Paleozoic limestone and other sediments. The croppings are prominent and some are extensive. They consist principally of masses of brown and blackish iron, copper and manganese-stained quartz containing malachite and azurite. Some of the ore is reported to assay from 17 to 20 per cent. in copper and to contain also gold and silver.

The Black Mountains Group

The deposits of the Black Mountains are mostly on the western slope of the range. They occur in well-defined fissure veins, but differ in most respects very markedly from those of the Cerbat Range. They are found chiefly in the Tertiary volcanic rocks, and belong to the great group of deposits found in this class of rocks throughout the West.

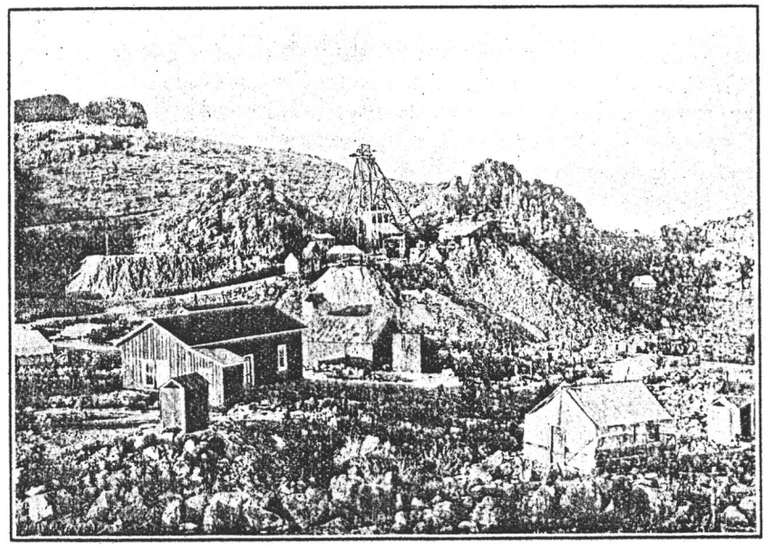
Until recently the most favorable ore horizon was regarded as in the green chloritic andesite and the undifferentiated volcanics, with profitable though subordinate deposits occurring also in the upper rhyolitic series. Recent developments, however, seem to indicate that, in the Tom Reed-Gold Road district at least, the main ore zone probably extends to a deeper horizon, in the so-called older andesite or still lower rocks.

The veins in general trend northwest-southeast with steep northeast dip. They are fairly regular, but the walls are usually rough, broken and frequently full of stringers branching off from the vein. There is a general absence of fluccan or gouge. The gangue primarily was mainly calcite and dolomitic carbonates, but these minerals have largely been replaced by quartz and adularia, a variety of orthoclase free from sodium, semi-translucent and which is so intimately intercrystallized with the quartz that it is not recognizable to the eye. The gangue contains also many inclusions of brecciated altered country rock.

A striking feature of the gangue in many places, particularly in the Tom Reed-Gold Road district, is its characteristically laminated or platy, bladed and cellular structure, pseudomorphic after calcite, barite or other spar in which many contiguous or connecting plates are variously arranged. This material is aptly termed by the miner "fish-scale quartz," from the adjacent plates partly overlapping one another. The plates range from minute up to an inch in diameter and from the thickness of paper to $\frac{1}{10}$ in. in thickness. Much of the quartz intimately associated with the better-grade ore is of greenish or yellowish-green color and waxy luster, which has led to inquiry concerning the source of the color. The cause of the color is not definitely known, nor easy to determine. From preliminary tests it seems to be mainly silicates of iron, manganese, and perhaps other minerals, chlorite, actinolite, rhodonite, dioptase, etc., which may be an important source of the black iron and manganese oxides common as stain, small bodies and pockets in the croppings and more oxidized ores. It is noticeable that the greenish quartz

occurs more frequently in a crustified or banded form than does the uncolored gangue, which method of forming more readily favors the entering of various salts and minerals into its composition. In the Miller mine on the Hardy vein, 2 miles west of Gold Road, the greenish color of the quartz seems to be due largely to fluorite which is present in considerable quantity in the vein, much of it being replaced by quartz.

The deposits seem to have been formed near the surface by thermal solutions which circulated through the lavas at the close of igneous activity. They seem to belong to the late Tertiary epoch of metallization. They are oxidized to depths of 600 to 700 ft. and, as a rule, contain little or



Bulletin 397, U. S. Geological Survey.

FIG. 5.—GOLD ROAD MINE, MAIN SHAFT LOOKING SOUTH.

Silicified lode and vein wall croppings on both sides. Edges of heavy flows of volcanic rocks in left background.

no sulphides. Gold is almost exclusively the valuable constituent, usually no base metal being present. The gold as a rule is free, but occurs in very minute particles and is best recovered by the cyanide process. Gold telluride is reported from a few mines.

There is no gossan nor iron hat in the outcrops of the veins. In general, the veins weather in relief only where the filling consists chiefly of quartz or a mass of cemented silicified rock. There the croppings form prominent reefs. Likewise, the vein walls are frequently strongly silicified and hardened with the result that they too weather in forms rising to heights of 20 ft. or more above the surface and extending for considerable distances as seen at the Gold Road mine, Fig. 5. This hardened wall

rock, or so-called "ledge matter," is sometimes netted by stringers of quartz branching off from the vein. It denotes arresting or damming back of copious mineral-bearing solutions that circulated at the locality, and generally indicates workable deposits in the adjacent underlying portion of the vein as described later under the Gold Road mine. Many of the deposits, as exemplified by the Tyro, the Gold Road, and other veins, carry relatively unimportant values near the surface.

Of the ten or more districts in the range the most important is the Tom Reed-Gold Road district.

Tom Reed-Gold Road District

General Description

The Tom Reed-Gold Road district lies about 25 miles southwest of Kingman, mainly on the west slope of the range. In keeping with present usage, the term as here used comprises what was formerly known as the Gold Road and Vivian districts, and the area is approximately co-extensive with the southern part of the San Francisco district of early days. The district has a north-south length of about 10 miles and a width of 6 miles. The principal camps and centers of activity are Oatman, the settlement of the Tom Reed and neighboring mines, situated in the west slope of the range 27 miles from Kingman, and Gold Road, 2 miles north of Oatman. For more than a year Oatman continued to be the center of attraction in the Southwest.

Mineral was first discovered in the district, as aforedescribed for the Mohave County region, in the early sixties at the Moss mine 4 miles northwest of Gold Road. The mine soon produced $240,000, in gold from rich surface ore.

Production in the district has continued more or less steadily since the discovery of the Gold Road mine in 1902. Recently discoveries in the Tom Reed mine and vicinity have been attracting attention to the district, with the result that the value of the plants and machinery now installed at the various mines is said to aggregate nearly $2,000,000. Some 50 odd plants are in operation. The greater portion of them have been installed since the first of the year 1915, during which time nearly 200 companies have been organized to operate in the district, of which 150 are fully equipped and most of the others are receiving machinery. Thirty or more properties hitherto dormant have become active, and the population, which is gathered from all the mining camps in the West, has increased from 600 to more than 7,000 and is gradually increasing. Oatman, which is said to recall Goldfields' boom, is described as a well-equipped, substantial town, a cleanly, orderly, model camp, where living is such as one expects to find only in large towns. It is electrically lighted, has three newspapers, schools, churches, a stock exchange, and well-stocked stores and business houses of all kinds. It is rapidly becoming the outfitting center for a large territory containing many new districts for a distance of nearly 100 miles north and south along the range. Wildcatting is checked by the laws of Arizona.

Owing to the demand for building space, a new camp, Old Trails, has grown up in the broad wash south of Oatman and there are a dozen other surrounding town sites and additions. Mail, passenger, and express service is by automobile chiefly from Kingman. A similar service exists between Oatman and Needles, 20 miles distant on the southwest, in which the Colorado is crossed by boat. Freight is delivered in the district at a cost of $11.50 per ton by motor truck, road locomotive, and mountain tractor from Kingman, and from Topock, formerly Mellen, located 25 miles distant at the east end of the railroad bridge crossing the Colorado. Early construction of a branch railroad from Topock to Oatman, which is quite feasible, is reported under consideration.

Good water for domestic use is pumped from neighboring springs found mostly in the porous rhyolite tuff or water rock. Seemingly, ample water for milling purposes is being found in deep mining. It also is palatable, being suitable for domestic and all other purposes. Should an additional water supply be required, it can be pumped from the Colorado River 14 miles distant, preferably from wells sunk in the gravel beds on the bank of the river. For this purpose, it is said, a company is being organized.

Development

With a capitalization of more than $53,000,000, operations are being actively prosecuted by 125 separately organized mining corporations and the activity seems to be warranted by substantial results of nearly all deep development. More than half of the companies now in the field are sinking or prepared for deep mining. Ten have good milling ore opened up and four have large producing mines of proven merit. Mining operations are steadily increasing in volume and area; more than 2,200 miners are actually employed in the district and more than $25,000 per day is being expended for wages and equipment.

The approved method of prospecting is sinking to depths of 300 to 500 ft. and then crosscutting and drifting. Practically no surface work is carried on. Gas-engine hoists, compressors, and Jackhamer drills are the usual equipment. Usually also much lateral development must be done before pay ore in large quantities is found and the mine proved. The automobile, a prominent feature in the present activity, has taken the place of the burro in prospecting.

The cost of mining and milling is about $6 per ton, of which $1.25 is for power. The power at the larger mines is electric power supplied

by the oil-burning plant at Kingman. At the Gold Road mine, treating 200 tons of ore daily, the best record obtained for mining and milling is reported to be slightly less than $3 per ton. At the Tom Reed mine, however, where 20 stamps are used, the cost is about $6. There is said to be no profit in treating $5 ore in the district on a small scale. Both the Gold Road and Tom Reed mines treat their ore by the cyanide process, and have installed the counter-current decantation system.

From what has been said of the Tyro and Gold Road veins, and from the large number of other widely distributed profitable orebodies being found at depth and the cost of mining and milling, this is not a camp for the small operator but seems rather to offer encouraging possibilities for capital to engage in deep mining. The district has received the approval of many eminent mining engineers, a number of whom have become investors there and are now directors in some of the larger companies.

Topography

The district lies mainly in the Black Mesa Mountains, which, with an average elevation of 4,000 ft., extend from Gold Road 20 miles southward to the end of the range east of Needles. Their rugged forms are due chiefly to deep dissection of a huge volcanic plateau known as Black Mesa.

The district ranges in elevation from 2,000 ft. on the west and about 3,000 ft. on the east to 4,500 ft. at the top of the range. The range portion, which is about 4 miles in width, is marked by deep canyons, steep slopes, and peaks. In a horizontal distance of about 1½ miles, the surface declines from the elevation of 4,500 ft. at the crest to 2,500 ft. on Silver Creek just below Gold Road. The edges of the harder lava beds present steplike cliffs (Fig. 3 *A*).

The principal outliers are the Hardy Mountains, a group of hills situated about 3 miles west of Gold Road. They are about 3 miles in diameter and rise about 600 ft. above the surrounding country. Two miles to the north is a smaller group, the Moss Hills, while Leland Mountain at Vivian represents similar features on the southwest.

Geology

The Tertiary volcanic rocks prevail, particularly in the eastern or range portion of the district. They practically constitute the range, dip gently eastward toward its axis and are in places covered by younger rhyolite, andesite and basalt. In the southern part the green chloritic andesite is dominant, while on the west occur also local areas of the pre-Cambrian gneiss, younger granite porphyry and micropegmatite, greenstone agglomerate, and overlying sheets of supposed Tertiary conglomerate and younger gravel and lava flows. Locally intervening between the pre-Cambrian and the overlying volcanics are occasional remnantal patches of tilted and metamorphosed Paleozoic limestone and shale belonging to the Grand Canyon Section. These sedimentary rocks are not as yet known to have any bearing on the deposits or mining other than to indicate to the miner where encountered the general lower limits of the volcanics.

Recent mine developments have disclosed the geology of the ore-bearing volcanics to be more complicated and seemingly of more importance to the district from a gold-producing standpoint than was at first supposed.

In the vicinity of Vivian, and extending from there toward Oatman, occurs the older or basal andesite, which is light gray, calcitic, 300 ft. in thickness, and rests mainly on the pre-Cambrian complex and Paleozoic sediments. The older andesite, however, is not known to be of wide extent in the district, a fact seemingly overlooked by Bancroft and others. It is seemingly absent from Secret Pass where the next higher rock, the green chloritic andesite, rests directly upon the pre-Cambrian granite, and from the Hardy Mountains where the green chloritic andesite similarly rests upon the Mesozoic granite porphyry or micropegmatite.[3] It is not known to be present at the Gold Road mine, and according to Sperr[4] the rock underlying the green chloritic andesite in the deep workings of the Tom Reed mine does not correspond to the older andesite described at Vivian. The older andesite is unconformably succeeded by another series of flows, the green chloritic andesite which contains an important part of the mineral deposits in the Tom Reed-Gold Road district (Figs. 1 and 3*B*). The flows aggregate a known thickness of 800 ft. The rock consists mainly of a greenish, fine-grained groundmass containing abundant whitish feldspar phenocrysts. It is very chloritic and calcitic. It is intruded by black latite and younger lavas.

The intrusive character of the green chloritic andesite or rocks grouped with it is well shown at the head of the wash, just west of the Leland mine, where dikes from 2 to 20 ft. in width, given off from the main mass, extend ⅛ mile or more westward into the older andesite. A black, fresh-looking specimen of it collected by the writer from the Leland mine proved by microscopic study and chemical analyses to be latite, and it contains chlorite in abundance throughout.[5]

The intrusive nature of the green chloritic andesite and the association of ore deposits with its intrusive phases in various parts of the district are also abundantly corroborated by later work of Sperr, Probert, Bancroft, and other engineers. Probert[6] believes it to be both intrusive and

[3] *Bulletin No.* 397, *U. S. Geological Survey*, p. 35, and Fig. 2 (1909).

[4] J. D. Sperr: The Tom Reed-Gold Road Mining District, Arizona, *Engineering and Mining Journal*, vol. 101, No. 1, pp. 1–5 (Jan. 1, 1916).

[5] *Bulletin No.* 397, *U. S. Geological Survey*, pp. 36–37 (1909).

[6] Frank H. Probert: Oatman, Arizona—A Prohibition Camp, *Mining and Scientific Press*, vol. 112, No. 1, pp. 17–20 (Jan. 1, 1916).

extrusive, that dikes and sills of it occur in the older andesite and that mineralization is dependent upon this association.

Bancroft[7] writes that in the vicinity of the mines which he examined in localities rather widely scattered in the district, he found evidence of the intrusive nature of this formation, and that the orebodies are largely formed within the intrusive.

More recently, according to Smith,[8] the bottom as well as the collar of the Tom Reed shaft at 1,075 ft. in depth was in the green chloritic andesite which in the bottom of the shaft was ore-bearing, and he suggests that the rock may here be intrusive. The supposition of the rock being here intrusive, probably as a neck, would help to account for the unusual thickness of the formation at this point, which seems to be local, since elsewhere in the Tom Reed mine and in the neighboring United Eastern, Pioneer and other properties the workings, according to Schader,[9] passed through the green chloritic andesite and into the older underlying andesite at shallower depths and have workable ore in the lower rock.

Therefore, according to the observations of six or more investigators, the green chloritic andesite (formation) contains rocks which vary considerably mineralogically from the normal andesite, rocks with which the ore deposits in general seem to be associated and which are known to be intrusive into the older andesite. The most important of these rocks seems, to the present writer, to be the dark latite occurring at the Leland mine and elsewhere. It seems to intrude not only the older andesite but also the green chloritic andesite as sheets, necks and dikes, and to be intimately connected genetically with the ore deposits. More recently, Sperr,[10] whose observations in the district have been extensive, regards all the commercial ore as occurring in the andesites intimately associated with latites. The intrusive nature of the rocks associated with the ore deposits obviously favors continuity of the deposits in depth.

The deposition of the green chloritic andesite was followed by a period of great fissuring and faulting accompanied and followed by eruption of the next higher group, the undifferentiated volcanic rocks 2,000 ft. in thickness, containing the Gold Road and other important veins, and by intrusions of younger rocks, especially latite and rhyolite in the form of dikes, necks, and rounded plug or stocklike masses, and seemingly the formation of many of the larger fissure veins. The undifferentiated volcanics are succeeded by a series of younger light-colored tuffaceous

[7] Howland Bancroft: Geology of Gold Road District, *Mining and Scientific Press*, vol. 3, No. 1, p. 21 (July, 3, 1915).

[8] Howard D. Smith: The Oatman District, Arizona, *Mining and Scientific Press*, vol. 3, No. 5, p. 172–175 (July 31, 1915).

[9] Carl F. Schader: Personal letter, Feb. 6, 1915.

[10] J. D. Sperr: "Conversational Geology" at Oatman, *Engineering and Mining Journal*, vol. 101, No. 26, p. 1119 (June 24, 1916).

rhyolites locally 1,000 ft. in thickness and known as the "water rock," which is succeeded by dark reddish andesite which in turn is followed by black olivine basalt, the youngest of the effusive rocks, which remains as a capping over a large part of the Black Mesa Mountains.

With the extensive development recently done in the district, the rocks merit detailed study with reference to their sequence and bearing on the genesis of mineralization. Such a diagnosis seems certain to prove of great economic value in preventing useless expenditure of money in some directions and leading to profitable development in others.

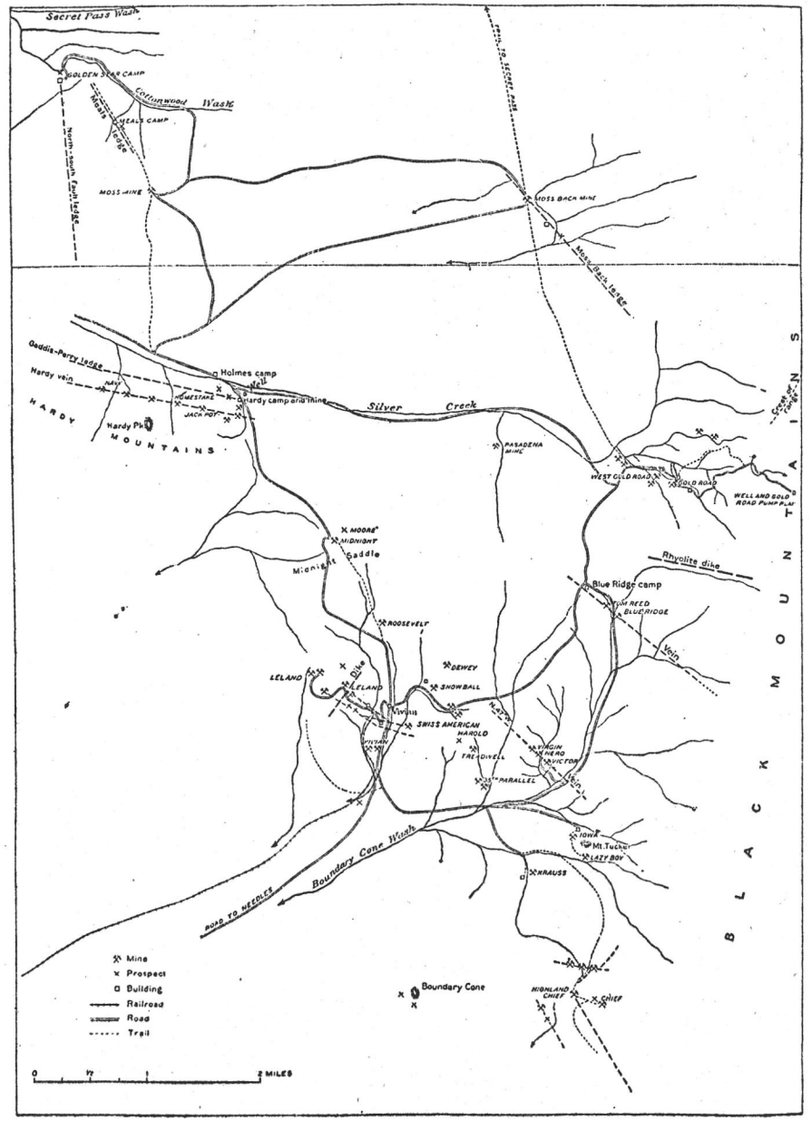
Ore Deposits

General Description.—The deposits, which are numerous, are chiefly gold-bearing fissure veins or lodes of the character already described for the Black Mountains. The veins vary from 5 to 70 ft. in width and from a few hundred feet to several miles in length. In general they are strong and persistent. They strike northwest with steep dip to the northeast. They are almost devoid of metallic sulphides, the gold being free. They occur chiefly in the lower part of the undifferentiated volcanic series, the green chloritic andesite, the granite porphyry and micropegmatite, other underlying rocks and also along certain contacts, where latite and rhyolite are generally the intrusives. Some of the deposits are very rich, but the large bodies of low-grade ore constitute the main resource. Ore having a metallic content of $10 or less is considered low-grade.

The older andesite, from the ill behavior and feathering out of certain vein deposits on entering it from the green chloritic andesite, was originally regarded by the writer as unfavorable for mineral, or essentially barren, particularly in the Vivian district. Owing to its tufaceous brecciated and fragmental nature it is almost devoid of lava-cooling shrinkage cracks and fissures, which elsewhere form favorable repositories for ore deposition. According to Palmer[11] "the occurrence of any ore shoots in the earlier (older) andesite is yet to be demonstrated."

Also, E. W. Brooks limits the area of commercial mineralization in this part of the field to the green chloritic or "younger andesite." Later developments, however, it is gratifying to note, in the Oatman and Vivian camps, report workable ore deposits in the older andesite also. It is hoped that with development similar reports may be received from several mines near Vivian which, though well-equipped for operations nearly a decade ago, have remained inactive. That the writer has never doubted that major veins probably occur in and below this formation is evidenced by the following statement: "The veins cut through the great mass of Tertiary volcanic rocks which characterize the range and un-

[11] Leroy A. Palmer: The Oatman District, Arizona, *Mining and Scientific Press*, vol. 113, No. 6, p. 195 (Aug. 5, 1916).



Bulletin 397, U. S. Geological Survey.

FIG. 6.—MINES AND VEINS IN THE TOM REED-GOLD ROAD DISTRICT.

doubtedly continue in depth into the underlying pre-Cambrian granitic rocks."[12]

According to Palmer,[13] "some ore of value has recently been found in the pre-Cambrian."

Since the deposits are confined to the vein filling and do not as a rule form metasomatic replacements in the wall rock, as at Cripple Creek and other camps, the selective preference which any bounding wall rock by reason of its more favorable physical or chemical properties for replacement may exert in favor of ore deposition seems to be practically nil. Accordingly, there is no apparent reason, other conditions being equal, why the deposits should not be equally developed in any one of several formations through which the fissure vein with like strength may extend.

The deposits consist of two types—those in which the gangue is chiefly quartz and adularia and those in which it is chiefly calcite. The source of the quartz and adularia is referred to the siliceous magmas and that of the calcite to basic or andesitic magmas with possible contributions derived from underlying limestones. The former carry the best values, occur mostly in the undifferentiated volcanic rocks and in granite porphyry and have a general northwest-southeast trend. The latter seem to occur mainly in the green chloritic andesite and trend more nearly north-south. Among the most important of the former type are the Gold Road and Tom Reed veins; among the latter, the Pasadena, Mossback and Meals veins (Fig. 6). In some cases the veins are associated with boldly cropping silicified dikes of which the deposits in certain instances may be in part replacement.

According to Platts,[14] the most productive veins, such as those in the Tom Reed, United Eastern, and Big Jim mines, are in a complicated series of fissures, part of which strike about N. 45° W., and others N. 60° W., producing with each other a conjugated system with numerous intersections near which many large orebodies are found.

Zones.—Surficially, the veins seem to mostly fall into four main zones[15] which, named in order from north to south, are the Gold Road, Tom Reed, Vivian, and Black Range zones. The Tom Reed zone is the best developed and contains the most interesting discoveries.

There seem also to be two or more horizons or vertical ore "zones." The largest and richest orebodies seem in general to lie in a "zone" of enriched oxides between the 300-ft. and 500-ft. levels. Below this zone

[12] *Bulletin No. 397, U. S. Geological Survey*, p. 48 (1909).

[13] Leroy A. Palmer: *Op. cit.*, p. 195.

[14] J. B. Platts: Geology of Oatman, *Mining and Scientific Press*, vol. 112, No. 23, p. 814 (June 3, 1916).

[15] Leroy A. Palmer: The Oatman District, Arizona, *Engineering and Mining Journal*, vol. 101, No. 21, p. 895 (May 20, 1916).

the ores decrease in value, but continue to be of workable grade beyond the deepest point yet penetrated by any working. The richness of this zone as suggested by Smith[16] is probably due to secondary enrichment, by contributions leached from shallower depths, in support of which the presence of vugs and manganese oxide in the upper part of the veins is cited. This view is also seemingly corroborated by the tendency of the zone to parallel the contour of the surface. For instance, its occurrence at about the same depth in the Gold Road mine as in the Oatman camp, though at correspondingly greater elevations and higher geologic horizons. The gold was probably precipitated in large part along with the manganese oxide.

If the thickness of 600 or 800 ft. assigned to the green chloritic andesite be correct, this ore zone in the Oatman camp or, more generally speaking, in the triangular area of several square miles comprised between the Tom Reed, Pioneer, and Pasadena mines, should lie mainly in this formation.

There seems to be also present, notably in the Oatman camp and vicinity, a shallow or surface ore zone of leached oxides to which pay ores found at or near the surface are generally confined. It extends to depths of about 150 ft., between which and the zone of enriched oxides, or 300-ft. level, lies a 150-ft. intermediate zone of leached or relatively barren ground, although the valuable ore shoots, according to Sperr,[17] almost without exception come at least within 100 ft. of the surface.

These two zones have probably suffered about the same amount of leaching, the upper zone certainly not less than the intermediate or barren zone. The upper zone seemingly owes its greater ore content to the more siliceous, and consequently resistant, character of the ore which accordingly better withstands the process of leaching.

Differing from the view of enrichment by leaching and redeposition in the main zone is that of Platts[18] which holds that the ore is essentially a primary deposit formed by heat ascending solutions, that from the nature of the gangue it is evident that acid solutions could not exist, and that, except for the oxidation of the pyrite, there is no evidence of the action of surface water on the ore.

It seems quite possible, as suggested by one writer, that the ground-water table in the district may be in part dependent upon the neighboring Colorado River. If this view be correct, physiographic study will probably be able to correlate certain horizon features of the vertical section as leaching, etc., with relatively prolonged pauses in the historical down-cutting of the river. It does not, however, seem safe to assume that the water table at Oatman coincides with the level of the Colorado River,

[16] *Op. cit.*, p. 173.

[17] J. D. Sperr: "Conversational Geology" at Oatman, Ariz., *Engineering and Mining Journal*, vol. 101, No. 26, p. 1119 (June 24, 1916).

[18] J. B. Platts: *Op. cit.*

which is 2,000 ft. lower than Oatman, and that therefore the ores if they persist downward will continue to be oxidized and of the same milling character to that depth as advocated by Palmer.[19] Owing to the greater elevation of the gathering zone on the east, which probably extends to the Hualpai Mountains, or longitude of Kingman, the ground-water table is not a level surface but gradually rises from the Colorado River, eastward, and at Oatman it probably stands several hundred feet or more above the level of the river.

Structure of Ore Shoots.—The ore occurs chiefly as a series of more or less tabular or lenticular ore shoots and pay streaks dipping and plunging variously within the vein, with which they exhibit a greater or less degree of parallelism. The shoots vary from 1 ft. wide to the width of the vein. They usually carry gold for their full width. They range up to nearly 1,000 ft. in length and depth, and there is a general similarity or repetition of the shoots in the same vein. They seem to have been formed by thermo-aqueous processes that followed igneous activity. In general, the quartz and values favor the hanging wall, which of the two walls is generally the best defined, and contains stringers branching off obliquely from the vein, while the spar or calcite favors the footwall. The gold is mostly associated with the quartz-adularia gangue and not rarely where sulphides have existed, it, according to Platts,[20] occurs in hematite (which is pseudomorphic after pyrite) in the quartz.

According to Palmer,[21] the first indications of the vein encountered in sinking are small stringers of quartz and calcite scattered through the andesite, usually accompanied by slight pyritization in the vein-wall andesite which yields a little free gold in the pan, while in the ore shoots the vein matter shows pronounced hematite and manganese stains. It is said that the problem in development is not so much the finding of veins as the discovery of ore shoots in the veins, that nothing sufficiently tangible has yet been found to use as the basis for a theory to guide the operator in the search for ore.

Though no rigid rule can be laid down to guide the operator in search for ore, nevertheless, from the apparently well-established facts that the metallic values have been largely imported by the replacement quartz-adularia solutions and that more gold is found where the replacement of calcite is most nearly complete, in formulating plans of exploration much benefit in most cases should be derived from a correlative study of the criteria indicating the probable courses followed by these solutions, namely, quartzose vein croppings, silicified wall rock, the quartz pseudomorphic structures, etc., which have been described. It was the quartz

[19] L. A. Palmer: The Oatman District, Arizona, *Mining and Scientific Press*, vol. 113, No. 6, p. 196 (Aug. 5, 1916).

[20] J. B. Platts: *Op. cit.*

[21] L. A. Palmer: *Idem.*, vol. 101, No. 21, p. 896.

adularia or siliceous waxy-appearing character of the deposits seen in the Tom Reed mine and the recognition of their marked similarity to the then-producing deposits of the Gold Road mine that apparently led to the resumption of operations in the Tom Reed mine following the writer's visit in 1907.

Gold Road Mine

Some of the principal mines in which the deposits have been worked are the Gold Road, Tom Reed, Leland, Pioneer, Victor-Virgin, Midnight, and United Eastern. Their general distribution is shown in Fig. 6. The most important producers are the Gold Road and Tom Reed mines.

General Description.—The Gold Road mine, owned by the United States Smelting, Refining and Mining Co., is situated at Gold Road, on the western rugged slope of the range about 1 mile below the crest, at an elevation of about 2,900 ft., mainly on the western part of the Gold Road vein. From its croppings, the Gold Road vein has long been known, but the discovery of values which resulted in the opening of the mine was made about 1902. The mine soon began to be worked systematically and paid dividends of 5 per cent. on the capitalization of $500,000. Several years ago it was acquired by the present owner for $1,500,000.

The mine is opened to a depth of 1,000 ft. or more, mainly by shafts and drifts, and ore has been mined in quantities for a distance of 4,000 ft. on the vein.

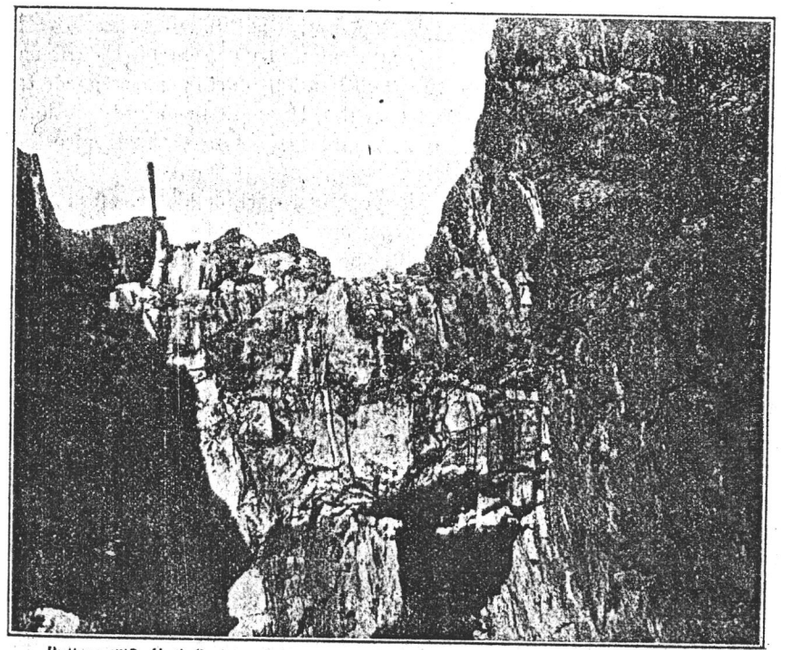
Most of the work done up to 1907 was comprised in the ground extending about 200 ft. from the main or Gold Road shaft (then known as the Gold Road mine), in either direction on the vein, and to the depth of 500 ft. Since then, however, extensive developments have been made, especially to the east on the Billy Bryan and adjoining ground.

The gross production of the property is estimated at more than $6,000,000. To the end of 1907 the production was about $2,250,000, most of which was made during 1905 and 1906. Since 1909, the output has averaged about $800,000 annually, which figure in some years was much exceeded. The present monthly production is nearly $80,000 in gold bullion.

Geology.—The country surrounding the mine is occupied by the undifferentiated volcanic rocks consisting mainly of heavy sheets of volcanic flows (Fig. 5). The series comprises andesite, trachyte, latite, rhyolite, and dacite, which aggregate nearly 2,000 ft. in thickness and are difficult to separate. The series extends from a point about 1,000 ft. west of the main shaft eastward nearly to the crest of the range. On the west it gives way to the underlying green chloritic andesite, which in the West Gold Road mine, situated near the contact, has been penetrated to a depth of 455 ft. On the east it is overlain by the upper rhyolite. The

contact on the west is probably a fault contact, as some of the green chloritic andesite occurs in the main shaft workings. The dominant dynamic structure is a pronounced close sheeting, which strikes N. 40° W., with vertical dip. The series is intruded by dikes of rhyolite and the younger dark andesite. Much of the rhyolite carries gold values. A dike of it, 40 ft. in width, located about 600 ft. south of the mine, is said to average about $5 in gold to the ton, the gold occurring chiefly in contained stringers of quartz and calcite.

Ore Deposits.—The Gold Road vein extends from a point about 700 ft. west of the main shaft southeastward through the Gold Road, Rail-



Bulletin 397, U. S. Geological Survey.

FIG. 7.—GOLD ROAD VEIN AT EAST OF LINE ROAD CLAIM, LOOKING NORTHWEST.

road, Billy Bryan and Last Chance claims to beyond the crest of the range, a distance of nearly 1¼ miles. It dips about 80° NE. approximately parallel with the close sheeting in the country rock. It varies in width from 22 ft. on the west to less than 1 ft. on the east. Between the bottom of the mine and the crest of the mountains it has a known vertical range of about 2,300 ft., and its croppings have a vertical range of about 1,300 ft. They consist essentially of iron and manganese-stained quartz, silicified rock, and calcite. In places they form conspicuous reefs or knobs rising 20 or 30 ft. above the surface, as at the main shaft or Gold

Road mine (Fig. 5). Here the associated hard silicified prominent wall-rock croppings on both sides of the vein have a lateral extent of 20 to 60 ft. The best ore usually underlies these prominent croppings, which seem to represent pool-like courses along which mineralizing solutions deposited more freely than elsewhere. Where the croppings weaken or break down, the underlying portion of the vein generally becomes lean or barren, though the fissure and its walls and filling may continue unchanged.

The vein consists essentially of quartz and adularia, with some calcite and brecciated altered rock, and is locally more or less crustified (Fig. 7). Since the more siliceous portions frequently exhibit a perfection of crustification not found in the calcic portions, and it is difficult to see how this structure could be derived from massive calcite by process of replacement, the quartz-adularia filling in the well-banded portions is regarded as largely primary rather than replacement. It seems to have been deposited in reopenings of the calcite vein and extension of the fissure itself eastward into the axis of the range.

In 1907, the vein in nearly all workings within 200 ft. of the main shaft and from the 300-ft. level to below the 700-ft. level was mostly good milling ore from wall to wall, the amount of waste in mining as shown by the dump (Fig. 5) being very small. Elsewhere, however, as seen on the Billy Bryan and other ground, portions of the vein, sometimes for a considerable extent, are relatively barren.

The vein is strongest on the west, where, as developed in the main shaft workings, it is uniformly about 10 ft. in width. It is usually in sharp contact with well-defined firm walls of the country rock, consisting of andesite, trachyte, latite, and rhyolite. It is, in general, "frozen" to the walls and is locally enriched where stringers extend from it at acute angles into the hanging wall. As a rule, hard and rough walls indicate good ore, and conversely, soft and smooth walls generally correspond with lean ore. The ore consists chiefly of fine-grained, light-greenish or waxy quartz Much of it is platy or hackly with a peculiar chalcedonic or drusy appearance. Much of it is pseudomorphic after calcite and many of the pseudomorphic plates are thickly studded with minute quartz crystals of a still younger growth. The gold, as seen microscopically, and in places by the naked eye, is very finely disseminated, principally in the quartz-adularia portion of the gangue. On the 600-ft. level, however, the vein contained more spar or calcite than on any other level, and here the ore shoot is reported to have had an uninterrupted extent of 1,100 ft. Some sulphide ore containing pyrite, the first encountered in the mine, was found here, and it is reported to have contained higher values than the overlying oxidized ore, which is probably due to arrest in the downward progress of leached concentrates. On the 700-ft. level, the country wall rock, consisting of green chloritic andesite, was more or

less pyritic and seemed to indicate that the mine was entering the sulphide zone. The mine has not produced much ore from depths shallower than the 300-ft. level. The lowest-grade ore taken out was obtained between the surface and the 300-ft. level, where it fell to $5 a ton. The ordinary mill-run ore, it is said, rarely falls below $8 or $9 and ranges from that up to $22 a ton. It averages about $10 to the ton, but $100 ore and upward is occasionally encountered on the hanging wall, where nearly all the high-grade ore occurs.

On the Billy Bryan claim, nearly ½ mile from the main Gold Road shaft, the vein and the associated rocks show essentially the same characteristics and relations as in the Gold Road mine. The variations and phases of the rocks are well displayed in the large dump at the mouth of the drift. The principal rock corresponds to trachyte. It is in general considerably altered. The croppings of the vein are prominent and wall-like. The vein varies from 1 to 20 ft. in width and dips, in general, steeply to the southwest instead of normally to the northeast. It consists mostly of spar or calcite, which contains bands of greenish quartz. Beyond the southeast limits of the Billy Bryan claim, and, in fact, to the end of the Railroad claim, quartz prevails and carries good values. The quartz is greenish with glassy luster and locally is very brittle, closely crustified, wavy, and crinkled, its structure resembling the fine flow structure of certain lavas. Weed,[22] having access to later development, described the vein filling as "the usual mixture of calcite flakes and waxy quartz varying to a dense waxy yellow quartz in curly or crinkled bands and shreds sometimes showing a faint blackish stain."

In the eastern part of the Line Road claim, and in a considerable portion of the Billy Bryan and Railroad claims, the vein has produced very rich shipping ore from surface workings, and it is under these workings, notably on the Billy Bryan and Railroad claims, that the Gold Road Co. in 1908 encountered good ore in depth.

In its extension eastward through the Last Chance claim, and across the crest of the range, the vein contains some good-looking croppings and openings, but it is split by horses at several points and locally narrows to unworkable dimensions. In August, 1915, the mine was reported to have good-sized bodies of $20 ore on the 800-ft. level, and in November it is said to have encountered on the 900- and 1,000-ft. levels a body of higher-grade ore than any hitherto found on the lower levels.

Recently it is reported that the vein as stoped averages about 12 ft. in width. Three ore shoots are being stoped on the 500-ft. level and at greater depths. These are respectively 1,200 ft., 70 ft., and 700 ft. in length, being separated by small intervals of barren ground.

[22] Walter Harvey Weed: The Kingman District of Arizona, *Mining World*, vol. 2, No. 23, pp. 1113–1114 (June 4, 1910).

Tom Reed Mine

General Description.—In the last year or two, owing to new discoveries, interest in the district has centered mainly in the Tom Reed mine and neighboring properties, wherefore this part of the district is known as the Tom Reed district or camp, Oatman district or camp, or simply Oatman. Here the geology and ore deposit are similar to those of the Gold Road camp, except that the deposits occur largely in lower geologic horizons in the green chloritic andesite and still older rocks (Fig. 3A). Some of the veins are "blind," being covered by later flows of rhyolite and younger rocks whose contact is traceable by the softened character of the contiguous weathered portion of the underlying rock.

The Tom Reed (formerly Blue Ridge) mine is situated at Oatman about 2 miles south of the Gold Road mine and about 200 ft. below it. It lies on open ground in Blue Ridge wash, near the base of the central part of the range, at an elevation of about 2,700 ft. (Fig. 3A). It is one of the well-known mines of the country and contains well-defined ore shoots, which for nearly a decade have been worked with great profit.

It was discovered about 1900 and was soon after owned by a party composed of Ely Hilty and others. About 1901, the Gold Road Co. sunk two shafts on the property, the Ben Harrison and the Tom Reed shafts, each to a depth of about 100 ft. with good results. About 1904, the mine was purchased by the Blue Ridge Gold Mines Co., which installed a mill and operated the mine and mill for about a year and a half, milling on an average about 30 tons of $7 ore a day. In 1906, the Blue Ridge Co. was succeeded by the present owner, the Tom Reed Gold Mines Co., which resumed operations in 1907, and in 1908 the mine was reported to be working and making gold bullion shipments regularly, since when it has been a steady producer. A little later a 12-ft. wide body of $12 ore is said to have been encountered on the 300-ft. level.

The property comprises a group of 11 or more claims, adjoining one another in part end on and extending along the vein for a distance of about 3 miles. The mine is located near the middle of the group.

Ore Deposits.—The country rock is mainly the green chloritic andesite. The vein, the Tom Reed (formerly Blue Ridge) vein, strikes about N. 50° W. and dips about 70° NE. It nearly parallels the Gold Road vein on the north and the Victor-Virgin vein on the southwest, to both of which it is geologically and mineralogically similar. On the Tom Reed property, it has an extent of about 3 miles, Fig. 6, and it is said to be continuous with the Pasadena vein on the northwest, in which event it has a length of about 4½ miles, being probably the longest vein in the district. At the Tom Reed mine it ranges up to about 40 ft. or more in width with the fissure walls usually ill defined. It outcrops boldly for the length of nearly two claims. The croppings consist principally

of the usual dark iron and manganese-stained quartz, silicified rock, and calcite.

The vein is mainly of the quartz-adularia-calcite type. Of the early-day ore, a considerable portion is reported to have run $25 in gold to the ton for the first 30 ft. in depth and about $12 from that point down.

In the Ben Harrison shaft and its workings, the vein has a width of 16 to 22 ft. On the 100-ft. level the vein consisted chiefly of 16 ft. of crushed quartz and rock with neither wall well defined; but toward the hanging-wall side there was 6 ft. of good-looking, more or less porous, clear quartz ore.

On the 150-ft. level the vein consisted mainly of crushed rock, but the footwall side of the drift was in quartz; the hanging wall contained vugs 6 in. to 1 ft. in diameter, containing blackish, porous, oxidized quartz ore.

Development.—The mine is opened to a depth of 1,400 ft. It has more than 30,000 ft. of underground work, with the longest drift extending more than 4,000 ft. out from the shaft and in ore nearly all the way. The production to June, 1916, was nearly $6,000,000. That for the year ending March 31, 1916, was $661,870.68, the average value of the ore being $22.12 to the ton and the extraction 98.6 per cent. Dividends paid during the year amounted to nearly $164,000, or 18 per cent. on the par value of the outstanding stock. By estimate 11,000 tons of ore were blocked out in the stopes at the end of the year. The mine has paid more than $2,500,000 in dividends. The net realization on the mine by June, 1913, was $3,019,569.75. By June 24, 1914, the 44th dividend had been declared. Later the mine was reported to be paying for the last several years monthly dividends of from 6 to 7 per cent. on the par value of the stock, and the ore then blocked out, by estimate $2,000,000 worth, was said to be sufficient to continue their payments for several years to come. By 1907 the production considerably exceeded $120,000, and that since 1910 is more than $5,000,000. The annual production for the last few years is reported to average about $1,200,000 in bullion, besides which a large tonnage of ore is accumulating at the mine, especially of $10 ore in the workings.

Up to June, 1913, much of the ore produced had been drawn from an orebody between the third and fifth levels, where about an equal amount remained, and this same orebody had been proven to a further depth of 200 ft. below the fifth level. The seventh-level drift, at this time 233 ft. in length, was all in ore of about the same average value as that on the fifth level. Recently, in the Black Eagle section of the mine, the crosscut on the 400-ft. level is said to have passed through 35 ft. of good ore, 30 ft. of which averages $25 to the ton, and the ore tonnage on the 600-ft. level is very large.

Later, good orebodies were reported on the 500, 600, 700, 900, 1,075,

1,200 and 1,400-ft. levels. The ore on the 1,200-ft. level is said to be similar in character and grade to that on the upper levels. Progress work on the 1,400-ft. level it is said has revealed a vein width of 12 ft. with a large orebody having a known extent of 300 ft., averaging $12 to the ton and containing some high-grade ore.

Explorations on the 1,075-ft. level for 225 ft. west of the shaft have shown the ore shoot throughout that distance to have a width of about 18 ft. and to range from $22.50 to $40 to the ton. On and below this level the vein is reported to be disturbed by a fault, but at the 1,175-ft. level it has fully recovered its former size and values.

Character of Ore.—The ore is similar to that of the Gold Road mine. It consists of a mixture of flaky calcite, waxy quartz, adularia, brecciated altered rock, and pinkish argillaceous material which is frequently of high grade. According to Weed,[23] a dense quartz whose color and luster closely resembles that of beeswax constitutes the richest ore. The ore is not hard and most of the gold is free, especially in the ore from the lower levels, but it requires fine grinding to free the finely disseminated gold and expose it to the action of the cyanide. The gold is seldom visible even in rich ore.

In milling, the total sliming system of cyanidation is employed, followed by treatment of the ore in Pachuca vats and Dorr thickeners. "Dorr thickeners," according to Smith, "appear to be particularly suited to conditions in this district where little silver is present, weak solutions are used, and the slime settles quickly." The ore amalgamates about 50 per cent. of its value on the plates and a high extraction is obtained at reasonable cost by cyanidation. In 1910, the average extraction was $42.46 to the ton. In 1912 it was $23.22. The amount of ore treated in 1911 was 39,447 tons; in 1913, 948,110 tons, with an average extraction of $24.09, and a recovery of 97.05 per cent. The average value of the ore mined in the fiscal year 1914 to 1915 is $21 to the ton. The gold is generally pure, the proportion of silver present being very small. The mill treats about 4,000 tons of ore a month.

Other Mines

Among the new properties which are attracting most attention is the United Eastern which adjoins the Tom Reed mine on the northwest and is often referred to as the "Bonanza." It is but a year and a half old, and is reported to have in sight, according to the estimates of conservative mining engineers, $11,000,000 worth of $26 ore. The mine contains more than 2,000 ft. of drift and has good orebodies on all levels between the depths of 300 and 700 ft. The vein is reported to be 43 ft. wide on the 555-ft. and 665-ft. levels, and the entire width is pay milling ore. Of this

[23] *Op. cit.*

width, 30 ft. proven for the distance of 650 ft. averages $40 to the ton and carries considerable free gold. Since August, 1915, daily shipments of $30 ore removed during development are being made to the Gold Road mill. A new 200-ton cyaniding plant, in which gyratory crushers and ball mills instead of stamps will be used, is being installed at the mine. The equipment will be adequate for sinking to the depth of 2,000 ft.

Many other new properties like the United Eastern are being opened up and in many of them good ore is being found at depths of from 200 to 500 ft. A score or more are worked by incorporated mining companies.

Extensive developments are being undertaken at the Pioneer (formerly German-American) mine by the Oatman Pioneer Mines Co. which by coöperation and use of its efficient machinery and 400-ft. level will immediately facilitate the exploration and working of adjoining properties. The Pioneer is on one of the three main lode outcrops of the district, and is said to have $1,000,000 worth of commercial ore in sight between the 400-ft. level and the surface. It is working on two veins of the 400-ft. level, of which the northeast, or Pioneer vein, has an 8-ft. oreshoot having a known extent of 600 ft. and averaging $16 to the ton, and on the southwest, or Snowball vein, the crosscut has penetrated a width of 16 ft. of good-grade ore with the outer wall not yet reached. On the 200-ft. level, a 2-ft. shoot of high-grade ore is being worked.

The Boundary Cone mine adjoining the Pioneer on the east has good ore on the 750-ft. level, and is said to contain a 5-ft. shoot of ore that averages $100 to the ton on the 200-ft. level. On the 500-ft. level, where the ore shoot has been proved for a distance of 90 ft., it has a width of 12 ft. and averages about $20 to the ton. The mine is credited with a considerable production of high-grade ore, some of which contained crystallized gold.[24]

In the Big Jim mine, a mile northwest of Oatman, the vein on the 400-ft. level is said to be 51 ft. in width, of which 46 ft. averages about $8 to the ton and 8 ft., on the hanging-wall side, $15 to the ton with some pay streaks which are very rich. On the 485-ft. level, the same ore shoot has been opened for the extent of 200 ft. and is good milling ore, most of which averages more than $12 to the ton. Here the ore is said to be more oxidized and silicified than on the upper levels. The vein parallels the projected course of the Tom Reed vein, but whether it is the northwestward extension of the Tom Reed vein which may here be faulted to the northeast, or a new vein, has not yet been determined. The mine is daily shipping about 30 tons of ore removed in development.

In the Carter mine, ½ mile south of Oatman, the main ore shoot, about 15 ft. in width descending from the 150-ft. level to the 400-ft. level, is said to contain 5 ft. of ore which averages about $30 to the ton, and 8

[24] W. P. DeWolf: The Tom Reed-Gold Road, *Salt Lake Mining Review*, vol. 17, No. 13, p. 16 (Oct., 1915).

ft. that averages $8 to the ton. This property is said to have shipped, several years ago, some very rich ore taken from between the surface and the 150-ft. level. This same vein is thought to extend through the adjoining Telluride and Lucky Boy properties, where on the 300-ft. level the entire width of 25 ft. is good milling ore.

The Gold Reed mine, a mile south of Oatman, has 4 ft. of $32 ore on the 375-ft. level.

On the Times property, the vein recently opened at 270 ft. in from the portal of the Martin tunnel, reveals 5 ft. of ore, averaging nearly $24 to the ton.

On the north, the Gold Ore mine, ½ mile northeast of Gold Road, is credited with a 9-ft. vein on the 500- and 550-ft. levels containing a 6-ft. shoot of ore which for the distance of 300 ft. averages about $12 to the ton, and a considerable portion of it nearly $100 to the ton. More than 75,000 tons of ore are said to be blocked out above the 550-ft. level. Daily shipments of ore averaging nearly $25 to the ton are made to the Gold Road mill.

The old Moss mine, where the original discovery of mineral in the Mohave County region was made, is being developed by the owners of the Gold Road mine and $60 ore is being mined from the 200-ft. level.

In the Ivanhoe mine, 2 miles northwest of Oatman, the vein, whose footwall is a partially mineralized 75-ft. "quartz porphyry dike cutting andesite and underlying sedimentaries," on the 250-ft. level, has a width of 60 ft., and on the 500-ft. level 6 ft. of milling ore has just been crosscut on the footwall side. Some high-grade ore has been shipped to the Gold Road mill.

Attention is also being attracted to the Secret Pass district, 6 miles north of Gold Road, which with a small mill is making considerable production mostly from high-grade surface ore. Here the occurrence is unusual, the ore, according to Payne,[25] being found chiefly as replacement deposits in the rock walls of a fissure occupied by a dike which the ore seems to postdate. The bullion, which is shipped to the U. S. Mint at San Francisco, is said to average about $15 to the ounce in gold. The population during the last few months of 1915 increased from 100 to 400, with prospecting extending over an area of several square miles.

At about 6 miles south of Oatman, promising deposits are reported in the Black Range zone, where a dozen companies are operating. Concerning the rocks in this part of the field, which have been roughly grouped with the undifferentiated volcanics, little is known as yet.

The deposits occur in a series of veins of which the one on which the principal mines are located is a prominent quartz outcrop known as the Nellie vein. It has been traced for the distance of several thousand feet and opened to the depth of 300 ft. on the Black Range, Nellie and Green

[25] C. Q. Payne: Oral communication.

Quartz properties. Associated with the more pronounced quartz replacement phase of the vein on the Black Range and Nellie ground, are said to be rich streaks of ore that show coarse gold when panned. The Black Range mine is said to have milling-grade ore of irregular occurrence on the 300-ft. level, of which 3 ft. averages about $30 to the ton. Here, also, the country wall rock extending along the vein, for a width of 60 ft. or more, is impregnated with replacement deposits and averages nearly $6 in gold to the ton.

In referring to the future of the Tom Reed-Gold Road district, some men favorably compare it with Goldfield, Cripple Creek or other large camps and hold that it will become one of the greatest gold-producing districts in the United States. Among the more conservative and seemingly reasonable views is that of Palmer,[26] who believes that it will become comparable with the Tintic district, Utah, that it will become a large low-grade camp with several producing mines which will yield dividends for many years to come.

Fields Similar to the Tom Reed-Gold Road District

Recent investigations[27] have shown that the southern end of the Black Mountains containing the Tom Reed-Gold Road district is the easterly one of a number of similar volcanic areas which extend interruptedly westward on either side of the railroad through the distance of nearly 100 miles to the longitude of Barstow, Cal. In these areas—which embrace the Mohave and Chemehuevis Mountains, the ranges west of Von Triger, Clipper Mountain, the Cady Mountains, the Newberry-Ord district, and the well-known Calico Mountain group and others—the geological and mineralogical conditions are very similar to what they are in the Tom Reed-Gold Road district. The areas lie from a few miles to 25 or 30 miles back from the railroad. Their volcanic rocks, which in character, recurrence, and succession, are in general identical with those in the Tom Reed-Gold Road district, range up to 2,000 ft. or more in thickness, are frequently well-mineralized, and contain strong veins. Most of the areas have been but little prospected, but some, as that of the Calico Mountain group, are productive.

[26] *Op. cit.*, p. 900.

[27] N. H. Darton and others: Guidebook of the Western United States, Part C, The Santa Fe Route, *Bulletin No.* 613, *U. S. Geological Survey*, pp. 142 to 162 and sheets 21, 22, and 23 (1915).

Discussion

J. Dana Sperr, Jerome, Ariz. (communication to the Secretary*).—Very little accurate information has been published about this district. Most of the geological data appearing in the technical press are based on "careful observations" made from an auto stage and a casual glance through the *U. S. Geological Survey Bulletins*, No. 340 of 1908 or No. 397 of 1909, both by F. C. Schrader. Mr. Schrader's report is still the best publication on the district. A really careful study of this report will uncover only a very few statements which have since proven questionable. This is a remarkable record when it is considered that only a short time was spent by Mr. Schrader in the field and that there was very little development work done at that time.

The mining world and especially Mohave County, Ariz., will feel a sense of gratitude to Mr. Schrader for revising his early report on this district and publishing it through the American Institute of Mining Engineers.

It would be absurd for me to dwell on general conditions, geological or otherwise, at this time, so I shall confine these notes to a few personal observations and opinions which may be of interest.

The "Conversational Geologists" delight in showing a proficiency in distinguishing the rocks of the district from hand specimens and proving Mr. Schrader wrong in the conclusion (erroneously laid to him) that the older andesite is non-productive.

One qualifying statement made by Mr. Schrader (p. 181 of *Bulletin* No. 397) in which he seems to have expressed one fact of greater economic importance than all the others combined, has generally been overlooked.

"So far as learned, the older andesite as a rule does not contain workable mineral deposits except along lines where the latite has erupted through it."

That statement is just as true today as it was 10 years ago. With the possible exception of the Big Jim, not a single commercial ore shoot is known to exist in the andesites which is not intimately associated with a latite. (In this district I prefer to use the name "latite" to classify any rock too acid to be an andesite and too basic to be a rhyolite. It is generally impossible to classify any of the intermediate rocks in the locality from hand specimens or even by the microscope. Mr. Schrader remarks that some of the rocks which he calls "green chloritic andesite" may be latite, so, what I refer to as a latite may, in some instances, be the equivalent of the "green chloritic andesite.")

It is impossible to classify positively the different rocks in the field, and nearly so with a microscope, owing to the extreme alteration which they have undergone. As engineer for the Tom Reed, I had some 50

* Received Jan. 17, 1917.

specimens examined by C. F. Tolman, Jr., of Stanford University and succeeded in getting three or four definite classifications. However, it is generally possible to map the different flows, at least over local areas.

There is in the district an andesite younger than the vein system, which is a little more basic than the biotite or chloritic andesite and resembles, from the descriptions, the older andesite. This later andesite is found as a capping to a depth of from 200 to 300 ft. on the Black Eagle claim of the Tom Reed. It probably belongs to the undifferentiated

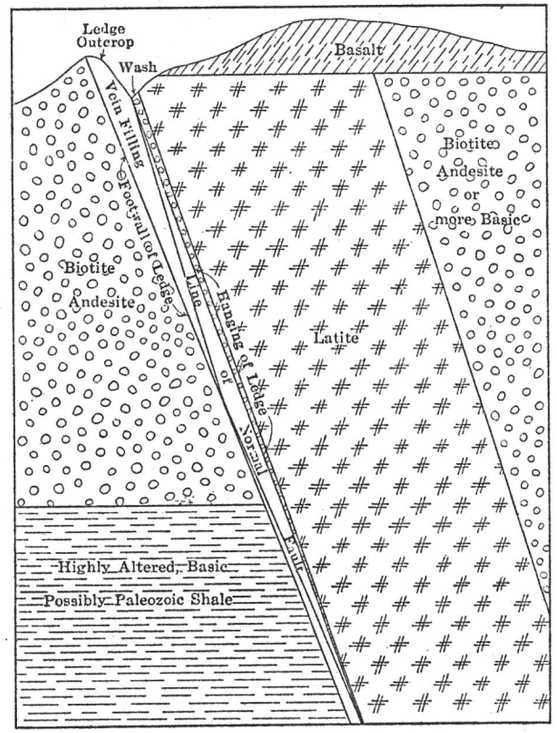


Fig. 1.—True Cross-Section of Tom Reed Zone, Oatman, Ariz.

series mentioned by Mr. Schrader. It accounts for the impression, frequently gained, that the older andesite is sometimes younger than the green chloritic andesite. I have thought it possible that the occurrence of an andesite under the green chloritic andesite described by Mr. Schrader might possibly be due to a faulting which had placed this still later andesite in a relatively lower position over local areas. This possibility might be supported by the fault, which I am informed exists, between the two andesites described as found at the Leland.

It must be noted that the physical appearance of different parts of the same flow may vary considerably. This fact, I believe, has led to some very erroneous conclusions. My notes show that the foot wall of the United Eastern mine is a nearly normal biotite andesite from where the shaft first penetrated the ledge to at least 600 ft. in depth, although the physical appearance of the rock at 200 ft. and at 500 ft. is decidedly different. Probably the same condition has existed in other places where the ore is reported to be found within the older andesite.

I cannot admit the intrusive character of the andesite of the Tom Reed, as the bottom levels show a nearly horizontal contact between the andesite and a basic rock which may possibly be an earlier flow or a remnant of the Paleozoic sediments. But the latite on the hanging wall is almost certainly an intrusive. This latite is green and chloritic, but the microscope shows it to be a nearly normal biotite latite.

Mr. Schrader notes that the gangue was primarily mainly calcite and dolomitic carbonates, but these minerals have been largely replaced by quartz and adularia. I have observed that the greater the amount of quartz after spar, as a rule, the richer the ore. Lower levels observed show a constantly decreasing amount of quartz with uniform decrease in the gold content. At depth the vein filling seems to grade into a pure spar. Bottoms of well-developed ore shoots show very little replacement. There is no questioning the continuance of the main fissures to greater depths than will ever be opened up. The real question is whether there will be a limit to the barren calcite zone and the conditions favorable to replacement again exist.

As to the vertical horizons, the richest ore ever mined in the district was found between 200 and 300 ft. in depth.

At the bottom of p. 217, Mr. Schrader outlines a general rule to guide the operator in search of ore, with which I am heartily in accord.

If a given vein or vein system in the district shows the quartz pseudomorphic structures, etc., mentioned, its development is an excellent gamble. But so far the calcite veins have proven too uncertain to be very safe.

A condition frequently observed is the occurrence of basalt plugs, often found on the strike of the main fissures. These plugs break up the continuity of the veins, sometimes reversing the pitch and causing other freaks. Some of these plugs come to surface and may even spread as a capping over a considerable area. Others do not reach the surface. Basalts seem to be good things to stay away from.

The accompanying cross-section through the Tom Reed zone may be of interest.

It will be noted that the main fissure is the line of a strong fault. While the amount of throw of this fault is not known, it is probably about 900 ft. The physical character of the rib of andesite on the hanging wall

of the ledge at the 900-ft. level is very similar to that of the foot wall at or near the surface. No further evidence is known to the writer as to the amount of the throw.

The fault plane marked through the vein filling is a post mineral slip, very regular and distinctly traceable. I recall the first time I observed this slip. A raise had been driven carrying this slip as a foot and as I climbed through the raise I thought it had been concreted, the wall was so smooth and even. Deep vertical striations are the only irregularities.

The latite shows an intense crushing action wherever opened. In early work it generally appeared that the latite was the line of a main fault, but finding andesite on the hanging wall opposite a lower rock on the foot rather disproves this theory.

The andesite found on the hanging wall of the latite does not appear to be the same andesite within which the ledge occurs. It may be a glassy phase of the biotite andesite, but probably it is a more basic variety.

Angular inclusions of the andesite have been found within the latite 50 ft. from the actual contact. This seems to be characteristic of the latite andesite contacts in this zone.

Microscopic examination showed a resorption by remelting of the phenocrysts within the border of the andesite on the foot of the latite intrusion.

All of the rocks show an intense hydrothermal action. Practically all of the specimens collected were too highly altered for accurate determination. All but the latites show high oxidation. Pyrite in fine cubes is the strongest characteristic of this latite.

The drawback to mining is the high cost of prospecting, but when it is remembered that one United Eastern will pay 6 per cent. on 50 or more well-financed prospects and one Tom Reed will do over twice as well, the gambling chances will not seem so discouraging.

JOHN B. PLATTS, Hawthorne, Nev. (communication to the Secretary*).—I will confine my remarks to the Oatman district and to two points in which my ideas are in opposition to those of Mr. Schrader.

First, regarding the older andesite (or earlier andesite), I note that Schrader admits that this formation has greater importance in the district than he allotted to it in his former report on the district. Schrader was the first to describe the older andesite, and it is for him to say what it shall include, but in my work I have taken it to include everything between the Paleozoic and the base of the green chloritic andesite. Between these limits may be found not only the rock described by Schrader near the Vivian mine, but a number of variations from this type. The rock is always light gray in color and is nearly always in the form of consolidated tuff, or breccia and tuff, but sometimes appears as hard uniform lava flows. I was able to trace this formation on the sur-

* Received Jan. 2, 1917.

face from a point near the Ivanhoe mine to a point several miles south of the Black Range mine, a total distance of about 8 miles. In some places, notably near the Gold Range shaft, the beds of tuffaceous andesite are intercalated with thin beds of limestone. The older andesite beds may often be distinguished from the overlying formations by the difference in dip. They dip from 15° to 20° eastward and the upper lavas dip from 4° to 5° eastward. The upper surface of the older andesite forms a wavy contact with the overlying andesites, indicating a former rolling surface in an advanced stage of erosion. This indicates a long time interval between the eruption of the older andesite and the succeeding eruptions. It would seem that there was first a series of island volcanoes followed by quiet and elevation into continuous land. After a period of erosion and tilting, volcanic activity broke out afresh in the eruption of the green chloritic andesite and after a short period of quiet, the latites. After another short period of quiet the rhyolites were intruded in the form of thick dikes and stocks.

The second point has to do with the genesis of the orebodies. Schrader regards the profitable ore as the result of secondary enrichment, and says, on p. 216: "The gold was probably precipitated in large part along with the manganese dioxide." Statements similar to this have been made by a number of writers. So far the only tenable hypothesis to explain secondary enrichments in gold deposits is that proposed by W. H. Emmons. His idea is that manganese dioxide acts on chlorides, setting free chlorine which acts on any gold present, forming gold chlorides. These being soluble in cold acid water, are carried away and precipitated on the first reducing agent or alkaline substance encountered. It is evident that the gold deposits will not be found with the manganese dioxide but with the precipitating agent. Miners working in gold veins containing rich bunches in the oxidized zone are familiar with the idea that the gold will be found in the iron-stained quartz and that the black manganese stains indicate barren spots. It is evident from the chemical nature of calcite that gold chlorides cannot form in its presence, and that it can only act as a gangue for secondary gold when it is absent from the greater part of the vein that held the primary gold, both from the vein matter and from the walls.

It is unnecessary to enlarge on the application of the above principles to Oatman veins. There the wall rock is so calcitic that it will effervesce with weak acids, as limestone will. The gangue of the largest veins, including the most important so far found, such as the United Eastern, The Big Jim, and the Aztec, contains rather more calcite than quartz. It is, therefore, evident that any secondary gold deposits must be extremely localized and relatively unimportant.

The rhyolitic intrusions seem to be a more probable source of the gold-bearing quartz than the latites. Gold and silica dissolved with

alkaline sulphides could have been driven off from them through cross fissures and the more permeable andesite beds, passing outward and upward until they encountered andesite dikes in the case of the prominent siliceous outcrop veins, and calcite bodies in the case of the three large mines previously mentioned. Incidentally, the finding of these large non-outcropping orebodies does not favor Schrader's idea that the siliceous outcrops are a guide to the finding of profitable ore. Also, a number of cases might be cited where prominent outcrops have proved to be the tops of unprofitable veins.

JOHN CARTER ANDERSON, Kingman, Ariz. (communication to the Secretary*).—From an extended study of the Oatman and Secret Pass districts of Mohave County, Arizona, I believe that the genesis of the ore deposits, in most cases, is directly connected with rhyolitic intrusions later than the Tertiary flows; and that the developments of the future will prove these intrusives to be the primary source of the ore.

In support of this opinion I will instance the Wilhelm-Eclipse dike in Secret Pass and the Murdock, Nellie, Black Range dike and ledge in the southern part of the Oatman district.

The Wilhelm-Eclipse dike is a very fine-grained light-colored siliceous rhyolite dike with a strike of N.45W. traversing the full length of the Secret Pass district about midway between two major faults which mark the easterly and westerly boundaries of the district. These faults have lifted the block between so that erosion has exposed the pre-Cambrian granitic complex which underlies the range. The geological conditions present on surface are, therefore, analogous to what would probably be the 2,000-ft. level of the Tom Reed mine in Oatman, or several hundred feet deeper than the deepest opening in that mine. From the Wilhelm group of claims in the southeast end of the district, where the granitic complex is best exposed, to the Nancy Lee mine at the other end of the district, the surface rises several hundred feet. About one-third of the way from the Wilhelm to the Nancy Lee the granite is overlain by the green chloritic andesite. The dike is opened by several shafts from 40 to 200 ft. deep, the deepest being on the Eclipse claim just below the contact between the andesite and the granite. In every opening ore has been exposed. The gold is all fairly coarse as compared with the Oatman gold and some seams and streaks of high-grade have been cut which show wire gold up to ½ in. in length.

The high-grade ore is usually found in the rhyolite along the foot-wall contact. In the high-grade the gold occurs principally along seams and fracture planes in the rock, or in recementing quartz veinlets showing visible free gold. A cross-cut from a 50-ft. shaft on the Wilhelm cuts 45 ft. of rhyolite which is very much shattered and open, with a great deal of manganese dioxide in shrinkage cracks and fracture planes,

*Received Feb. 14, 1917.

and carries from a trace to several dollars in gold. The rock is heavily impregnated with hematite, which is clearly pseudomorphic after pyrite; and carries the best values where least altered and the poorest where the manganese is most abundant. At the Nancy Lee, where the thickness of the green chloritic andesite above the granitic complex is several hundred feet, the dike cuts a quartz and calcite cross-vein similar to those of the Oatman district, some good values resulting in the quartz vein near the intersection.

Similar conditions are being disclosed by the development of the property of the Murdock Mining & Milling Co. in the Black Range section of the Oatman district. Through the kindness of Mr. Porter, the General Manager, I have been able to learn of the results of their underground work.

The Murdock property is situated just southwest of the Boundary Cone and covers the extension of a mineralized rhyolite dike. Eastward from the end line of the Murdock the dike is largely covered by wash in its course through the property of the Oatman Syndicate. Still farther eastward its place is taken on the property of the Nellie by one of the typical quartz and calcite veins of the district.

The country rock at the Murdock is the older, or basal andesite, which directly overlies the pre-Cambrian granitic complex. An exposure of the granitic complex is to be seen just south of the dike. A cross-cut on the 300-ft. level from a shaft sunk in the hanging-wall andesite, after passing through 82 ft. of rhyolite and a 12-ft. contact ledge on the foot wall, cuts the granite. At the Nellie the country rock on the foot-wall side of the vein is the basal andesite, while the shaft sunk in the hanging wall was in the next higher flow of trachyte for 250 ft. There is a cross-fault between the Nellie and the Murdock and the block in which the Nellie is located is relatively downthrown with reference to the Murdock.

The rhyolite of the dike on the 300-ft. level of the Murdock is heavily impregnated with hematite and assays low in gold for the full width. The character of the rock, the mineralization, and the gold content are exactly similar to that in the Wilhelm-Eclipse dike coming from the same geological horizon. In both instances the gold is free, relatively coarse as compared with the gold in the producing mines, and is contained in the heart of the hematite.

At the Nellie, the vein filling on surface and where cut on the 350-ft. level is largely calcite and a pseudomorphic replacement by quartz and adularia; but one specimen from the 350-ft. level, said to be from the highest-grade streak cut, was quartz and rhyolite impregnated with hematite and identical in character with the rhyolite of the Murdock.

As the dip and strike of the dike on the Murdock and the vein on the Nellie are practically identical and the connection can be traced on

surface, I believe that a rhyolite intrusion, exposed by the deeper erosion on the Murdock, came up along a preëxisting fissure already filled with a calcite vein filling and that the solutions emanating from the dike were the agencies by which the calcite was replaced wholly or in part by quartz and adularia and the vein filling impregnated with auriferous pyrite.

This connection between the rhyolite dikes and the quartz and calcite ledges of the district cannot elsewhere be traced so conclusively, as few rhyolite dikes have been exposed by the erosion in the areas covered by the Tertiary flows. In the eroded areas, as at Secret Pass, however, the intrusive dikes are as frequent as veins in Oatman, and I believe that deeper development in Oatman will result in discovery that the ore-bearing quartz and calcite-filled fissures connect in depth with rhyolite dikes having a primary auriferous pyrite in the body of the dike; and possibly a richer contact vein between the dike and the granite.

In drifting along the contact vein exposed on the 300-ft. level of the Murdock, according to Mr. Porter, alternating small shoots of rich and lean ore have been cut; the face of the drift for several feet of advance at times averaging as much as $50. Specimens of this ore appear to be composed largely of brecciated and recemented rhyolite, similar to the high-grade ore from the Wilhelm-Eclipse dike, and show free gold in hematite and in the recementing quartz veinlets. It is probable that at points of greatest shattering, as at intersections and crossings, this recementing will be sufficient in extent to form good-sized shoots of high-grade ore.

Further evidence in favor of the rhyolite as the source of the primary ore is found in certain silicified flows which carry low values wherever sampled. The average of a number of samples recently broken by the writer at random from a silicified surface flow of rhyolite over four claims was 82c. per ton.

What the tenor of the primary ore will be, it is impossible to say, as the oxidation of the pyrite, and possibly the impoverishment of the primary ore, extends below the deepest workings in the district. There are undoubted evidences of leaching and reënrichment in the higher horizons of the veins, probably as a result of the percolation of surface waters later than the original deep-seated oxidation of the pyrite. A similar leaching of a portion of the gold in the primary ore may have accompanied the oxidation of the pyrite to depths as yet unknown. The nearest approach to an approximation of the value of the primary ore is found in the values cut in the body of the dike at the Wilhelm on the 50-ft. level and the Murdock on the 300-ft. level, and I believe that the values which will be found below the present water level of the Wilhelm will be higher than those in the cross-cut on the 50-ft. level.

With reference to the pyritic andesite cut on the 700-ft. level of the Gold Road mine indicating the near approach of the sulphide zone, it is

my observation that this pyritization of the green chloritic andesite is characteristic of the wall rock, usually on the hanging wall, in a number of instances, and the unoxidized pyrite extends practically to surface, where that formation is exposed on surface. Among the places where I have noticed this occurrence of pyrite in the wall rock is the cross-cut into the hanging wall on the 200-ft. level of the Black Eagle mine of the Tom Reed, in the hanging wall of the 300-ft. level of the main Tom Reed mine, in the cross-cuts on the 300-ft. level of the Oatman Amalgamated and in two places in Secret Pass. The oxidation that has taken place in the veins to an unknown depth seems to have had little effect on the pyrite in the wall rock. This is probably due to the fact that the water of the district is almost wholly confined within the walls of the vein itself. In only one instance that I know of does the pyritic wall rock carry gold minerals. That is at the Orphan group of claims, now the Secret Pass Gold Top Mining Co., in Secret Pass. Here the ore from a winze which enters the pyritic andesite at about 50 ft. carries $8 in gold.

This is the property spoken of by Mr. Payne. The mineralizing solutions here have come up along a major fault which marks the westerly boundary of the Secret Pass district, spreading out irregularly into the wall rock. Several thousand dollars worth of high-grade ore from a shallow glory hole were milled in a two-stamp Tetrault mill by leasers, and a considerable tonnage of surface ore running from $8 to $15 per ton in gold was opened up. This fault is later than the Tertiary flows and the rhyolite intrusions which it cuts. It is easily traceable for several miles and just east of the Orphan mine has lifted the pre-Cambrian granitic complex to a contact with an andesite later than the green chloritic andesite, which in Secret Pass immediately overlies the granite. The granite on the foot-wall side is irregularly mineralized, and in several places high-grade gold ore has been found in prospect holes.

One other ore occurrence in Secret Pass is worthy of particular notice. A rhyolitic dike of a somewhat coarser texture than the Wilhelm-Eclipse dike and having a strike of N. 35 W. which is paralleled by the major fault marking the easterly boundary of the mineralization of the district, has mineralized the granite for from 25 to 35 ft. on each side of the dike. The granite is stained a deep red by iron oxides and a sample across 23 ft. on the foot-wall side of the dike at a depth of 12 ft. assayed $4 in gold. No deeper development has yet been undertaken on this ledge.

Fuel in Turkey

BY LEON DOMINIAN, NEW YORK, N. Y.

(Arizona Meeting, September, 1916)

CONTENTS[1]

I. INTRODUCTION

APART from local needs in the country's development, the interest attached to Turkish fuels grows chiefly out of the importance of the railway industry in Asiatic Turkey. Geographical conditions make of the tracks in this region the most essential link in a chain of world-girdling lines. By its position Asia Minor can be likened to a bridge in the through routes destined to connect European factories with Asiatic and African markets. An uninterrupted right-of-way from points in central Europe to populous Indian cities must necessarily pass through the valleys of Anatolia. Crossing thence the Taurus Mountains, its natural passage is indicated as the Mesopotamian lowland and the shores of the Indian Ocean. Similarly, land connection between Europe and Africa can be obtained only by passage through Asia Minor, Syria and Palestine.

The occurrence of fuel within an area of such significance from the

[1] Part of the notes on Coal have already appeared under the writer's name in The Coal Monograph published by the Twelfth International Geological Congress. These are presented here in revised and amplified form.

The principal development in 1907 consisted of 12 or 15 shafts ranging from 25 to 60 feet deep and about 500 feet of drifts.

The mine has long been idle. It was worked by a room-and-pillar method; the cover over the flat vein was relatively shallow. Prospecting was done through shallow shafts. The ore was pulled up a slight incline out of the mine then up to the mill bins.

The remnants of a cyanide plant are still on the ground.

Hall

The Hall mine is situated in the southern end of the district in granite. The vein is steeply dipping, varies in thickness up to 2 feet and is associated with diabase dikes. The vein filling is mostly quartz, some being of the honeycomb variety. Some of the ore was very rich.[41] In 1907 a 24-ton mill was being operated at the mine.

The mine was developed in 1907 by a 210-foot shaft and two levels with 200 feet of drifts.

Great West

The Great West mine is near the Hall. The vein is about 3 feet wide and consists of iron-stained quartz. The ore in 1907 was reported to run from $10 to $80 per ton. Fifty tons were shipped to the Kingman sampler in 1926.

Pocahontas

The Pocahontas mine is near the Hall. It is developed to a depth of 200 feet by a shaft and drifts. A cyanide plant had just been built in 1907 to replace an amalgamation mill.

Gold Bug district

The Gold Bug district is near the summit of the range 3 miles north of the Mocking Bird district, 3 miles south of Eldorado Pass, and 30 miles northwest of Chloride. The veins dip steeply and occur in a volcanic rock. The district was busy in 1907, when Schrader visited the area. It was long idle, but in 1935 some interest was again being shown in the area. In addition to the following mentioned mines, work has been done on a number of properties in the district.

Gold Bug

The Gold Bug has been the principal producer in the district. Early operations ceased in 1908. Some development work was done in 1931 and a small tonnage of ore was mined in 1932. In May 1935 Joseph Gardner and partner, lessees, were shipping to the Tom Reed mill. In a year's time 290 tons had been shipped; a 5-ton lot of selected ore ran $72 per ton and 285 tons ran from $14 to $26. The ore came from a shoot 60 feet long in a vein 2 feet wide on the 90-foot level.

41/ Schrader, F. C., work cited (see footnote 40).

The mine is developed to a depth of 512 feet by a shaft and 5 levels. Open-stope method of mining was used; some waste was sorted out and left in the stopes.

Top-of-the-World

The Top-of-the-World is 29 miles from Chloride and 2-½ miles from the old Kingman-Boulder road. The mine had been idle for about 20 years. The dump shows that considerable underground work had been done; no production data are available.

In May 1935 Arthur Black and three associates had a bond and lease on the property. Three men were taking out some high-grade ore about one-half mile from the main workings.

The country rock is gneiss and granite. A ridge of rhyolite and another one of andesite are near the new workings. The vein consists of a number of fractures cutting the formation. The ore consists of a 6-inch streak of quartz; it contains about 2 ounces of gold to the ton. The gold is free and visible to the naked eye in places. The ore shoot is small. No values are found beyond the 6-inch streak. An open-cut was being made on the ore at the side of an old 30-foot shaft. The cut was down 15 feet at the time of visit. A small shipment had been milled with Gold Bug ore at the Tom Reed.

Mojave Gold

The property of the Mojave Gold Mines Co. is about 1 mile west of the Gold Bug. A camp was built in 1934 and a 112-foot shaft sunk and 500 feet of lateral work done on the 40-foot level. In May 1935 only a watchman was on the property.

Golden Age

The Golden Age is about 1 mile north of the Gold Bug. J. H. Omie, owner, with one man was getting out a shipment from the vein at the surface in May 1935.

The country rocks are schist, granite, and porphyry. The vein dips 25° and is 1 to 6 feet wide, averaging 3 feet. The ore occurs in bunches. A drift has been run 125 feet on the vein.

Eldorado Pass district

The Eldorado Pass district is in the northern part of the range at the Eldorado Pass at an elevation of 2,500 to 3,000 feet. The topography is one of gentle relief. The country rock is granite intruded and locally overlain with volcanic rocks. Schrader briefly mentioned the district but did not describe the individual mines. There has been some minor activity in the area during the past few years.

Pope (Expansion)

The Pope mine is at the side of the old Kingman-Boulder road 32 miles from Chloride on the east slope of the range.

In May 1935 Ben Fortner and Peter Wilson were working the property under a lease and option. In the 4 months previous to May 1935 10 cars of ore had been

shipped to a Utah smelter. Water for mining purposes was hauled 10 miles from the Colorado River.

The mine is developed by a 100-foot 1-½-compartment shaft with drifts on the 50- and 100-foot levels. The shaft was sunk in 1927 and ore was shipped from a stope on the 50-foot level and from another on the 100-foot level. One 50-ton car of ore gave a return of $1,100.

The vein occurs in the granite, dips 70°, and on the 50-foot level is 1 to 3 feet wide. The high-grade ore occurs in lenses in the vein. Low-grade ore adjoins that which can be shipped. A shoot 50 feet long and with a rake of 40° had recently been mined from above the 50-foot level. One carload ran $100 per ton and nine others about $50 per ton; the total net from the smelter was $11,000. The cut-off for shipping ore was $40 per ton.

The ore, besides gold, contains some lead carbonate and a reported trace of vanadium. No galena had been found up to May 1935. The ore is different in character from any other found in the range. The ore was being mined by an open-stope method in 1935. Two chutes were used in each stope. The ore was hoisted in an 800-pound bucket.

The equipment consisted of an 8-horsepower gasoline engine, a one-machine-capacity portable compressor, and a 20-ton bin.

The ore was trucked 53 miles to Kingman for $3.50 per ton. It was loaded from the bin and shoveled into cars.

Hoover

The Hoover mine is near the Pope. It is developed by a 100-foot shaft. A lessee shipped 5 tons of $60 ore to the Tom Reed in the spring of 1935. The shaft had been sunk within the last 2 years.

Other mines

Schrader mentions the Burrows, Bogg, Young, and Pauley as the principal mines in the district in 1907. He states that the Burrows had a reported production of $10,000.

SUMMARY

Gold deposits occur throughout the Black Mountains of western Mohave County. Gold is the only valuable metal (except a minor amount of associated silver) found in the range; there is a remarkable similarity in the occurrence of gold in the veins.

Several periods of activity have occurred in the range with relatively quiet periods between. The first mining was in the early sixties, when some rich surface deposits were found. At the beginning of the century work was being done throughout the range at a large number of deposits. The greatest activity in the Oatman district was between 1917 and 1924 during the life of the United Eastern, from which $14,000,000 in gold and silver was produced. The so-called "Oatman boom" occurred at this time, and considerable unproductive work was done on

wildcat promotions. After the boom, production fell off gradually, and at the beginning of 1933 the area outside of Oatman, where one small mine was operating, was virtually deserted except for desultory work by a few lessees.

Interest was revived in the range when the higher price of gold was established. The Tom Reed and Katherine mills were again put in commission and began taking custom ore; before long more custom ore was being offered than could be accepted. This condition persisted up to the time of writing (spring, 1935). The Tom Reed, Gold Roads, and other old mines were reopened. Important new ore bodies were discovered in the Tyro, Ruth-Rattan, Portland, Minnie, and other mines. One new mill, the Pilgrim, was built in 1934. This was at an old mine with a negligible previous production. The total production to the end of 1933 was $37,000,000 in gold and over $600,000 in silver.

Datman on San Francisco Dist.
Mohave City. AZ

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXXVI.—*On some of the Mining Districts of Arizona near the Rio Colorado, with remarks on the Climate, &c.;* by B. SILLIMAN.[1]

Itinerary and characteristics of the Mojave Desert.—In July, 1864, I visited the Colorado river for the purpose of seeing some of the mineral districts near Fort Mojave. The route followed was from Los Angeles in California by the Cajon Pass and Mojave Desert to Fort Mojave. After leaving the vineyard of Cocamunga the journey is made by encampments. The distance from Los Angeles to the Colorado is about 250 miles, which we made in nine encampments. Few of the stations on this route are laid down on any of the published maps, and are generally watering places only, the whole distance being an uninhabited wilderness, nearly destitute of the means of supporting life. The Mojave desert is entered at the summit of the Cajon Pass, where the road passes through a dug way in masses of sandstone, upturned beds of, probably, Tertiary age. The highest point of this pass is (by barometer) about 4000 feet above tide, and is distant about 25 miles from Cocamunga vineyard. The Mojave river is passed at the 'upper crossings,' about 20 miles from the 'Toll Gate' of the Cajon Pass, and at an elevation of about 2650 feet. The Mojave river, as is probably pretty well known to most readers, is a river in name only, existing, so far as it has water at all, as a series of lagoons with long intervals where not a trace of water can be found. At the so-called

[1] Read before the National Academy of Sciences at Washington, D. C., January, 1866.

'Upper Crossings' it is seen a few inches deep, flowing with a gentle current eastwardly over a pebbly bottom, but disappearing in a short distance, and never appearing again as a running stream. At the Fish Ponds, Camp Cady, and the Caves, the water re-appears but only in stagnant or torpid pools. The line of the river is however perfectly well marked by rounded boulders and smooth river shingle, and along its dry banks grow some shrubs of which the the so-called willow (a bignoniaceous plant with narrow willow-like leaves) is the most conspicuous, and more rarely the Mezquit bean of the Mojave Indians (*Cercidium Floridium*).

The rough road, often very difficult for an ambulance, follows the dry bed of this so-called river, the grade being pretty steadily downward from the 'Pass' to Soda Springs, 150 miles or thereabouts from the Toll Gate.[3] At Soda Springs the barometer stood at 29·355 inches, being the lowest point in the desert of the Mojave, and differing, by the mean of my observations, only 0·195 in. from the level of the Rio Colorado at Fort Mojave.

Soda Springs marks the site of an ancient lake, the surface of the saline plane being as level as the sea. A powerful spring of calcareous water breaks out on its western margin, charged with sulphate of lime, and bearing, among the ignorant guides of these desert regions, the reputation of containing arsenic or some other deadly metallic poison. We drank freely of it, however, with no ill effects to man or beast, and were very glad to obtain so potable a water after several days of great dearth of this essential of comfort.

The term 'Soda Spring' is a misnomer, as the water is destitute both of carbonic acid and alkalinity (it did not affect reddened litmus); has doubtless received its name from its bright sparkling appearance, so much in contrast with the green stagnant water of the 'government holes,' or wells, dug by the roadside for the supply of travellers.

A gigantic fly abounds at Soda Springs and Marl Springs. They were such an annoyance to our animals as to compel us in each case to move on before we were ready, to avoid the torments they inflicted on the poor beasts with their sharp lancets, drawing blood every time when, with a droning sound like that of a humble bee, they struck the skin. They seem to attack the animals in preference to men, as none of our party suffered from them.

From Soda Springs—"the sink of the Mojave"—the road, going toward the Colorado, rises in 25 miles to "Marl Springs"

[3] An adventurous pioneer on the outskirts of civilization has erected a toll gate just before entering the Cajon Pass, where he exacts a fee of all passers in return for some labor bestowed upon the road at that point; this 'black mail' is cheerfully paid to the self-constituted supervisor.

nearly 3000 feet, and thence in 18 miles farther, at 'Rock Springs,' it reaches an elevation of nearly 3800 feet above Soda Springs. From this point it rapidly descends again in 23 miles to Pah Utah creek, about 1800 feet, and from that point the grade is rapidly descending to the Rio Colorado at Fort Mojave, falling in 24 miles a little over 2000 feet.

Climate at Fort Mojave and vicinity.—Dr. John Stark, Post-surgeon at the military station, Fort Mojave, has kindly furnished me with a copy of his record of temperatures kept at the fort for one year, from Nov., 1863, to Oct., 1864. The following table of monthly averages, prepared by me from Dr. Stark's observations, for the three daily periods of observation, is of interest in this connection.

Table showing the mean monthly temperatures for one year, and also the maxima and minima at Fort Mojave, Arizona, very near Lat. 35°.

	MEANS.			MAXIMA.			MINIMA.		
	7 A. M.	2 P. M.	9 P. M.	7 A. M.	2 P. M.	9 P. M.	7 A. M.	2 P. M.	9 P. M.
1863.	°	°	°	°	°	°	°	°	°
November,	48·96	72·50	58·76	63	85	76	38	54	46
December,	42·02	65	53 96	57	77	62	86	58	49
1864.									
January,	40·97	68·58	53·38	62	80	70	31	56	43
February,	52 31	78·48	63·06	69	90	77	28	56	43
March,	52·12	80·00	64·35	58	90	75	41	70	57
April,	69 83	90·11	80·01	83	102	87	52	73	60
May,	73·64	89·29	78·64	85	102	92	62	70	60
June,	77·40	99·10	87·10	88	106	98	68	88	72
July,	84·23	106·09	96·38	94	111	102	78	101	91
August,	87·35	106·67	97·48	95	115	104	79	99	87
September,	76 30	100 80	88·03	88	108	97	65	90	72
October,	62·09	86·22	72·29	74	100	83	45	70	59

From this table December is seen to be the month of lowest mean temperature, although the minimum degrees of heat are seen in January and February.

The greatest heats are found in July and August, when the temperature is seen to be most remarkably uniform, the maximum being in fact almost identical for the three daily periods of observation respectively throughout, while at 2 P. M. the minimum temperature reaches the remarkable extreme of 101° in July, and 99° in August.[3]

In the San Francisco District, Arizona, the maximum temperature observed by me in August was 101°.

[3] "No rain of any consequence," says Dr. Stark, "falls at this post except during the months of July and August, though heavy rains are of very frequent occurrence in the surrounding hills. The rain gauge has not been regularly kept at this post, but I estimate the mean amount of rain for the years of observation to be about four inches.

"At Fort Yuma, near the mouth of the Rio Colorado, accurate observations show only three inches of rain for the year. Snow has not fallen in this valley since I have been here, now two years.

"The atmosphere, of course, is very dry, dew never being seen. In view of this

The barometer (aneroid) at Fort Mojave was noted in my journal as 29·55 to 29·75. At Allen's Camp, San Francisco District, it was 28·193, average of twelve observations between July 26th and Aug. 1st, the greatest difference being ·055.

The highest temperature noted in the sun was 120° F., at San Juan Camp, (bar. 27·65), Aug. 6. In the sand the mercury rose to 136°, and eggs are coagulated by burying in the sands in 20 or 30 minutes exposure.

The wet-bulb thermometer, which was observed thrice daily during our journey out and back, indicated all through the Mojave Desert and the Colorado regions a remarkable dryness of the air. A few examples will serve as illustrations.

July 21, Mojave Desert, 2 P. M.,	air 104°,	wet-bulb 66,	dif. 38°
" 22, " "	" 104	" 70	" 34
" 26, Fort Mojave, "	" 108	" 75	" 33
" 28, Allen's Camp,	" 101·5	" 70	" 31½
Aug. 1, 10 miles south of Fort Mojave,	" 109	" 73	" 36

Even at night this difference was very remarkable, sometimes as much as 20°, thus:

Aug. 13, Forks of Mormon Road, 9½ P. M.,	air 82°,	wet-bulb 60°,	dif. 22°
" 14, Cottonwood, 9 P. M.,	" 76	" 59	" 17

The 2 P. M. observation rarely gave less than 20° difference between the wet- and dry-bulb thermometers.

Hot wind storms, or sirrocos, are not unfrequent in the desert and on the Colorado. I find this mention of one of these sand storms on the desert in my notes of the journey. "Soon after we had spread our blankets at a 'dry camp' on the plain, about 9 P. M. we heard a roaring sound coming up from the south like the sound of breakers on the shore. As the noise came nearer the resemblance to the roar of the ocean increased, and presently the blast struck us hot as the wind from a furnace, bearing along with it a blinding and almost stifling hurtle of sand, pelting the skin like hail. In vain did we seek to shut it out by covering the head with our blankets. It sifted through all our defenses, filled the hair, was inhaled by nose and mouth and gritted in the teeth, making the skin feel like sand-paper, while the oppressive heat was made ten-fold worse by our efforts to exclude the sand by burying our heads under blankets. It seemed for a time as if we should be buried alive under the drifting sands, but in about an hour the violence of the storm abated, vivid lightening and powerful thunder to the east of us succeeded, and, an hour later, a dash of rain for a few moments, just the outer skirt of the thunder storm, but enough to drive me to seek the shelter of the ambulance.

At Fort Mojave we experienced another similar wind-storm with the temperature over 100°, occasioning more annoyance from the scorching effects of the powerful hot wind.

The officers at Fort Mojave assured us that these hot wind-storms blow sometimes with great violence for a whole week, when it is impossible to go abroad; men and animals being liable to be lost if overtaken on the open desert, as it is then no longer possible to observe the way, gain a shelter, or find water, the latter difficult enough under the best circumstances."

Any notice here of the geology of the Mojave Desert, would extend this paper beyond its proper limits.

fact I hazard nothing in saying that a more healthful and healing climate for those laboring under that great destroyer, phthisis, could not be desired. These cases seldom present themselves, and then only among emigrants. With simple remedies nature immediately restores good health. I should be glad if this fact were more generally known to those suffering from this disease in eastern cities. * *

"I am now stationed here about two years and have not had a death among the troops during that period; evidence that good health is our epidemic."

San Francisco District.

Situation and approach.—The San Francisco Mining District is located upon the eastern side of the Colorado river, Allen's Camp, about the center of the district, being stated as 11½ miles from Fort Mojave. Allen's Camp is situated upon Silver Creek so called, a dry arroya which divides the San Francisco District into two nearly equal parts. Measured upon the course of the river, this District extends about twenty miles, or ten on each side of Silver Creek, from north to south. In the other direction, from east to west, the District extends about ten miles, the eastern limit being the first range of mountains, of which the most conspicuous point is known as Boundary Peak.

General Features and outcroppings of the Mineral Veins.—The observer is struck, upon entering this District, with the singularly wild and fantastic outline of its bounding mountains and intermediate ridges; he learns with surprise that the bold and serrated peaks stretching from east to west, and rising, now in delicate needles, and again prolonged in acute ridges, are the outcrops of gigantic quartz lodes, among which are seen conspicuously the Moss lode on the north,—the Skinner and Parsons on the south. The general aspect of these outcrops is different from that of those seen in any other portion of the Great American Desert that I have had the opportunity of examining. Whether from the influence of volcanic heat or of atmospheric causes, or,—which is more probable—of both combined, the aspect of these great quartz ridges is more rugged than any others which we have observed. The general course of the lodes in this District is that of pretty strict parallelism to the east and west magnetic equator, the deviations from this course seldom exceeding 4° or 5° by the compass.

This is true of by far the greater number of all the outcroppings in the District. There is another set of lodes, however, much less numerous than the first, whose general direction is northwest and southeast, or more exactly N. 20° W.: these lodes, if prolonged, must obviously intersect, at certain points, some of the east-and-west lodes. They differ not only in their course and direction, but essentially in their mineralogical constitution. The first series, the east-and-west, are quartz lodes, characterized by the presence of feldspar and fluor spar as the peculiar associate minerals; showing also rather rarely at surface metallic sulphurets and free gold. The second set of lodes may be called calcareous, being composed to a great extent of magnesian carbonate of lime or dolomite, flanked in some cases by quartz linings with polished walls, and as a general rule quite barren and unpromising in their outcrop. The Virginia, Olive Oatman, and Buffalo are conspicuous examples of the calcareous lodes. A third class of lodes is observed in the San Francisco District whose main direction is northeast and southwest. This class is very small, not including more than three or four, namely, the Pride of Mexico, Triumvirate, Wright, and Morning Star.

Resources in timber and water.—San Francisco District, like all the neighboring regions of the Colorado, is entirely destitute of timber, and at present is very imperfectly supplied with water. Timber is said, however, to exist in considerable abundance,—cotton-wood, cedar, pitch-pine, and nut-pine,—on or near the banks of the Colorado, within 100 miles of Silver Creek; at points from which it can be brought at a moderate cost for the supply of fuel and mining timber to meet the future demands of this district.

When we remember the experience in Nevada, especially the dearth of water on Mt. Davidson, in the early history of mining on the Comstock lode in Virginia City, and its present comparative abundance there as the result of mining operations, we are encouraged to believe that a similar result may be expected in San Francisco District, especially since the very limited explorations which have been carried out here have resulted in the discovery of water even in the driest situations.

This region is liable, like all the adjacent semi-desert districts, to sudden and violent storms of rain and wind, which may, as we had occasion to observe during our residence at Silver Creek, in a single hour, convert the dry arroya into a broad and roaring torrent, sweeping everything before it; while a few hours after scarce a trace of the inundation remains beyond the sand bars and pools of slime which a few days sun reduces again to the condition of dust. Wells sunk along the line of these dry water courses find an abundant supply of water at a few feet from the surface, which although hard, becomes reasonably good if constantly used.

Saline or alkali incrustations.—Like all other regions of the Great American Desert the surface of this District is abundantly charged with saline substances familiarly known as "alkali;" salts derived from the decomposition of the alkali minerals of the porphyritic and volcanic rocks which characterize the region. It is the solution of these substances in the drainage waters which gives most of the springs in this section those deleterious properties known as alkalinity. It is to be observed that the water which will flow from tunnels and shafts, excavated here in the processes of mining, will possess little or none of the qualities belonging to the surface waters which dissolve away from every rain-fall the soluble saline matters that capillarity, aided by the powerful evaporation of a semi-tropical sun, concentrates upon the surface of the earth. This evil of bad water may therefore be expected to disappear with the active prosecution of mining enterprises.

Climate and healthfulness.—Under a previous head the climate of the Colorado has been characterized. The San Francisco District, being elevated some 1500 feet above the river, is less fervid during the hot months, the temperature averaging about ten degrees less than at Fort Mojave. The months of June, July, and August, are, however, extremely hot, and all active work in the open air, unless in the early morning or at evening, is interdicted, the temperature ranging in the neighborhood of 100° F. The air is extremely dry, 30° to 40° at times marking the difference between the wet- and dry-bulb thermometer. This circumstance favors exertion by lowering the temperature of the human body. Deep mining will, however, offer a refuge from the tropical summer heats, rendering labor agreeable and supplying also water of a lower temperature and better quality than can be found at the surface.

In point of healthfulness no region can be more free from diseases than this. I ascertained by enquiry from the physician at the military post that there were literally no climatic diseases known on that portion of the Colorado.[4] Malaria is unknown, and fevers equally so; chronic diarrhea occurs rarely, and then is traceable to causes independent of climate. This healthfulness may be considered as nature's compensation for some of the privations incident to this fervid region. The effect upon the urinary organs, due to the use of the saline waters of the desert, disappears immediately upon the use of the river water or any other pure water, and is always under the control of vegetable acids and of moderate doses of alcoholic stimulants.

[4] See note (3), page 291.

Cost of transportation and labor—The important elements of cost in mining upon the Colorado river and its adjacent district are labor and freight. The former is found to be about the same as in Virginia City and Nevada territory generally, viz., from $4 to $5 per day. So far as present experience justifies an opinion —no considerable amount of active mining having been done here—there is no dearth of labor. Most of the miners who have gone to this country have gone in the capacity of "prospectors" or adventurers, and are to a great extent owners of claims as well as laborers. This is in accordance with the general experience of all new mining districts on the Pacific coast. Those bold and adventurous men have often been the pioneers of discovery, and subsequently the authors of the laws and regulations of the mining districts which their own sagacity and industry have developed, and in the organization of which they become officers as well as co-laborers.

Freight, by sea from San Francisco, costs now about four cents the pound, or eighty dollars a ton. The cost by land over the Mojave Desert is much greater; and nothing but the saving of time will justify the use of the Los Angeles route, and then only for the lighter descriptions of freight such as food and the smaller mining supplies. The time by sea up the Gulf of California is about three, not unfrequently four months. Over the Desert the time by government teams is 78 days from Wilmington or San Pedro to Fort Mojave. The navigation of the Colorado is continually improving, especially by the introduction of a class of steam vessels better adapted to this service. The shifting sands of the river, and the high tides—about 25 feet at its mouth—will, however, always make this navigation difficult and uncertain; and the low water of the river in the winter months occasions not unfrequent interruptions in the navigation. All these causes continue to render it highly desirable to improve the Mojave desert road by the establishing of more frequent watering stations, a thing believed to be quite feasible,—and by the improvement of the road itself by the removal of obstructions.

The agricultural capacities of the bottom lands of the Colorado remain to be developed. The Indian tribes now resort to them for the growth of corn, wheat, beans,—of most excellent quality,—yams or sweet potatoes, melons and pumpkins. The native Mezquit bean (*Cercidium Floridium*), and the 'screw bean' (*Strombocarpa pubescens*), furnish excellent food for animals, and is largely consumed by the native tribes for their own support. There can be little doubt that both corn and other grains for stock can be raised here for the wants of a considerable population, as well as all the esculent vegetables and most important fruits. At present the best lands are occupied by the Indians, from whom, by purchase or treaty they can soon be obtained. In respect to agricultural capacities this region is more favored than most of the mining districts of Nevada, and may be in a good degree rendered self-supporting.

General features of the Geology of the District and successive epochs of eruptive rocks.—The rocks of this District are exclusively porphyritic or volcanic. The porphyry consists for the most part of the feldspathic variety, the crystals of feldspar being implanted in a violet or lavender-colored paste of various shades. Like most of the porphyries observed in the great American desert, for example at Virginia City and at Esmeralda, at Bodie and in the Mojave desert, these rocks yield to atmospheric influences, either crumbling into incoherent masses or breaking away into acute and fantastic cliffs. The porphyries in the San Francisco District are of at least two distinct epochs. Along the right-hand branch of the arroya of Silver Creek for the distance of a mile or more, occurs an olive-green, sometimes leek-green porphyry, in which are imbedded—like boulders in a conglomerate—large masses or fragments of the violet-colored porphyry and of other associated plutonic rocks; for example masses of basalt and diorite. This fact leads us to the conviction that the greenish porphyries are of more recent age than the violet-colored ones whose fragments they contain; fragments identical in character with the violet-colored porphyries which constitute the main mountain masses of the district. As the quartz lodes of this region,—for example those gigantic dikes known as the Moss and Skinner lodes,—contain imbedded in their mass, especially at their surface, fragments of scoriaceous lava, and present in general a burned and roasted appearance, I am led to the conclusion that not long subsequent to the time of their separation from the masses of porphyry through which they cut, there was a general and violent volcanic action resulting in the upheaval or injection of many dikes of basalt, diorite and olive-green porphyry imbedding fragments torn from the older rocks as already described. That this period of activity was general and simultaneous for this region, seems almost certain from the fact of the parallelism of the east and west lodes, as well as from their mineralogical and metallurgical identity, so far as present observation and exploration justify an opinion.

A second period of eruption appears to be clearly indicated by the existence of the second class of lodes already noticed, namely, the calcareous lodes, whose main course is northwest and southeast, and the mineral constituents of which are entirely unlike those of the east-and-west lodes. There is evidence also in this district, as well as in the country at large, of volcanic eruptions of a much more recent date than those which have given origin to the mineral lodes. This evidence is seen in the

cappings of basaltic lava which surmount many of the hills with plane tables, or which occur in parallel bands, interstratified with masses of volcanic tufa, sometimes of enormous thickness. We have no data for fixing the epoch of this third class of volcanic phenomena, but it seems clear that like the two others it was sub-oceanic; and in this respect all three are distinctly separated from a fourth and extremely well-marked group of similar phenomena which were plainly sub-aerial, and which occurred, geologically speaking, at a very late period, after the surface topography had assumed its present features. To this fourth class of volcanic phenomena we refer those extinct cones, so conspicuous just east of the Organ cañon of the Mojave,—cones whose lava streams now stretch their rugged course in long and regular inclined planes to a distance of eight or ten miles from the craters, standing with vertical basaltic walls ten or twenty feet above the plain, capped with scoria whose surface still speaks of the sluggish nature of the once molten mass.

Characteristics of the Mineral Veins.—The first thing which arrests the attention of the mineralogical observer in the San Francisco lodes, as compared with those of most other regions, is the general absence of the metallic sulphurets, and of the carious or porous character so common in the outcroppings of quartz in most auriferous regions. In this respect the San Francisco outcroppings are not unlike those seen in some portions of Nevada. There is reason to believe, so far as our own observations have extended, that this character of the outcroppings of the quartz lodes in San Francisco District is common to most the outcroppings in the porphyritic or plutonic rocks of other mining districts in Arizona; as in the districts of Eldorado Cañon and the Wauba Yuma. The larger lodes of the San Francisco District, such as the Moss and Skinner, are characterized also at surface by a cross structure at right angles to the general course of the lodes, breaking them up into a series of subdivisions or headers which include often large masses of the adjacent porphyry walls, or of other rocks more or less distinctly volcanic. Whether it is due to the volcanic action to which the surface of these lodes has been subjected, or to some other less probable cause, it is a fact that most of the lodes in this district show an absence of the fringe or lining of fluccan or clay material, generally found in softer rocks. The lodes of this district are in general glued fast to the adjacent walls of porphyry, but that this characteristic is only superficial seems probable from the fact that the Allen shaft, sunk upon the Moss lode, intersecting the line of its southerly or hanging wall shows a distinctly marked fluccan or fringe, separating the vein from the adjacent porphyry at a few feet depth from the surface,—although at the surface no such structure was visible. The surface of the quartz also, at this portion of the Moss lode has the appearance of having been burned, looking like quartz containing pyrites which has been roasted in the fire and then quenched in water, leaving the surface deeply stained with red oxyd of iron; this stain penetrating by numerous rifts and fissures to a considerable depth from the surface. It was in quartz of this description that the extremely rich samplings of gold were taken which have rendered this lode famous. In similar quartz from this portion of the Moss lode, I found it still easy to obtain rich specimens. The inference is that the surface of these lodes has been subject to the action of heat, probably through hot waters, dissolving or decomposing the metallic sulphurets and leaving the superficial portion of the lodes in a hardened and changed condition, unpromising for metallic value, but giving place in depth to vein stuff of a softer character, and more charged with metallic sulphurets. This change is very conspicuous in the Techatticup lode in Eldorado cañon which has been open to a depth of 140 feet, and shows, as I am informed by Henry Janin, a gradual increase to this depth of metallic sulphurets, from a condition at surface of a quartz lode destitute of these compounds. On the Moss lode a shaft of 52 feet has shown a similar change in the relative hardness of the including walls of porphyry, and the gradual softening of the contents of the vein. As yet the explorations in the San Francisco District are quite too limited in depth to enable us to apply this reasoning with certainty to any number of the lodes, and it is by analogy only that the conclusion is reached which seems to warrant this probability.

Mineral contents of the lodes.—The Moss, Skinner, and in general the larger lodes of the San Francisco District, are characterized by the presence of an abundance of white feldspar, forming sometimes the mass of the vein; the quartz existing then as a subordinate vein in the feldspathic and porphyritic gangue.

The mineral most characteristic of the east and west lodes in the San Francisco District, next to the quartz and feldspar which form the great mass of the lodes, is *fluor spar*, a mineral frequently seen elsewhere in the world as an associate in silver-bearing lodes—as, for example, in Freiberg in Saxony—but which is of rare occurrence in this country in a similar association. This mineral is found abundantly in the Skinner lode, the Dayton, the Knickerbocker, and the Quackenbush; and has been observed also in the Moss and several others. It is associated in them with free gold, horn silver sometimes in distinct dodecahedral crystals, and iron gossan.

Description of some of the veins of the San Francisco District.—In general the lodes in San Francisco District are remarkably vertical, rarely deviating more than 30° from the perpendicu-

lar; and their outcroppings are commonly very strong and well marked, forming, in the case of the larger lodes, conspicuous features in the topography of the country—landmarks seen for many miles.

To describe all the lodes in this district would be tedious and unprofitable. The amount of work performed on them has in general been no more than is essential to conform to the easy conditions imposed by the laws of the district upon claimants; and has in most cases been too little to furnish important data for the guidance of the judgment. I shall therefore confine myself to those which are best developed or of the most general interest and importance, commencing with the Moss lode, which has received more attention than any other one of the San Francisco lodes.

Of the Moss lode.—The outcroppings of the Moss lode form a most conspicuous feature in the landscape, being seen, standing up in bold crests and pinnacles, from a long distance. The observer who enters the Colorado valley from the Mojave Desert has his attention arrested by the crests of the Moss lode, as soon as he emerges from the valley of Pah-Utah creek, at a distance of at least twenty miles in an air line. This lode stretches in a continuous line for at least 7,800 feet, and is 'claimed' for double that distance. Its distance north of Silver creek is about two miles, and its course is about W. 5° N., or nearly at right angles to the river, from which it is distant about five miles. This vein shows at surface about fifty feet of thickness, as well as can be judged in its present state of development, while its croppings rise to a height of from fifty to one hundred feet or more above the arroya or wash, sinking at times to the surface and then towering away again in bold peaks and crests. Its height above the Colorado must be at least 1500 feet. Its dip is southerly 65° to 70°, or 15° to 25° away from the vertical. The weathered aspect of this vein is reddish and rich brown, but on breaking away the weathered surfaces it is found to be composed of whitish compact feldspar and quartzose porphyry, intersected by veins of very red, often marbled quartz, at times violet-colored, and rich in free gold. There are included in this vast mass, not merely numerous sets of feldspar, hornstone, and quartz veins, but also masses of gray porphyry and lumps of tufaceous and vesicular lava, indicating the action of heat, either of thermal waters or of direct volcanic agency. Some masses of a cellular structure have the vesicles filled with hyaline quartz or hyalite,—possibly also with some zeolite—and these masses so resemble the siliceous sinter of Steamboat springs in Washoe valley, as to recall at once the probability of a thermal origin. This probability is further strengthened by the occurrence of veined and marbled jaspers and hornstones. Drusy

surfaces of crystalline quartz are also seen abundantly in all the "shuts" or closures of the vein.

The hanging wall of the Moss lode is an ash-gray feldspathic porphyry, often intersected by thread veins of quartz and hornstone, but barren of metallic sulphurets, and showing at the surface no clay wall or fluccan, separating it from the vien. The absence of this character of permanent and well defined lodes at the surface of the Moss ledge is in analogy with the character of many veins in Nevada, which, however, at moderate depths acquire this feature, as the Allen shaft shows to be the fact for the south or hanging wall of the Moss lode. The entire outcrop on the Moss lode has a burnt up, dried and hardened aspect, as previously explained; and this character is shown now by ver moderate explorations, to be quite superficial.

The characteristic veinstone of the Moss lode is feldspar with veins of chert or hornstone, in which matrix occur veins of highly ferruginous quartz, sometimes almost an iron jasper of various colors, sometimes compact and again cellular. The surfaces of closure are drusy, not separated from the gangue by any parting, but cutting it with a dip usually more highly inclined than the dip of the vein itself. These intercalated or subordinate veins of quartz appear to maintain a course quite parallel with the main vein. Too little work has however been done on the lode to justify this generalization in any more than a limited sense, as far as can at present be seen.

The rich specimens of free gold in quartz, of which over a ton weight were taken at one time in 1864, were obtained on one of these subordinate veins of deep red iron-stained quartz, just behind the point on the so-called San Francisco claim where Allen's shaft is now being sunk. I caused some blasts to be put in at this point and was able to obtain a considerable amount of quartz of similar character, highly charged with gold. That the gold is not confined to this point I found by breaking some specimens at several points along the face of the outcrop for a distance of 250 feet; and it is easy to detect minute particles of the precious metal along a line of 500 feet, by careful observation.

The Moss lode has been opened by a shaft called Allen's shaft, sunk on the San Francisco claim, ten or twelve feet in front of the spot where the first lot of rich ore was obtained, to a depth, in Aug. '64, of 42 feet. This shaft was set to cut the hanging wall of the lode and pass through its entire thickness in an estimated depth of about 100 feet. Where it cut the southern edge of the lode ore was found from which an assay was obtained, showing $4,200 per ton of precious metals.

I ordered this shaft cleaned up, to exhibit the nature of the section it has furnished of this side of the lode. The result was

interesting: the "pay streak" or productive ore ground is seen to be here about three feet wide in two nearly equal divisions, separated by about one foot of soft yellowish and reddish material, which prospects well for gold. This softer seam has come in on sinking and is not seen at all at surface. It is increasing in width as the shaft descends and is easily worked by the pick alone. Its dip is such that it passes out of the shaft in twenty-seven feet, the shaft being eight feet wide. The hanging wall is perfectly definite and shows smooth "slickensides," with a clay lining between them in places from three to four inches in thickness. The upper-rock is a reddish feldspathic porphyry, with thread veins of quartz. The vein stuff shows very little sulphurets and the porphyry comes in between the walls. The quartzose ground increases as the shaft descends, until at its present bottom it is nearly all quartz.

The bullion obtained from this vein contains silver enough to give it a pale yellow color. The gold appears in beautiful polished scales, the flat surfaces often embossed with crystalline lines. The precious metal is sometimes imbedded in a compact red jaspery quartz, presenting, when cut and polished, beautiful graphic goldstone. This rich gold-bearing mass of ferruginous quartz it will be understood formed the outcrop of this gigantic vein at only isolated points. Subsequently having an opportunity of comparing the physical features of the Moss vein with the surface show upon the "Comstock lode" in Nevada, I was forcibly struck with the great resemblance of these portions of the Moss vein with that portion of the Comstock which is still seen at Gold Hill, south of Virginia City, where similar rich deposits of low grade gold in the quartz outcrop gave its name to the town which has since sprung into such wonderful activity as the result of the development of the mines which have been opened upon this remarkable silver vein. The inference seems probable that the explorations of the Moss lode will likewise develop a silver mine, and if the magnitude of the outcroppings afford any just ground of comparison, the future of the Moss lode should not suffer in the contrast. But there is this important feature of difference, the rich sulphids of silver associated with native silver which were found in such remarkable abundance in that part of the Comstock, now known as the Ophir ground, has never been seen on the Moss lode.

I am permitted to copy the following certificate of assay and experiments with sodium amalgam made by Dr. Torrey & Son on a sample of ores taken from the rich 'chimney' of the Moss lode. The sample in question was collected in the summer of 1863 by Mr. Chas. W. Strong, who is now engaged in an active exploration of this interesting locality on behalf of a party of New York capitalists:

U. S. Assay Office, New York, Feb., 1866.

Sample of ore from Arizona Territory.

Weight of sample 34 lbs. 14½ oz. Bullion obtained $59·04.
By assay the bullion contained in 1000 parts,

Gold,	682
Silver,	308
Copper,	010
	1000

The value per ton by assay is $3,572.00

a. After treating the ore by *panning* to remove the coarser portions of the free gold, the remainder was subjected to a series of experiments to test the comparative value of amalgamation by ordinary mercury and the Wurtz process with sodium amalgam.

First the tailings of *a* were assayed and gave,

Gold per ton,	$1072.00
Silver "	60.00
	$1132.00

b. 8 lbs. of the ore (tailings) were amalgamated with ordinary mercury, and the bullion obtained weighed 2 dwt. 14 grs., which assayed as follows:

Gold,	706·5
Silver,	291·0
Copper,	2·5
	1000

Value of Gold obtained from *b*: $1.88=45 pr. ct. of fire assay.
" Silver " " .04
$1.92

c. 8 lbs. ore (tailings) were treated with sodium amalgam, (Wurtz process) and the button obtained weighed 4 dwt. 11½ grs., which gave by assay

Gold,	705
Silver,	146
Copper,	149
	1000

Value of Gold obtained from *c*: $3.26=78 pr. ct. of fire assay.
" Silver " " .04
$3.30

The total quantity of gold in 8 lbs. of ore by fire assay is $4·19.

Jno. Torrey & Son.

The assays of samples of the ore of this vein collected by myself and others, show a value of from $70 or $80 to several thousand dollars to the ton of 2000 lbs. But all such results

are of little value compared to the actual reduction of large quantities of the ores in working processes.

Other lodes of this district.—My notes contain mention of over fifty lodes or veins, most of them probably distinct, which I visited in the course of my explorations of the San Francisco district, and which belong to the east-and-west system. The parallelism between the lodes of this system is almost exact, and there is a great similarity in their mineralogical character.

The 'Skinner,' on the south side of Silver Creek, is one of the most conspicuous, forming like the Moss lode bold and fantastic crests, rising sometimes in slender needles to a remarkable height. The boldest outcrop is called the "center claim," of 1600 feet. But those portions called the Rochester (1800 feet) and the San Francisco (2400 feet) are nearly as bold. This lode shows drusy quartz, both compact and cellular and ferruginous with numerous cavities where fluor-spar has been weathered out. Hornstone is also seen frequently. Very small traces of sulphids show at surface, which is much stained by black oxyd of manganese, rendering portions of the outcrop quite black.

This vein varies from 50 to 150 feet in thickness. Its walls of ash-colored feldspathic porphyry are seen in places beautifully polished on the line of the dip 70° N. It appears glued first to the porphyry, without a lining of clay, (fluccan), but this is so commonly the case in the outcrops of Nevada that it is no proof of the absence of this important character of a true vein at a moderate depth.

An exploratory shaft has been sunk near the center of this claim on the foot wall, at a point designed to cut the lode at the depth of 100 feet, but at a depth of 50 feet the resources of the explorer gave out. Eighteen feet of water in this shaft confined my observations to the materials thrown out, showing the correctness of a statement made to me, that a branch vein or offshoot of the main vein had been cut, carrying green and purple fluor in octahedrons in a quartzose and feldspathic gangue, with occasional gray spots of minutely diffused sulphid of silver. Three assays of the ore from this shaft proved the presence of silver to the value respectively of $25, $74, and $83 to the ton of 2000 lbs. From a second shaft sunk on the N.E. side of the wash, in the body of the vein, to a depth of 25 or 30 feet, I obtained beautiful octahedral crystals of green, white, and purple fluor spar. The gangue and the whole mineralogical character of this vein, so far as explored, is of the most promising character, and it offers a most legitimate field for judicious exploration, with a reasonable expectation of the discovery of silver ores in remunerative quantity. At the same time it must be remembered that such an exploration is sure to be costly and its result is always doubtful.

The Parsons, Hurst and Leeland are other gigantic lodes,

south of the Skinner and of generally similar character, but, at the time I saw them, almost completely unexplored.

Some of the smaller lodes of this district appear to me to offer the hope of a much less costly exploration, and with the promise of quicker returns. Of this class I may mention the Caledonia and Dayton, a few hundred feet south of the Moss lode, and the Quackenbush and Knickerbocker, some distance south of the Skinner and Parsons. These veins are from three to ten feet in thickness, well defined, and showing at surface all the characters of true metalliferous veins. Besides well characterized and abundant iron gossan in cellular quartz, I observed in them fluor spar, feldspar, green carbonate of copper, horn silver, and free gold. Samples from these outcrops, collected by myself, yielded when worked in an experimental mill, from forty dollars to two hundred and fifty dollars per ton of two thousand pounds.

In no other mineral district which I have seen are there so many remarkable outcroppings of quartz veins carrying the precious metals, crowded into so small an area and on a scale of such magnitude in development as in the San Francisco District.

In the vicinity of Austin, (Reese River) Nevada, the veins are more numerous, probably, but are also much smaller and quite inconspicuous, having, in fact, almost uniformly no outcrops to attract the attention of the explorer.

Both districts are situated in a desert and inhospitable region, but the fervid heats of the Arizona summer are fully counterbalanced by the severe cold and snows of the more northern locality. Supplies can be brought with tolerable certainty by sea and river to Hardy's Landing, immediately in front of the San Francisco District, and within five miles of the Moss lode.

With these facilities for development we ought not to remain long in ignorance of the true character in depth of these very remarkable mineral veins, nor is it too much to hope that they will, with an honest and prudent use of capital reward the adventurers with handsome returns for the capital employed in the exploration.

Of neighboring mineral districts.—My observations extended east of the San Francisco District to Trout Creek, a branch of Bill Williams' Fork of the Rio Colorado, where there is a mineral district called the Wauba Yuma, about 60 miles east of the Colorado, and in a region entirely beyond the present limits of civilization. Passing the range of Boundary Peak, over a crest of volcanic tufas and red porphyry rocks of some 1500 feet elevation at the point of crossing, above Allen's Camp, or over 3000 feet above the river,[5] the traveller descends eastwardly in

[5] The peaks on either side of the pass are, however, much higher, but I had no opportunity to measure them by the barometer.

a dry valley, called Massacre Valley, from the sad tragedy of the murder of a large party of Texan and Arkansas emigrants in 1857 by the Mojave, Wallupi and Pah Utah Indians. We found the melancholy evidence of this catastrophe scattered along the line of Beale's Road for several miles, over seventy persons with their teams and baggage wagons having been destroyed. The bleaching bones of the oxen, half burned remnants of waggons, with cooking utensils and household furniture scattered about or lying as they fell, attest the savage ferocity of these treacherous tribes. About twenty miles beyond the easterly margin of the San Francisco District, there is an entire change in the geological character of the country. The porphyritic and volcanic rocks give place to metamorphic schists, gneiss, and granitic rocks abounding, with numerous veins of white quartz. From the Rio Colorado to the eastern limit of the Massacre Valley, 30 miles or more, the rocks are entirely porphyritic or volcanic. The same rocks which are seen on the west side of the Colorado are repeated here. The mountains possess a fantastic, almost grotesque outline, due, probably to their peculiar mode of decomposition. Many needle-shaped porphyritic masses adorn the ridge and are thrust through horizontal and gently inclined beds of volcanic tufa and cement of various striking colors, usually light, sometimes almost white, variegated by zones of brown, red, chocolate, and yellow. Large blocks and irregular fragments of volcanic or basaltic rocks, usually black or deep brown, are seen implanted in the overhanging and undercut cliffs of tufa and cement 250 to 300 feet high along the narrow gorge through which the trail crosses the crest, near "Meadow Springs." These volcanic beds appear to be of sub-aqueous origin. All the loose river drift and boulders on the plane are cemented into a firm concrete with a white cement derived probably from these beds.

The change in the geology of the region is very marked in the transition from volcanic rocks to those of the granitic family, and is accompanied by a corresponding change in the character and direction of the mineral veins, and the commencement of a region better wooded and watered than that previously described. Near the western margin of the Wauba Yuma District occurs a considerable vein of auriferous quartz, accompanied by ores of copper and sulphurets of iron. It first appears in a pretty high granitic mountain to the northwest, and its course has been traced about three miles to the southeast. This lode, which has been called the "Pride of the Pines," appears to be about ten feet wide, and possesses promising characteristics. The sample collected by me, although showing no free gold, yielded $30 to $50 to the ton of assay. It possesses the characteristics common to the auriferous lodes of the Sierra Nevada, and the same general N.W. and S.E. direction, while, it will be remembered,

the silver veins of the San Francisco District are nearly east and west in direction.

The granitic range in which the "Pride of the Pines" vein occurs extends for at least fifty miles, in a line nearly north and south, and forms a mountain mass of no mean proportions. Its altitude I could only conjecture, having sent my barometer in another direction, and crossing the ridge only at subordinate points. Its crests, however, may be from five to six thousand feet above tide.

Immense drift deposits of angular fragments without arrangement occur upon the flanks of this range, and so greatly resembling in their character glacial moraines as to command my careful notice. In a dry arroya which had been cut by torrents through this ancient drift, I saw for two and a half miles a section, averaging perhaps one hundred feet in depth, of the mass of one of these moles of glacier-like materials, chiefly angular fragments of granite, some of quite large dimensions, mixed with smaller angular fragments, sand and mud, with no trace of arrangement or stratification whatever. These moraines (if they are such) are of all dimensions, from one mile to eight miles in length, some of them as regular as a rail-road embankment and forcibly recalling those of unquestionably glacial origin jutting out upon the American Desert from the eastern escarpments of the Sierra Nevada near Mono lake, Aurora, and between Wellington's and the Palmyra districts.

These Arizona mounds run southeast from the main mountain mass, in lines seemingly parallel but really radii of the mountain valleys or gorges, between which they occur, falling away in gently inclined planes from the ridge. On their outer edges some traces of stratification appear, as in river drift, but this appearance seemed plainly a partial rearrangement of the materials by the torrents to the course of which they are limited. I record the observation with the impressions made at the time. My field notes contain the remark "true glacial drift." The latitude was about 35°, lower than true glacial phenomena have been recognized, if I am correctly informed. There were no exposed surfaces of rocks to show glacial scratches, and the exigencies of travel in this difficult region did not permit me to ascend the rocky peaks in search of them.

These alluviums, whatever their origin may be, cover an area ten miles to fifteen miles in width, going east of Pine Mountain ridge to the next and parallel ridge, which I have in my notes called "Castle Ridge." The recurrence of volcanic rocks and wide spread sheets of basaltic lava, as a capping to the mountains and hills, gives it a character entirely in contrast with the familiar features of the metamorphic and granitic mountains just noticed. These features are especially seen in a lofty table mountain of the 'Castle Ridge' on the traveller's left, as he leaves

Pine Mountain ridge behind him. This bold land-mark I named in my notes "Mount Brewer." "Fortress Rock," on Trout Creek, is another fine example of the same kind, but the valley north is filled with similar table mountains from a few hundred to a thousand or twelve hundred feet above the surrounding country. Here the same horizontal and gently inclined beds of light colored tufas already noticed as occurring near Silver Creek, fifty miles or more west of this, recur and are capped in a like manner by basaltic columns.

Enormous dikes or reefs of quartz and of coarse quartzose feldspathic granite cut through the reddish gneissoid granite which forms the basement rock over a large part of the Wauba Yuma District, rising in one case 100 to 150 feet above the cañon which cuts the vein at a point where I examined it, and where it is 50 feet thick. I could not discover in those gigantic veins much evidence of any metallic value, nor had there been any exploration upon them.

The Sacramento District, about 45 miles N.E. of Fort Mojave, I did not visit, but inspected a large collection of argentiferous galena from its veins, made chiefly by soldiers of the Post. These lead veins occur in metamorphic rocks, and are such in size and metallic value, so far as I could learn, as to lead to the belief that they will one day be worked when labor and supplies are cheaper and more abundant, and they may furnish a most important auxiliary to the treatment of the silver ores of adjacent districts.

The Iratаba district, south of Fort Mojave, comprises a number of veins carrying copper, but few of them, in the opinion of my assistant, Mr. Frank Sample, who visited them, are worthy of exploration.

ART. XXXVII.—*A method of Giving and of Measuring the angles of Crystals, for the determination of species, by the use of the Reflecting Goniometer;* by JOHN M. BLAKE.

IT seems desirable that more general use should be made of angular measurements of crystals for the purpose of determining species, than the ordinary methods of measurement and comparison will allow.

The time and study required to understand the various forms of symbols adopted by different authors, and then to locate the planes on the given crystal before making the measurements, make the pursuit of the subject in this way a difficult matter, even to those who have spent considerable time in the study.

Now it is possible to describe a crystal, giving measurements which will locate every plane occurring upon it, without the use

of symbols having reference to any system of crystallization. By thus making the measurement of a crystal, simply a mechanical operation, this description will be sufficient to determine again the same species, so far as it can be done by angular measurement of the planes.

The method consists in taking advantage of the existence of certain natural laws, which determine the arrangement of the planes upon a crystal into zones; and noting the angular distance of each plane in a zone, from one of them fixed upon as the starting point; this to be done by simply giving the goniometer-reading for each plane; and, further, binding all of the measured zones together by noting a sufficient number of their points of intersection.

Since a zone is a number of planes making parallel intersections with each other, if we adjust any two of the planes for measurement, we have at the same time adjusted all, and can readily go on and record the reading of the instrument for each plane.

We thus preserve the relative position of the planes, which gives the measurements a value which cannot be attained by the ordinary method of separate measurements, for the location of which we have to depend upon our knowledge of certain symbols.

It can be seen that there is thus a saving of labor, and of space in recording, if we consider that the object in view is to get a *complete* measurement of a crystal.

This measurement of zones may be carried to an extent which convenience will determine for each species. Four or five zones will often include nearly all the planes on a crystal, perhaps all that would be actually needed for the determination of species. To bring in the remainder, to complete the description, it may be best to make separate measurements; or to give only portions of zones, where to give the complete zone would be an unnecessary repetition of what had already been well noted.

To show what can be done by this method, suppose in the case of sulphate of copper, ($CuOSO_3+5HO$) each plane to have its opposite, there will be more than twenty-eight planes upon a complete crystal.

All of these planes can be brought into three zones intersecting in a common plane (*b*, of Rammelsberg).

It will be necessary to add a fourth zone, crossing the others, to bind them together and make the description complete. The species, sulphate of copper, is selected, because it belongs to the triclinic system of crystallization, and therefore it might be considered more difficult of description than the average of species, and the remeasurement of a crystal for comparison, an op-

Tucson, Arizona
April 6, 1976

To: A.J. Perry

From: N.I. Colburn

Subject: Literature Summary of Oatman - Katherine Mining Districts, Mohave County, Arizona

Location

The Oatman and Katherine Mining Districts, Mohave County, Arizona combine to form the San Francisco Mining District (not in common usage), located in the central part of the Black Mountains, extending about 20 miles N-S and 6 to 12 miles E-W. The Katherine District borders on the east bank of the Colorado River and is crossed by the highway connecting Davis Dam and Kingman. The Oatman District is the larger of the two and and is located about 8 to 18 miles SE of Davis Dam and west of the crest of the Black Mountains. The mining "ghost" town of Oatman lies within the eastern edge of the known mineralized vein area.

Recommendations

The following are recommended areas for further checking:

1) normal-faulted, off-set (down-to-west) vein tops in the Leland-Vivian, Pioneer veins areas;

2) wide zones of "low-grade" gold values in the Moss quartz monzonite porphyry and selected areas in the Katherine District;

3) field check of a) the area to the south and southwest of the Boundary Cone rhyolite plug (some minor prospects are reported here) to determine if this is the true southern edge of the mineralized area; b) the area between the Katherine and Oatman Districts (between the Arabian Mine and the Moss-Meals veins) to determine if the apparent gap in mineralization is real, or if because of cover, only small scattered prospects have been found so far; and c) the west edge of the rhyolite-tuff cliffs forming the central ridge of the Black Mountains to determine if erosion since the 1920's or 1940's could possibly have exposed eastward extensions of Oatman District veins;

4) a possible "NE" trend continuation from Hardy and/or Moss veins.

Included in ABM Bull 137, pp 99-100, 108 is a summary of "future possibilities" of the Katherine-Oatman Districts. Based on vein characteristics alone, these districts have probably been thoroughly explored. One approach that could prove useful is the use of detailed petrology and volcanology to determine the presence of further favorable areas based on a tectonic-volcanic model (i.e. Thorson's "caldera-cycle magma").

Summary

The Oatman-Katherine districts contain identical gold (alloyed silver)- quartz veins of remarkable continuity. The veins are directly associated with rhyolite porphyry diking and are affected by various faulting events.

Generally Tertiary to Quaternary volcanics, mainly Na-rich flows, ash-falls and rhyolitic ignimbrites rest on a basement of Precambrian granite. The quartz veins cut the older, more basic units of the lower sequence. The volcanics are young enough to retain good evidence of original eruptive centers (agglomerate deposits, tuff beds, etc.). The whole area has been modified by rhyolitic plugs, and rhyolite, andesite, and diorite feeder dikes, as well as at least two masses of intrusive quartz monzonite porphyry. The main tectonic overprint after the gold-quartz vein emplacement is an extrusion of the capping basalts (Quaternary) and relatively simple normal faulting, predominantly down-to-the-west. Erosion and weathering has exposed and affected the quartz veins, especially on the west near the Colorado River.

The Oatman District was discovered around the 1860's and major production was between 1903 and 1943, mainly along a single vein or faulted segments of this vein (Tom Reed and United Eastern mines) traced for over 4 miles. Other veins in the Oatman District are just as prominent, although not as continuous in length. Usually the gold values drop off and the mineralized quartz stages pinch out below 500 to 800 feet, although a few deeper zones were mined.

Faulting is more prominent in the Katherine District, and cuts off some of the veins. Production in this northern area occurred mainly between 1900 and 1930.

A listing of producing mines in both areas is included in ABM Bull. 137, facing p.80. This same bulletin contains concise descriptions of many of the better mines.

General Vein Characteristics

In both the Katherine and Oatman subdistricts, all ore veins are characterized by the presence of calcite and quartz, especially when the quartz is at least partially pseudomorphic after calcite. The higher values of gold are closely associated with the occurrence of andularia (often microscopic) and greenish or yellowish-colored, "waxy" appearing quartz.

Lausen has worked out the following composite sequence of veining events for the Oatman district, which probably applies also to the Katherine district. See ABM Bull. 137, p. 85.

The later veining stages contain most of the gold values. Not all phases occur in a single vein and the number of phases can vary from place to place along a single vein. The Oatman-Katherine gold-quartz veins are considered epithermal and are closely tied to the sequential development of the surrounding volcanics. The gold-quartz veins formed prior to the final rhyolite events.

Two further features are common to both districts. All of the veins occupy former fault zones or were faulted themselves between various veining stages. Secondly there is a general lack of sulfides associated with the deposits.

Variations in Appearance and Occurrence of Veins

Silver content: Various amounts of silver occur alloyed to the gold, giving a lightish color to the primary ore. In the Oatman District the silver/gold ratio is quite low. In the eastern deposits of the Katherine District, silver may be more abundant than gold and for this northern subdistrict, the silver values seem consistently higher.

Surface weathering features: Surface outcrops, when they occur, are quite variable ranging from prominent quartz ridges or "Ledges" to scattered calcite veinlets. Iron-oxide stained quartz ridges are probably the least consistent indicator of good ore values. At least near Oatman, high-grade zones were more likely to be found under swales formed in calcite zones, especially when gypsum occurs as a weathering residual.

Most zones with some gold values are associated with mixed quartz-calcite outcrops, with FeOx and MnOx staining. The intensity of staining becomes especially important where secondary gold occurs in hematite.

Secondary enrichment: Supergene effects account for most of the dark colored, free gold available in the veins. Secondary gold is more likely to occur where deeply stained (FeOx-MnOx) calcite is present.

Several of the better ore zones in the Oatman District had small near-surface pods of secondary enrichment, as at the Gold Road mine. In some veins at the west edge of this district the primary ore was too low grade to be mined and the enriched portion accounted for production. The Katherine District deposits are either entirely secondary or weathered to the depths mined.

Low-grade deposits: Numerous veins in the south-central or western part of the Oatman District contain narrow zones (10' or less) of low-grade gold over some few 100's feet length. However two areas contain such low-grade (.15-.20 oz/T Au) zones with widths up to 90 feet or greater. One area in the Oatman District is the west end of the Moss mine vein. According to Ransome this width extends to the 220 level of the mine. The second area covers several zones in the Katherine District also reaching this width, and carrying similar or higher Au-Ag values. Interestingly it is from these same two areas that CuOx stains have been reported at depth.

Vein contacts: The veins themselves may be massive and show internal banding, but more likely are a clustering of smaller veins within a single zone. Such veins or veinlets are commonly anatamose, and bits of non-mineralized wallrock may be preserved between veins. The vein walls may be quite sharp, but often they are described as "frozen" or irregular with small off-shoots extending into the wall rock. In some portions of the veins less involute contacts occur only in faulted zones. In other cases the brecciated zone may contain mineralized fragments or be mineralized itself. Intersection of veins show no increase in metal content, and perhaps only slight changes in the size of quartz pods.

Alteration: Alteration associated with the gold quartz veins varies according to the rock type and any prior, more regional effects. Silicification of the wallrock is more, or just as common as "bleaching", which is more noticeable in the chloritic Oatman andesite (propylitic alteration). Sericite appears to be lacking in the trachyte and andesite flow rocks, and when it is present it is very fine grained. Disseminated pyrite occurs in the more basic volcanics (i.e. Oatman andesite and some of the trachytes), but also occurs in the Moss quartz monzonite porphyry near the Moss and/or Mossback veins. In addition, felted masses of sericite are found in this porphyry.

Volcanic Sequence and Vein Occurrence

The best brief rock descriptions are found in Lausen. Ransome's earlier work contains some useful field descriptions. Ransome's map covers the northern end of the Oatman District as well as the southern half, remapped by Lausen. Thorson's 1971 Ph.D. thesis continues and updates the petrology of this Na-rich volcanic sequence.

Oatman District

The gold quartz veins themselves are older than most of the Gold Road latite (distinguished from parts of the underlying Oatman andesite by the presence of "brown" biotite). Some minor faulting or quartz veinlets extend upward into the latite in the cliffs east of Gold Road, but soon pinch-out or become indistinguishable. But some ore-bearing quartz veins do cut the lower part of the Gold Road latite sequence.

Most of the better-grade and more extensive veins occur in the Oatman andesite. These extensive veins change trends along their length, from E-W in the south to NW-N-S in the north, and shorter veins in the area parallel these trends in the central Oatman District.

Veins do continue downward into the underlying trachytes. In the southern Oatman District, east of Boundary Cone, a number of similar gold-bearing veins cut across the Esperanza trachyte. These generally show E-W or WNW trends.

Veins cut both Gold Road latite and Oatman Andesite or Oatman Andesite and Esperanza trachyte exposed in adjoining areas (see Lausen, geol. map). In both these zones mineralization dies out westward and downward into the underlying Alcyone trachyte. The vein structure or brecciation may continue further, but become impossible to trace.

Rhyolite dikes and plugs intrude the Gold Road latite and older rocks. Boundary Cone, Elephant Tooth and possibly Thumb Butte are such rhyolite plugs. The rhyolite porphyry dikes can be cut by ore veins, parallel such veins, or actually have veins form one wall, usually faulted. In general the rhyolite dikes trend NW or E-W. However some NE trends and flat (30°) dips occur in the Katherine District.

Compositionally the rhyolite or felsite porphyry dikes and the Gold Road latite are similar to two intrusive bodies, the Times porphyry and the Moss quartz monzonite porphyry. These intrusives have a common contact and are exposed in the west half of the Oatman District.

Lausen relates the Times porphyry to the rhyolite dikes and an intrusive doming and collapse to form the dikes. He also thought the Times porphyry intruded the Moss porphyry. But this contact is well-brecciated and actually Thorson has absolute dates of 22 m.y. for the Times porphyry and 10 m.y. for the Moss porphyry. Thorson concludes that the Moss porphyry intruded its own roof material (including the Gold Road latite) "beneath a maximum cover of 3000 ft.". Since it is crossed by gold-quartz veining (Moss and Ruth veins) it seems more directly involved in the mineralization events than the Times porphyry. The Times porphyry is also crossed by an ore vein, the Hardy vein.

These younger than expected dates (Pliocene) make it impossible for the typical Tertiary weathering cycle to be complete. Therefore very deep erosion of the western portion of a tilted mountain block did not occur.

Basin and Range faulting has occurred. This faulting, down-to-the-west, has affected the ore veins, as for example the Mallory fault (non-mineralized) which offset the top of the Tom Reed vein and caused the classic "apex" law suit between the Tom Reed and United Eastern companies (see Ransome for details).

Other such offset of vein tops is possible, so that further hidden ore vein sections as at the United Eastern could be present. However once the faulting was disclosed in the 1920's, exploration was begun for such targets. Most of the more obvious areas have probably been tested to some extent. This exploration included deep drilling from United Eastern's workings.

Comparison of Katherine and Oatman Districts

Characteristics of the quartz vein material and rhyolite porphyry dikes are identical in both areas. However, the Katherine District is almost totally lacking the volcanic flow-tuffs rocks, except for one outcrop possibly equivalent to the Alcyone trachyte, and rhyolitic units which may or may not be contemporaneous to the Gold Road latite (the "younger rhyolites" would be the other choice). Other than the quartz vein-rhyolite occurrences the Katherine District stringer veins are closely associated with faulted zones and occur within a "Precambrian granite". Mapping and exploration in this area is made difficult by the lack of outcrops. Some ore zones were only found from underground exploration (as the Katherine Extension) or from small outcrops with extrapolation of slightly mineralized zones under the gravels. It could be possible that heretofore unrecognized younger crystalline intrusive may exist in the Katherine District.

Additional Comments

Tentatively the major regional effect of the rhyolite and monzonite porphyry intrusives is a NW trend superimposed on an earlier E-W trend. These vein and dike trends and an overall shallow (15° to 30°) dip within the volcanics (probably near-original attitudes) are locally shifted near the Times and Moss porphyries. Assuming the volcanics to be part of a caldera sequence, the tectonic pattern of quartz veins and rhyolite dikes is incomplete (ie. ring and/or radial dike swarms).

One possible "zonation" occurs in the southern part of the Oatman district. Here although there are no ore pods formed at vein intersections, there appears to be a NE alignment of richer lenses occurring in each of the series of WNW trending veins. This could result from "NW" trending controlling fracture pattern, but with a "NE" trend of the "ore" source.

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Note: several small articles from Eng. & Ming Jour., AIME. Trans. but list incomplete.

bottoms in

FRIDAY PE-

SEPTEMBER						
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Success

23

SEPT. 1983

5' int. 2<<». Tm

25' - .057

78 ÷ 032

100' - .020

Roadside - 17 holes

- Kerry Durning -

602 753-1622

DAY OF THE YEAR
266 - FRIDAY, SEPT. 23 DAYS REMAINING - 99

Fischer-Watt Mining Co. Inc.

ADMINISTRATIVE OFFICE: 114 TUCKER, SUITE 7
KINGMAN, ARIZONA 86401
PHONE: (602) 753-1622
Hm. 619-723-5560

FISCHER-WATT MINING INC.

A BRIEF HISTORY

AND

- Paul Drobeck -

PROJECT SUMMARY

Roadside - drill 16 holes.
hammer, reverse
100' at .020
40-50' - .03 - .04
Strike length of ~4 mi.

Owned - Dr Exp - 4 old farts - has it.
other guy has lease on part, so sublease this
they then lease the rest.
3% - 4% NSR

2 assays for Fire Assays.
- 100 - 150 holes

Commit to drill program
~200' average

Drilled best part of it already -
(the open-pit part)

Detachment Flt.
Wash Hthn. Pt ix. under
Central Calcite stockwork zone

January 17, 1983

Genetic Modeling and Exploration for Picacho and Borealis-Type Deposits 1982-Present

Through library research, university contacts and extensive field research, FWM has developed genetic models for two types of newly recognized bulk tonnage gold deposits. The characteristics of these deposits are not generally appreciated by competing exploration groups. The Picacho Mine (6 million tons of .05 o/T Au) and the recent Goldfields discovery (41.5 million tons of .056 o/T Au), both in Imperial County, CA., occur in a newly recognized structural environment. Through literature research, contacts with academic leaders, field work at the Picacho Mine, and geochemical orientation surveys at known deposits, FWM has established exploration criteria for discovering other Picacho-type orebodies. Specific geographic areas in which new discoveries are likely to occur have been identified by FWM. Fischer-Watt Mining has acquired two very attractive targets, the Roadside Mine, AZ., and the Rattlesnake Mine, CA., which fit the genetic model and which are ready for drilling.

FWM has also characterized the surface geologic and geochemical expression of the Borealis Mine located in W-central Nevada (3.2 million tons of 0.075 o/T Au). Based on studies by FWM at the Borealis Mine as well as library research and theoretical modeling, FWM is now able to delineate, in the field, targets similar to Borealis. One such target has already been identified and others are currently being evaluated.

Summary

In its short history, FWM has become an industry leader in ore deposit modeling for newly developing and little understood ore deposit types. FWM has successfully integrated this modeling into field evaluations which have resulted in land acquisition recommendations and successful evaluation programs. Success in exploration is not directly related to how much money is spent but how well it is spent. FWM has, with very limited funds, put together and enviable portfolio of gold-silver properties but has lacked sufficient funds to satisfactorly drill all defined targets.

Possible interest?

SUMMARY OF FWM PROJECTS

PROJECT	LAND HOLDINGS ACRES LOCATED	LEASED	FWM INTEREST	ORE RESERVES AREA	TONNAGE	o/T Au	o/T Ag	%Pb
GATMAN, AZ.	± 3000	±1400	25%	United Western	+200,000	0.20	-	-
				Kokomo	5,400	0.63	-	-
				Add. Potential	±1,000,000	±0.60	-	-
McCRACKEN, AZ.	± 785	90	40%	North Pit	249,000	-	5.1	1.9
				South Pit	130,000	-	3.6	2.5
				Stonehouse Vein	55,000	-	10.9	1.5
				Palace Vein	25,000	-	7.8	2.5
				Tailings	25,000	-	3.82	1.2
				Add. Potential		small		
SILVER KING, AZ.	± 180	±100 under neg.	100%	Potential	unknown but could be large			
HY PROJECT, NV.	± 3800	220	20% & 100% managed by CMRC	Potential	unknown but could be large			
HAYDEN HILL, CA.	155	130 1200 may be open for lease	25%	Dumps	92,000	0.084	0.81	-
				Tailings	40,000	0.062	1.53	-
				Open Pit	850,000	0.042	-	-
				Potential	1-2,000,000	?	-	-
DEXTER MINE, NV.	0	465	24%	Dexter Mine	+ 180,000	.090	3.0	-
				Potential	± $1x10^6$	±0.07	±1.5	-
COMSTOCK, NV.	0	827 Additional land under negotiation	80%	Dumps	300,000	0.034	.55	-
				Open pit	50,000	0.062	.70	-
				Potential	Large and high grade			
ROADSIDE, AZ.	0	± 800 lease in preparation	100%	Sample indicated	±75,000	0.042	-	-
				Potential	$1-+2x10^6$	+0.05	-	-
RATTLESNAKE, CA.	0	±800 lease in preparation	100%	Drill indicated	+200,000	±0.06	-	-
				Potential	1 to $3x10^6$	±0.06	-	
BUFFALO VALLEY, NV.	0	2980	5% Managed by Texas General	Drill indicated	750,000	0.07	-	-
				Potential	+500,000	0.07	-	-
ASH PEAK, AZ.	280	380 under neg.	80%	Potential	.5-$1x10^6$	0.035	9	-
ARICA, CA.	0	290	50% managed by CMRC	Potential	+400,000	.15	-	-
DELAMAR, NV	2889	±1500 under neg.	50% managed by CMRC	Dumps	50,780	.073	1.31	-
				Open Pit	173,000	.081	-	-
				Potential	$1.5x10^6$	+.15	-	-
KLONDYKE, AZ.	0	6,000	50% managed by CMRC	Open Pit	74,000	0.09	0.50	-
				Potential	500,000-+1,000,000	0.06-0.10	.50	-

F. Fischer-Watt Interest

FWM has a 80% net profits interest in the Comstock District, CMRC retains a 20% net profits interest because of its funding of the original mapping.

VIII. ROADSIDE MINE, ARIZONA

A. Location

The Roadside Mine is located about 25 miles west of Kingman, Mohave County, Arizona. Access is via county graded dirt road north of state highway 68.

B. Land Holdings

Fischer-Watt Mining has an agreement with the owners of 53 unpatented lode claims totaling ± 800 acres which cover the Raodside Mine Prospect.

C. Geology

Gold ore at the Roadside Mine occurs in a nearly north-south 30° west fault zone in Precambrian granite. Where this fault zone is cut by intersecting high angle east-west faults and intruded by rhyolite sills low grade quartz-gold stockworks are developed. Locally massive zones of quartz are developed. which contain the ore grade values mined in the past. Past production came from 1 large lens of brecciated quartz and stockwork veined Precambrian granite and yielded ±30,000T grading 0.30 o/T Au. This stope was up to 150' long, was mined for 150' downdip and up to 50' thick. It is the low grade stockwork veined material adjacent to the past productive stope and the potential for new discoveries to the north that are the objective of this program.

Detailed mapping and underground sampling have been completed on the prospect. Sample indicated reserves are 75,000T of 0.042 o/T Au.If the original high grade pod still remained this grade would be 0.115 o/T Au for 105,000 T of ore. Drilling by the owner extended the mineralized zone 200 ft. north of the mine. Low grade mineralized intercepts ± .03-.05 o/T Au were encountered over intervals of up to 100 ft. Additional mineralization in sparse surface outcrops occur over 1500' to the north of the mine and have never been explored at depth.

D. Ore Reserves and Potential

Sample indicated reserves at the mine are 75,000 T 0.042 o/T Au. Additional reserve potential is estimated to be 1-+2x10^{6}T +.05 o/T Au ameanable to open pit-heap leach technology..

E. Project Status

Fischer-Watt has completed the underground sampling and mapping and defined specific drilling targets. Some additional surface mapping is required in peripheral areas. Preliminary heap leach metallurgical tests indicate recovery of .02 o/T Au after 7 days and the tests are still in progress (1/16/83).

F. Fischer-Watt Interest

Fischer-Watt controls 100% of the project subject to an underlying lease agreement with the property owners.

IX. RATTLESNAKE MINE, CALIFORNIA

A. Location

The Rattlesnake Mine is located about 20 miles north of Goff, San Bernardino County, California. It is accessable by county maintained and good dirt roads.

B. Land Holdings

Fischer-Watt Mining has under lease 42 unpatented lode claims covering over 800 acres.

C. Geology

Gold mineralization at the Rattlesnake occurs along a N30E 30°-35° NW fault zone in Precambrian granite and granite gneiss. Brecciation and crushing occur over widths of up to 100' but the foot wall 40' carries the only economic mineralization found to date. There is no signficant hydrothermal altheration or mineralization and the gold mineralization appears to be dispersed in crushed Precambrian granite. The prospect is similar in many respects to the Picacho Mine in SE California. The fault structure, probably a thrust, is traceable for over 6000 feet. Sixteen hundred feet of strike length and 150 feet of dip length have been drilled by the owner. Of the 26 holes for which we have data only eight found no values greater than .02 o/t Au. in the mineralized structure. Sampling and mapping by FWM confirm the probable validity of the owners drilling results.

Mining Record 5/19/84

Saratoga Mines Signs Lease

Mining and Milling

at the

[redacted]

Mohave - Yuma Cty - Exploration

Targets - Epithermal type deposits - (not veins particularly)
- Detachment related deposits (structural control)
- Intrusive related deposits (with or w/out Cu)
- Precambrian age deposits - massive sulfides, skarns

Exploration predicated on either a new idea or concept to guide exploration ie. detachment or "hot spring model" ideas or more thorough exploration methods or both

Areas

Epithermal deposits

Oatman Dist. - Stress association here in particular with late rhyolite dike - plugs with mineralization - good evidence suggests rhyolite intrusive are "mineralizers" in area, ie. no large intrusives, close temporal - spatial assoc. w/ deformation, arsen - low grade gold in intrus. etc.

refs. for Oatman / Union Pass

- ~~Best~~ specific types of areas to look are along contacts of rhyolite with wallrock, partic. where note intense alteration incl. silic., brecciation, mineraliz. (Py.), flat structures
- specific areas are Boundary Cone area, Secret Pass area, placer areas along Silver Creek (no known veins to account for), Moss Mine area and areas west of Oatman, S. of Gold Rd., Gaddis - Perry Area, Hardy vein.
- this area would be enlarged to Union Pass area to north where also have assoc. w/ rhyolite dikes, some flat - lying. ~~stock~~

in the condition of the orebodies since their original formation. There is no distinct zone of secondary enrichment (barring the small amounts of chalcocite), a fact best indicated by the silver values which show no marked change from the upper part of the orebodies to the lowest levels, several hundred feet below the water level. There is a gradual increase of silver values on descending, but this is entirely due to a corresponding increase in lead. As has been stated previously, the lead-zinc ore maintains the same character from the surface to the lowest levels, varying somewhat in the proportion of one to the other but not due to any later rearrangement. As stated above, there is a gradual increase in silver and lead on descending. This is not, however, at the expense of the zinc, which also increases slightly, but is due to the almost entire disappearance of gangue minerals and of low-grade patches in the solid core.

The age of the orebody itself is extremely difficult of determination. The overlying sediments have been eroded from directly above the orebody and whatever patches of ore have been found in them at other points are of small size and may have been formed from already existing bodies in the tuff. This is not, however, certain and the barrenness of overlying sediments may be due to their unfavorable character as regards replacement by sulphides. If the overlying sediments are later than the ore deposition, it would mean that the orebodies are early Ordovician or late Cambrian. If the sediments, however, antedate the period of ore formation it becomes impossible to determine the age of the orebodies.

AIME Trans. v. 56, 1916

Geology and Ore Deposits of Mohave County, Arizona*

BY FRANK C. SCHRADER,† WASHINGTON, D. C.

(New York Meeting, February, 1917)

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* Published with the permission of the Director of the U. S. Geological Survey. Originally presented at a meeting of the Southern California Local Section, October, 1915.

† Geologist, U. S. Geological Survey.

Introduction

The present sketch is submitted by request in the hope that it may serve as a basis for geologic discussion of the mining camps in Mohave County, which is experiencing a marked revival of activities.

The region, commonly known as the Mohave district and Kingman district, lies in western Arizona in the southern part of Mohave County, bordering California and Nevada on the west (Fig. 1). Kingman, the principal town, is situated near the center of the area on the Atchison, Topeka & Sante Fe Transcontinental Railway.

This region is composed of naked desert ranges of mountains and broad detritus-filled valleys, the southern extension of the characteristic topography of the Great Basin. In altitude it varies from 500 ft. in the southwest to 8,300 ft. on Hualpai Peak southeast of Kingman.

The mountains trend north-northwest. They rise about 3,000 ft. above the valleys, are generally rugged and were formed mainly by erosion. They are composed in the main of a complex of pre-Cambrian granitoid rocks which underlies the area as a whole. Like the valleys, they average about 10 miles in width. Beginning on the east, they are the Grand Wash Cliffs, the Cerbat Range, the Black Mountains or River Range, and the Eldorado Range.

The upper or dominantly cliff half of the Grand Wash Cliffs, marking the edge of the Colorado Plateau, is composed of nearly horizontal sedimentary Paleozoic strata of the Grand Canyon section, and the lower half of the underlying pre-Cambrian complex.

The Cerbat Mountains situated in the central part of the area, and the Black Mountains situated between Detrital-Sacramento Valley on the east and Mohave Valley, the great trough of the Colorado River, on the west, are locally flanked or overlain by Tertiary volcanics (Fig. 2). The latter consist of five groups of mountains of which the most important is the Black Mesa group on the south.

The Eldorado Range, rising from the great trough of the Colorado on the west and containing Searchlight, Eldorado Canyon, and other camps, is topographically and geologically similar to the Black Mountains.

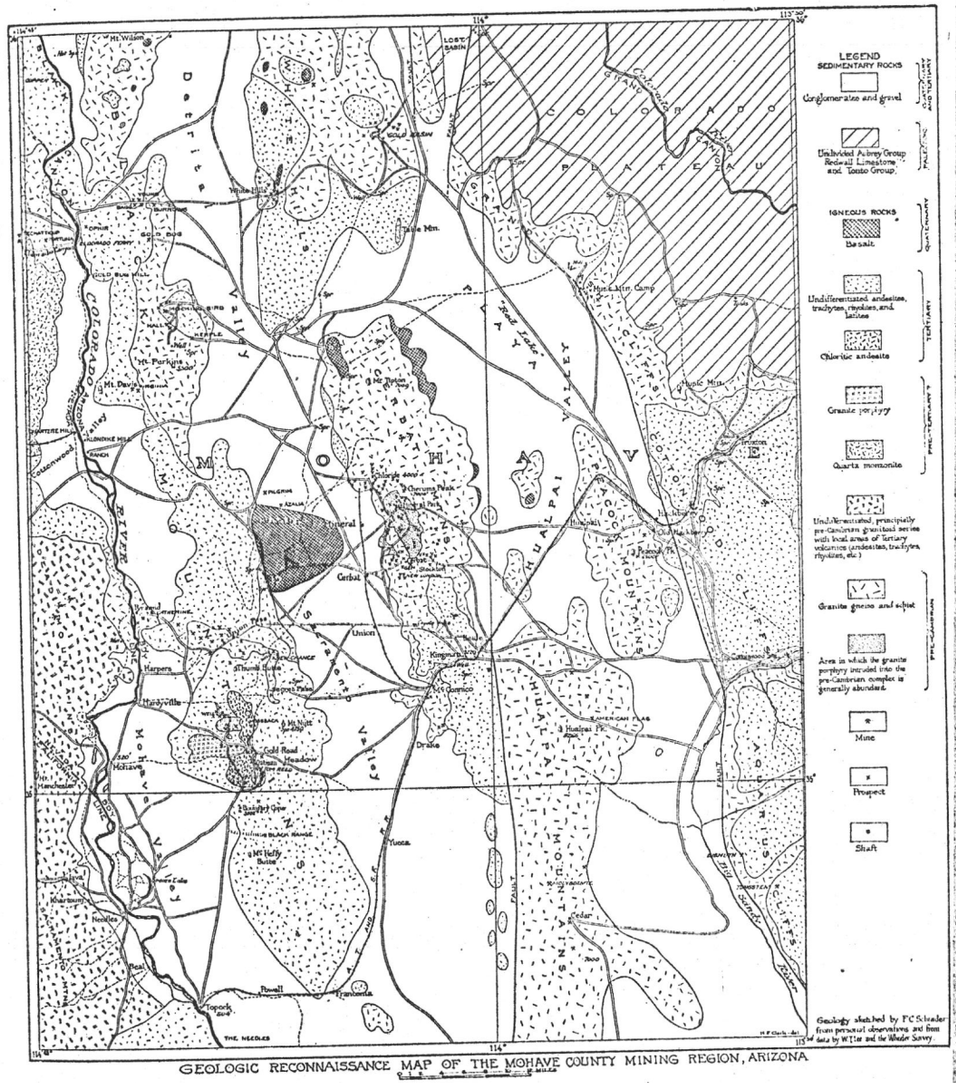
Geology of the District[1]

The rock groups beginning with the oldest are the pre-Cambrian complex, Paleozoic sediments, pre-Tertiary intrusives, Tertiary volcanics, and Tertiary (?) and Quaternary sediments (Fig. 1). The first and third of the divisions named are the most important.

The pre-Cambrian complex consists of gray gneissoid granites, coarse,

[1] A fuller description of the rocks appears in *Bulletin* No 397, *U. S. Geological Survey* (1909).

porphyritic granitoids and their related schists, all of igneous origin and with varying degrees of metamorphism. It is traversed by a schistose

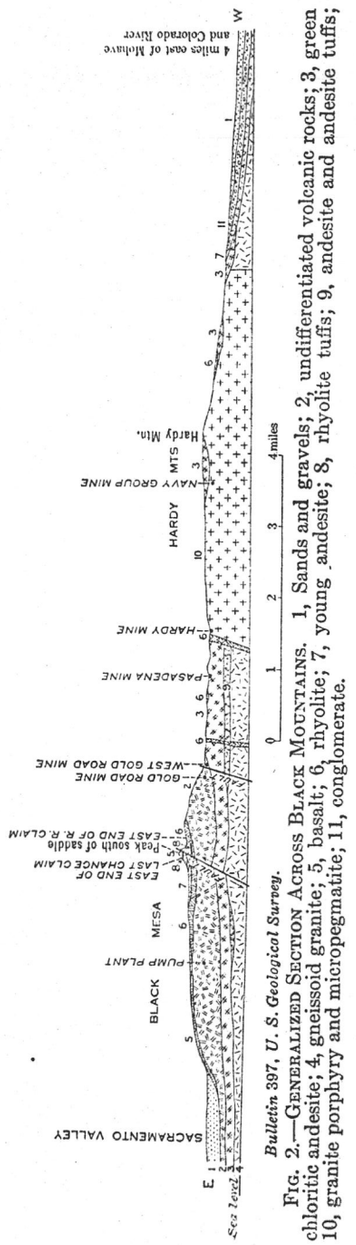


GEOLOGIC RECONNAISSANCE MAP OF THE MOHAVE COUNTY MINING REGION, ARIZONA

Fig. 1.

structure trending N. 30° E., and contains nearly all the mineral deposits of the Cerbat Range and Grand Wash Cliffs.

The Tertiary (?) and Quaternary sediments consist of several placer



Bulletin 397, U. S. Geological Survey.

FIG. 2.—GENERALIZED SECTION ACROSS BLACK MOUNTAINS. 1, Sands and gravels; 2, undifferentiated volcanic rocks; 3, green chloritic andesite; 4, gneissoid granite; 5, basalt; 6, rhyolite; 7, young andesite; 8, rhyolite tuffs; 9, andesite and andesite tuffs; 10, granite porphyry and micropegmatite; 11, conglomerate.

gold-bearing detrital formations or "wash", locally 2,000 ft. in thickness, partially filling the intermontane valleys.

Locally intruding the pre-Cambrian rocks are pre-Tertiary igneous masses and dikes thought to be of late Jurassic or early Cretaceous age. They occur chiefly in the Cerbat Mountains and are connected with the genesis of the deposits. The most important are granite porphyry, a light gray medium-grained rock, and lamprophyric rocks, the latter occurring mainly as dark, complementary, narrow dikes accompanying the acidic intrusives.

The Tertiary volcanics consist mainly of andesites, trachytes, rhyolites, and latites, lying in broad superimposed sheets, flows and beds locally aggregating 3,000 ft. in thickness (Fig. 2). They are best developed in the Black Mountains, particularly in the southern part (Fig. 3). They contain most of the mineral deposits of the range and played an important part in their genesis.

ORE DEPOSITS OF THE DISTRICT

General Description

The discovery of mineral and the beginning of mining in the Mohave area date from the finding of ore at the Moss mine, 4 miles northwest of Gold Road in the early sixties. From 1904 to 1914[2] the production was nearly $16,000,000, of which $11,500,000 is in gold, nearly all derived from the Tom Reed and Gold Road mines. Besides gold and silver, zinc, lead, copper, tungsten, molybdenum, and bismuth are produced. The distribution of the districts or camps, about 30 in number, is shown in Fig. 4.

[2] *Mineral Resources, U. S. Geological Survey*, 1904–1914.

The deposits are contained in two distinct groups of fissure veins. The first group consists of the veins of the Cerbat Range which occur chiefly in the pre-Cambrian rocks and are genetically connected with the Mesozoic intrusives, especially granite porphyry and lamprophyric rocks. They are quartz fissure veins in which the quartz carries principally silver but also gold and ores of the other aforenamed metals. They were deposited in depth by hot waters. Their deep-seated character and close association with the major geologic structures indicate continuity in depth. They seem likely to continue productive long after the gold deposits now attracting so much attention in the volcanic rocks of the Black Mountains shall have become exhausted. Oxidation extends to depths of about 300 ft. At present the sulphide ores are principally utilized, though the rich secondary oxidized silver ores furnished most of the early-day production.

The second group comprises the veins of the Black Mountains which occur chiefly in the Tertiary volcanic rocks and whose filling besides quartz includes calcite, adularia, and fluorite. They are deeply oxidized. The valuable constituent is almost wholly free gold.

The Cerbat Mountains Group

General Description.—The deposits of the Cerbat Mountains are mostly located at from 9 to 20 miles north of Kingman. Their production for the year 1915, according to the Chloride Mining Bureau, is $3,000,000. They occur in two sets of well-defined fissure veins, with steep dip-forming conjugate systems, one striking about N. 20° W., parallel with the dominant jointing, and the other N. 60° W. perpendicular to the schistosity of the rocks. Many of the veins have a length of nearly a mile. The structure is irregularly massive. Among the primary-ore minerals, the most important are pyrite, chalcopyrite, arsenopyrite, galena, and sphalerite; more rarely, molybdenite, gold-silver telluride and stibnite. The decrease in galena and increase in pyrite noted in the lower levels, suggests a gradual change in the primary filling. Silver and lead predominate in the Chloride, Mineral Park, and Stockton Hill districts; gold, zinc, and silver in the Cerbat district. The primary ore is leaner in gold and silver than the oxidized ore, and many mines which near the surface were silver mines, with increase in depth carried more lead, and at still greater depths have become cupriferous. The so-called "copper belt" of the area extends from Mineral Park northwestward toward Chloride for a distance of several miles. It contains the Pinkham and Midnight copper mines, and in the Mineral Park end of the belt a recently discovered "copper porphyry" deposit which is attracting attention.

The water level is found at a maximum depth of about 400 ft. In general, the ores above the water level are oxidized, but in many places

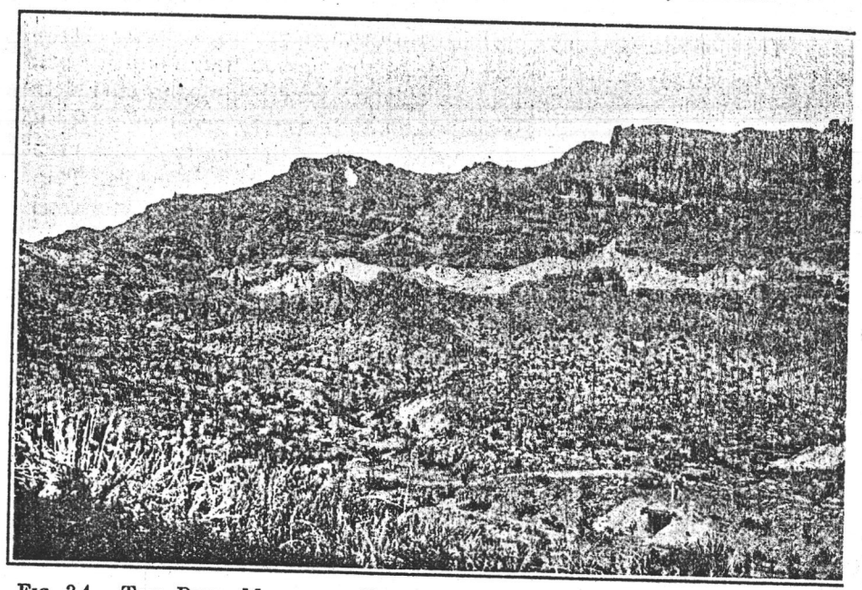


FIG. 3A.—TOM REED MINE AND VICINITY, LOOKING NORTHEAST (IN 1907). DARK VOLCANIC ROCKS OF RANGE IN BACKGROUND, INTRUDED BY LIGHT-COLORED RHYOLITE.

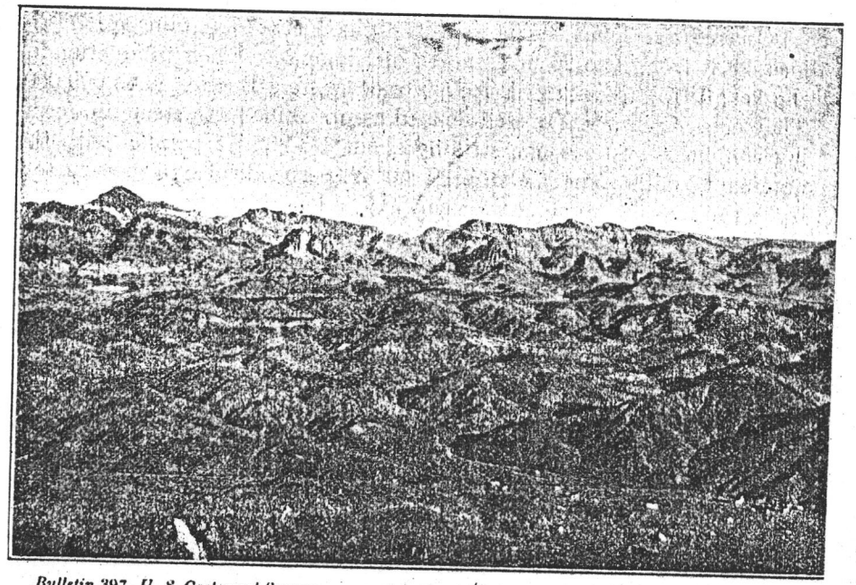


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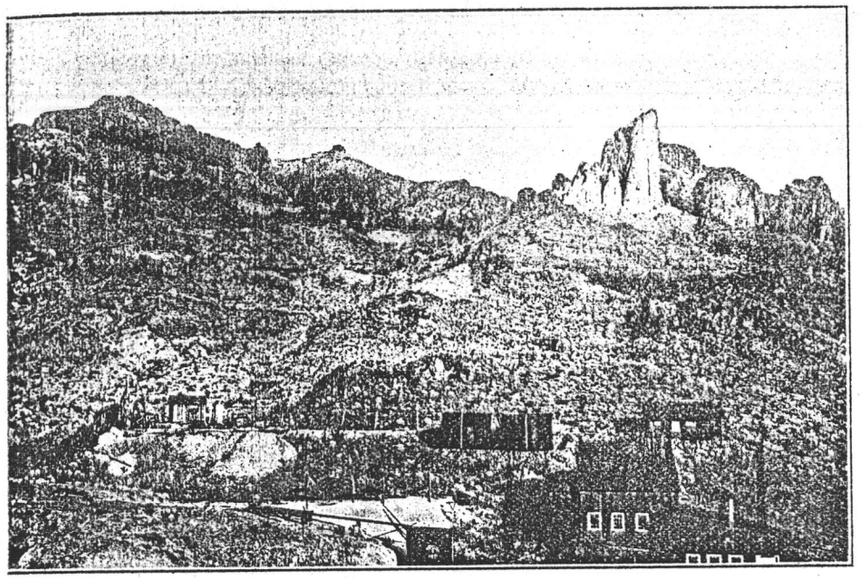
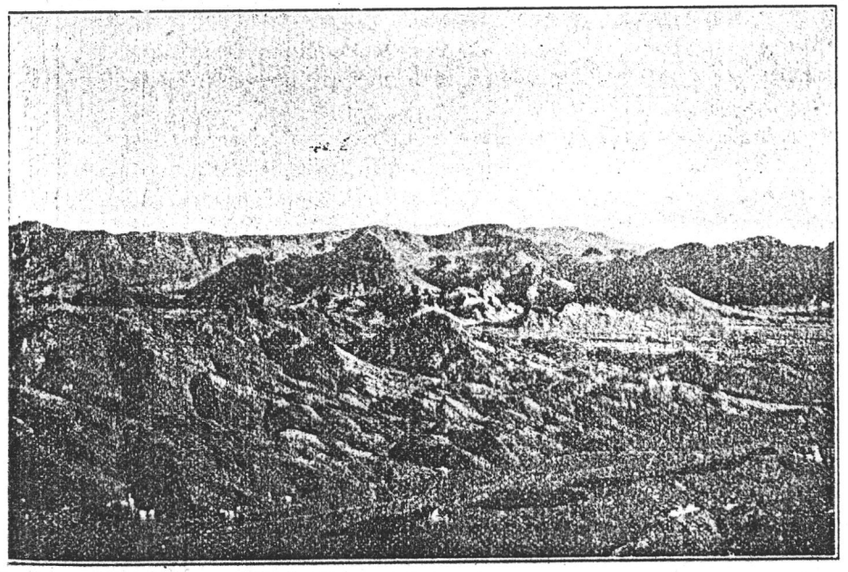
FIG. 3B.—FOOTHILLS OF GREEN CHLORITIC ANDESITE, LOOKING EAST FROM LELAND RANGE, 4 MILES DISTANT, IN BACKGROUND.



MINE. MINES NEAR VIVIAN, AND GREEN CHLORITIC ANDESITE IN FOREGROUND; MAIN



(*e.g.*, in the Tennessee vein) galena, and also, locally, pyrite, appears near the surface in association with oxidized ores. In a few mines oxidized ores are found below water level, but not to great depth. The secondary,

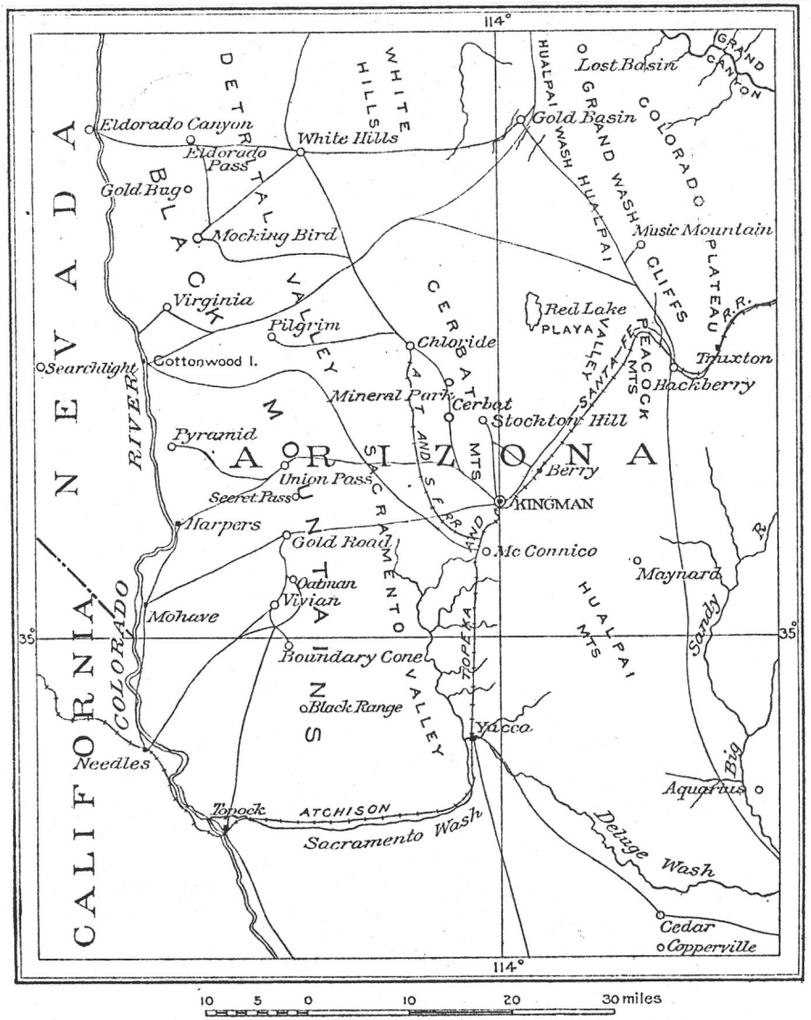


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FIG. 4.—MAP SHOWING MINING CAMPS IN THE MOHAVE COUNTY MINING REGION, ARIZONA.

or oxidized ores, consist chiefly of native silver, horn silver, and cerusite. Ruby silver and argentite are also present with oxidized ore, but do not occupy any well-defined zone between the oxidized and primary ores.

Many of the ore shoots coincide with intersections or forkings of veins. Good examples were noted in the Pinkham, Elkhart, Rainbow, Pay Roll, and Tennessee mines.

Tennessee Mine.—In the Chloride district, a dozen or more mines are opened to depths of 200 to 1,000 ft. or more, and expose large quantities of good gold-silver and other ores. Among them the Tennessee mine, situated a mile east of Chloride and owned by the United States Smelting, Refining & Mining Co., has long been one of the greatest lead-zinc producing properties of the State. It is credited with a present monthly production of $150,000. It has good orebodies on the 400, 800, 900, 1,000, 1,200, and 1,400-ft. levels, the last-named being the present limit of development. During a considerable portion of the time in recent years it has shipped about 200 tons of ore daily, mostly to Needles. The present daily output is said to be about 300 tons, mostly from the 1,170, 700 and 500-ft. levels.

The mine is on the Tennessee vein, which is regarded as a part of the great lead-bearing "lode" on which the Schuylkill and Elkhart mines to the north are situated. The vein is 12 ft. or more in width, and is locally banded. It dips about 68°E. in pre-Cambrian gneiss, with granite and schist near by and a pegmatite footwall reported in the lower levels. The orebodies which occur as lenses in the vein average about 5 ft. in width. The ore consists mainly of galena and blende, but carries a fair amount of silver and some gold and copper. At present the zinc ore is shipped to the company's smelter at Bartlesville, Okla., and the lead ore to Midvale, Utah.

The mine has been productive almost from the surface down. From between the surface and the 400-ft. level, thousands of tons of rich galena ore have been shipped. Here the main ore shoot had a horizontal extent of about 250 ft., and in places was 15 ft. in width. On the 400-ft. level, an orebody 21 ft. in width with 5 in. of pure galena was mined for the distance of about 40 ft. From the fourth to the fifth level there was a predominance of blende, but from the fifth to the sixth level galena increased to the proportion found in the upper part of the mine.

The 500-ft. level contained good ore for a distance of 800 ft., and the raise from it showed 12½ ft. of almost pure galena. On the 600-ft. level, the vein contained about 10 ft. of good ore. Besides the aforedescribed deposits, large bodies of good zinc ore, some 12 ft. in width, on the 200-ft. and 500-ft. levels, have been left standing in the mine. According to recent reports there has just been opened up on the 1170- and 1400-ft. levels fine bodies of ore averaging about 25 per cent. each in lead and zinc. The body on the 1,170-ft. level has an average width of 8 ft. and a known horizontal extent of 250 ft.

Midnight Mine.—The Midnight mine, located about 2 miles south of Chloride, and adjoining the Pinkham mine, is said to have been recently

purchased by Salt Lake parties for $250,000. It has produced considerable high-grade copper ore, which contained also important amounts of silver and gold. It is opened to the depth of 300 ft. and is said to have 25,000 tons of pay ore blocked out in the workings, including workable bodies of relatively pure zinc ore. On the 200-ft. level, where the lode is 40 ft. in width, the average zinc content is 15 per cent.

Mineral Park.—The copper porphyry deposit recently discovered near Mineral Park and owned by the Copperfield Copper Porphyry Co., occurs in "porphyry" which seems to be the intrusive granite porphyry aforedescribed, the abundant source of mineralization in this part of the field. The deposit is said to have a width of 1,000 ft. and a length of ½ mile. It contains seams and small bodies of chalcocite and native copper disseminated through the porphyry, which, throughout the greater portion of a 160-ft. crosscut tunnel, carries from 3 to 30 per cent. of copper, with a width of 6 ft., averaging 25 per cent. The deposit is reported to contain by estimate 100,000 tons of 5 per cent. ore. Ore removed in doing development work is reported being shipped to the Humboldt smelter.

Golconda Mine.—The deposits of the Golconda mine operated by the Union Basin Mining Co., in the Cerbat district, occur chiefly in the Golconda vein in the pre-Cambrian complex and seem to be associated with the Mesozoic intrusives. They have produced from essentially surface workings several hundred tons of rich ore containing chiefly gold, silver, and lead with some copper and zinc. The drift on the 300-ft. level is said to have been driven 200 ft. on a 4-ft. ore shoot that averaged about 50 per cent. of zinc, and more recently the mine is reported to be daily shipping to Bartlesville about 100 tons of high-grade zinc ore on which net returns of 9 c. per pound of zinc is realized. Some ore averaging about $12 to the ton is also treated in a 30-ton oil-flotation plant at the mine. The present monthly production is said to be about $250,000.

The mine is reported to have commercial ore on the 1,100-ft. level and a large amount of good ore in all other levels. The present production is derived mainly from the 800-ft. level. On the 900-ft. level, the ore shoot has a known extent of 850 ft. and a large tonnage of high-grade ore is being stoped. From this level a crosscut is being extended to the Tubb vein which parallels the Golconda vein 120 ft. distant on the west and has produced considerable lead-silver ore. On the 700-ft. level, the stopes are working in a 12-ft. shoot of excellent milling ore.

During the year 1915, the mine is reported to have paid two dividends of $85,000 each, which is about 20 per cent. on the issued capital, and having proved the continuity of the ore shoot in depth the company is now erecting a 200-ton oil-flotation plant for treatment of zinc ores. There is said to be $400,000 worth of zinc in the tailings on the dump and in the old stopes in the mine. The mill will be operated by electric power supplied by the Desert Power and Water Co. from its oil-burning

plant at Kingman for about $12 per horsepower per month. The power line is also being extended to Chloride and the Tennessee mine. The introduction of electric power into the Cerbat Mountain districts seems likely to result in production from many mines now dormant but which, like the Tennessee and Golconda, are known to contain workable deposits. The prospect of cheaper power in the near future is said to be good.

Other Ore-bearing Districts.—Deep development is also being done by the Middle Golconda Co. on the adjoining Big Bethel and Silver claims, which are believed to contain the north extension of the veins of the Golconda mine. Here the main vein is 50 ft. wide and contains much good-grade zinc ore.

A few miles to the east, the Arizona-Butte Mines Co. is building a very complete mill to treat zinc-lead-gold-silver ores of the Banner and other Stockton Hill mines.

South of Kingman in the Yucca, Cedar Valley, and Aquarius Cliffs districts, respectively, plants are in operation producing concentrates of tungsten, molybdenum and bismuth ores.

Lost Basin District.—In concluding remarks on the eastern part of the region, attention is here called to certain copper deposits known for a decade or more in the Lost Basin district on the northeast. The occurrence of these deposits on the trend of the great northwest-southeast mineralization belt of Arizona which contains Bisbee, Ray, Globe, Prescott, Jerome, and other important districts, and under similar geologic conditions as productive deposits in most of those districts, seems to render them worthy of mention at this time.

With a width of about 9 miles, the Lost Basin district extends from the Colorado River at the mouth of the Grand Canyon southward in the Grand Wash Cliffs for the distance of about 20 miles, with Hualpai Wash roughly forming the western boundary. The topography is mostly rugged. The country rock consists of the pre-Cambrian granitic complex, which here is considerably schistose, and the overlying Paleozoic sediments of the Grand Canyon section (Aubrey group, Redwall limestone and Tonto group).

Important gold- and silver-bearing veins occurring mostly south of the middle part of the belt in the pre-Cambrian rocks have long been worked from time to time, and some are now producing. They strike about north. Their ores are fine in texture and are excellent cyaniding ores.

The copper deposits extend from the middle of the belt eastward nearly to the summit of the Grand Wash Cliffs and edge of the Colorado Plateau. They consist of copper-bearing quartz veins and lodes which trend northwest-southeast, some being exposed by erosion through a vertical range of several hundred feet or more. They occur chiefly in the granitic rocks, but some of them, notably on the east, are in the