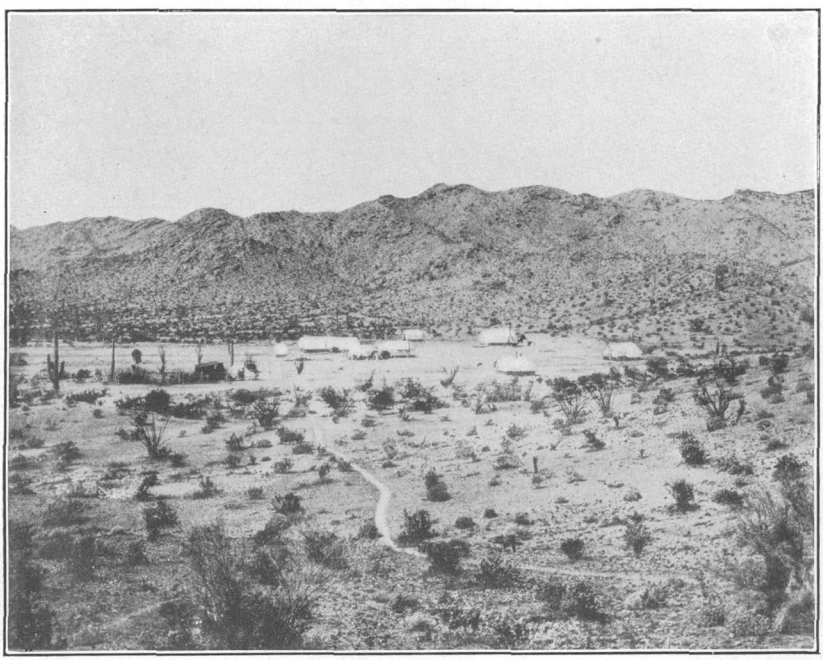


FIGURE 20.—Three sections of the Critic vein, Cunningham Pass Copper Mining Company.

The gangue is principally brecciated country rock and soft red hematite, with some specularite and limonite. Quartz is present in large quantities and occurs also in vugs, and occasional veinlets of calcite and barite were noted filling post-mineral fractures. In the zone above ground-water level the chief ore minerals are chrysocolla and chalcopyrite, with which are associated a little malachite, cuprite, and some chalcocite. Below water level, which is at a depth of 320 feet in shaft No. 3, the chief ore mineral is chalcocite, with which are associated some chalcopyrite and pyrite. Quartz is prominent as a gangue mineral and in places contains magnetite. The ore here does not occur as massive pure chalcocite, but contains much silica, and this in the form of jasper and quartz is distributed throughout the ore, which is porous, many of the cavities being lined with quartz crystals. Sorted ore from the workings near the surface contains an average of 50 to 60 per cent silica, 10 to 14 per cent iron, 1 to 1.6 per cent sulphur, 12 per cent copper, and one-half to 1 ounce of gold per ton. Lower down in the vein the silica in the ore seems to increase, in some cases attaining a percentage of 75 in sorted ore that has been shipped. The soft red hematite is reported by the general manager



A. HEAD FRAME, DUMP, AND OTHER FEATURES AT CRITIC SHAFT, CUNNINGHAM PASS MINE.



B. CAMP OF CORONA COPPER COMPANY.

Hills in background show schistose structure.

to contain from 1 to 2 per cent copper and from $10 to $20 in gold per ton.

Origin of the ores.—Apparently the ores have been derived from the leaching and the subsequent concentration of values contained in pyrite and chalcopyrite, this in all probability being the source of the gold values and the chalcocite found in the vein. Presumably this secondary enrichment of copper glance has been accomplished by downward moving waters.

Many ledges of impure siliceous hematite, some of considerable thickness, were observed in the vicinity, both on property belonging to the Cunningham Pass Copper Mining Company and on ground northeast of the camp. It is possible that a chalcocite zone may be found below some of these ledges.

BULLARD PEAK VICINITY.

LOCATION AND DEVELOPMENT.

The peak which is known throughout this part of Arizona as "Bullard's" is a small knob projecting about 300 feet above the desert. It is separated from the main mass of the Harcuvar Range by a shallow wash, which on the north seems to have followed the line of contact between the older underlying pre-Cambrian rocks and the comparatively young lava, of which a small remnant forms Bullard Peak.

This locality is in the Ellsworth or Harcuvar mining district, on the extreme eastern border of the area under reconnaissance and is nearly 10 miles in a direct line a little east of north of Golden, where no railroad station is maintained. The town nearest Bullard's is Wenden, 21 miles southwest in an air line and about 25 miles by wagon road. Near Bullard Peak a company once known as the Yuma Copper Company[a] operated for a short time a small smelter and worked ore from prospects near by.

Water is obtained from a well a short distance northeast. The prospects are located in the peak, near the top.

Various shallow inclined shafts have been sunk, and some drifting has been done. The property was idle when examined, and hence much information was not available. No machinery is installed, and the work in the past has been done entirely by hand.

GEOLOGY.

The oldest rocks in the vicinity are of the pre-Cambrian granite gneiss schist complex, which forms the Harcuvar Range east of the peak called by that name. These dip southeast at angles varying from 15° to 30° and are overlain near their contact with the surrounding desert by the material which forms Bullard Peak. The base

[a] Not to be confused with a company of the same name now operating north of Vicksburg.

of this peak is a conglomerate about 75 or 100 feet thick, composed of fragments of various sorts, principally andesitic. On top of this is about the same thickness of tuff, and this is capped by a few feet of bluish-green and brown augite andesite, which in the field somewhat resembles basalt. Examination of thin sections fails to reveal any olivine, although the rocks may once have contained some. In this rock occur the ore deposits.

ORE DEPOSIT.

The deposit occupies a simple fissure in augite andesite. This vein has a dip of about 45° in a southerly direction and varies in width from 18 inches up to 4 feet, the ore course having an average width of 6 inches, ranging up to 12 inches in places. Quartz and calcite form the gangue, the latter occurring also in small stringers traversing the andesite in all directions. Some hematite was noted and epidote is present in places in the country rock. The principal ore mineral is chrysocolla, and with this occurs some malachite, a little copper glance, and a small showing of cuprite. The vein shows brecciation and subsequent cementation by siliceous material. The ore has probably been derived from chalcopyrite, and the deposit is clearly of Tertiary age.

CORONA VICINITY.

LOCATION AND DEVELOPMENT.

The properties examined which have been prospected in this locality belong to the Corona Copper Company and are located in the Santa Maria or Bill Williams mining district, 20 miles in a direct line northwest of Wenden, the wagon road between the two places being 23.4 miles long. Bouse is only 16 miles southwest of this camp, but at present is not connected by wagon road. Water for the camp is obtained from a well about 1 mile southeast of the camp.

The company holds 54 claims, none of which are patented and only three of which have been actively prospected. These are the Mammoth, the Chicago, and the Copper Glance, which were located by Mr. Butler about fifteen years ago and relocated by him in 1908. One carload of ore has been shipped from the Copper Glance which is reported to have carried 22 per cent copper and from $4 to $5 in gold to the ton.

On the Chicago claim an adit tunnel has been driven for a distance of 400 feet, including a short crosscut, and a shaft has been sunk 125 feet. The Copper Glance workings consist of a small surface cut and an inclined shaft about 200 feet deep. The Mammoth claim is developed by a short inclined shaft and a level connecting with an upraise to the surface. The camp is composed of a few tents, and no machinery has been installed on the prospects. Plate VIII, *B* (p. 118), shows the Corona camp with the mountains of gneiss in the background.

GEOLOGY.

Gneiss and schist apparently of granitic origin constitute the oldest rocks in the vicinity and are probably of pre-Cambrian age. These are cut by intrusions of pegmatite, aplite, and a slightly schistose rock having the composition of a diabase, which is now an amphibolite. The Chicago and Copper Glance workings are located in rocks of these types. The gneiss has a general southerly dip, although many changes from this direction are apparent. Just east of the camp there is a small butte not over 100 feet in height above the desert and about 1 mile long, composed of brecciated material which very much resembles a conglomerate near the base and a granitic breccia above. This has the appearance of being the remnant of a detrital deposit formed from the erosion near at hand of granitic material, and the age of the formation is decidedly uncertain. In the section on general geology this was provisionally classed as Tertiary. This butte rests upon the uneven eroded surface of the gneiss and schist. Because of the large amount of iron oxide present in the cementing material of the breccia, the butte has a reddish-brown tone and forms a conspicuous topographic feature. The Mammoth workings are located at the base of this butte on its contact with the underlying gneiss schist complex.

CHICAGO DEPOSIT.

This deposit is located about eight-tenths of a mile N. 70° W. from the Corona camp and seems to occupy a slightly mineralized fault plane of no great magnitude in the gneiss. The strike of the vein is S. 35° E. and the dip is 80° to 90° NE. The shaft is located at an elevation of 1,860 feet, and the portal of the adit tunnel is some 15 feet higher up. The vein is only a few inches wide and is filled principally with barite, associated with which is some quartz, both occurring also as linings in vugs. A little fluorite was noted in the vein, and hematite is a conspicuous feature not only in the deposit, but also in the aplite dikes which are a common accessory of the gneiss schist complex. Brecciation of the country rock is a noticeable feature, and thin films of barite occur as a covering to these fragments. In places slickensided surfaces of gangue material were noted, showing post-mineral movement as well as that which occurred before. The vein is very sparsely mineralized with chrysocolla, and dioptase is reported as present in the deposit.

COPPER GLANCE DEPOSIT.

This is similar in many respects to the Chicago. The geologic section is identical and the mineralization more extensive. An inclined shaft is sunk on a small vein which strikes S. 52° E. and dips 60° NE. to a depth of 140 feet, where a post-mineral basic dike shatters the vein, which seems to spread out in several very small stringers.

Below this point the shaft is inclined 45°, and reaches water level at a depth of 171 feet, below which exploration is not extensive.

The vein itself occupies a shear zone in the country rocks and is of relatively small proportions, being only a few inches wide. The gangue is quartz and hematite with a very little magnetite, and a small amount of epidote and chlorite were noticed in the vein. The ore minerals are chiefly copper silicate and a little chalcopyrite. Copper glance is said to occur in this shaft at a depth of 190 feet.

Origin of the ores.—Concentration by oxidation of lean primary ores would be sufficient to account for these small deposits. The presence of barite and fluorite indicates a late introduction, and solutions bringing in these minerals are possibly the ones which have accomplished the concentration.

MAMMOTH DEPOSIT.

This deposit differs from others in the vicinity in that it occurs, as already noted, between the underlying gneiss schist complex and the overlying granitic breccia. The actual contact between the two formations is separated by a few feet of fine-grained material cementing small fragments of rock, and this takes the form of a consolidated silt, dipping 30° SW. Solutions carrying iron and a little copper have percolated through this more or less porous medium between the two formations with a resulting deposition of considerable red iron oxide and a small amount of copper silicate. Quartz, a little barite, and traces of fluorite were noted in the vein.

PLANET PEAK VICINITY ON THE SOUTHWEST.

PROPERTIES EXAMINED.

There are many prospects in this general locality, among which the Dome City, the Mineral Zone, the Mail Pouch, and the Pride, were examined in a cursory manner. These are all located in the Santa Maria or Bill Williams mining district [a] within a short distance of one another and are near a place locally known as Osbourne's Well, where water is obtainable. Parker is at present the most accessible town, but the active operation of the Arizona and Swansea Railroad will afford easier methods of approach. The properties have been but scantily prospected, shallow shafts and surface cuts representing the principal development. No large shipments are known to have been made from any of the above-mentioned workings.

GEOLOGY.

Gneiss and schist, presumably of pre-Cambrian age, form the oldest rocks in the vicinity, and all of the deposits examined in this locality except the Pride, occur in these rocks. Aplite, pegmatite,

[a] For map of mining districts see figure 4 (p. 45), prepared from official records by the clerk of Yuma County, Ariz. The Mineral Zone, Dome City, and Mail Pouch are located between the Ogden and the Pride prospects, both of which are shown on Plate I (in pocket).

and basic dikes were noted cutting the formation. About 2½ miles northeast of Osbourne's Well, limestone, associated with the intercalated amphibolite, overlies the older gneiss schist complex, and in this series occurs the Pride deposit.

PRIDE.

The Pride deposit resembles on a small scale those seen at Planet. Limestone has been partially replaced by hematite, with which is associated a little copper silicate. A 50-foot shaft has been sunk in the limestone, which is reported to show ore at the bottom. Several adit tunnels have been driven farther up in the series, and these disclose a small amount of mineralization along the joint planes in the amphibolite schist. The limestone dips in general about 15° to 20° S.

MAIL POUCH.

This deposit is said to be an extension of mineral zone No. 2 and represents a fissure in the gneiss schist series. The strike is S. 20° E. and dip is 40° N. 80° E., and the planes of schistosity of the country rock dip S. 10° W. The vein is highly siliceous and shows a brecciated character, with a little free gold occurring in some of the joints and fractures of the vein.

MINERAL ZONE NO. 1.

This prospect is similar in many respects to the Mail Pouch and shows a 4-foot brecciated vein, cutting across the schistosity of the gneiss, filled with silicified fragments and cemented by quartz. The vein strikes S. 50° E. and dips northeast.

DOME CITY.

Inclosed in the gneiss and appearing to dip conformably with the planes of schistosity in the Dome City property is a thin layer of calcareous material very much resembling limestone, but which is probably a vein of calcite. This has been replaced in large part by specularite having large flakes one-fourth of an inch across. The vein filling apparently occupies a shear zone in the gneiss schist series, and shows some brecciation. Mr. Osbourne, the owner of the property, states that the vein changes in direction of dip 80 feet down in the shaft from southeast to northeast, this probably representing a fold.

M'CRACKEN LEAD MINE.

LOCATION AND DEVELOPMENT.

The McCracken deposit, located in the Owens mining district, is the only property which the writer had the opportunity of visiting in southern Mohave County, and it has many individual characteristics. According to Mr. H. C. Hodge,[a] this deposit was discovered on August 17, 1874, by Messrs. McCracken and Owens, who retained a part interest in the property after it was incorporated into a San

[a] Hodge, H. C., Arizona as it is, 1877, pp. 70–73.

Francisco company. Mr. Hodge states that a 10-stamp mill was erected at Greenwood on the Big Sandy River, which place is probably now known as Signal. This is about 12 miles almost due east of the McCracken, the distance by wagon road not being known to the writer. Mr. Patrick Hamilton,[a] writing in 1884, states that an additional 20-stamp mill had been erected, and presumably this was located near the other mill. He also stated that the production, while the property was operated, reached a total of $1,000,000, and that operations had been suspended several years previous to the time of his writing because of the heavy freight charges and the high cost of supplies.

Just how much work has been done on the property since that time the writer is unable to say. A ditch several miles long, for carrying water to the mine, is reported to have been built. This method of conveying water proved a failure in that the ground absorbed the flow. At the present time the mine is in a complete stage of dilapidation, all of the buildings, tramways, and wagon roads having either been torn down or become useless through abandonment

Should the mine be again opened, transportation facilities would be a little more convenient than they have been in the past, although at the present day the nearest railroad point is Swansea, distant 20 miles in an air line, and approximately 40 miles by the present wagon road. Haviland, on the main Santa Fe line, is 30 miles northeast of Castaneta Well in a direct line, and the McCracken mine is 8 miles by wagon road east of the well, so that the distance to Haviland by overland route would probably be between 40 and 45 miles.

The top of McCracken Mountain has an elevation of 3,400 feet, the northeast and southwest slopes of which are decidedly steep, while the northwest and southeast slopes are more gentle and form a long prominent ridge. The surrounding desert has an elevation of between 1,650 and 2,000 feet, so that McCracken Mountain forms a very prominent topographic feature. The workings examined are located on top of and on the southwest side of the upper 500 feet of the mountain, which rises abruptly above the general ridge in the form of a dome.

In 1877 Mr. Hodge [b] stated that the property had been developed by "over 700 feet of shafting and over 1,200 feet of tunnels." He also said that "the deepest shaft is 367 feet, and the shafts and over 1,000 feet of tunnels are in vein matter all the way." If there was this amount of development as early as 1877 the natural conclusion is that nothing has been done on the property since then except in the matter of stoping, two large "glory holes" having been noted which showed excavations in the vein, each measuring at least 20 by

[a] Hamilton, Patrick, The resources of Arizona, 1884, p. 224.
[b] Hodge, H. C., Arizona as it is, 1877, p. 71.

30 by 70 feet. The upper one of these is on top of the ridge and the other one a short distance below.

The drift just under these large stopes is probably not much over 300 feet long, from which there are numerous short crosscuts. Below this two levels have been run at vertical distances of 100 and 200 feet, respectively. The former is quite short unless caving has so ingeniously blocked the level that a natural face is presented, and the latter is a short crosscut which does not reach the vein. Probably other developments are present, which are inaccessible because of caving. The upper workings seem to have been connected by winzes.

GEOLOGY.

Coarse-grained gray to pink quartz-mica schists, apparently derived from quartz-mica diorites, constitute the main mass of the mountain. These rocks, prior to or at the time of their metamorphism, were intruded by granitic material so that the resulting schists appear as gneiss in many places, and especially so on the northwest continuation of the ridge from McCracken Mountain. Schistose dark-green basic diorite is intercalated with the quartz-mica schists, and the whole series is cut by pinkish pegmatite dikes which show some shearing. Later intrusives of greenish-gray basic diorite cut across the schists, and these are possibly responsible for the mineralization. The mineral constituents of the rocks are all remarkably fresh and show little alteration other than that produced by dynamometamorphism.

Two large fissures form the receptacles for the veins, and these veins run in a north-south direction, parallel to which are one set of joint planes in the rocks, which form a conspicuous feature in the mountain. Two other sets of joints are prominent, one at right angles to the direction of the veins, and the other parallel to the planes of schistosity in the rocks. Innumerable stringers of quartz are present, filling small fissures and fractures in the country rocks.

ORE DEPOSITS.

Two fissure veins, striking north-south and dipping approximately 65° E. form the ore deposits. One of these ledges is very continuous, having been observed for a distance of at least 2,000 feet on the north of McCracken Mountain, and it is reported [a] to have been traced continuously for a distance of 2 miles and to outcrop in places several miles south of this mountain. The width of this vein as observed in the vicinity of the workings varied from 12 to 20 feet. The other vein is not so extensive and was observed near the workings only, the width varying from 6 to 12 feet. Figure 21 shows the outcrop of the veins on top of the mountain and their relation to the quartz-mica schists.

[a] Hodge, H. C., loc. cit.

The gangue in the vein filling consists principally of carbonates and sulphates with some silicates cementing fragments of schist and quartz. The carbonates are principally calcite and siderite, with which is associated some dolomite, the former being stained by iron and manganese in such a way that many colors result, the pink-stained calcite clearly resembling rhodochrosite. Laboratory tests, however, revealed only a minute quantity of manganese and an appreciable quantity of iron. Some of the highly iron-stained calcite resembles hematite. Quartz is present in large quantities, some of which is amethystine, and crystals of the mineral line many cavities in the vein. Barite is the principal sulphate present, and this occurs in large quantities, usually showing banded structure, which is prevalent in the gangue minerals in this vein. The relative age of the various minerals which form the gangue is not known. One phase of quartz appears to be next to the youngest mineral, for it fills fractures which cut across most of the other minerals and many vugs are lined with it. Calcite is deposited in vugs on top of this quartz.

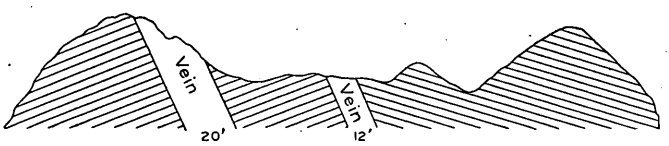


FIGURE 21.—Sketch of top of McCracken Mountain, showing veins.

Formerly deposited quartz is severely fractured and cemented by the carbonates.

The most conspicuous ore mineral is galena, which is reported to be argentiferous. At the time of the writer's visit to this property not a great deal of this was visible, and the natural conclusion is that it occurs in bunches scattered through the vein. Cerusite is probably present in substantial quantities, although its definite identification was not possible. Three assays of vein material in which no metallic sulphides were visible to the unassisted eye gave traces of lead and gold with 2.6, 2.8, and 11.56 ounces of silver to the ton.

Age of the vein and origin of the ores.—That this vein is of comparatively recent origin is almost certain, but it is impossible to state definitely when the disturbances occurred which formed the fissure now occupied by the vein. Probably this represents a part of the Tertiary period of vein formation. As the vein shows evidence of brecciation and subsequent deposition of material, solutions were active during several periods, and it is impossible to state with which, if with any one in particular, the galena was introduced.

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