61st Congress, 1st Session | HOUSE OF REPRESENTATIVES | Document No. 96

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

BULLETIN 397

MINERAL DEPOSITS

OF THE

CERBAT RANGE, BLACK MOUNTAINS, AND GRAND WASH CLIFFS

MOHAVE COUNTY, ARIZONA

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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Scale 1/250,000

0 1 2 4 6 8 10 12 Miles

Contour interval 250 feet

1908

LEGEND

SEDIMENTARY ROCKS

- Conglomerates and gravel — QUATERNARY AND TERTIARY
- Undivided Aubrey, Redwall, and Tonto — PALEOZOIC

IGNEOUS ROCKS

- Basalt — QUATERNARY
- Undifferentiated andesites trachytes, rhyolites, and latites — TERTIARY
- Chloritic andesite — TERTIARY
- Granite porphyry — PRE-TERTIARY ?
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- Granite gneiss and schist — PRE-CAMBRIAN
- Area in which the granite porphyry intruded into the pre-Cambrian complex is generally abundant — PRE-CAMBRIAN

- Mine
- Prospect
- Shaft
- Well
- Section corner
- Buildings
- Fault
- Strike and dip

MINERAL DEPOSITS OF THE CERBAT RANGE, BLACK MOUNTAINS, AND GRAND WASH CLIFFS, MOHAVE COUNTY, ARIZONA.

By F. C. SCHRADER.

INTRODUCTION.

FIELD WORK AND ACKNOWLEDGMENTS.

The field work forming the basis of this paper is a reconnaissance made by the writer, under the direction of Mr. Waldemar Lindgren, during the period extending from October, 1906, to February, 1907. The purpose of the paper is to furnish a general idea of the character, occurrence, distribution, and development of the mineral resources of a part of western Arizona (see fig. 1) concerning which little has hitherto been known. The reconnaissance covered almost the whole of Mohave County, except some smaller camps in the extreme north and in the southern part of the county, which could not be reached in the time allotted to the work.

Owing to the desert conditions of the region—the scarcity of grass and water—a camp outfit was dispensed with and subsistence was obtained from the mining camps and prospectors.

The general method of work employed was to make hasty sketch maps and sections of the various camps or mines, using a box compass and aneroid for determination of bearings and elevations, and tying the work wherever practicable to Land Office section or township corners, railroads, other surveys, and mining-claim monuments.

The early reconnaissance maps of the Geological Survey, especially the Camp Mohave and Diamond Creek contour sheets, though for the most part too crude for local use, were found to be of material service in general. In a broad sense they represent fairly well the physical features of the region and are used as the base of the geologic map (Pl. I) in the present report.

Wherever available, the geology of portions of the area not visited by the writer has been compiled from the maps and reports of the

earlier surveys, notably those of Newberry, Gilbert, Marvine, and Howell, and the later ones of Lee and Ransome, of which a fuller account appears on subsequent pages.

To the various mining companies, prospectors, and mining men throughout the field grateful acknowledgments are due for courtesies, hospitality, transportation, and other assistance, which was extended

FIGURE 1.—Index map showing position of area covered in this report.

with unusual generosity. Especially important aid was received from the companies in the Gold Road, Silver Creek, Pyramid, Mocking Bird, Stockton Hills, Cerbat, Chloride, Gold Basin, and Music Mountain districts.

Among the individuals to whom the writer wishes to express his sincere thanks for assistance rendered are superintendents S. R.

Porter, J. W. Moore, O. F. Kuencer, C. V. Turner, W. C. Howard, F. L. Garrison, W. H. Cushing, Leonard Hoffman, H. L. McCarn, and J. D. Jordan, and Messrs. Daniel Bosqui, Levi Suthers, J. de Sallmarde, A. M. McDuffee, Robert Brannack, C. J. Hutchinson, C. J. Rhodes, George Aitken, John Barry, A. W. Braettlund, Daniel McFarland, Thomas Patterson, C. E. Heimer, and R. C. Jacobs. In the office the microscopic determinations of the rock and ore sections were made by Mr. Lindgren and Mr. B. S. Butler, and the chemical analyses by Messrs. George Steiger and E. C. Sullivan.

PREVIOUS WORK.

Probably no other region in the United States of equal importance in respect to mineral resources has received so little attention as western Arizona. No official report has treated the mining geology of this area, though its general geologic and geographic features have been known for some time through the earlier explorations. In 1853–54 Jules Marcou, as geologist of the Pacific Railroad route expedition, visited the southeast corner of the area, and his notes, published in the reports of the expedition,[a] include a preliminary description and map of the geology of this section. In a later work[b] the same author, referring to the same region, gave the principal formations composing the Cerbat Mountains, and showed on his geologic map of North America the geology of the entire region, but only in the most general manner.

A more complete account of the region was later given by Newberry, who, as geologist with the Ives expedition[c] in 1857–58, ascended Colorado River to the mouth of the Virgin and later traversed the area in a northeasterly direction from Camp Mohave, on the Colorado, to Music Mountain, at the edge of the Colorado Plateau. He very ably describes the geology and geography of the country along his route of travel, and includes in his description some notes on the mineral deposits of the Cerbat Range.

Further contributions on the mineral deposits of this region were later published by Silliman, who, entering from the west by way of Camp Mohave, visited the Silver Creek and other regions in the San Francisco mining district in 1864.[d]

In 1871 to 1873 the northern and eastern portions of the area were visited and mapped by Gilbert, Marvine, and Howell, geologists with the Wheeler Survey.[e]

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[a] Pacific Railroad Reports, vol. 3, 1856, pp. 156–158.

[b] Marcou, Jules, Geology of North America, 1858, p. 24.

[c] Newberry, J. S., in Lieut. J. C. Ives's report on the Colorado River of the West, 1861, pt. 3, pp. 29–54.

[d] Silliman, Benjamin, jr., On some of the mining districts of Arizona: Am. Jour. Sci. 2d ser., vol. 41, 1866, pp. 289–308.

[e] U. S. Geog. Surveys W. 100th Mer., vol. 3, pts. 1, 2, 3, and 5, and atlas sheets 66, 67, and 75.

In 1900 Comstock, whose experience with the mines and veins of Arizona and adjoining regions had been extensive, published a paper[a] in which he sketched the stratigraphy and mineral deposits of Arizona, presented a sketch map showing three systems of structure lines related to ore deposits, and cited portions of the Cerbat Range in discussing the persistence of his so-called latitudinal gold belts of the primary uplift.

About 1902 detailed topographic work by the Reclamation Service on the lower part of the Colorado was extended northward to a point above Round Island, at about the middle of the western edge of the area here discussed.

During the seasons of 1903 and 1904 a more complete geologic reconnaissance of the area than that of the Wheeler Survey was made by W. T. Lee,[b] who traversed the area in various directions, mapped the geology, and made a collection of igneous rocks that have been determined by Albert Johannsen.

More recently, in 1906, F. L. Ransome made a reconnaissance of the mineral deposits and mines of the Searchlight and Eldorado districts[c] in southern Nevada, bordering the Mohave area on the west, and, in connection with his report on the mines and formations, published a sketch map of the districts, a part of which has been used in the present report.

GEOGRAPHIC RELATIONS.

LOCATION.

The region herein described lies in the western part of Mohave County, Ariz., bordering California and Nevada on the west and north. (See Pl. I, in pocket.) It extends from the thirty-sixth parallel near the Big Bend of Colorado River, on the north, to the south end of the Black Mountains, near latitude 34° 40′, on the south, and from Hackberry and the Grand Wash Cliffs at the edge of the Colorado Plateau, near the 113° 30′ meridian, on the east, to Colorado River, near longitude 114° 45′, on the west. Its longer diameter trends north and south, in which direction it has an extent of about 95 miles; its width is about 75 miles and its area about 7,100 square miles.

The region is composed of naked desert ranges of mountains and broad, desolate, detritus-filled valleys, the southern extension of the topography of the Great Basin. It is best reached by way of the Atchison, Topeka and Santa Fe Railway, the only railroad line traversing it. Near Seligman the railroad begins to descend rapidly

[a] Comstock, Theodore B., Geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 1038–1102.

[b] Lee, W. T., Geologic reconnaissance of a part of western Arizona: Bull. U. S. Geol. Survey No. 352, 1908. Mr. Lee kindly gave the present writer access to his unpublished maps.

[c] Ransome, F. L., Bull. U. S. Geol. Survey No. 303, 1907, pp. 63–79.

to the southwest. Passing through picturesque canyons and washes, in the course of 60 miles it descends 2,000 feet to Hackberry, at the eastern edge of the area described. Picking its grade by detours around the mountains, the railroad continues its descent to Mellen, in the southwestern part of the area, where it crosses Colorado River at an elevation of 500 feet, or about 5,000 feet below its position on the edge of the plateau at Seligman. Near the middle of its course across the area it passes through a gap in the Cerbat Range, a partial break of erosion known to the early explorers as "Railroad Pass." Near its middle this pass widens into a sort of basin in which is situated Kingman, the county seat of Mohave County and the metropolis and distributing point for nearly all the mining regions of northwestern Arizona. Kingman is reached in thirteen hours from Los Angeles.

CLIMATE AND VEGETATION.

The climate of the region is arid, with hot summers and mild winters. The temperature of June, July, and August averages high, but the intensity of the heat is mollified by the dryness of the atmosphere, a more or less constant breeze, and cool nights. The hottest belt follows Colorado River. The climate ranks among the most healthful in the United States.

The annual precipitation, according to E. C. Murphy, of the United States Geological Survey, is about 5 inches—very much less than the evaporation. During hot weather it is largely concentrated in cloud-bursts, and the country is subject to sudden and violent winds, which in the valleys are often accompanied by sand storms. Most of the mountains as well as the valleys are free of snow during winter, and the highest mountains become free of it in early summer.

Portions of the Hualpai Mountains are forested with timber and contain areas of excellent pine suitable for lumbering and mining purposes, and there are a few open groves of scrub piñon or cedar, such as occur at Mineral Park, but otherwise the area is timberless. The vegetation is of the desert type and is confined mostly to the valleys, mesas, and lower slopes of the mountains. It consists mainly of cacti, greasewood, yuccas, soapweed, sage, and cat-tails. The tree yucca (*Y. arborescens*), or "joshua tree," grows in open groves in portions of the White Hills, and during the activity in the White Hills and Gold Basin camps it supplied the fuel used in operating the hoists. Many species of cactus are represented, but the *Sahuaro*, or giant cactus, so common in southern Arizona, does not appear. The branching prickly pear, attaining a height of 4 or 5 feet, is abundant in the Hualpai and Detrital-Sacramento valleys, as is also the greasewood or creosote brush.

White sage is present throughout the area. Grass is usually of scanty growth, but burros live on it, in connection with sagebrush,

the year round, and a few horses and cattle are kept in the Hualpai and Detrital-Sacramento valleys, where also a small amount of wheat and other cereals is grown. On some of the irrigable bottom lands along the Colorado, notably in the southwestern part of the area, six crops of alfalfa a year are reported to be raised. The greater part of the Hualpai and Detrital-Sacramento valleys, if supplied with water for irrigation, would also prove excellent for agriculture.

SETTLEMENT AND MEANS OF COMMUNICATION.

The principal settlements, whose locations are shown on the accompanying map, are Kingman, with a population of about 1,000; Chloride, with 500; Goldroad, with 300; and Hackberry, with 200. In respect to churches, mail privileges, newspapers, mercantile and other business houses, fraternal orders, schools, telegraph and cable service, and other social and business facilities, these places compare favorably with any others of their size. The population consists essentially of enterprising, law-abiding Americans and includes representatives from nearly every State in the Union.

Chloride, situated at the terminus of the Arizona and Utah Railroad, about 20 miles north of Kingman, where it connects with the main line of the Atchison, Topeka and Santa Fe Railway, is the subdistributing point for the camps in the northwestern part of the area, and even as far as Eldorado Canyon, Nevada. Hackberry, about 30 miles east of Kingman, on the main line of the Santa Fe, is the distributing point for camps in the eastern part of the area, including Lost Basin, Gold Basin, and Music Mountain.

The settlements and camps are nearly all connected by wagon road, stage line, mail, and telephone, with their distributing points and Kingman, and most of them with one another. The distances of the more important camps from their distributing points are as follows:

Distances of the more important camps from their distributing points.

From Kingman to—	Miles.	From Kingman to—	Miles.
Stockton Hill	11	Pyramid	36
C. O. D. mine	16	Hardyville	30
Gold Road	24	Fort Mohave	44
Vivian via Gold Road	28	From Chloride to—	
Silver Creek via Gold Road	28	Mineral Park	6
Todd Basin	16	Todd Basin	12
Cerbat	14	Cerbat	14
Layne Springs	17	White Hills	23
Mineral Park	20	Eldorado Canyon, Nev	49
Chloride	26	Virginia Camp	15
White Hills	49	From Hackberry to—	
Gold Basin	66	Music Mountain	25
Cedar via Yucca	51	Gold Basin	40
Eldorado Canyon, Nev	74	Lost Basin	50
Virginia Camp	40	Scanlan Ferry	60
Sheeptrail Mines	28	Signal	85

Stage lines run from Kingman to Gold Road and to Cerbat daily except Sunday. Semiweekly service is maintained from Hackberry, via Big Sandy, to Signal and to Gold Basin; also from Chloride to White Hills and Eldorado Canyon.

PHYSIOGRAPHIC FEATURES.

COLORADO PLATEAU.

As shown by Gilbert, Marvine, and others, northwestern Arizona lies mainly in two well-known provinces, the high Colorado Plateau on the east and the Great Basin on the west. These provinces, which reach their best development and are best known in Nevada and Utah, maintain in their southern extension into Arizona the relation which they have farther north. This relation is well expressed in the northern part of the area delineated on Plate I, where the Grand Wash Cliffs, extending from Music Mountain in a northwesterly direction across Colorado River, form for the most part a sharp boundary line between the Grand Canyon country, or Colorado Plateau province, on the east and the Great Basin on the west. Along this line descent is made from the plateau, at an elevation of 6,500 feet, by steep, rocky cliffs, bluffs, and finally talus slopes, into the basin 3,000 feet below. The dominant features of the plateau in this portion of Arizona are benched mesas or table-lands, composed of generally horizontal stratified rocks. Through this table-land area the deep trench of the Grand Canyon of the Colorado has been cut.

GREAT BASIN PROVINCE.

The chief features of the Great Basin portion of the area—the portion with which this paper is principally concerned—consist of ranges of mountains trending nearly north and south and separated by broad, plain-like, detritus-filled valleys.[a] On the west lies the great trough of Colorado River, which has cut through these desert ranges without greatly modifying the general physiography of the country.

DRAINAGE.

The entire area drains into Colorado River. In most of the northern portion, that which extends westward from the Colorado Plateau, the drainage flows northward, chiefly by way of Hualpai Wash and Detrital Valley, to the Colorado below the mouth of the Grand Canyon, just beyond the northern edge of the area. The drainage of the southern portion of the area finds its way to the Colorado

[a] For a single map showing comprehensively the great number and distribution of these ranges in the adjoining States of Nevada and California, see Bull. U. S. Geol. Survey No. 208, 1903, Pl. I.

chiefly by way of Big Sandy Wash, a tributary of Williams River, on the southeast and Sacramento Wash on the southwest.

RELIEF.

The altitude of the area ranges from 500 feet in the southwestern part to nearly 8,300 feet on Hualpai Peak, the highest mountain, the total vertical range being thus about 7,800 feet. The mountains collectively average somewhat less than 5,000 feet in elevation, the valleys about 2,500 feet, and the land mass of the area as a whole about 4,000 feet. The general slope of the area is southwestward toward Colorado River.

MOUNTAINS.

The mountain ranges trend north-northwest, nearly parallel with the edge of the plateau. They seem in general to be due to erosion, but some are, in part at least, deformational ranges or fault blocks. They exhibit considerable variation in height, but for the most part rise about 3,000 feet above the neighboring valleys and are generally rugged. Like the valleys, they average 10 or 12 miles in width, and their aggregate area is about equal to that of the valleys. They are composed in the main of pre-Cambrian granitoid and metamorphic rocks, flanked or overlain by younger rocks of volcanic origin. The sedimentary deposits of the Colorado Plateau, which at one time must have covered this entire area and which, according to Spurr,[a] as folded strata compose the mountains in the Nevada and Utah portion of the Great Basin, have here been completely removed by erosion.

The ranges west of the Grand Wash Cliffs, as represented on the map, are three in number—the Cerbat Range, the Black Mountains, and, west of Colorado River, the Eldorado Range. This paper deals chiefly with the Cerbat Range and the Black Mountains.

GRAND WASH CLIFFS.

The Grand Wash Cliffs constitute the great break of the Colorado Plateau into the Great Basin. They undoubtedly represent a fault line, as has been described by previous writers, and are so shown on the accompanying map (Pl. I).[b] Dutton[c] describes the Grand Wash fault as a gigantic displacement in which the whole country to the west has dropped down 6,000 or 7,000 feet. This fault is best developed along the edge of the plateau, extending from the mouth of the Grand Canyon southeastward to Music Mountain, a distance of about 50 miles, with a height of escarpment of about 3,000 feet

[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 133.

[b] The faults here shown are copied from Lee, W. T., Geologic reconnaissance of a part of western Arizona: Bull. U. S. Geol. Survey No. 352, 1908, Pl. I.

[c] Dutton, C. E., Second Ann. Rept. U. S. Geol. Survey, 1882, p. 126.

and an average width of about 3 miles. The regularity of its course is locally interrupted by embayments or short, deep canyons cut back into the plateau, the most marked example being that at Clay Spring, north of Music Mountain camp.

From the edge of the plateau the general trend of the slope is west-southwest into Hualpai Valley. Typically this slope is made up of three topographic elements; these are, in descending order, (1) an upper, more or less precipitous cliff or scarp, about 1,500 feet in height, composed of the nearly horizontal strata of the Grand Canyon section; (2) an intermediate mountainous belt, in many places steep and rugged, composed of pre-Cambrian rocks having a vertical range of 1,000 or more feet and a breadth of about 2 miles; (3) a less steep foothill belt of irregular hills and ridges, consisting of similar granitoid rocks, which, with immense local deposits or fans of steep-lying talus or coarse, mostly granitoid, débris, descend from 600 to 1,000 feet to the edge of the valley.

At Music Mountain the Grand Wash Cliffs divide, the upper or sedimentary portion extending eastward under the name of Yampai Cliffs, and the lower or crystalline portion continuing southward under the names of Cottonwood Cliffs and Aquarius Cliffs, forming the edge of the Truxton Plateau.

CERBAT RANGE.

The Cerbat Range extends nearly north and south through the middle of the area. In the latitude of Music Mountain it lies about 16 miles west of the Grand Wash Cliffs, which it in general parallels and from which it is separated in the northern part of the area by Hualpai Valley, 15 miles wide, and in the southern part by Big Sandy Valley, 10 or 12 miles wide.

The Cerbat is a broken range. As originally used by Lieutenant Whipple the term includes the Cerbat Mountains, the Hualpai Mountains on the south, and the White Hills on the north. Lee includes, in addition, the Aubrey Hills, a small group of low mountains to the south of the Hualpais. The range is the direct southerly extension of the Virgin Mountains, across Colorado River, in Nevada.

Cerbat Mountains.—The most important part of the range, so far as the present discussion is concerned, is the group known as the Cerbat Mountains, which lie in the central part of the area, between the Hualpai Valley on the east and the Detrital-Sacramento Valley on the west. On the north they are separated from the White Hills by a very low, detritus-filled pass, directly connecting the detrital deposits of the Hualpai Valley with those of the Detrital Valley. On the south, however, the Cerbat Mountains are somewhat loosely connected with the Hualpai Mountains by an intervening low, dis-

sected volcanic mesa, whose surface lies but a few hundred feet above Kingman, situated near its center, and which for convenience of reference may be designated the Kingman Mesa. (See Pl. IV, *A*.)

The Cerbat Mountains have a length of about 30 miles and an average width of about 10 miles. They attain their maximum width—about 12 miles—just north of Chloride, which is situated near the middle of their western border. They are high and rugged, and seem to be essentially of erosional origin.

The most important valleys, so far as mining interests are concerned, are those in which lie Cerbat, Todd Basin, Mineral Park, and Tennessee washes on the west and Stockton Hill, I. X. L. Basin, and the C. O. D. washes on the east. These valleys head near the axis of the mountains and debouch on the plains at right angles to its trend. The mountains are composed of pre-Cambrian granitic rocks, with their edges locally flanked on the west and south by Tertiary volcanic rocks and on the east by younger basalts. The crest line lies at about 6,000 feet, or 3,000 feet above the adjacent valleys. The culminating peaks are Cherums Peak, near Chloride, and Mount Tipton, at the north end of the group, both of which reach altitudes of about 7,000 feet.

White Hills.—The White Hills are situated in the north-central part of the area, north of the Cerbat Mountains, between Hualpai Wash on the east and the Detrital Valley on the west. They consist of a belt of low hills about 15 miles in width, extending northward for 25 miles to Colorado River. Here the Virgin Canyon separates them from the Virgin Mountains on the north. They rise from 100 to 2,000 feet above the valleys on either side, but nowhere do they attain an elevation of 5,000 feet, and their topography is in the main of a gentle type. The White Hills are composed of pre-Cambrian granitoid rocks, covered locally with Tertiary volcanic rocks or younger basalt and patches of Quaternary conglomerate and gravels.

Hualpai Mountains.—The Hualpai Mountains lie in the southeastern part of the area, southeast of the Cerbat Mountains, south of Hualpai Wash, and between the Big Sandy Valley on the east and the Sacramento Valley on the west. They extend from the latitude of Kingman southward a few miles beyond the limits of the area shown on the map (Pl. I, in pocket), in which direction they have a length of about 40 miles. On the north they have a width of about 16 miles, which, however, diminishes somewhat within a short distance to the south. Their average height, as given by Lee, is 7,000 feet. Their culminating point is Hualpai Peak, which is situated in the northern part of the group, 11 miles southeast of Kingman, and attains the altitude of 8,266 feet.

These mountains are composed of pre-Cambrian granitic rocks and seem to be a fault block tilted eastward. The precipitous western

slope, according to Lee, meets the detrital plain of the Sacramento Valley at high angles. Its base is flanked on the north by the Kingman Mesa, and similar flat lava-topped buttes and hills, rising a few hundred feet above the surrounding plain, extend southward nearly to the south end of the range.

The eastern slope of the mountains, according to Lee,[a] is not so precipitous as the western. He says:

> At altitudes of nearly 6,000 feet the crystalline rocks begin to disappear beneath a corrugated detrital slope of comparatively low gradient, which extends eastward to Big Sandy Wash, a distance of 10 to 15 miles. In this distance the descent is about the same as that attained in the western slope in a much less distance.
>
> At the southern end of the range the mountains cease rather abruptly, giving place to low isolated hills separated by broad passes occupied by the detrital accumulation of the plains. To the east are several comparatively small spurs and detached mountain groups.

Peacock Mountains.—Northeast of the Hualpai Mountains, lying between them and the Cottonwood Cliffs and interrupting the continuity between the Hualpai and Big Sandy valleys, are the Peacock Mountains, an outlying group having a length of 20 miles and a width of 6 or 7 miles. Like the Hualpai Mountains, they are composed of pre-Cambrian granitic rocks and have their steeper slope on the west. They culminate in Peacock Peak, a few miles southeast of Hackberry, near the middle of the group, at an altitude of 6,268 feet.

BLACK MOUNTAINS, OR COLORADO RANGE.

In the western part of the area and the extreme western part of Arizona, lying between the Detrital-Sacramento Valley on the east and the great trough of Colorado River on the west, are the Black Mountains, known by the early writers as the Blue Range and on the Wheeler maps and in a still later report by Spurr as the Colorado Range. At present this range is often called the River Range, but it is more generally known as the Black Mountains, and this name has been adopted for it by the United States Geographic Board.

This range is the southern extension of the Muddy Range in southeastern Nevada, from which it is separated on the north by Boulder Canyon, situated east of the Great Bend of the Colorado. It extends from Boulder Canyon for 100 miles southward, to the valley of Sacramento Wash, or nearly to the southern edge of the mapped area, east of Needles. Though continuous throughout, it is more or less irregular in height and width. It varies in width locally from 5 or 6 miles in the northern and middle parts to 10 miles or more in the southern part; and the crest line varies in altitude from

[a] Lee, W. T., Geologic reconnaissance of a part of western Arizona: Bull. U. S. Geol. Survey No. 352, 1908, p. 24.

5,500 feet in Mount Perkins and Mount Wilson to about 3,000 feet in Eldorado Pass, west of the White Hills.

The topography is, in the main, that typical of a mass of volcanic flows eroded into rugged peaks, ridges, cliffs, canyons, and gorges. In some regions, however, where erosion has been less intense, the original type of table-land and mesas is still preserved. As shown in figure 2, the usually short eastern slope meets the plain of the Detrital-Sacramento Valley at an average elevation of about 2,000 feet; the long western slope descends to Colorado River, which here flows at an average elevation of about 540 feet.

Much of the northern portion of the range, however, lies close to the river, where its rocks form the walls of the Black Canyon of the Colorado. According to Newberry,[a] a magnificent exposure of volcanic rocks is displayed at this locality. Toward the south, however, broad, gravel-covered, inclined, graded planes or mesas, 2 to 5 miles in width, intervene between the mountains and the river or the alluvial flats which locally border it.

The range is essentially composed of the pre-Cambrian granitoid complex, flanked or overlain, and in the southern part deeply buried, by extensive areas of Tertiary volcanics. A few smaller batholiths of granite porphyry or quartz monzonite of intermediate age are intruded into the pre-Cambrian rocks.

Topographically the range consists of five groups of mountains—the Mount Wilson, Perkins, Detrital-Sacramento, Mount Nutt, and Black Mesa groups, named in order from north to south.

The Mount Wilson group, named from its highest peak, which is situated toward its northern part and has an altitude of 5,500 feet, extends from Boulder Canyon southward to Eldorado Pass, a distance of about 25 miles. From Mount Wilson the altitude diminishes to about 3,000 feet at Boulder Canyon on the north and at Eldorado Pass on the south. The rugged western slope presents a view which for " wild, savage grandeur " Newberry describes as scarcely equaled by anything he had seen elsewhere.

The Mount Perkins group, an elongated ridge, extends from Eldorado Pass southward to Union Pass, a distance of 40 miles. It culminates in Mount Perkins, 5,500 feet high, situated near the center of the group. From this peak southward the altitude diminishes to 3,500 feet at Union Pass. The southern lava-covered portion of this group is, in part, of a mesa type.

The Detrital-Sacramento group occupies an area about 8 miles in diameter and extends eastward from the southern part of the Mount Perkins group nearly across the Detrital-Sacramento Valley southeast of Chloride, forming for the most part the divide between

[a] Newberry, J. S., Geological report (Ives, J. C., Report upon the Colorado River of the West, pt. 3), 1861, p. 40.

the Detrital Valley on the north and the Sacramento Valley on the south. It is composed of many small, irregular hills of basaltic rock.

The Mount Nutt group, of which Mount Nutt, 5,000 feet high, situated south of the center, is the culminating peak, extends from Union Pass southward to Gold Road (formerly Sitgreaves) Pass. It is a rugged group, composed of volcanic rocks with precipitous fault scarps along most of its southern and western portions. At Gold Road Pass the altitude of the crest line diminishes to 3,550 feet. In the latitude of Secret Pass (elevation 3,400 feet) the range is tripartite, being composed of three well-defined, north-south ridges, situated 2 or 3 miles apart.

The Black Mesa group extends from Gold Road Pass southward to the end of the range at Sacramento Wash, which is traversed by the Atchison, Topeka and Santa Fe Railway. It has a length of 20 miles, a width of about 10 miles, and an average elevation of about 4,000 feet. It diminishes in altitude toward the south. Its topographic form is the result of deep dissection of a huge volcanic plateau known as Black Mesa, whose rocks are about 3,000 feet in thickness and which formerly had a much wider extent. At the eastern portion the mountains form a relatively regular escarpment, rising about 1,000 feet above the Sacramento Valley; the western border is more deeply eroded and irregular, with projecting ridges and peaks, of which Boundary Cone and Leland and Hardy mountains are examples.

The mountains shown at the lower edge of the map, extending south of the railway along Colorado River, are a part of the Mohave Mountains on the east and of the group known as the Needles on the west. They are composed essentially of Tertiary volcanic rocks, and 8 or 10 miles southeast of Mellen connect with the Chemehuevis Mountains, which are made up of the pre-Cambrian complex.

ELDORADO RANGE.

Rising from the great trough of the Colorado on the west is the Eldorado Range, whose eastern slope only is represented on the accompanying map. This range is topographically and geologically similar to the Black Mountains, from which Colorado River separates it on the east, being composed of the same classes of rocks, with a somewhat greater proportion of monzonite and syenite. The Tertiary volcanic rocks predominate in the northern part and the pre-Cambrian crystalline complex in the southern part. The highest point is Dead Mountain, which has an altitude of nearly 6,000 feet and is situated near the middle of the range. Although the range does not properly form a part of the area here described, this brief sketch of it is given because it has close geographic, geologic, and

economic relations with this area. It contains the Searchlight, Eldorado Canyon, and other producing mining camps.

VALLEYS.

DETRITAL-SACRAMENTO VALLEY.

The principal valleys of the area, apart from the great trough of the Colorado, are the Detrital-Sacramento and the Hualpai. The former lies between the Cerbat Range on the east and the Black Mountains on the west. As defined by Lee,[a] it extends from Colorado River on the north to Williams River, 30 miles beyond the area mapped in Plate I, on the south, and between these points has a length of 130 miles and a width of 5 to 15 miles.

In the region of Chloride the valley is traversed by a low divide separating the drainage of the northern part from that of the southern part. The portion north of this divide, known as the Detrital Valley, drains northward by way of Detrital Wash, which empties into the Colorado between Virgin and Boulder canyons. The central portion, known as the Sacramento Valley, drains southward via Sacramento Wash, which joins the Colorado at Mellen. The portion south of Sacramento Wash has no distinctive name.

As noted by Newberry, Lee, and others, the Detrital-Sacramento Valley seems to be due mainly to erosion and must have been at one time occupied by a large river. The depth to which it was eroded is estimated by Lee, who has examined it on the north and on the south, as probably more than 2,500 feet; the amount of filling it contains, consisting of detrital deposits of conglomerate, sand, gravel, wash, clay, and intercalated sheets of basalt, is not known. Since the infilling, however, considerable erosion has taken place.

HUALPAI VALLEY.

The Hualpai Valley is situated northeast of the central part of the area, between the Grand Wash Cliffs on the east and northeast, the Cerbat Mountains and White Hills on the west, and the Peacock and Hualpai mountains on the south. It is about 75 miles long and 25 miles wide. It is for the most part an undrained basin; the lower portion, which has an elevation of about 3,000 feet and is about 16 miles in length by 10 miles in width, is known as Red Lake. This "lake," however, is a playa, or dry, barren, mud flat most of the time, owing to the evaporation of the flood waters or their absorption by the underlying filling of the valley. The principal drainage entering the basin comes through Truxton Creek, the bed of which is usually dry.

[a] Bull. U. S. Geol. Survey No. 352, 1908, p. 52.

The Hualpai Valley is a structural trough situated in direct alignment with the Grand Wash fault extending southward from the mouth of the Grand Canyon, where, according to Dutton, the throw is from 6,000 to 7,000 feet. According to Gilbert [a] it occupies a pseudomonocline formed by the fault. As suggested by Lee, this fault probably extends through the valley and is continuous with that west of the Hualpai Mountains.

Other evidences of deformation are tilted basalt sheets exposed in buttes and ridges dipping eastward beneath the floor of the valley along its western edge, and according to Lee the sedimentary rocks at the north end of the valley are also tilted to the east.

The thickness of the filling contained in the valley is unknown. A well 700 feet deep near the head of Hualpai Wash does not go through it.

The northern part of the valley, known as Hualpai Wash, is very much narrower than the main valley and has a length of 25 miles; it drains northward into the Colorado at Scanlon Ferry. It is a structural depression, and in its lower part contracts almost to a canyon. The divide at its head, which separates it from the undrained portion of the valley, rises but 300 feet above Red Lake and in time will probably be lowered by back cutting so that the lake will be drained by the wash.

BIG SANDY VALLEY.

The Big Sandy Valley is situated in the southeastern part of the area, between the Cottonwood and Aquarius cliffs on the east and the Hualpai Mountains and Aubrey Hills on the west. It extends from Hackberry southward to Bill Williams River, a distance of 75 miles, and has a width of 10 or 12 miles. The lowest portion of the valley occurring within the area here described is Big Sandy Wash, whose principal tributaries from the plateau region on the east are White Cliff, Trout, and Sycamore creeks. According to Lee, these streams enter the Big Sandy through deep, narrow canyons. He continues: [b]

> That portion of the valley between the Hualpai Mountains and Big Sandy Wash consists of a long, graded detrital slope, more or less deeply cut by parallel washes, such as Deluge Wash. This highly inclined detrital slope, the western fault scarp of the Hualpai Mountains, and the fault scarp to the east (Aquarius Cliffs) all terminate at the south in practically the same latitude.

Big Sandy Valley, as defined by Lee,[c] is a fault trough formed by the downthrow of the Hualpai Mountain block on the east, as marked by the fault extending southward along the Cottonwood and Aquarius cliffs. The overlying Tertiary volcanic rocks, having been

[a] Gilbert, G. K., U. S. Geog. and Geol. Surveys W. 100th Mer., vol. 3, 1875, p. 60.
[b] Lee, W. T., Bull. U. S. Geol. Survey No. 352, 1908, p. 50.
[c] Idem, pp. 50–51.

dropped from the level of the plateau on the east, now floor the valley and abut against the underlying granite along the fault plane at the base of the cliffs. The detrital filling of the valley, according to Lee, consists of several formations of sand, gravel, clay, tufa, etc., that are unconformable with one another. They represent different periods of deposition and aggregate 1,000 feet or more in thickness.

GREAT TROUGH OF THE COLORADO.

Location and character.—A most striking feature of the area is the great trough of Colorado River, extending north and south along its western border between the Black Mountains on the east and the Eldorado Range on the west. Its great sides, sloping from the crests of the ranges, 5,000 to 6,000 feet in altitude, meet in the bed of the river, which here flows at an altitude of about 540 feet. The floor of the stream is in some places bed rock; in others it consists of deposits of infilled débris of unknown thickness. The bottom of the trough consists mainly of stretches of open valley alternating with usually shorter canyons, whose steep walls rise precipitously above the river, locally to heights of more than 1,000 feet. Of these the most important are Black and Pyramid canyons.

The principal features of the trough were early described by Newberry, who, in association with the Ives expedition in 1857–58, ascended the river to Fortification Rock, situated above Black Canyon in the big bend of the river.

Black Canyon.—Black Canyon is situated in the northwest corner of the area, between the Detrital basin on the north and the basin of Cottonwood Valley, heading a few miles above Eldorado Ferry on the south. It has a length of about 18 miles and consists of a deep, narrow rock gorge, with few interruptions and no open valleys or alluvial deposits. The nearly perpendicular walls on either side of the water's edge rise to heights of 1,000 feet or more. According to Lee and Newberry, they are composed mainly of massive rhyolite, with pre-Cambrian granite in places outcropping at the base.

Cottonwood Valley.—Between Black Canyon on the north and Pyramid Canyon on the south the Colorado flows through an open basin-like area 30 miles long. It is the northernmost of a series of similar areas which extend southward to the Gulf of California. Its central part is known as Cottonwood Valley. Its flood plain bordering the river is in turn bordered by gravel bluffs between which and the foot of the mountains, 4 or 5 miles distant on either side, " are long corrugated slopes covered with angular rock débris or wash from the mountains " and local areas of basalt sheets.

Pyramid Canyon.—Pyramid Canyon lies about west of Union Pass, between the basin of Cottonwood Valley on the north and Mohave Valley on the south, Pyramid being located at its head. It

has a length of about 8 miles. Its depth is only 300 feet, but it is steep walled and is cut in the pre-Cambrian granitoid rocks, which here form a low neck extending from Dead Mountain eastward across the bottom of the trough to the base of the Black Mountains. Surmounting the granite cliffs on either side at 250 to 300 feet above the river are deposits of stratified gravel, similar to and continuous with those occurring above and below the canyon.

Mohave Valley.—Mohave Valley is the largest of the basin-like areas along the lower Colorado. It is elliptical in outline, being about 35 miles long and 15 miles broad. It extends from the foot of Pyramid Canyon southward to the Needles and Mohave mountains and is practically surrounded by ranges of rugged and picturesque desert mountains.

From the bases of the mountains long débris-covered slopes extend toward the river, giving way to gravel-covered mesas that descend in a succession of half a dozen terraces to the alluvial flood plain, about 80 square miles in area, bordering the river in the center of the valley.

GEOLOGY.

PRINCIPAL ROCK GROUPS.

The principal rocks of the region, beginning with the oldest, are the pre-Cambrian crystalline complex, the Paleozoic sediments, the post-Paleozoic intrusive rocks, the Tertiary lavas, and the Quaternary and recent sediments. They are approximately outlined on Plate I (in pocket). As detailed descriptions of them will be given under the heads of the camps in which they occur, only a general sketch is here attempted. With reference to the mineral deposits the first and third of the divisions mentioned are the most important.

PRE-CAMBRIAN ROCKS.

CHARACTER AND DISTRIBUTION.

The fundamental and oldest rocks of the area are those of the pre-Cambrian crystalline complex, which consists essentially of coarse, more or less porphyritic and roughly gneissoid granitic rocks, with gneiss and schist of various kinds. Altered sedimentary rocks may possibly be present in the complex, but of this there is little evidence. It contains numerous quartz veins or lodes in which occur the mineral deposits mined in the Cerbat Range and Grand Wash Cliffs and in part in the Black Mountains.

Though locally concealed, the pre-Cambrian complex underlies the area as a whole and constitutes the uneven floor upon which all the other rocks rest. It forms the larger part of the Grand Wash Cliffs, and extends eastward beneath the Paleozoic rocks of the Grand Canyon district. As shown by its outcrop area on the accompanying

map (Pl. I), it composes the greater portion of the White Hills and practically the whole of the Cerbat, Hualpai, and Peacock mountains. It is also the principal rock mass in the northern part of the Black Mountains. On the west side of the region it outcrops along the Colorado near Black and Pyramid canyons and beyond the river in the vicinity of Eldorado Canyon, Dead Mountain, and at other points in the Eldorado Range.

Outlying knobs and isolated outcrops, together with borings and exposures in washes and canyons, show that the pre-Cambrian complex extends from range to range beneath the detrital deposits of Hualpai and Detrital-Sacramento valleys, and thus continuously underlies the entire area.

PETROGRAPHY.

As a whole, the pre-Cambrian rocks consist of gneissoid granites, which are of varying degrees of schistosity, but which always preserve indications of their igneous origin. They are coarse grained and usually gray or reddish in color and consist of quartz, microcline, orthoclase, microperthite, oligoclase, and small amounts of biotite. The original structure is eugranitic. With increasing schistosity the crushing of the constituents becomes more apparent and muscovite develops from feldspar and biotite, while chlorite forms from the biotite. Garnet of pale reddish color is present in some of the rocks. Pegmatites and aplites are noted from many places and are evidently merely facies or products of differentiation of the prevailing rock.

At Stockton Hill, in the Cerbat Range, the gneisses are in places more schistose with accompanying development of chlorite. There also occurs an amphibolite, containing brown hornblende, labradorite, and magnetite; this rock is a pressed diorite. Other similar rocks contain hornblende, orthoclase, andesine (?), titanite, and magnetite. Entirely similar rocks were observed in the Chloride and Cerbat districts. In the White Hills, at the north end of the Cerbat Range, the gneisses are decidedly schistose with strong development of sillimanite and sericite. There are also amphibolites composed of light-green hornblende, brown mica, and sericitized feldspar.

In the Gold Basin district a quartz-sericite schist was found in addition to the usual gneisses, but it probably represents only an extreme schistose development of the granite. Coarse microcline granite showing some evidence of pressure appears at the base of the Grand Wash Cliffs, but along with it are found massive quartz monzonites which are probably post-Cambrian in age. The normal coarse gneissoid microcline granites prevail in the Union Pass district of the Black Mountains, toward the Colorado River side. Some of these are unusually schistose with remaining "augen" of microcline.

Of the specimens of gneisses and schists examined none indicated a sedimentary origin, except possibly a graphite schist from the Cerbat Range between Mineral Park and Stockton Hill.

STRUCTURE.

A schistose structure is characteristic of the pre-Cambrian granitic rocks in this region. The trend of the schistosity is, in general, about N. 30° E., with the dip vertical or eastward at usually steep angles; the dominant jointing strikes north-northwest, with the dip vertical or steeply to the east-northeast. This latter direction is also approximately the trend of most of the fissures containing the quartz lodes above referred to.

Besides the general structure above stated, the rocks have suffered material alteration in regions of intensity of movement, such as fault planes or shear zones, the otherwise massive granites being locally converted almost beyond recognition into fissile mica schist, hornblende schist, and other schists.

PALEOZOIC SEDIMENTS.

About the only Paleozoic sediments of the area are those of the Grand Canyon section, forming the upper part or cliff-making portion of the Grand Wash Cliffs and the adjacent portion of the Colorado Plateau. As they have no material bearing on the subject of this paper they may be dismissed with the following brief notice:

The series, taken in ascending order, consists apparently of a basal quartzite and greenish shale, the two constituting what in the Grand Canyon district is called the Tonto group, of Middle Cambrian age, about 1,000 feet in thickness, and resting, as seen at Music Mountain camp, almost horizontally upon the base-leveled surface of the pre-Cambrian crystalline complex above described.

Above the Tonto is 1,000 feet or more of Carboniferous limestone, the Red Wall (lower Pennsylvanian and upper Mississippian), which rises to the adjacent summit of the plateau. It is mostly heavy bedded, is the principal cliff maker of the Grand Wash Cliffs, and seems to be the northwest extension of the great belt of Carboniferous limestone which, extending northwest and southeast across Arizona, has in association with it many of the Territory's mineral deposits.

Above the Red Wall limestone lies an undetermined thickness of the Aubrey group, of Carboniferous (upper Pennsylvanian) age.

These Paleozoic rocks must have formerly extended entirely across the area here described and covered it much the same as they now cover the Grand Canyon district to the northeast, but they have since been largely removed by erosion. The only other localities at which traces of sediments probably belonging to this series were encountered are Silver Creek and Kingman.

Along the road which leads from Silver Creek to the Moss mine, at a point about three-fourths of a mile south of the mine, where the covering of Tertiary volcanic rocks has been more or less removed by erosion, occur a few inconspicuous outcrops of purplish, dark iron-gray, and blackish metamorphosed shale, which seems to rest upon the pre-Cambrian granite exposed near by and probably represents unremoved remnants of the basal portion of the Paleozoic series of the Grand Canyon.

At Kingman material excavated from a well on the ground of Judge Metcalf, in the northwestern part of the town, contains limestone bearing organic remains, and may be related to the Paleozoic rocks above described.

INTRUSIVE ROCKS.

The pre-Cambrian gneisses and schists are in places intruded by igneous masses and dikes which are considerably older than the Tertiary volcanic rocks, next to be described, but whose exact age is unknown. Very likely they are of late Jurassic or early Cretaceous age and of the same period of intrusion as the batholiths of California and western Nevada. The most important of these intrusives are granite porphyries of varying types and dark lamprophyric dike rocks such as minettes and vogesites. Being similar in composition to the pre-Cambrian granites, the younger granites and porphyries are in places difficult to distinguish and separate, especially as they show here and there a certain close jointing or schistosity and are nearly everywhere strongly sheeted. The larger stocks of granite porphyry are accompanied by dikes of the same material and by characteristic complementary dikes of minette or vogesite. These intrusives are found in the more important mining districts and are probably connected with the genesis of the ore deposits. Many of the lamprophyric dikes are followed by fissure veins.

GRANITE PORPHYRY AND MICROPEGMATITE.

Granite porphyry occurs mainly in the Cerbat Mountains, where it extends with interruptions from Stockton Hill to Chloride. It is practically coextensive with the mineral belt of the mountains. The principal masses, however, occur in the Mineral Park district, where the granite porphyry forms the upper part of the prominent knob on the northwest known as "Niggerhead." It also constitutes a considerable portion of the mountains on the opposite side of the wash to the south, and extends with interruptions throughout the greater portion of the basin eastward for a distance of 1½ miles into the slope of the range. Its sheeting or jointing, well shown across the northern part of the Mineral Park district, dips westward at angles of about 35°.

In a fresh specimen the rock is light gray to white and of medium to fine grain. Thin sections show it to be a coarse granite porphyry with phenocrysts of quartz and orthoclase in a microcrystalline groundmass. The rock contains some secondary sericite and is greatly crushed. There are many types of this rock in the Music Mountain district, and particularly in the dikes of the Cerbat Range. A specimen from Charcoal Canyon shows large phenocrysts of quartz, oligoclase (?), biotite, and hornblende, the latter two largely converted into chlorite. The groundmass is microgranular and consists of quartz and orthoclase.

A dike from the Lucky Boy mine in the Chloride district approaches a syenite porphyry, but contains no biotite or hornblende. Others look very much like aplites in thin section.

An allied rock occurs in two masses in the Black Mountains. One of these makes up the Hardy Mountains, an outlying group several miles in diameter, about $2\frac{1}{2}$ miles west of Gold Road. The other occupies an area embracing the hills near the Moss mine, 4 miles northwest of Gold Road. The rock is pinkish, is of medium to coarse grain, and is composed of quartz, orthoclase, and microperthite, in micropegmatitic intergrowth. The accessory minerals consist of a few crystals of iron ore, biotite, sphene, zircon, and apatite. The feldspars are clouded with kaolinite, and a little calcite is also present. The quartz contains numerous fluid inclusions and negative crystals. These usually contain a bubble of gas and some of them a colorless crystal of a double refracting mineral.

A partial analysis, by E. C. Sullivan, of a specimen from the Navy group mine, 4 miles northwest of Gold Road, gave: SiO_2, 73.16; CaO, 1.35; Na_2O, 3.71; K_2O, 5.21. This rock is perhaps best termed a micropegmatite. Some varieties range toward a quartz syenite porphyry.

Quartz monzonites and hornblende granites occur in the Music Mountain district, as later intrusives in the pre-Cambrian gneisses.

LAMPROPHYRIC DIKE ROCKS.

Many acidic intrusive masses are accompanied by narrow dikes of a basic character and peculiar structure. In the Cerbat Mountains a number of these dikes were noted. They are found at the Minnesota-Connor and Towne mines in the Chloride district, at the Champion and Windy Point mines in the Cerbat and Mineral Park districts, and at many other places.

The rock is black when fresh, but in many places appears altered and has a brownish or greenish earthy aspect. It usually contains phenocrysts of brown biotite and, in thin section, shows a panidiomorphic structure.

According to their mineral composition the rocks are termed minette, kersantite, or vogesite. A characteristic specimen from the Champion mine (No. 46) was analyzed. It has porphyritic structure, with abundant phenocrysts of biotite and a few of augite. The panidiomorphic groundmass is composed of andesine, augite, orthoclase, iron ore, and apatite. Named in the order of their relative abundance, the constituent minerals are andesine, biotite, augite, orthoclase, iron ore, and apatite. In general the order of crystallization may be stated as follows: Apatite, iron ore, augite, andesine, biotite, and orthoclase. Exceptions to this order will be noted later. The andesine occurs mainly in fine lath-shaped crystals. It contains inclusions of apatite and iron ore, but rarely biotite, and it is only exceptionally that the plagioclase is included in the latter mineral. The light-brown biotite occurs in foils and well-formed crystals containing abundant inclusions of the earlier minerals as noted. The pale-green augite is usually in granules, though here and there it shows crystal forms. Orthoclase was the latest mineral to crystallize, and usually fills the space between the other constituents, though some small crystals appear to have formed earlier. Iron ore forms several per cent of the rock. The analysis indicates a titaniferous magnetite. Apatite, as calculated from the analysis, forms 2.02 per cent. The minerals for the most part show little alteration. Some of the feldspar has been replaced by carbonate. A green fibrous chloritic mineral frequently associated with biotite is plentiful. Needle-like crystals of a highly refracting character are abundant in nearly all the minerals. The rock stands between a minette and a kersantite.

Analyses of minette and vogesite.

[George Steiger, analyst.]

	1.	2.
SiO_2	49.59	48.36
Al_2O_3	15.30	.....
Fe_2O_3	5.01	.....
FeO	4.19	5.35
MgO	4.50	.....
CaO	5.51	7.47
Na_2O	2.24	3.15
K_2O	3.80	2.17
H_2O-	2.98	.....
H_2O+	3.59	.....
TiO_2	1.50	.....
ZrO_2	.05	.....
CO_2	None.	1.16
P_2O_5	.94	.....
S	.09	.....
MnO	.11	.....
BaO	.21	.....
SrO	.12	.....
	99.73	.....

1. Dike rock (No. 46) from Champion mine, Cerbat district.
2. Dike rock (No. 100) from Minnesota-Connor mine, Chloride district.

The calculation of the norm of No. 1 is unsatisfactory on account of the large amount of water, which is not taken into consideration in the quantitative system of rock classification. It leads, however, to the placing of the rock as a shoshonose.[a]

The analysis indicates clearly that the rock is a product of differentiation; the high percentages of phosphorus, titanium, barium, and strontium are noteworthy. Still more peculiar is the high percentage of water driven off above 110°. The rock is fresh, on the whole, and the small amount of chlorite can not account for the water. It is difficult to avoid the belief that the rock contains some analcite that is so hidden as to be scarcely detectable under the microscope.

The dike rock from the Minnesota-Connor mine (No. 2) is a rather fine-grained rock with a few phenocrysts of feldspar. The primary minerals are, in order of abundance, orthoclase, plagioclase, and basaltic hornblende; the accessories, biotite, iron ore, and apatite. The secondary minerals are chlorite, sericite, calcite, epidote, kaolinite, zoisite, green amphibole, and pyrite. A brown hornblende was the earliest of the essential minerals to crystallize, following the apatite and iron ore; orthoclase crystallized last, though this was in part contemporaneous with the plagioclase. The feldspars are highly altered, making accurate determinations uncertain. Orthoclase is probably slightly more abundant than plagioclase. Several crystals of plagioclase were determined as andesine and one as labradorite. Probably most of it is andesine. Sericite, epidote, calcite, chlorite, kaolinite, and zoisite were all recognized as alteration minerals in the feldspar. Many of the hornblende crystals show an alteration around the margins to green amphibole, and some have been replaced by chlorite and epidote. Only a few crystals of biotite were recognized. This rock has the mineral composition of vogesite though it is close to the line between vogesite and camptonite.

DIABASE.

Dikes of normal though locally chloritized diabase were noted at the Ellen Jane mine in the Music Mountain district and at the Champion, Hercules, Treasure Hill, Gem, and Midnight mines in the Cerbat Range. They probably belong to the older (Mesozoic ?) intrusive rocks. Other dikes in the Black Mountains are more likely holocrystalline facies of Tertiary basalts.

[a] Washington, H. S., Chemical analyses of igneous rocks, published from 1884 to 1900, with a critical discussion of the character and use of analyses: Prof. Paper U. S. Geol. Survey No. 14, 1903, p. 266.

TERTIARY VOLCANIC ROCKS.

GENERAL FEATURES.

The great event that took place after the erosion of the Paleozoic sediments from the Great Basin portion of the area was the eruption and effusion of a mass of Tertiary volcanic lavas which more or less completely flooded the region. As shown on the map, the present areas of these rocks, which vary from local outcrops to mountain masses several hundred square miles in extent and several thousand feet in thickness, are mere remnants of the former vast lava field which extended over the entire region.

The rocks consist of andesites, trachytes, rhyolites, latites, and basalts, lying in broad superimposed sheets or flows with intercalated beds of ash, tuff, and breccia. They are best developed in the Black Mountains, particularly in the southern part, contain most of the mineral deposits of the range, and probably played an important part in the genesis of these deposits.

Similar effusive rocks are shown by the Wheeler Survey and by Spurr, Ransome, and Ball to continue interruptedly far northward into Nevada and California.

These volcanic rocks have not been differentiated on the accompanying map (Pl. I), but their order of succession is shown in the generalized section (fig. 2) extending across the southern part of the Black Mountains in the vicinity of Gold Road. They rest upon the eroded surface of the pre-Cambrian complex.

BASAL ANDESITE.

The oldest or basal formation of the Tertiary volcanics, as well exposed in the Vivian region, is a light-gray, purple, or pale-green andesite. It has a thickness of at least several hundred feet and occupies the border of the foothills from the vicinity of the Vivian and Leland mines southwestward to the gravel mesas of Colorado River. It is designated No. 9 in figure 2. It consists of flows, tuffs, and breccias. It is more or less chloritic, calcitic, and locally silicified, and is not known to contain mineral deposits of commercial value. It shows a northeasterly sheeting not observed in the overlying rocks and is intruded by the green chloritic andesite to be next described and by rhyolite dikes. Thin sections of specimens obtained near Vivian indicate that this rock is an andesite, though its alteration hardly permits exact determinations.

GREEN CHLORITIC ANDESITE.

Overlying the above-described andesite, and roughly differentiated on the map as green chloritic andesite, is another series of flows of andesite which contains an important part of the mineral-bearing

lodes in the Gold Road region. It is known locally as "antique porphyry." At Secret Pass it rests directly on the pre-Cambrian granite, and in the Hardy Mountains on the granite porphyry or micropegmatite. It occupies an area of 35 or 40 square miles and has a maximum thickness of about 800 feet. It is disposed in heavy beds or flows inclining gently eastward into the range. (See fig. 2.) In places it is associated with or grades into black latite, which could not be differentiated in the field; hence the general use of the term "green chloritic andesite" in this report does not imply that latite may not also be present.

The rock consists mainly of a dark greenish to olive or light-green fine-grained groundmass containing numerous whitish feldspar phenocrysts, which in certain localities constitute about 40 per cent of the volume of the rock and show some degree of parallel disposition due to flow. The phenocrysts vary in appearance from fresh and glassy to dull and are of all shapes and sizes, ranging from minute slender laths to stout, approximately equidimensional prisms having a maximum length of about one-half inch. In the fresh, unaltered rock, irregular black bodies of which occur inclosed in the greenish portion above described, well exposed at the Pasadena mine, the groundmass is black and the phenocrysts are fresh and glassy.

Under the microscope the rock is generally found to be decidedly chloritic and calcitic and in some sections pyritic; in others it con-

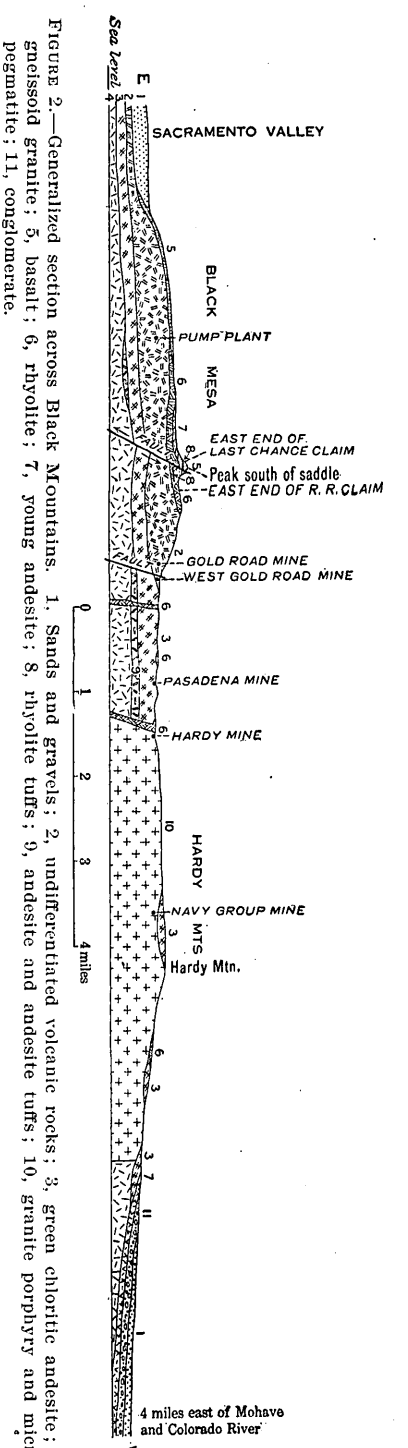

FIGURE 2.—Generalized section across Black Mountains. 1, Sands and gravels; 2, undifferentiated volcanic rocks; 3, green chloritic andesite; 4, gneissoid granite; 5, basalt; 6, rhyolite; 7, young andesite; 8, rhyolite tuffs; 9, andesite and andesite tuffs; 10, granite porphyry and micropegmatite; 11, conglomerate.

tains magnetite, but no pyrite, and in others it is silicified. In some localities it is so decomposed that no bisilicates remain. Some slides show characteristic propylitic alteration zones, particularly along veins. The rock is traversed by numerous mineral-bearing veins or lodes, particularly in the Vivian region.

The most important intrusive into this rock is rhyolite in the form of large dikes and rounded pluglike or stocklike masses. The following partial analyses have been made:

Partial analyses of green chloritic andesite.

[Analyst, E. C. Sullivan.]

	1.	2.
SiO_2	53.55	53.13
CaO	5.60	7.96
Na_2O	2.62	2.43
K_2O	3.14	3.13

1. West Gold Road mine, Black Mountains (No. 369).
2. Pasadena mine, Black Mountains (No. 437).

No. 1 is a highly altered greenish porphyritic rock, with abundant phenocrysts of orthoclase and acidic plagioclase, in a groundmass of fine laths of andesine and oligoclase with abundant orthoclase. The accessory minerals are iron ore and apatite, neither being plentiful. The secondary minerals, which form a high percentage of the rock, are, in the order of abundance, chlorite, calcite, epidote, and pyrite. Quartz also occurs, with chlorite and calcite, as filling of small cavities. Though the rock is andesite in character, the mineral composition shows it to be an intermediate rock, and it may be classed as trachytic andesite.

The dark-green andesitic rock (No. 2) contains phenocrysts up to 7 or 8 millimeters in length, of labradorite with a few of orthoclase and an unstriated feldspar with index above Canada balsam. The fine trachytic groundmass is composed of andesine and orthoclase, the latter being but slightly less abundant than the plagioclase feldspar; small crystals of magnetite are abundant. Secondary minerals are chlorite and carbonate, with a little epidote, and form a large percentage of the groundmass. The phenocrysts show less alteration, though all are partly and some entirely replaced by chlorite and carbonate, with sericite in some places. A small vein crossing the slide is filled with quartz, calcite, and adularia.

Like No. 1, this type of the green chloritic andesite is really an intermediate rock standing between the andesites and the trachytes.

At Vivian the rock cuts the earlier andesite as dikes. A specimen of it collected from the Leland mine proved to be latite, as follows:

Partial analysis of latite from lower east tunnel of Leland mine, at Vivian, Black Mountains.

[Analyst, E. C. Sullivan.]

SiO_2	56.33
CaO	4
Na_2O	2.60
K_2O	5.19

This is a black, fresh-looking rock with phenocrysts of orthoclase and acidic plagioclase, albite, and oligoclase. The groundmass is composed of the same feldspars, orthoclase being more abundant than plagioclase. Some quartz is present, but very little if any is primary. The accessory minerals are iron ore and apatite, the latter being rather abundant. The secondary minerals are chlorite, calcite, quartz, sericite, and pyrite. Chlorite is abundant throughout the rock. Calcite and quartz occur principally as filling of cavities, though the altered feldspars contain considerable carbonate.

UNDIFFERENTIATED VOLCANIC ROCKS.

Overlying the above-described green chloritic andesite in the Gold Road region are about 2,000 feet of undifferentiated volcanic rocks, consisting of andesites, trachytes, rhyolites, and latites. They compose the bulk of the range in this locality and are important economically, as they contain the Gold Road vein now worked and neighboring prospects. They extend from the region of the Gold Road mine nearly to the summit of the range, and present the rugged cliff, steep slope, and deep gulch topography shown in Plate XI.

Like the andesite just described, these rocks lie in heavy beds slightly tilted and dipping gently eastward into the range, and are cut by several systems of sheeting, the most important of which trends in a northwesterly direction, and has an approximately vertical dip. Like the basal andesite, they consist of flows, tuffs, and breccias. The upper part of the section is essentially rhyolitic.

These rocks are all represented in the Gold Road mine. The andesites are usually green or dark greenish-gray, generally porphyritic, and in some places much resemble the green chloritic andesite. They are locally pyritic. The trachytes are light greenish gray, purple, or red, very porphyritic, and differ markedly from the andesites microscopically and chemically, as may be seen by comparison of the analyses on page 39. The rhyolites range from dense reddish, iron-stained silicified rocks, with banded or platy structure due to flow, to pale greenish, yellowish, pinkish, and whitish porous or massive tuffs.

Microscropic and chemical analyses of the more important of these rocks show that what were called andesites in the field are

really intermediate rocks approaching latite. Some of the members of the series are true trachytes. So far as shown by the analyses even the rocks which would be called andesite from a study of thin sections would show on analysis a high percentage of potassium.

Partial analysis of latite near Mocking Bird mine, Black Mountains.

[Analyst, E. C. Sullivan.]

SiO_2	59.50
CaO	5.60
Na_2O	3.37
K_2O	4.33

This is a purplish-gray rock containing phenocrysts of labradorite and bytownite, as well as foils of biotite, in a fine groundmass composed largely of orthoclase with abundant iron ore. Apatite is plentiful. All the biotite crystals show strong resorption bands of iron ore and the smaller crystals have been entirely resolved. Probably much of the iron ore of the groundmass has resulted from the magmatic alteration of biotite. A number of crystals entirely replaced by carbonate, or carbonate and quartz, appear to be pseudomorphs after pyroxene. Calcite is the most important secondary mineral.

Among the undifferentiated volcanic flows later examinations disclosed some normal trachytes, rocks which are rather uncommon among the Tertiary effusives of the West. These rocks were principally identified from the vicinity of the Gold Road mine. In the field they are not easily distinguished from the andesites and latites, especially as all the rocks are in an altered condition. Their extent is probably great, but can be ascertained only by detailed petrographic field work. The rocks are greenish, partly altered, and locally pyritic, and contain abundant white phenocrysts of sanidine.

The following analyses have been made:

Analyses of trachytes from Black Mountains.

[Analyst, George Steiger.]

	1.	2.	3.
SiO_2	58.74	66.46	65.12
Al_2O_3	15.09	14.14	.....
Fe_2O_3	4.66	4.07	.....
FeO	.84	.40	.....
MgO	2.75	.67	.....
CaO	2.68	.78	.....
Na_2O	.25	1.26	.....
K_2O	8.05	9.26	.....
H_2O-	2.08	.78	.....
H_2O+	3.09	1.28	.....
TiO_2	.98	.83	.....
ZrO_2	.02	.05	.....
CO_2	.61	None.	.....
P_2O_5	.40	.25	.....
S	None.	None.	.....
MnO	.09	.03	.....
BaO	.07	.06	.....
SrO	.04	.03	.....
	100.44	100.35	.....

1. Gold Road mine, face of 80-foot crosscut on 700-foot level (No. 483).
2. Gold Road mine, Billy Bryan drift (No. 414).
3. Line Road tunnel, Gold Road mine (No. 420).

No. 1 is of light greenish-gray color with abundant phenocrysts of tabular sanidine. There are also biotite foils and possibly also prisms of hornblende, but both are altered to chlorite, epidote, serpentine, and very fine grained quartz. The groundmass is of very fine grain, in part probably devitrified glass. The rock has been subjected to propylitic alteration, but this has probably not greatly changed its composition, except that some of the soda is likely to have been leached and that some secondary adularia has formed, with consequent enrichment of potassium. The rock appears to be a normal trachyte.

No. 2 is a brecciated dark purplish-gray rock containing small phenocrysts of orthoclase, albite, also some of biotite, in a fine groundmass composed largely of orthoclase with a little quartz, though this mineral does not appear nearly as abundantly in the section as the chemical analyses would indicate.

The accessory minerals are iron ore, apatite, and a few zircon crystals. The secondary minerals include quartz, iron ore, serpentine, epidote, and sericite. The dark-brown biotite is largely altered. Some crystals are filled with iron ore and have a rim of the same mineral; other crystals have the rim of iron ore, while the center is largely serpentine; and still others have a center of secondary quartz usually accompanied by some serpentine. Quartz occurs in veinlets as well as replacing the mica, and it is probable that most of the free silica shown by the analysis is from these sources. Most of the iron ore appears in the zones of crushing between the breccia fragments and

is probably introduced during the alteration of the rock. Sericite and epidote are present in the feldspar crystals, but neither is abundant. Much of the quartz is secondary, and the rock is without much doubt a trachyte, somewhat affected by propylitic alteration.

Norm of trachyte from Billy Bryan drift, Gold Road mine.

Quartz	22.
Orthoclase	55.04
Albite	9.96
Anorthite	1.39
Corundum	1.53
Hematite	4.16
Ilmenite	.91
Titanite	.78
Apatite	.50
Enstatite	1.60
	98.01

In the quantitative system this rock is designated as omeose.[a]

No. 3 is a porphyritic rock with phenocrysts of orthoclase and a few of biotite in a cryptocrystalline groundmass composed largely of orthoclase filled with minute specks of a mineral which shows rather strong double refraction and which is probably leucoxene.

The accessory minerals are iron ore, apatite, and a few crystals of zircon and sphene. The secondary minerals are quartz, leucoxene (?), limonite, and serpentine. The mica is a reddish-brown, highly pleochroic variety. Many of the crystals show a rim of iron ore, and some are entirely replaced by iron ore, serpentine, and quartz. The rock is filled with minute veinlets of quartz, and this mineral has partly replaced some of the feldspar crystals. The rock has the mineral composition of trachyte, though the secondary quartz makes it appear high in silica (65.12 per cent).

RHYOLITE SERIES.

The above-described undifferentiated rocks are overlain by a series of rhyolites composed of tuffs, flows, and breccias. In some localities this series attains a thickness of 1,000 feet or more. It extends interruptedly throughout the length of the Black Mountains, and is known as the "water rock," from springs that occur in it. In the Cerbat Range it essentially composes the Kingman Mesa, situated between the Cerbat and Hualpai mountains, where the tuffs seem, in part at least, to be water-laid, and it borders a considerable portion of the Cerbat Mountains on the west. Rhyolite dikes cut nearly all the underlying volcanic rocks as well as the pre-Cambrian complex, and the rhyolite in turn is cut by the younger andesite and basalt.

[a] Washington, H. S., Chemical analyses of igneous rocks, 1884–1900: Prof. Paper U. S. Geol. Survey No. 14, 1903, p. 145.

The rhyolites are as a rule light-colored reddish or pink rocks, with small phenocrysts of biotite, feldspar, and quartz; but they also assume many other aspects and colors, such as dark brown and black. They are normal rocks of their type, as shown by the following analyses and description. The groundmass is felsitic, rarely coarser and microcrystalline.

Analyses of rhyolites from northwestern Arizona.

[Analyst, E. C. Sullivan.]

	1.	2.	3.
SiO_2	72.64	67.03	79.30
CaO	1.42	.66	.16
Na_2O	.46	2.68	1.42
K_2O	9.06	5.36	6.12

1. Mocking Bird mine, Black Mountains (No. 160).
2. Cement rock near Kingman (No. 267).
3. Union Pass, near Hutchinson Camp, Black Mountains (No. 284).

No. 1 is a light-colored rhyolite of tuffaceous aspect. It contains phenocrysts and spherulites of orthoclase, with a few scattering crystals of quartz and biotite in a cryptocrystalline groundmass that is too fine for definite determination of the minerals, but is probably orthoclase and quartz, as indicated by the chemical analyses. The accessory minerals include iron ore, apatite, and zircon. Calcite is rather abundant through the groundmass.

No. 2 is a glassy cellular rock containing scattered crystals of quartz, orthoclase, microperthite, and biotite. There is a little iron ore and a few small highly refracting crystals, probably zircon. Many of the cavities are partly and some entirely filled with amorphous silica. The rock is low in silica and approaches a trachyte.

No. 3 is a pinkish-gray dense rock containing phenocrysts of orthoclase and albite in a microcrystalline groundmass of orthoclase and quartz. It contains a few small apatite crystals. The secondary minerals are confined to small clouded masses, probably carbonate, and altered pyrite crystals.

YOUNGER ANDESITE.

Overlying the rhyolites and locally cutting them as dikes are local flows of dark-reddish andesite which, compared with the andesites already described, has a relatively fresh appearance and is free from the structures that traverse the older rocks. It occurs in the Black Mountains in the Gold Road and Silver Creek regions, and in the Cerbat Mountains north and northwest of Kingman. It is locally amygdaloidal.

OLIVINE BASALT.

The youngest of the effusive rocks is olivine basalt. It occurs in sheets covering the older rocks, including the Quaternary gravels, and cuts them as dikes. It ranges from black to dark iron gray and reddish brown in color, is fine to medium grained, and is locally vesicular or amygdaloidal. At many places its sheets form a series of cliffs or scarps, exhibiting very perfect columnar structure. It originated in two or more periods of eruption separated by intervals of erosion. The thin sections show little that is new or interesting. A basalt from a point 5 miles northwest of Chloride contains some hypersthene, a mineral elsewhere generally absent.

In the Black Mountains both hypocrystalline (glassy) and holocrystalline (diabase) structures occur. The latter development is shown by a basalt from Gold Road Pass.

TERTIARY (?) AND QUATERNARY DETRITAL ROCKS.

Greggs breccia is a name given by Lee[a] to a Tertiary (?) detrital formation filling Grand Wash Trough. Lee describes it as having a thickness of 1,400 feet and being composed of coarse, unassorted, poorly stratified, mostly granitic material, cemented toward the top with lime carbonate, and containing local deposits of travertine.

Temple Bar conglomerate is a name applied by Lee[b] to a Quaternary formation of slightly consolidated sand and gravel which rests unconformably upon the Greggs breccia and older formations and has a wide distribution in southern Arizona. Locally it contains also sheets of basalt, and thus far has yielded no fossils. It occurs in the Colorado and other valleys, filling the low places to elevations of about 3,000 feet. Along the Colorado it is a river deposit, but grades laterally into angular mountain wash. It is regarded as equivalent in age to the detrital accumulations filling the low plains of the Southwest generally and forming the deserts of Arizona and a part of southern California. It is similar to the Gila conglomerate described by Gilbert, Ransome, and Lindgren, and resembles the Lake Bonneville beds described by Gilbert.

The term Chemehuevis gravel is applied by Lee[c] to the series of Quaternary gravels resting unconformably upon the Temple Bar conglomerate and forming terraced bluffs from the mouth of the Grand Canyon to the Gulf. They have a thickness of about 700 feet and are confined to a relatively narrow belt, having been deposited during an aggrading stage of the river.

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[a] Lee, W. T., Bull. U. S. Geol. Survey No. 352, p. 17.
[b] Op. cit., p. 17.
[c] Op. cit., p. 18.

MINERAL DEPOSITS.

DISCOVERY, HISTORY OF MINING DEVELOPMENT, AND PRESENT CONDITIONS.

The discovery of mineral deposits in this area dates from very early in the sixties, when prospectors from the gold mines of California found rich ore on what has since been known as the Moss vein and mine.[a] The Moss mine is situated about 25 miles southwest of Kingman and a few miles north of the old government Camp Mohave trail in the long, sloping belt of country lying between Colorado River on the west and the Black Mountains on the east. It is about 10 miles southeast by east of Hardyville, 12 miles northeast by east of Mohave, 4 miles northwest of Gold Road, and a few miles west of the base of the range, which at that time was known as the Blue Range.

Some of the ore shipped to San Francisco is reported to have been of extremely high value. The report of this rich find brought a rush to the region which, in the years that followed, resulted in extending explorations into the mountains to the east by prospectors from California and Nevada. Owing to the hostility of the Hualpai and Paiute Indians, explorations were for some time confined to the Black Mountains and Cerbat Range, until early in the seventies the inrush from Nevada overawed the savage tribes and made the life of the pioneer less perilous. In 1872 hundreds of men came in from Pioche, Nev., and the gold regions of California, and the rich veins of the Cerbat and Hualpai mountains were discovered. The ores from these veins were so rich that they yielded large profits, although the expense of freight and treatment ran into hundreds of dollars a ton, owing to the fact that the ores had to be packed long distances on burros (there being no roads in the county at the time) to Colorado River, thence by river steamer to Port Isabel, down the gulf to Point Arena, and up the coast to San Francisco, whence they were shipped to England for treatment. Later a small 10-stamp mill was erected at Hardyville to handle the ore from the old Moss mine, but it was not a success, and although one small custom mill was erected at Mineral Park in the later seventies, the above-described method of marketing ores was followed until the advent of the railway in 1882.

[a] At the time of the discovery of the Moss mine this part of Arizona was a part of Dona Ana County, N. Mex. In 1864 Arizona Territory was created, and Mohave County became one of the four political divisions into which the Territory was divided. The county seat was located at Callville, but in 1865, when the State of Nevada was created, that part of Mohave County west of Colorado River, which took in the Vegas and part of the Muddy country, was annexed to the new State, and the county seat was removed to Hardyville. With the influx of people the seat of county government was soon established at Cerbat, where it remained but a few years, being then taken to Mineral Park. In 1887, after the completion of the Santa Fe Railway, the county seat was established at Kingman.

The pioneers suffered untold hardships in the opening of the new country. Supplies had to be brought in by way of the Gulf of California and Colorado River or be freighted over 400 miles of sand and alkali deserts, which made the cost abnormally high. The miners had to pay as high as $2 a pound for black powder. Bacon cost from 35 cents to $1 a pound, sugar 3 pounds for $1, flour 15 to 50 cents a pound, and other things in proportion.

The discovery of silver-gold ores in the mountains of the Cerbat and Hualpai ranges in the early seventies drew the attention of prospectors from the gold mines of the River Range, and for some time the area was classed as a silver-producing region; but a few years ago the low market value of silver stimulated the prospecting for gold. Under the new conditions the first important mine to be opened was the Snowball, near Vivian. This mine showed ore that ran as high as 40 ounces of gold to the ton. It is now embraced in the German-American group of mines. Later the Sheeptrail group, in the upper end of San Francisco district, was opened. One of these mines yielded ore that ran thousands of dollars to the ton. Still later the deposits at the Gold Road mines were found, and it is to these mines that the San Francisco district owes its present prosperity.

For years the country was isolated owing to the lack of railroad connections and was without mining machinery, in consequence of which, up to the eighties, there were very few shafts more than 150 feet deep, although the production of high-grade ores ran well up into the millions, and it was only after the completion of the railroad that the mining era began and practically the first development work below water level was begun. After some years the mining industry drooped again, owing to the further depreciation of silver and to the fact that lower-grade ores were found in depth.

During the last few years, owing to the increase in the price of base metals and the general search for gold deposits, the mining industry has taken on new life, and many properties of well-known merit are being exploited and opened. Abandoned mines are being looked over and their dumps tested and cyanided or milled. The old mines are pumped out and put in shape, and with deeper and more systematic mining new ore shoots are found, and the once so-called "low-grade" bodies of ore are utilized by treatment in the latest milling and value-saving apparatus. In fact, the camps seem to be starting on a new era of prosperity. Naturally, speculators have invaded the area and floated many companies with properties of no or doubtful value; but this seems to be an inevitable accompaniment of any period of intense mining activity.

The establishment of the Arizona-Mexican smelter at Needles, on Colorado River, has provided an outlet for formerly unprofitable ores. The completion of the smelter of the Arizona Smelting Com-

pany, at Humboldt, Yavapai County, near Prescott, added to the facilities for disposing of the ores, but these reduction works were closed during the panic of 1907 and had not been reopened up to the fall of 1908.

The Santa Fe Railway Company has made the following rates on ore shipments from Chloride: Chloride to Needles, from $4.30 a ton for $100 ore to $1.10 a ton for $15 ore; Chloride to Humboldt, from $5.90 a ton for $100 ore to $2 a ton for $15 ore. Rates on shipments of ore or concentrates where the valuation is over $100 and not exceeding $300 are 130 per cent of the $100 rate. These rates are the same as from Kingman, and are the lowest established since the building of the railroad through the county. In general, $20 shipping ore can now be mined at a profit.

MINING DISTRICTS.[a]

The most important legal mining districts in the area here treated are the Wallapai (Hualpai), San Francisco, Weaver, White Hills, Gold Basin, Music Mountain, and Maynard districts. Elsewhere in this report the term "district" will be used in a more general way, without restriction to legal organization at miners' meetings. The term "mining camp" is employed to designate subdivisions of a district. The boundaries of the districts are for the most part uncertain.

The Wallapai district extends from the vicinity of Kingman on the south a little beyond Chloride on the north, a distance of 25 miles. It has a width of 8 or 10 miles and embraces somewhat more than the southern half of the Cerbat Mountains. It contains Cerbat, Chloride, and other important camps.

The San Francisco district lies in the southwestern part of the area, in the Black Mountains. It extends from a point a few miles below Boundary Cone on the south about 25 miles northward to a point above Union Pass and Pyramid on the north, and from the east base of the range westward to Colorado River. On the north it has a width of about 15 miles and on the south of about 20 miles. It contains the Gold Road, Vivian, Silver Creek, Union Pass, Pyramid, and other important camps.

The Weaver district also lies in the Black Mountains, and may be regarded as extending from a point about opposite Chloride northward 30 miles or more beyond Eldorado Pass and the White Hills. It contains the Mocking Bird, Hall, Virginia, and other camps.

The White Hills district is situated in the western edge of the White Hills, opposite the north end of Weaver district, the Detrital Valley intervening. It is a small district, about 4 miles in length

[a] The relatively meager treatment of certain districts and properties is in most cases attributable to temporary suspension of operations, inaccessibility, or want of adequate information rather than to relative unimportance of the deposits.

and less than 3 miles in width, being confined to the granitic area shown on the map.

The Gold Basin district lies about 14 miles northeast of the White Hills district, in the western edge of the White Hills or Cerbat

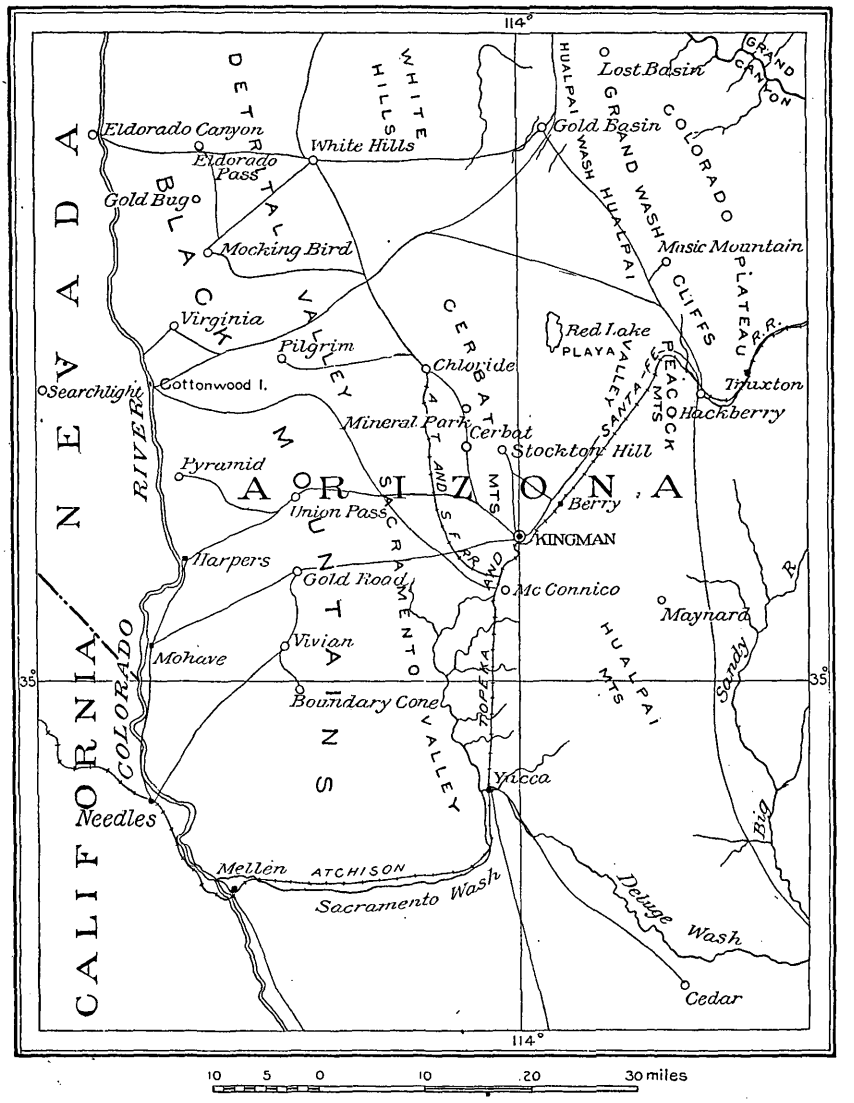


FIGURE 3.—Map showing mining camps in a part of western Arizona.

Range and west of Hualpai Wash. It consists of a somewhat irregular area about 5 miles in diameter.

The Lost Basin district lies northeast of the Gold Basin district, between Hualpai Wash on the west and Pierce Mill Canyon on the east. It extends from Colorado River southward to a point about 12

miles distant from Scanlon Ferry, embracing the Grand Wash Cliffs and adjacent country east of Hualpai Wash.

A part of the Greenwood district is situated in the southeastern portion of the area, principally in the Aquarius Mountains. It extends from Big Sandy Wash eastward beyond the limits of the area mapped and southward to Williams River.

The Maynard district, of whose extent little that is definite is known, embraces the Hualpai Mountains.

The Music Mountain district is situated toward the eastern edge of the area near its middle part, east of Hualpai Valley, and extends from the vicinity of Music Mountain, which lies 12 miles north of Hackberry, about 16 miles northwestward along the Grand Wash Cliffs, and from the base of the cliffs eastward a distance of several miles.

The Hackberry district is supposed to cover an indefinite area containing the deposits about Hackberry.

The Cedar Valley district lies along the western base of the Hualpai Mountains.

PRODUCTION OF MOHAVE COUNTY.

Although the early reports of the Director of the Mint contain many valuable notes on the mining industry of Mohave County, no detailed statistics for this area are available. The output since 1903, as ascertained by the United States Geological Survey, is as follows:

Production of Mohave County, Ariz., 1904–1907.[a]

Year.	Gold.		Silver.		Copper.		Lead.	
	Ounces.	Dollars.	Ounces.	Dollars.	Pounds.	Dollars.	Pounds.	Dollars.
1903	15,859	327,806	54,169	28,931				
1904	27,275	563,824	86,782	49,683	1,480	185	6,036	264
1905	26,272	543,090	73,536	44,416	30,399	4,742	112,266	5,277
1906	31,010	641,034	145,179	97,270	315,992	60,986	904,399	51,551
1907	28,307.90	585,383	80,897	53,392	601,210	120,242	1,229,654	65,171
1908	14,306.23	295,736	39,427	20,896	345,491	45,605	254,013	10,668

[a] Mineral Resources U. S., 1903–1908. In addition 30,666 pounds of zinc, having a value of $1,809, were reported in 1907, and 505,133 pounds, valued at $23,741, in 1908.

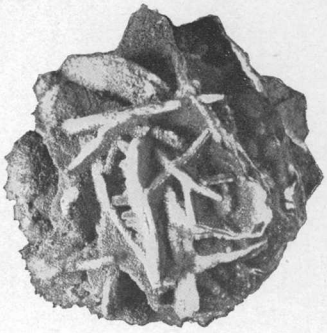
GENERAL CHARACTER OF THE DEPOSITS.

The metallic deposits of the ranges here described are chiefly fissure veins containing gold, silver, lead, copper, and zinc, quartz being the principal gangue mineral. They exhibit considerable diversity in character and occurrence, but naturally fall into two very distinct and sharply contrasted groups—(1) the veins of the Cerbat Range and (2) those of the Black Mountain Range. The nonmetallic mineral resources are less important and consist mainly of turquoise, cement rock, and building stones.

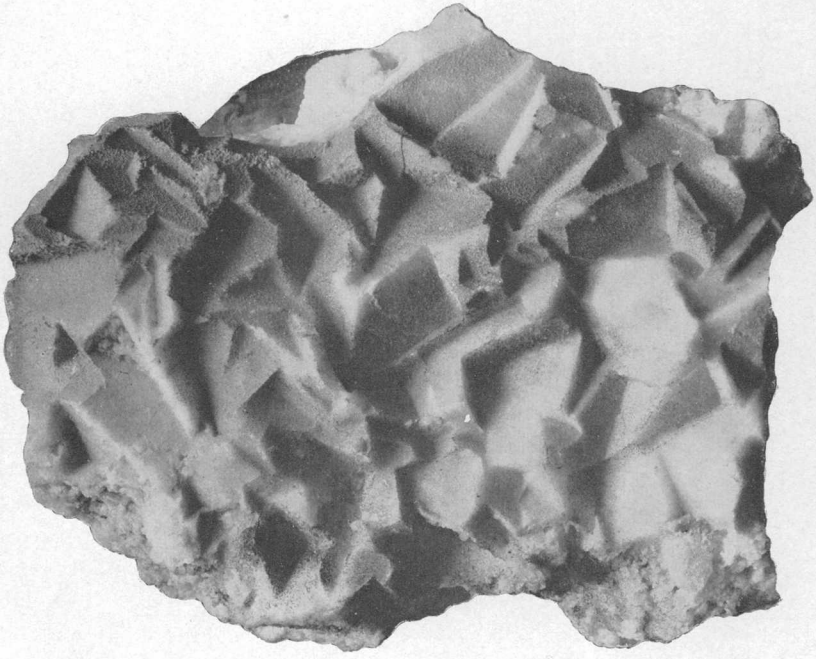
The veins of the Cerbat Range consist of quartz-filled fissures with a general northerly or northwesterly strike, which is also that of the

prevailing jointing of the country rock, and with commonly steep dip. The quartz contains pyrite, chalcopyrite, galena, zinc blende, and arsenopyrite, carrying principally silver but also gold. Free gold is scarce. Many of the veins are regular and persistent, with well-defined walls. They occur chiefly in pre-Cambrian granitic rocks, but are associated with post-Cambrian intrusions of granite porphyry and in places follow basic (lamprophyric) dikes. Many of the pay shoots coincide with intersections of fissures. Oxidation has altered the upper part to a depth ranging from 50 to 300 feet, and this oxidized zone changes to the primary ore within a vertical range of 10 to 40 feet. At the present time the sulphide ores are principally utilized, but the rich secondary ores, containing horn silver, native silver, and in some places ruby silver, furnished the bulk of the heavy production of the early days. The water level is found at 400 feet below the surface, but in some localities stands higher. The number of the deposits is very large and, owing to the fact that work was generally abandoned when the leaner primary ore was encountered, the area contains a large number of small mines which may be capable of future production. The deposition of these veins took place after the intrusion of the granite porphyry and the lamprophyric dikes and is probably an "after effect" of this igneous activity. The veins have suffered great erosion, and their mode of occurrence leads to the belief that they were deposited at comparatively great depths by hot waters.

The second group comprises the veins of the Black Mountains. These also are filled fissure veins with a general northerly or northwesterly strike and steep dip. The fissure filling is quartz, adularia, and calcite, and in many places there is evidence that the first two minerals have replaced the calcite, probably through the medium of hot solutions. (See Pl. II.) The values are almost exclusively in gold, which, as a rule, is very finely divided and can best be recovered by the cyanide process. The veins are fairly regular, but the walls are usually rough and broken and full of stringers from the main vein. The quartz filling contains many inclusions of the country rock. The veins cut through the great mass of Tertiary volcanic rocks which characterize the range, but undoubtedly continue in depth into the underlying pre-Cambrian granitic rocks. The most favorable ore horizon seems to be formed by the green chloritic andesite, and in the underlying older andesite the veins are barren. Profitable ore is, however, often found in the upper rhyolitic members of the series. The alteration of the country rock is of a propylitic character. The oxidation extends to a depth of 600 or 700 feet, and, as a rule, no sulphides are found. The water level is at least 700 feet below the surface. Compared with the veins of the Cerbat Range these deposits have suffered comparatively little erosion since



A.



B.

PSEUDOMORPHIC QUARTZ AFTER CALCITE.

Characteristic of veins in the San Francisco district, particularly of the Gold Road and Hardy veins.

their deposition. They bear evidence of having been formed rather close to the surface by hot waters which ascended through the lavas at the close of igneous activity.

MINERALOGY.

The region is not characterized by a great variety of minerals. The Black Mountains are especially poor in this respect.

The gangue minerals in the Cerbat Range consist of quartz, with some calcite, dolomitic carbonates, and siderite. Those of the Black Mountains are quartz, calcite, adularia, and pale-green fluorite. Limonite and hematite are common in both ranges as products of oxidation. The absence or scarcity of barite is remarkable.

The ore minerals of the Cerbat Range include silver, gold, pyrite, chalcopyrite, arsenopyrite, stibnite, galena, zinc blende, molybdenite, argentite, bornite, chalcocite, and ruby silver. Vanadinite and wolframite are known from the Gold Basin district. Among the oxidized minerals horn silver, cerusite, azurite, and malachite are the more important. The ore minerals of the Black Mountains are confined to native gold, pyrite, malachite, and a little argentite. Tellurides have lately been reported from several mines in the Gold Road, Vivian, and Union Pass districts, but none were found during the field work for the present report. Copper stains are present in places, indicating chalcopyrite or tetrahedrite. Vanadinite and galena are reported from the Gold Bug district.

CERBAT RANGE.

INTRODUCTION.

The principal districts in the Cerbat Range, named in order from north to south, are the Gold Basin, White Hills, Chloride, Mineral Park, Cerbat, Stockton Hill, McConnico, and Maynard. Of these the four most important are the Chloride, Mineral Park, Cerbat, and Stockton Hill districts, and these are often spoken of collectively as the Hualpai or Wallapai district. They are located in the middle part of the Cerbat Mountains, extending from a point just south of Stockton Hill and Cerbat to a point north of Chloride, a distance of about 12 miles, and they have certain features in common.

The rocks of this portion of the mountains are essentially of the pre-Cambrian complex, and consist of gray granite, gneissoid granite, and dark schists, including hornblende, mica, and garnet schists. They are flanked on the west in the Cerbat district by local areas of rhyolite and other Tertiary volcanic rocks. To the north, through Mineral Park and toward Chloride, they are intruded by distinctly younger masses of granite porphyry. Furthermore, they are locally

cut by dikes of pegmatite, aplitic granite, diabase, vogesite, minette, and rhyolite.

The deposits are well-defined fissure veins, of which there are two main sets, one striking about N. 10° to 30° W. and the other N. 45° to 70° W., usually with steep dips. According to Comstock [a] there is also a not generally recognized but important older latitudinal or east-west auriferous vein system, whose veins, usually not prominent or not apparent at the surface, have been encountered mainly in some of the deeper mines and have contributed handsomely toward the enrichment of the ores of these mines. The Elkhart and Tennessee mines at Chloride are given as examples. Veins of the same strike usually occur in two "conjugated systems"—that is, dipping in opposite directions, indicating that a compressive stress has originated the fissures. The dips are usually steep. The veins are more or less clearly associated with younger intrusions of granite porphyry, and some of them follow dikes of vogesite, minette, or aplite. The croppings, which are generally prominent, consist of dark reddish-brown quartz and altered country rock stained by the oxides of iron and manganese. The veins are straight and some are long. The walls are usually good and marked by soft gouge, although many veins are "frozen" to the walls. The gangue is quartz, in many places shattered and recemented by a later generation of calcite. Among the primary ores the most important are pyrite, chalcopyrite, arsenopyrite, galena, and zinc blende, more rarely molybdenite and stibnite. Silver and lead predominate in the Chloride, Mineral Park, and Stockton Hill districts; gold and silver in the Cerbat district. This primary ore is leaner in gold and silver than the oxidized ore, and many mines, notably in the Chloride and Mineral Park districts, which near the surface were silver mines, with increase in depth carried more lead, and at still greater depths seemed to become cupriferous. The so-called "copper belt" of the area extends from Mineral Park northwestward toward Chloride for a distance of several miles.

The water level is found at a maximum depth of 400 feet, but in some places lies considerably nearer the surface. In general the ores above the water level are oxidized, but the line between the two classes is not always sharply marked. In many places (e. g., in the Tennessee vein) galena, and locally, also, pyrite, appears near the surface in association with oxidized ores. In the Towne mine and a few others oxidized ores are found below water level, but not to any great depth, so far as known. The secondary or oxidized ores consist chiefly of native silver, probably also some native gold, horn-silver, and cerusite. Ruby silver and argentite are also present with oxidized ore, but do not seem to occupy any well-defined zone between the oxidized and primary ores.

[a] Comstock, Theodore B., Geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 1044–1054.

Many of the ore shoots coincide with intersections or forking of veins. Good examples are mentioned in the description of the Pinkham, Elkhart, Rainbow, Pay Roll, and Tennessee mines.

CHLORIDE DISTRICT.

LOCATION.

The Chloride district, the most important in the Cerbat Range, is situated about 20 miles north-northwest from Kingman, in the northern part of the Hualpai district, near the western slope of the Cerbat Mountains. It is comprised in an irregular area about 6 miles in diameter. As shown on the accompanying map, the principal mining locations are disposed roughly in two broad, irregular belts, intersecting each other near their middle points, one, about a mile in width, extending from the Samoa mines, at the crest of the range on the east, for about 6 miles to the west, terminating in the foothills or adjacent part of the Sacramento Valley plain about 2 miles west of Chloride. Its western half parallels the base of the mountains, which here depart from their normal nearly north-south course and extend several miles to the west, and its eastern half lies between the crest and the base of the mountain range on its western slope. The other belt parallels the north-south base of the range and lies mainly in its lower slope and the adjacent part of the Sacramento Valley. It diminishes in width from about 2 miles on the south to less than a mile on the north.

Chloride, the shipping and distributing point of the district, is situated a trifle northwest of its center, at the northern terminus of a branch of the Atchison, Topeka and Santa Fe Railway, connecting with the main line at Kingman. It is favorably located at an altitude of 4,000 feet on an open gentle slope near the base of the mountains. It is also the distributing point for the Weaver, Minnesota, and White Hills districts and for Eldorado Canyon, Nevada.

HISTORY AND CONDITIONS.

Chloride, so named from the character of its rich silver ore, was the first settlement laid out in this part of the area. As a camp it dates from the early sixties, when the first mineral discoveries were made, and as a town from the early seventies. The decline in the price of silver affected the district unfavorably, of course, but it has continued fairly active up to the present time. In 1900 it is said to have had a population of 2,000. For the last four or five years the district has been quiet. Several of the more important mines, however, are in active operation and considerable work on a moderate scale is being done on a score or more properties of well-known merit.

The following are the depths reached by the principal mines:

Depths of mines in Chloride district.

Juno	600	Pinkham	230
Elkhart	500	Midnight	200
Tennessee	600	Altata	200
Schuylkill	500	Payroll	400
Minnesota-Connor	530	Mollie Gibson	200
Lucky Boy	400	Distaff	180
Samoan	300		

The early prospectors were several times driven out by the Indians, and seven of them are said to have been killed. Owing to the prominent vein croppings, all the principal mines were located at about the same time.

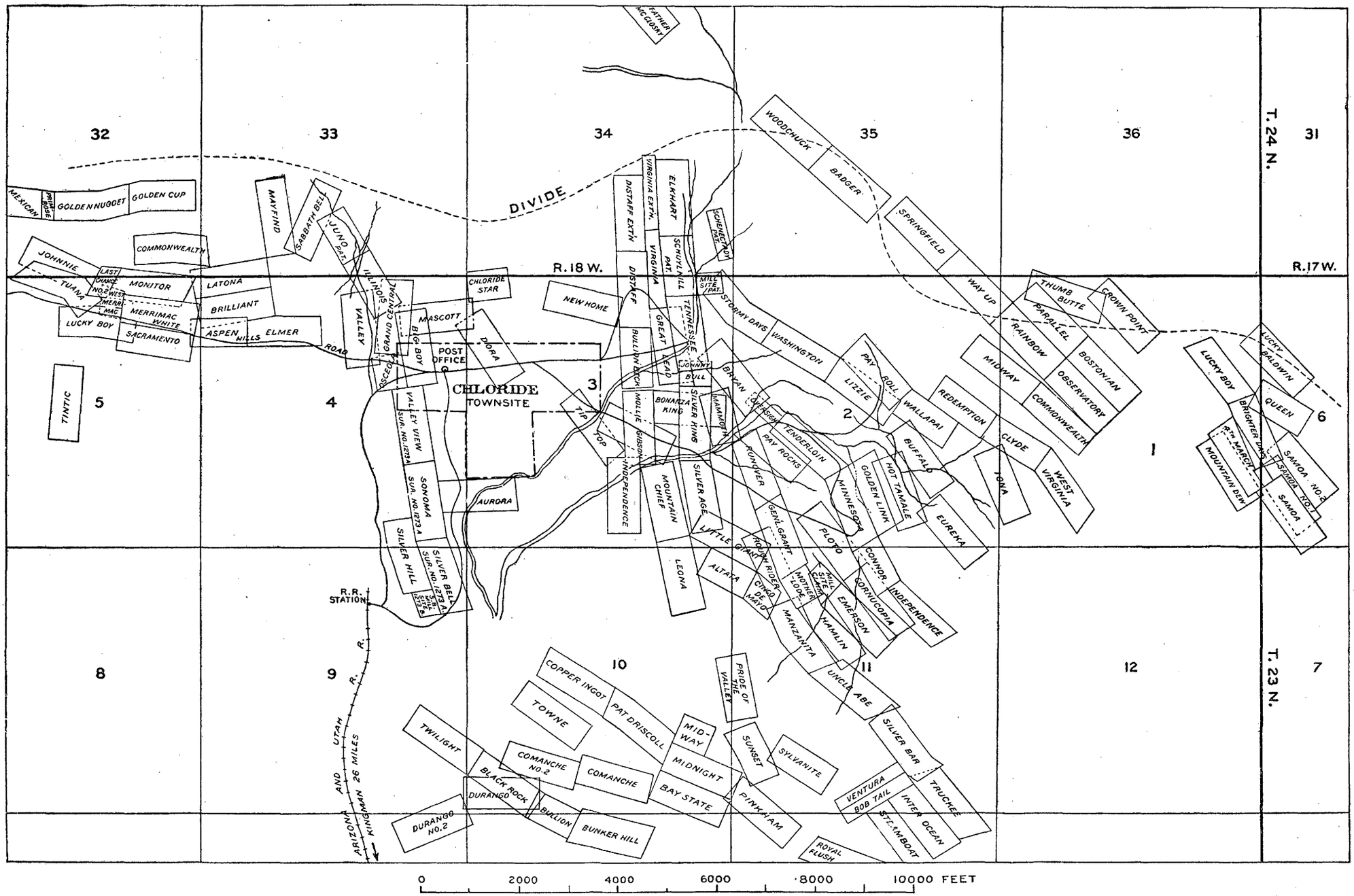
Among the first locations made were the mines now known as the Silver Hill properties, just southwest of Chloride, and the Golden Fleece, Tintic, Independence, and others. Some of the ores were of too low grade for shipment to San Francisco and to Swansea, England, but later, when a mill was built at Mineral Park, they were reduced there. Others, however, were so rich that when shipped abroad they netted their owners large sums. The district has produced a very large amount of lead and several million dollars' worth of gold and silver. It is not possible to obtain even approximate figures of the production. The lack of water has been one of the chief drawbacks of the camp, but with deep sinking plenty will be obtained.

Plate III is a map of the mining claims in this district, and Plate IV gives views showing the topography.

GEOLOGY.

The eastern part of the district is in part rugged, the topography being of the type produced by erosion and weathering of granite. In a distance of about 2 miles the surface descends from the altitude of 6,000 feet at the crest of the range to about 4,000 feet at its base, where it meets the plain of the Sacramento Valley. This plain is composed of detritus and wash derived from the range and contains deposits of caliche(?). (See p. 219.) The mountain slope is dissected by several main gulches, among which Samoa, Windmill, and Tennessee gulches are the chief. These drain southwestward into the Sacramento Valley. On the northwest the mountains are lower. Southward-sloping foothills, with no sharp line of demarcation, separate them from the adjacent plain of the valley.

The rocks are chiefly those of the pre-Cambrian complex. In the westward extension of the mountains, immediately north of Chloride, is an area of younger granitic rock, which is intruded into the pre-



MINING CLAIMS NEAR CHLORIDE.

Cambrian, and at first glance is difficult to distinguish from the older granitic gneisses, especially as it also has a distinct schistosity. It is a medium-grained granitoid rock, much resembling the granite porphyry of the Mineral Park batholith. It breaks down easily and weathers greenish or yellowish brown, and seems to impart the latter color to about all but the upper portion of the front of the range from Chloride northward. It is moderately schistose in a north-south direction, the dip of the schistosity being vertical, and it is sliced by a northwesterly sheeting which dips 70° NE.

GENERAL CHARACTER OF DEPOSITS.

The deposits occur in two systems of well-defined fissure veins. One strikes a little west of north and stands nearly vertical, another

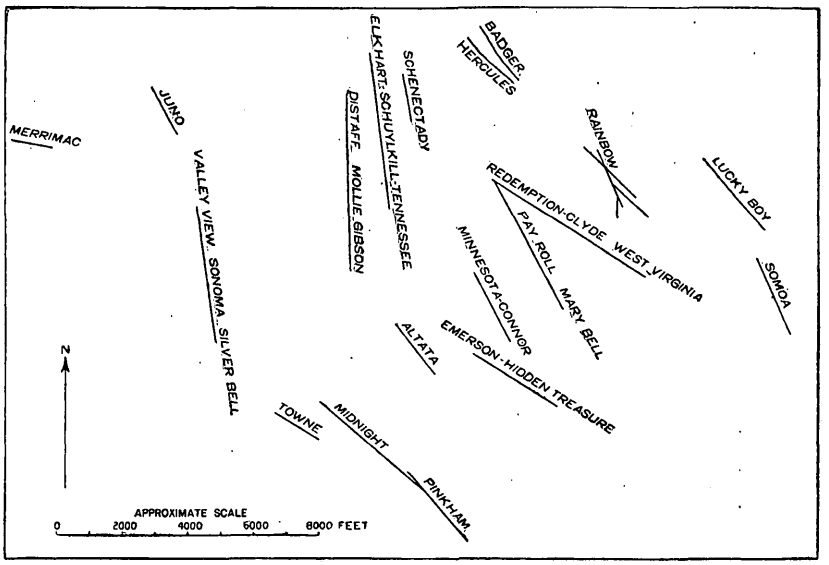


FIGURE 4.—Diagram showing trend and relative position of the principal veins in the Chloride district.

strikes about due northwest and dips steeply either to the northeast or to the southwest. (See fig. 4.) Many of the ore shoots are located at points where spurs or feeders join the vein in an oblique direction. The ores principally contain silver and lead with some gold and copper. The gangue is quartz with some calcite and other carbonates. The primary ore minerals include pyrite, chalcopyrite, arsenopyrite, galena, zinc blende, molybdenite, and probably bornite. The secondary minerals are silver, hornsilver, argentite, ruby silver, and chalcocite, together with various oxidized lead and copper minerals. In a reconnaissance report, like this one, only some of the more important properties can be described to convey an idea of the deposits and developments of the region.

TENNESSEE MINE.

The Tennessee mine is 1 mile east of Chloride, at the foot of the mountains, on the east side of Tennessee Wash, at an elevation of about 4,050 feet. (See Pl. V, *B*.) It is owned by the Tennessee Mining Company, of Chloride.

The Tennessee is an old mine and has been worked for more than fifteen years. It has produced hundreds of thousands of dollars in ore. Among the earliest owners were A. M. MacDuffee, and later Mr. Botsford, who held the property for eight or nine years and is still part owner with the present company, which took it over in 1906. For the six years ending in 1903 the Hualpai Mining and Development Company, with headquarters at Los Angeles, operated the mine and took out chiefly lead ore. For a long time during this period the production was a carload of concentrates a day, or sometimes 50 carloads a month, besides a large amount of high-grade ore that was constantly being shipped. From 1904 to the middle of 1905 the mill was shut down, but since then the present company has been running the mine and mill almost steadily, and the property is now being developed for handling on a larger scale.

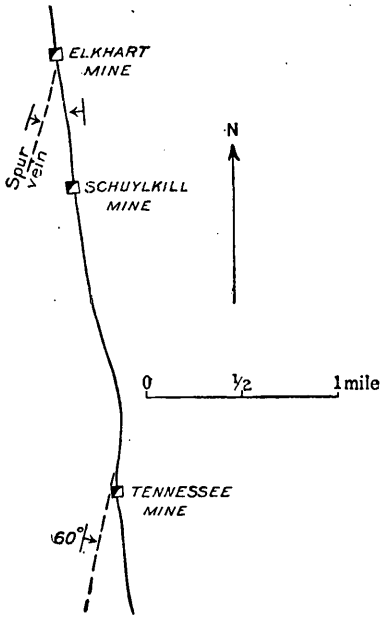
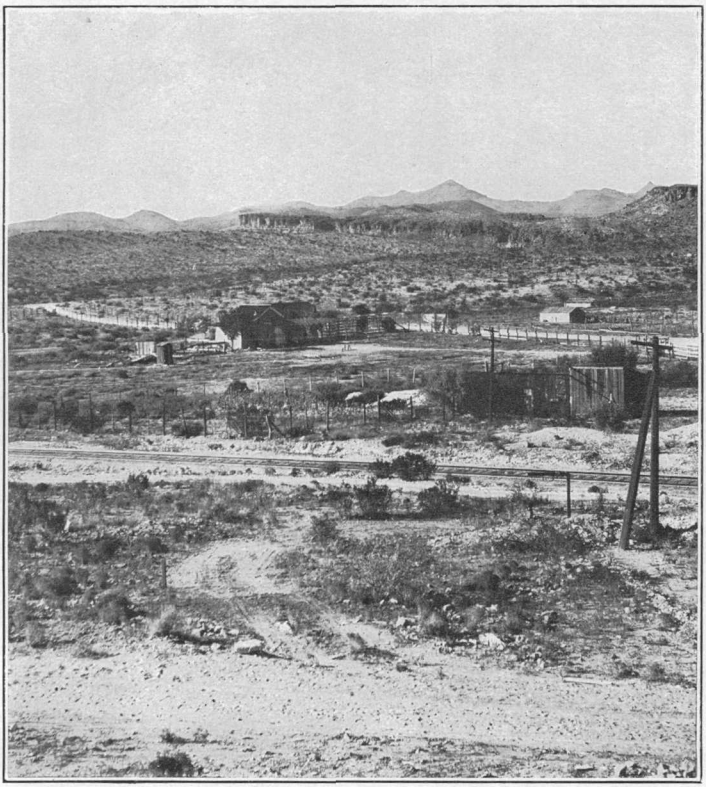


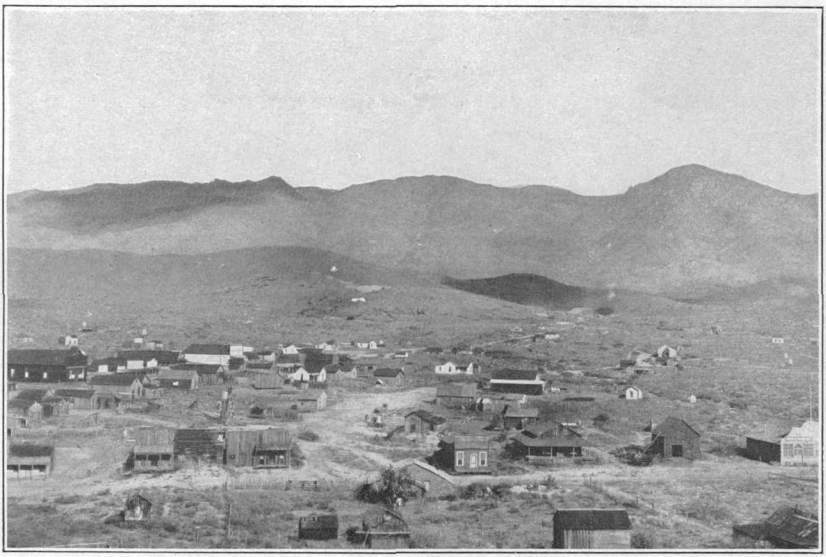
FIGURE 5.—Plan showing course of Tennessee vein.

The country rock at the mine is a gneiss with granite and schist occurring near by. The gneiss is composed chiefly of sericitized feldspar and crushed quartz with streaks of chlorite. The granite is a pinkish-gray medium-grained microcline rock, somewhat crushed, and contains very little biotite. The schist is the fine-grained, black, typical amphibolite variety and is composed essentially of brown hornblende, sharply defined feldspars, mostly triclinic, and a little pyroxene.

The mine is situated on the Tennessee vein (see fig. 5) and is developed by two inclined shafts and six levels. The shafts are located 280 feet apart. The main or northern shaft is 600 feet deep and the southern shaft 400 feet. The levels are spaced 100 feet apart vertically, the first level being 100 feet below the surface, as shown in the accompanying vertical section of underground workings



A. PART OF LAVA MESA SURROUNDING KINGMAN, LOOKING NORTHWEST FROM WEST SIDE OF TOWN.



B. CHLORIDE AND PART OF CERBAT RANGE, LOOKING EAST FROM SILVER HILL.

(fig. 6), which also shows the amount of drifting on the various levels.

The vein croppings, rising locally several feet above the surface, are reddish, brownish, yellowish, and blackish quartz and galena stained with iron and manganese. The vein is regarded as a part of the great lead-bearing "lode" on which the Schuylkill and Elkhart mines to the north are situated. At the surface the vein strikes N. 8° W. and dips about 68° E.

The main or north shaft starts on the vein, its slope at first coinciding with the dip of the vein. With increasing depth, however, the dip gradually diminishes until on the 400-foot level the vein lies 30 feet east of the shaft, and in the 200-foot drift on the 600-foot level the strike of the vein is N. 10° E. This change in strike, however, on this level may be occasioned by what seems to be a spur vein

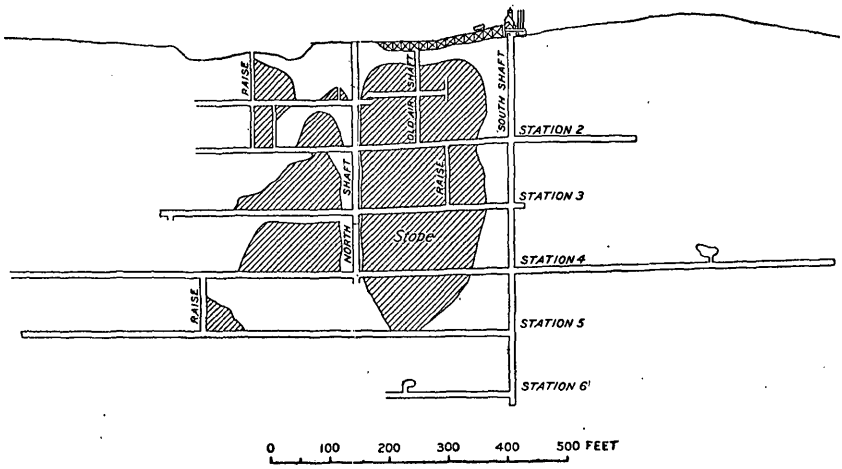


FIGURE 6.—Longitudinal section along Tennessee vein.

or feeder coming in from the west, as shown in figure 5, as there is a considerable body of rock, probably 5 or 6 feet in thickness, between the ore zone in the drift and that in the stope above, and as the structure in the crosscut from shaft to drift and main vein suggests the presence of such a spur vein which dips toward the main vein.

The walls for the most part are hard, smooth, and fairly regular. On the 600-foot level three systems of slickensides are shown, whose component direction indicates relative vein movement downward and northward at angles of about 40°. Slickensiding is also shown to a marked degree in some of the ore.

The Tennessee is a lead mine, and one of the most prominent lead-bearing properties of the Territory. The ore contains mainly galena, zinc blende, and pyrite, and also carries good silver values and some

gold and copper. Specimens collected from the 600-foot level consist of a medium to fine grained mixture of bright crystalline galena and dull resinous sphalerite in about equal amounts, and contain about 5 or 6 per cent of irregularly disseminated iron and copper pyrites. The galena locally exhibits an imperfectly banded structure, due to pressure.

The average run of mine ore, omitting the zinc, is about as follows: Lead, 20 to 70 per cent (concentrates, 75 per cent); silver, 8 ounces (concentrates, 25 ounces); gold, small amount; copper, some in deep part of mine, increasing in amount with depth.

Gold occurs only in small amount and is found in the pyrite. Of the total ore output about one-third is high-grade shipping ore; the remaining two-thirds is milled.

The mine has been productive from the surface down. From the ground between the surface and the 400-foot level thousands of tons of rich galena ore have been shipped to the smelter. The ore shoot had a horizontal extent of about 250 feet, and contained some bodies 15 feet in width. Extraction was easy with a small amount of timbering, but it is reported that owing to the extravagant management of the property the profits realized were small. There is said to be good ore still remaining in this part of the mine, but on account of caving of the stopes it will be difficult to extract.

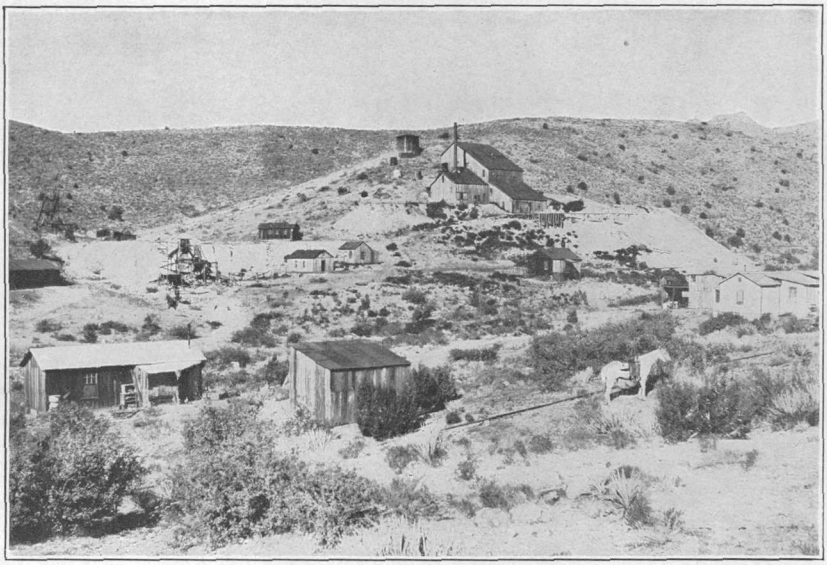
On the 400-foot level a vein 21 feet thick, with 5 inches of solid galena, was mined for about 40 feet horizontally. From the fourth to the fifth level there was a decrease in the value of the ore, due to the predominance of zinc blende, but from the fifth to the sixth level galena increased to the proportion shown in the upper part of the mine.

The 500-foot level contained good ore for a distance of 800 feet, and the upraise from it showed 12½ feet of almost solid galena. In the 200-foot drift of the 600-foot level, toward the end of the drift, the vein showed about as follows: Good ore, with quartz coming in toward right, 2 feet 9 inches; milling quartz, 8 inches; fair ore, with bunches of quartz, 7 feet.

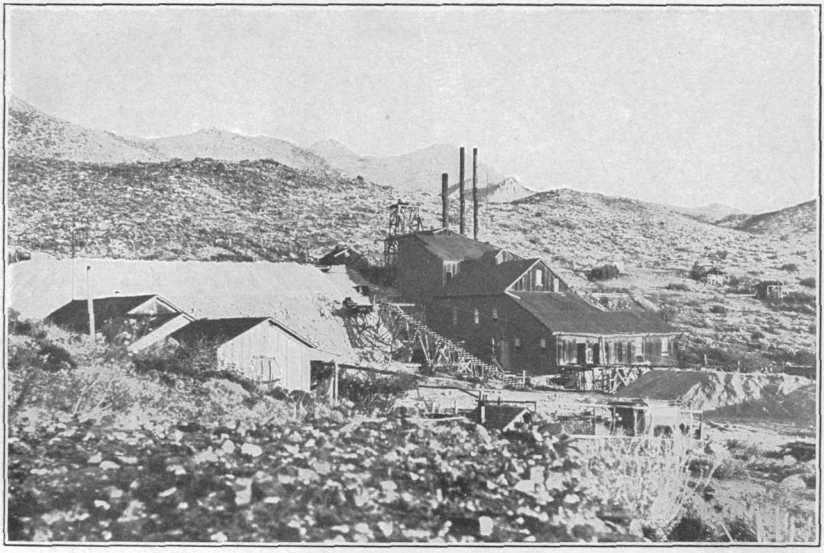
According to Comstock[a] the mine, about 1899, in its new workings encountered one of the buried older east-west auriferous veins or cross belts of mineralization, which increased the gold value of the mine product from $4 to $10 a ton.

No effort has ever been made to handle the zinc as a by-product, it being allowed to go into the tailings dump at the mill, which also contains values of the other metals, silver and gold. In addition, large bodies of good zinc ore, some 12 feet in width, on the 200-foot and 500-foot levels, have been left standing in the mine. The avail-

[a] Comstock, Theodore B., Geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, p. 1048.



A. ELKHART MINE AND MILL, LOOKING NORTHWEST.



B. TENNESSEE MINE AND MILL, LOOKING SOUTHEAST.

able tailings in the dump are estimated by H. L. McCarn at 12,000 tons, and they will concentrate about 60 per cent, or about 1 ton of zinc in 4 or 5, and will besides carry 8 to 10 per cent of lead and some silver and gold. Of zinc alone, by fine grinding and proper treatment, they are expected to yield about 300 tons of concentrates. There seems to be little doubt that the zinc, which heretofore has been regarded as a detriment, can be marketed at a good profit. In January, 1908, after the foregoing was written, Mr. McCarn informed the writer that the tailings were being worked over with jigs, tables, and electrostatic separators.

The most important of the surface improvements at the mine are a well-equipped steam concentrating mill, having a capacity of 100 tons in twenty-four hours, and two substantial steam hoists, that to the south having a capacity for a 1,000-foot shaft.

SCHUYLKILL MINE.

The Schuylkill mine, one of the oldest in the district, is about 1 mile northeast by east of Chloride, on a patented fractional claim adjoining the Tennessee on the north. It is on the west side of Tennessee Wash, and 100 feet above it, at an elevation of about 4,300 feet. It is owned by the Southwestern Mining and Smelting Company, a Pittsburg corporation.

The mine in early days was worked by Monroe Salisbury, who operated the Benson smelter, to which much of the ore was shipped. Later it was sold to the present company, which did the deep development work planned to extend to a depth of 1,000 feet, and is said to have blocked out much good ore ready for stoping when, about three years ago, work was suspended.

It is situated in alignment with the Tennessee and Elkhart mines and is supposed to be on the Tennessee vein (fig. 5); the country rock and ore are similar to those of the Tennessee mine. The vein here strikes N. 9° W. The large dump shows that much work has been done. The developments consist of a steam hoist, an excellent shaft 500 feet deep, two long crosscut tunnels, and considerable drifting and additional crosscutting. The mine has produced much good ore and has much more in sight reported to carry good copper and gold values. That from the surface workings was mostly of high grade. Rich silver-lead ore is also reported to occur on the 400-foot level, and on this and the lower levels are ores with native silver, running $100 a ton. The mine was closed at the time of the writer's visit.

ELKHART MINE.

The Elkhart mine (Pl. V, *A*) is situated a little more than a mile northeast of Chloride, west of Tennessee Wash, and adjoins the

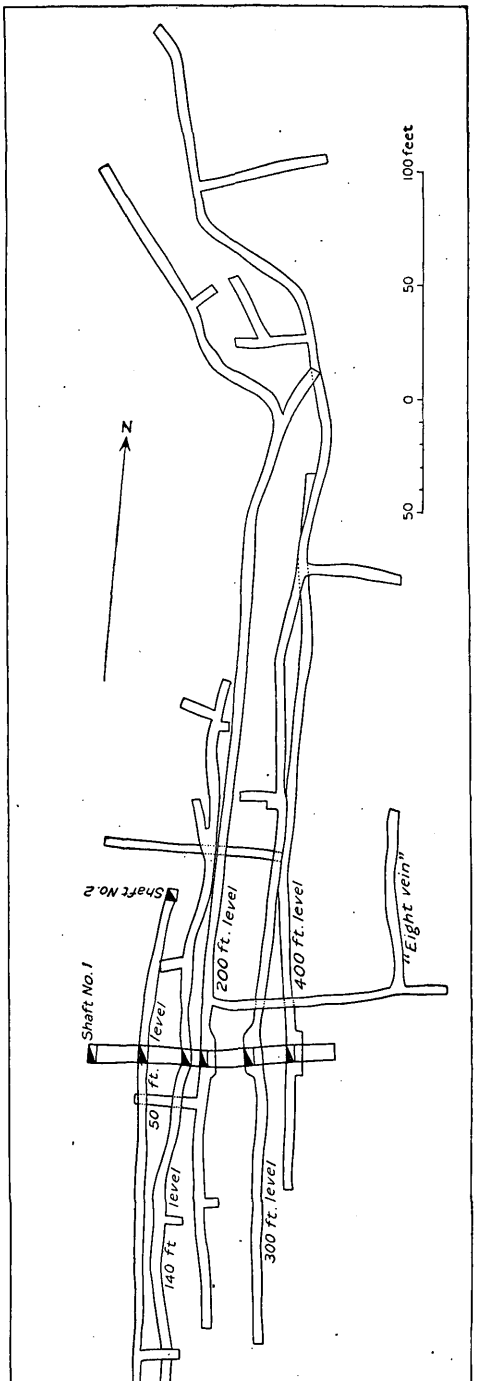


FIGURE 7.—Plan of Elkhart mine.

Schuylkill mine on the north. Its property embraces four claims, the Elkhart, Argyle, Dumferlin, and Bullion, as shown in figure 7.

The Elkhart is one of the older mines of the region. It was located in the early eighties and produced several thousand tons of rich ore from the surface down. Later it was worked by Ohio peopeople and still later sold to a Scotch company, of which Theodore Comstock was the general manager. He put up the mill and installed the machinery about 1895–96. In 1902 another company bought it from Mr. Comstock and later it passed into the hands of J. H. O'Neill, of Los Angeles. In 1906 it was acquired by the present company. The mill closed in April, 1906, but started later and ran until October 15. A large amount of money has been spent on the mine, for which it has returned but little. It is owned by a corporation of Glasgow and Los Angeles capitalists, with headquarters at Los Angeles. It is located on the northern part of the Tennessee or "big lead" vein, or a similar vein lying in its trend, and has associated with it one or two

parallel veins or supposed feeders or spurs. The country rock is pre-Cambrian granite and gneiss similar to that at the Tennessee mine. Some diabasic rock is present near by, but was not observed in association with the vein. The zone of oxidation extends to a depth of about 80 feet.

The mine is developed by shafts and levels. The main shaft is on the vein and is sunk to a depth of 500 feet; another is down 200 feet, and a third 80 feet. There are six levels, but they are somewhat irregular and there is reported to be about 400 feet of drifting on each level, not including numerous stopes and crosscuts. The principal surface equipments consist of a steam hoist with a capacity for a shaft 1,000 feet deep and a dry-crushing concentrator mill having a capacity of 100 tons in twenty-four hours. The mill is in good condition and formerly turned out a carload of concentrates a day. Both mine and mill are accessible by a good wagon road of easy grade.

The ore contains galena and carries gold and silver, the gold being contained mostly in the pyrite, as at the Tennessee mine; but the ore differs from that of the Tennessee mine in the absence or scarcity of zinc blende. The sulphide ore is reported to approximate as follows: Lead, 63 per cent; silver, 25 ounces per ton; gold, $10 per ton.

The ore is reported to be much the same in quality from the surface down, and to favor the hanging wall. The ore bodies are said to be 15 feet in width in some places.

According to Comstock [a] a parallel vein struck on the 200-foot level yielded $20 in gold to the ton, and on the same level prolonged northward a cross vein of similar type belonging to the old latitudinal series was worked, carrying ore plentifully sprinkled with yellow pyrites running well in gold, the gangue being entirely different from that of the main vein. This new vein is also present on the 300-foot level. On the 400-foot level white orthoclase feldspar dikes, which are probably aplite, are reported to be closely associated with the vein series to which it belongs.

In portions of the mine refractory clay or kaolin-like deposits of considerable extent, derived from kaolinization of the feldspar in the country rock, form the walls of the vein.

With the exception of some ore on the second level, the ore in sight is about all worked out down to the fourth level, and new ore bodies will have to be opened before the mine can produce much. The vein splits between the fourth and fifth levels, and above this split the ore, though principally lead, carries $8 to the ton in gold. The best ore

[a] Comstock, Theodore B., Geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 1048–1049.

encountered thus far has been taken from the 500-foot level. Here the vein is reported to be 14 feet thick and to contain some very high-grade ore. The dumps, which are large, contain much ore and are all to be milled.

DISTAFF MINE.

Three-quarters of a mile east of Chloride and about one-fifth of a mile west of the Tennessee vein and about parallel with it, lies the Distaff-Mollie Gibson vein, on which are situated the Distaff, Mollie Gibson, and other properties.

The Distaff mine is located on a patented claim in the foothills just north of Tennessee Wash, at an elevation of 4,100 to 4,400 feet. It is owned by Charles E. Sherman, of Mineral Park. The country rock is the younger medium-grained granite described under "Geology" as characteristic of the region lying north of Chloride. Hornblende and mica schist also occur, notably on the east side of the claim. The granite is roughly schistose and the vein is about parallel with the schistosity. The vein strikes north with vertical dip and has a known extent of about a mile. It is but 2 or 3 feet in width and is easily worked, but pinches on the northern part of the Distaff ground.

The principal developments consist of about 2,000 feet of underground workings, including a 240-foot shaft and drifts. Recent shipments of what was formerly considered low-grade ore from the old dumps of the Distaff are reported to have netted several hundred dollars per carload. The production has been about $50,000, the ore being chiefly chloride or horn silver, with much native silver occurring in slabs or chunks many pounds in weight in the deeper part of the workings.

MOLLIE GIBSON MINE.

The Mollie Gibson is situated south of the Distaff and beyond Chloride Wash, the Bullion-Beck claim intervening. It is on the same vein as the Distaff. It is credited with developments 200 feet in depth and with having produced considerable lead-silver ore, some being of high grade.

HERCULES MINE.

The Hercules is a small mine, situated about 2 miles northeast of Chloride and about one-half mile east of Tennessee Wash, at an elevation of about 4,700 feet. It is close to the wagon road leading to the Lucky Boy and Samoa mines.

The Hercules was discovered about 1899 and held by Comstock & Ferguson until 1903. They drove a 60-foot tunnel from the canyon side and sunk four shafts to the depth of 20 feet, with no material results. In 1903 F. H. Kraft, the present manager and part owner

of the property, sunk a little deeper and struck good $30 ore, and the mine has been a steady though small producer ever since.

The country rock is the usual pre-Cambrian gneiss. The vein is 25 to 30 feet in thickness. It trends N. 54° W. and dips about 70° SW., with porphyritic granitoid gneiss on the hanging wall and black hornblende-mica schist on the foot wall. A neighboring vein trends N. 80° W. and dips 80° N. It occurs in the dark foliated schist, and the mine is probably on a chimney or ore body enriched by the intersection of this vein with the Hercules.

The principal developments are a 90-foot shaft sunk on the vein and some drifting, notably on the 50-foot level. The bottom of the shaft shows a pay shoot of very good ore 1½ feet thick. The mine yields a plentiful supply of excellent potable water. The ore is galena, running high in silver and containing good values in gold.

BADGER MINE.

Two miles northeast of Chloride and one-eighth mile north of the Hercules mine, on what is known as the Badger ground, occurs a large 20-foot vein known as the "Big vein." It strikes N. 40° W. and dips 80° SW. It has produced considerable ore. Tests from surface pits sunk on it show $16 ore, of which $12 is in gold. In a canyon one-eighth mile east of the Hercules the vein is cut by a close sheeting or cleavage structure trending N. 80° E.

At about 250 feet northeast of the "Big vein" and parallel with it, but dipping 80° NE., lies the well-known Badger vein. It has been mined to a considerable extent at several points to the northwest and has produced considerable ore.

Among the properties situated on it are the Badger group and the Badger and Woodchuck mines, located on eastern tributaries of Tennessee Wash. The two latter, owned by S. L. Chadwick, have produced considerable rich lead ore, which occurs in large bodies, but some of the ore is said to contain much zinc. The Badger group property is reported to have produced several hundred tons of good ore, chiefly in gold and silver, from a 300-foot tunnel 150 feet deep at the face.

EMPIRE MINE.

The Empire mine is situated about 2 miles north-northeast of Chloride, in a northeast gulch of Tennessee Wash, on a large vein which is supposed to be the northwestward extension of the Badger vein. It is one of the oldest and first patented properties in the district. It is developed principally by a shaft 200 feet deep. The values are principally in silver, which is very soft and very rich, and the yield has been good from the surface down. The production has been about $70,000. The mine was owned by William Raymond, one

of the discoverers of Pioche, and was worked by lessees with good profit. Later E. F. Thompson sank the shaft to greater depth and shipped ore of good grade.

PAY ROLL MINE.

The Pay Roll mine is about 1½ miles east of Chloride, near the middle of the west slope of the Cerbat Range. It is situated on Pay Roll Gulch near its head, at an elevation of about 4,400 feet, whence the surface rises steeply to about 5,200 feet in Rainbow Mountain on the northeast. The mine is approached by a good wagon road of easy grade.

The property, aggregating 40 acres, consists of two claims, known as the Pay Roll and Black Prince quartz. It is owned by Mrs. Mary Murphy, of Kingman, and Judge J. J. Hawkins, of Prescott. It was located in March, 1887, by J. W. Murphy.

The country rock consists of the usual pre-Cambrian crystalline schists, with granitoid rock predominating in the hanging wall and schist on the foot-wall side. A diabase dike is locally associated with the vein, which is cut off on the northwest by a raised fault block of black hornblende schist. In the gulch just below the mine the schists are cut by dikes of relatively young light-colored garnet-bearing aplitic granite.

The principal development work, all on the Pay Roll claim, consists of three shafts, aggregating about 500 feet in depth, over 600 feet of tunnels, about 400 feet of drifts, and some crosscuts and stopes. Shaft No. 1, the main working shaft, sunk off the vein, is 225 feet deep, and contains water in the sump. Shafts Nos. 2 and 3 are sunk on the vein to depths of 100 and 60 feet, respectively. The main drift is about 500 feet in length and the main crosscut tunnel about 130 feet. Where the latter intersects the vein a winze about 50 feet deep is sunk on the vein.

The mine is situated on the Pay Roll vein or lode, which strikes about N. 30° W. and dips steeply to the northeast; the structure in the adjacent rocks trends about N. 40° W., with the dip approximately vertical. The Pay Roll is one of the large veins in the Chloride region. As shown by its persistent croppings it has a horizontal extent of nearly a mile, but is reported to be somewhat broken in the bottom of the mine. It varies from 6 to nearly 100 feet in thickness, 10 feet being perhaps a fair average, and contains in places a fair grade of concentrating ore. The gangue is mainly quartz, and the vein is in places separated from the wall rock by a thick sheet of argillaceous or talcose gouge.

Near the mine, as shown in figure 4, the vein is joined by the Redemption Clyde vein, which probably enriches the Pay Roll ore shoots.

The ore in the persistent pay shoots consists of lead carbonates and galena, with some pyrite and chalcopyrite; it contains both gold and silver. The total production of the mine was not learned, but it is reported to include many carloads of rich shipping ore that run about $80 a ton, mostly in gold, derived principally from the surface workings, excellent values being found in the south shaft. So far as can be judged at present the deposit is a good-sized body of low-grade ore.

REDEMPTION MINE.

The Redemption mine, also known as the Ferguson, is a new property situated 2 miles east of Chloride and half a mile east of the Pay Roll mine. It is working on the Redemption Clyde vein, which lies east of the Pay Roll vein and joins that vein at the Pay Roll mine. The Redemption Clyde vein strikes N. 60° W. and dips 85° NE., and is known to have an extent on the surface equal to the length of at least four claims. Where opened on the Redemption property it attains an elevation of about 5,000 feet. Like the Pay Roll vein, it lies in the pre-Cambrian crystalline schists. It is opened by tunnels and winzes. The vein is about 4 feet thick, and the ore shoot is about 18 inches thick. The ore contains chalcopyrite in quartz and carries about 8 per cent of copper, 1 to 2 ounces of silver to the ton, and some gold. The production amounts to 200 tons of ore.

LUCKY BOY MINE.

The Lucky Boy mine is about 3 miles east of Chloride and about a mile east of the Redemption mine. It is near the crest of the Cerbat Range, at an elevation of about 5,750 feet, in the head of a gulch which is tributary to Windmill Wash. The property embraces four claims, the Lucky Boy, Brighter Days, Queen, and Baldwin. The total output is said to have had a value of about $150,000.

The Lucky Boy mine is an old property, located in 1892. It has been producing more or less all along and has been operated steadily for the last seven years. For some time it was owned by the Scott Lucky Boy Consolidated Mining Company, of Norfolk, Va., and was leased and worked by a company composed of Kingman men, Fred Stull being superintendent. Early in 1907 it was reported that the property had just been sold to an English company. In 1908 it was worked only on a small scale by lessees.

The principal rock is a medium-grained biotite granite, in which biotite, quartz, orthoclase, and much oligoclase are the essential minerals. This rock may possibly be of post-Cambrian age. It is intruded by a light-colored, fine-grained granite porphyry.

The mine is worked by shafts, crosscuts, tunnels, drifts, and stopes, the underground workings aggregating somewhat more than 4,000

feet. The developments consist essentially of five or six levels spaced 50 feet apart, with 500 to 600 feet of drifting on each level. The main shaft is 300 feet in depth. The shafts are equipped with gasoline hoist and a pump.

There are two principal veins, which strike north-northwest and dip about vertically. They are parallel and are 64 feet apart. They range from 3 inches to 6 feet in width in shipping ore, a width of a foot being an average, and $100 a ton an average value for the ore. The veins are said to be regular in character and the ore fairly constant in value. Under the microscope a section of the ore shows native silver, silver chloride, pyrite, and quartz. The ore in the front or southeast vein runs 3 ounces of gold and 125 ounces of silver to the ton; that from the "back" vein 5 ounces of gold and 80 ounces of silver. The superintendent, Mr. Stull, states that in the lower part of the mine there is a heavy, brassy-looking sulphide ore whose assay values in carload lots are 5 ounces of gold and 130 to 140 ounces of silver to the ton.

In their southeastward extension the veins pass to the northeast of the Samoa mine and do not occur on the Samoa claims, but if driven far enough the Samoa workings will cut them in the depths of the mountain.

RAINBOW MINE.[a]

The Rainbow mining property, comprising nine claims, is situated about 2½ miles east of Chloride, at an elevation of about 5,500 feet, near the summit of the Cerbat Range. All the claims contain veins of more or less promise.

The production is about $75,000, the bulk of which—about $60,000—was made prior to 1891 by chloriders. Since then, according to Mr. MacDuffee, who became interested in the property about that time, the shipments, mostly for the years 1891 to 1901 inclusive, aggregated about 210 tons, with an average value of $72.55 a ton, amounting to over $15,000.

The Rainbow mine was discovered and located in 1883 by Erin Sherman and was worked intermittently until 1890. Recently it has been taken over and is now being operated by the Rainbow Mining Company, of Chloride.

The country rock is the pre-Cambrian gray gneissoid granite considerably altered and silicified along the veins and containing some of the usual acidic and basic intrusives. The principal workings are those of the Rainbow mine, near the middle of the group, and of the Rainbow claim, on the Rainbow vein.

The Rainbow vein is not large, but occupies a definite walled fissure extending throughout the length of the claim. It strikes

[a] In the preparation of this statement on the Rainbow mine the writer has freely drawn on an unpublished report by H. L. McCarn.

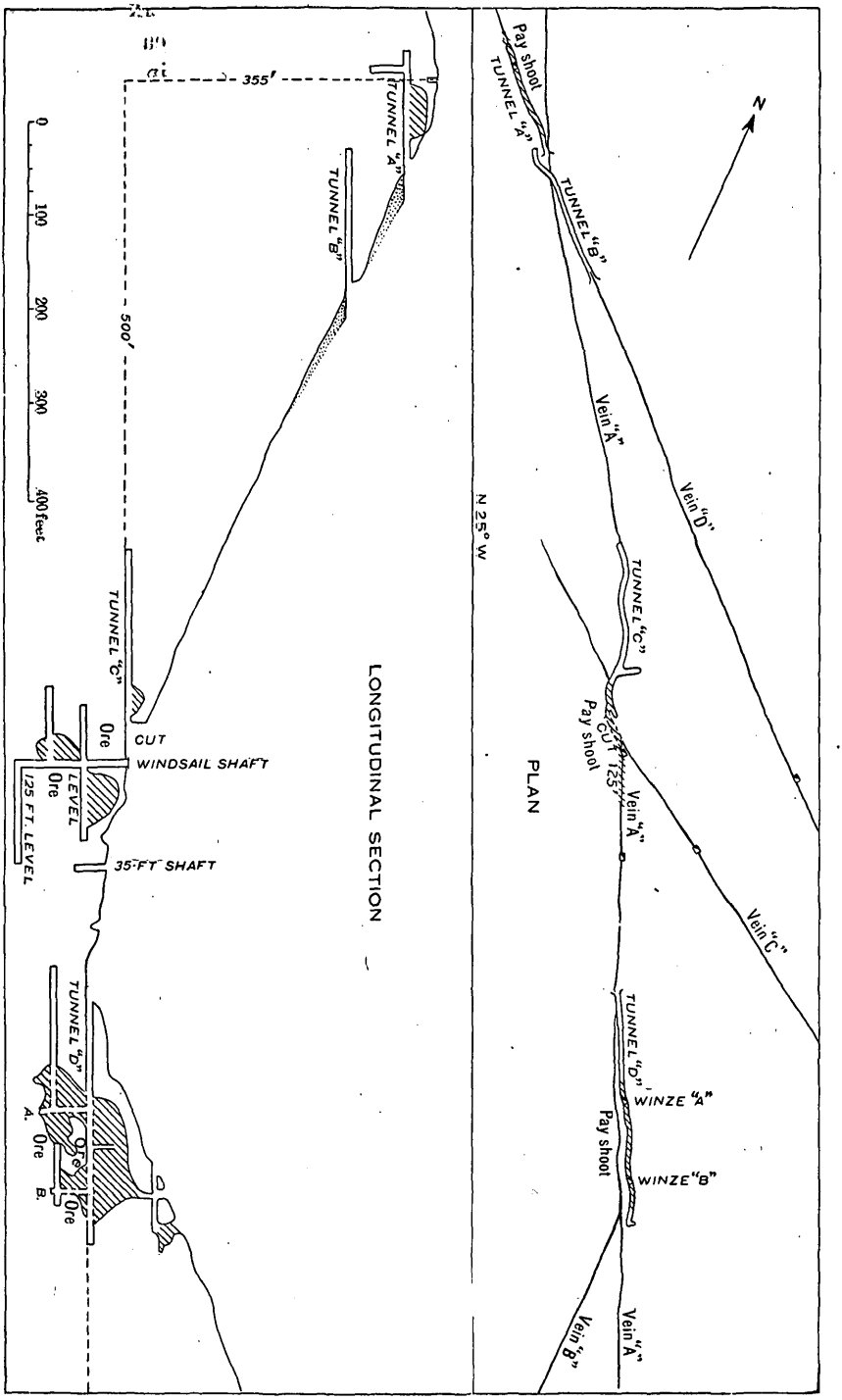


FIGURE 8.—Plan and longitudinal section of Rainbow mine.

north-northwest with vertical dip and is joined by several spur veins or feeders which come in at acute angles and materially enrich the ore shoots at junction. The ore streaks are persistent and easily followed and range from 6 inches to 3 feet in width, while in some parts of the old stopes there is said to have been 6 feet of solid ore, presumably situated where the vein is joined by feeders.

The principal developments (see fig. 8) are the Windsail shaft, 125 feet deep, and about 1,000 feet of drifts, crosscuts, stopes, etc., but owing to caving below the 50-foot level the lower part of the mine is not now accessible. No stoping has been done below the 100-foot level, and but little below the 50-foot. A wagon road of heavy grade crosses the northern part of the group and connects with the mine, about a mile distant, by a trail over which supplies and ore are now packed on burros.

Even the shallow depths reached by the mine show ore of good grade. Sulphide ore begins at a depth of about 100 feet below the surface. There are three main ore shoots, known as the North, Windsail, and South shoots. The North shoot is situated near the north end of the claim, 300 feet above the main part of the mine. It was extensively worked by chloriders in early times, and so far as known is a silver-lead shoot, containing fair values in gold.

The Windsail ore shoot is at the principal workings of the mine, near the middle of the claim. Here a streak of ore consisting of quartz and carbonate of lead of about equal width, and aggregating 12 to 15 inches in width, is exposed for 25 feet. Assays of the carbonate collected along a length of 25 feet show values of 2½ ounces of gold and 2 ounces of silver to the ton, and by estimate 12 per cent of lead—a total value of about $70 a ton. In the 50-foot level north the streak is pinched and lean, being disturbed by a dike, but it carries 4 inches of $40 ore, and just below this level excellent ore ($60 to $70) is said to have been taken from a streak 6 to 18 inches thick. A small stope above the 50-foot level south is reported to have produced more than 100 tons of $60 to $75 ore, and the block of virgin ground extending from this stope down to the 125-foot level, where a foot or more of good ore occurs in the roof of the drift, should produce a considerable quantity of good-grade ore.

The South ore shoot, situated 200 feet from the Windsail and worked by tunnel D, seems to be the principal ore shoot on the property and furnished the bulk of the ore shipped in early days. It is developed by a 260-foot drift, stopes, and winzes, and the ore has been mostly worked out down to the sulphide zone. Remaining portions of oxidized ore show good gold, silver, and lead values. The sulphide ore in the south end of the workings varies from 6 to 15 inches in width and averages about $42 to the ton in gold and silver. The sulphide ore in general is closely but not sharply banded

and finer grained toward the outer sides of the shoot, and coarser and more imperfectly banded inwardly. The microscopic section shows the ore consist essentially of pyrite, arsenopyrite, galena, and quartz. The ore shoot has an average width of about 12 inches of clean ore and a length of 150 feet along the shoot. There is considerable low-grade ore in the filling of the old stopes.

The average of about forty-five assays made from various parts of the Rainbow workings is reported as follows: Gold, about 2 ounces; silver, about 20 ounces; lead, about $5 (12 per cent); or an average value of about $65 a ton. The gold amounts to about three-fourths of the value.

Nearly all the other eight claims of the Rainbow group have veins of more or less promise, but on most of them but little work has been done. Considerable work, however, was done on the Old Timer years ago, when only high-grade ore would pay to work, and it is reported that a large quantity of such ore was shipped. There is a 15-inch shoot of good ore in the bottom of the 70-foot shaft, and ore carrying over $30 a ton in gold, silver, and lead now lies on the dumps. The Lindgren-Kemp is also a large fissure vein with definite walls, yielding assays of $6 to $25 a ton.

SAMOA MINE.

Location.—The Samoa mine is 3½ miles east by about half a mile south of Chloride, just north of Cherum Peak and about one-third of a mile south of the Lucky Boy mine. It lies at an elevation of about 5,900 feet, in the steep crestal slope of the Cerbat Range, at the head of a gulch which drains westward into Samoa Wash.

History and production.—The Samoa is one of the early locations and for many years has been the most active and constant producer of good-grade gold and silver ore in the district. The property comprises a group of four claims and a fraction, the Samoa, Samoa No. 1, Samoa No. 2, Fourth of March, and Mountain Dew. The property is owned by the Chloride Gold Mining Company, with headquarters at Pueblo, Colo.

The total production of the Samoa mine has been about $180,000. Approximately $70,000 was produced in early times, the remainder being obtained by the present management under Leonard Hoffman, which took effect in November, 1903. The mine has a record of being a steady producer. The present output is about 90 tons a month. The ore is shipped principally to the Needles smelter. Advices received early in 1908 report that the mine was then being worked on a small scale only by lessees.

Geology.—The vein is contained in the pre-Cambrian granitoid series; the predominating gray or dark-gray granitic rock is much

the same as that at the Lucky Boy mine. A distinct sheeting trends about north and south and dips at about 80° E.

The series is intruded by a large dike of fine-grained, schistose microcline granite, which a short distance below the mine along the trail is in turn cut by a 100-foot rhyolite dike trending northward toward the Lucky Boy mine.

Veins and ore.—There are six parallel veins which strike about N. 10° W. and stand nearly vertical or dip steeply to the east at angles of about 80°. Named in consecutive order, beginning on the east, they are vein No. 1 or Samoa No. 1; vein No. 1½; vein No. 2 or Samoa No. 2; vein No. 3; Fourth of March or Samoa vein (on which are located the Fourth of March and Samoa claims); vein No. 3½ or "Blind" vein; vein No. 4 or Mountain Dew. Vein No. 3½ does not, like all the other veins, outcrop at the surface, but was encountered in driving the crosscut tunnel. Nos. 1 and 2 are situated 551 feet apart and Nos. 2 and 3 are 138 feet apart.

The principal producing vein, the one on which nearly all the work has been done, is No. 3, the Fourth of March. Its average thickness is about 4 feet, and the ore shoot is up to 30 inches wide. The ore holds to the foot wall and is overlain by several inches to 1 foot of gouge or altered granite. The ore contains pyrite, galena, and zinc blende in quartz gangue; occasionally a little molybdenum is found in cross veinlets of spar. There is no copper. The principal value, however, is in the gold and silver contained in the sulphides. The ore now shipped, as shown by the smelter return sheets for 1903 to 1906, inclusive, runs about as follows: Gold, 1½ ounces per ton; silver, 15 ounces per ton; lead, 8 per cent; and zinc, 5 to 8 per cent.

The levels on this vein have been considerably extended since the field work for this paper was done. The most noteworthy feature of the ore is its constancy in good gold values. Some specimens show portions of the ore, especially the zinc blende, heavily coated with secondary enrichment or growth of the black silver sulphide, which, at 600 feet below the surface, seems to speak well for the mine. Some specimens also show considerable native silver. The first ore in shipping quantities was taken from tunnel level No. 1. The ore shoot at this point was about 65 feet long, and in tunnel level No. 2 the same shoot is reported to have had an extent of 400 feet.

The other veins and their ore are in most respects similar to No. 3. As yet but little more than development work has been done on them. Veins Nos. 1, 2, 3½, and 4 are leased to the Arizona Birmingham [Alabama] Gold Mining Company, which is now drifting on vein No. 1. This vein, thought by some to be probably one of the Lucky Boy veins, has produced some ore. When visited by the writer early in February, 1907, a new "strike" had just been made on this vein

on the 200-foot level, where the breast of the drift 80 feet south of the crosscut tunnel showed 20 inches of clean, good-looking ore.

Developments.—The principal developments consist of three tunnels, 350, 900, and 1,200 feet in length, a main working shaft 335 feet deep on vein No. 3, and various drifts and stopes mostly along this vein north and south of the main shaft. There are over 3,000 feet of underground workings on vein No. 3 alone. It has three levels spaced 100 feet apart vertically. Tunnel No. 1 is 140 feet above tunnel No. 2, which is 50 feet above the first, or 100-foot level, and runs southeast. Tunnel No. 3 is a 1,200-foot crosscut tunnel in the plane of the second level; it runs N. 75° E., strikes the main producing vein 350 feet in from the entrance, at a point a few feet north of the shaft, and extends a few feet beyond vein No. 1. On the first level the vein is drifted on for 300 feet to the north and 650 feet to the south; on the second level, 300 feet north and 434 feet south.

A large amount of ore has been stoped and shipped from vein No. 3 from the ground immediately above tunnel No. 2, and from the vicinity of the shaft just above the first level. Present shipments are from the second and third levels. On the third level but little stoping has been done, and most of the ground between the second and third levels still remains intact. The ore on the whole is opened for a length of more than 800 feet along the vein.

Two plants well equipped with gasoline engines are located at the collar of the main shaft and the entrance of the crosscut tunnel. A wagon road connects the mine with the railroad at Chloride, but as yet the ore is packed to the railroad more directly on burros. Thirty men were employed in 1907.

The Samoa mine is undoubtedly a promising property, but although it seems in all respects to have been honestly, and for the most part, ably managed, and although the workings have been in ore all the time, so far as could be learned, it has not paid much more than expenses. It is well to note that the mine as a whole is rather a low-grade than a high-grade property, and that therefore the ore should be handled with a view to the greatest economy. The support and operation of a large pack train entails in itself a very heavy expense. Furthermore, the mine has never had an underground survey. Up to the present time the work has been carried on without plats, plans, or records of any kind, a very unusual procedure for so large a mine and one with such a system of veins.

Recent reports state that the Samoa and Lucky Boy mines are to be worked jointly on a large scale through a main tunnel opening on Lucky Boy ground.

MINNESOTA-CONNOR MINE.

Location.—The Minnesota-Connor mine, one of the more important properties of the district, is about $1\frac{3}{4}$ miles southeast of Chloride

and half a mile south of the Pay Roll mine, at an elevation of about 4,400 feet. It lies at the head of an open gulch which drains southwestward into Sacramento Valley. It is reached by good wagon roads of easy grade from the northwest and the southwest.

History and ownership.—The property is owned by the Philadelphia and Arizona Mining Company, of Philadelphia, to which it was sold by John Barry about 1902. It consists of two claims, the Minnesota and the Connor, joining each other end on. The property was located in the early eighties, since which time it has been a good producer, having yielded several hundred thousand dollars' worth of rich ore. In the early days the surface ores were worked by chloriders with handsome returns. Later the mine was leased to Messrs. Kelley and McKennon, under whom also it was a prolific producer. During the last few years the property has been leased to a new organization, the Lehigh-Arizona Mining Company.

Vein and ore.—The country rock is the usual pre-Cambrian complex, which here consists mainly of pressed microcline-biotite schist, hornblende schist, gneiss, and syenite. It is cut by dikes of vogesite or kersantite, which locally occur on either wall, by dikes of pale pinkish pegmatite or aplite, and by seams of epidote one-eighth to one-quarter inch thick.

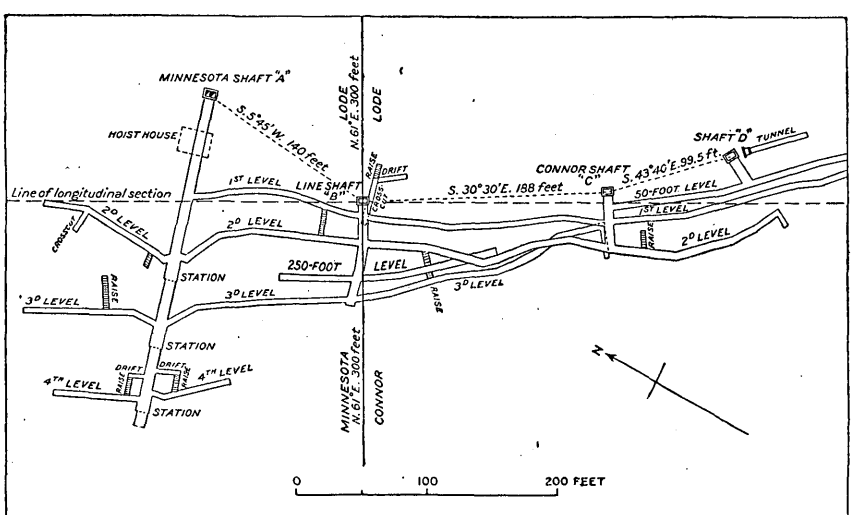


FIGURE 9.—Plan of Minnesota-Connor lode.

The vein strikes N. 30° to 50° W. and dips 60° to 80° SW. It is known to extend through a horizontal distance of 2,400 feet and varies from 5 to 20 feet in width. Where exposed on the surface and in the shallow shaft southeast of the mill it stands about vertical and is 5 feet in width, but it is reported to flatten and widen as it

goes down and in the deeper part of the mine it has in places a width of 20 feet of good ore.

The gangue is quartz, with some calcite, which locally seems to replace the quartz. The ore contains pyrite and arsenopyrite, as well as some chalcopyrite. The principal value is in silver, which in part is in the form of ruby silver, but the ore also contains some gold. Part of it is very rich, some large bodies running $200 or more to the ton. The production is reported to be about $100,000.

The property is developed to the maximum depth of 570 feet by four shafts and four levels, containing about 2,500 feet of drifts and other work approximately as shown in figure 9. The principal equipments are a very complete mill and hoists.

Owing to suspension of operations and the presence of water, the mine was not accessible at the time of visit, except the Connor shaft, northeast of the main workings. Here on the 50-foot level fair bodies of rich ore were found for a distance of 360 feet to the southeast of the shaft.

ALTATA MINE.

The Altata mine, one of the principal copper mines and one of the first mines worked in the district, is situated at the base of the mountains about 2 miles southeast of Chloride and about 100 feet above it and is easy of access. It is owned by the Altata Mining Company, of Chicago, and is steadily producing at a moderate rate.

The mine is developed principally by a main shaft and drifts to the depth of 180 feet. A large dump shows that considerable work has been done. The production is reported to have been about $200,000.

The country rock is pre-Cambrian schist, striking N. 23° E. with vertical dip. The vein strikes N. 40° W. and dips about 75° NE. Surface exposures indicate that it is not more than 2 or 3 feet thick, but it is reported to widen downward and to have contained a large body of good-grade ore near the surface, and also a similar one extending from the 130-foot level to a point below the 160-foot level.

The ore contains copper and silver in a quartz gangue, the copper occurring chiefly as bornite and being locally enriched by secondary chalcocite. Smelter returns show 32 carloads of the ore shipped some years ago to have averaged about $100 a ton, of which 20 per cent was copper and the rest silver. In the crosscut in the bottom of the mine a new vein, 20 feet thick, has recently been encountered with an 18-inch ore shoot on the hanging wall and a 24-inch shoot on the foot wall. The assay value of the ore varies from $12 to $15 a ton in gold, silver, and copper, and some similar ore is scattered across the intervening width of the vein.

EMERSON AND OTHER MINES.

The Emerson mine is nearly 3 miles southeast of Chloride and about 400 feet above it, in the lower slope of the range. The property comprises five adjoining claims. It is owned by Stephen Smith and Henry Schafer, of Chloride, and is producing on a small scale.

The topography is rough. The country rock is the pre-Cambrian complex. The vein is one of the strongest of the camp. It dips northeast at angles of about 77°. It is well defined and is reported to extend to the crest of the range, about 2 miles distant on the southeast. It is held by some to be the northwest extension of the Hidden Treasure vein and has the same characteristics. It is from 5 to 15 feet in width, 3 to 8 feet of which is mainly fresh hard quartz. The vein has been opened to a depth of about 200 feet, and three levels have been turned.

The valuable metal is gold associated with pyrite and chalcopyrite in a quartz gangue. The ore is ideal for concentrating and much of it is good grade shipping ore. The values are reported to continue the same in the sulphide zone as in the oxidized zone. An ore shoot 2 feet thick is said to average about $80 a ton.

In the vicinity of the Emerson mine are several other smaller properties, of which the most important are the Hidden Treasure, New Jersey, Manzanita, Good Road, and Mother Lode. The ores in these properties usually contain gold, silver, pyrite and galena.

The Hidden Treasure is reported to contain five parallel veins ranging from 2 to 8 feet in width, and is developed by several shafts, of which the deepest is 118 feet deep. The ore contains gold, silver, and lead, of which select lots run 3 ounces of gold and 10 ounces of silver to the ton, and 10 per cent of lead.

The New Jersey mine is developed by a 90-foot shaft and about 500 feet of drift. The vein strikes northwest. The face of the drift shows 16 inches of ore, with pyrite and galena, carrying good gold and silver values. Some of the ore has been shipped to the smelter.

The Manzanita property is developed by a shaft and is equipped with a steam hoist. The vein dips steeply southwest.

The Gladstone property lies about a mile southeast of the Emerson, in the first gulch south of Samoa Gulch. It is developed by tunnels and winzes and is bonded to persons who have recently begun deep sinking. The ore contains pyrite and chalcopyrite carrying gold and silver values.

TOWNE MINE.

Location.—The Towne mine is 1¼ miles south of Chloride and about half a mile from the base of the mountains, on open ground in the Sacramento Valley.

History.—The mine is reported to be the first property located in the Chloride district. It received favorable comment in the Wheeler Survey report as early as 1872. It was discovered and located as the "Porter and Black Smoke" in 1871, and immediately became a producer. It was first owned by a Mr. Parker, who took out considerable money, and later by W. H. Palmer, under whom it was known as the "Sunlight." Still later it was owned by F. H. McLaughlin until 1882, and since then it has been owned and operated by John Barry, a well-known pioneer and leading mining man of western Arizona. The mine is now producing in a small way. It is developed principally by six shafts, four levels, drifts, and stopes, the deepest shaft, No. 2, being 230 feet deep, and most of the others between 100 and 200 feet. The workings have a horizontal extent of about 400 feet. The mine has a considerable influx of water.

The production during the first decade of the mine's existence, which is reported to be considerable, was not learned. The production from 1882 to 1906 was about $1,000,000, and was derived mostly from the 70-foot level. The ore has been shipped to Socorro, Denver, Pueblo, and El Paso; it is now shipped to Needles.

Geology.—The country rock is pre-Cambrian amphibolite schist and biotite gneiss, with some bodies of pegmatite. The schistosity strikes N. 30° E. and dips steeply to the east. The rock is cut by vogesite dikes, which trend northwesterly. The one at the mine is about 200 feet in width.

Mineral deposits.—The mineral deposits consist of two veins about 40 feet apart. They lie nearly parallel and in places seem to be separated by the vogesite dike rock only. The one on the north, which is known as the "old vein," strikes N. 77° W. The other, and at present more important one, known as the "new vein," is the one now worked. It strikes N. 70° W. and dips about 70° NNE. It is about 3 feet in average and 8 feet in maximum width and is wider in the deeper part of the mine than near the surface. It is well defined and easily worked. The hanging wall is principally biotite gneiss and the foot wall the vogesite dike rock. Pronounced slickensides between the walls and the vein descend steeply east-southeast. At a point 108 feet east of shaft No. 3 the veins are abruptly cut off by a small fault, beyond which, so far as the work extends, the dip flattens to about 45°.

The gangue is quartz, much of which is shattered and pinched and the ore contains principally silver and gold, with some pyrite, zinc blende, and galena. It runs about $200 a ton, with nearly 200 ounces of silver, and 5 to 7 ounces of gold. Smelter returns show some carload lots averaging as high as 7 ounces of gold and 600 ounces of silver to the ton. Some of the richest ore shoots occurred on

the 100-foot level and east of shaft No. 3, where the ore averaged 10.4 ounces of gold and 240 ounces of silver, and some assays, it is stated, gave returns as high as 18 ounces of gold.

The ore shoots range from 3 to 18 inches in width, with an average of about 5 inches, depending on the quartz. The ore occurs almost wholly on the foot-wall or vogesite-dike side of the vein, with usually a small seam of talc intervening.

PINKHAM MINE.

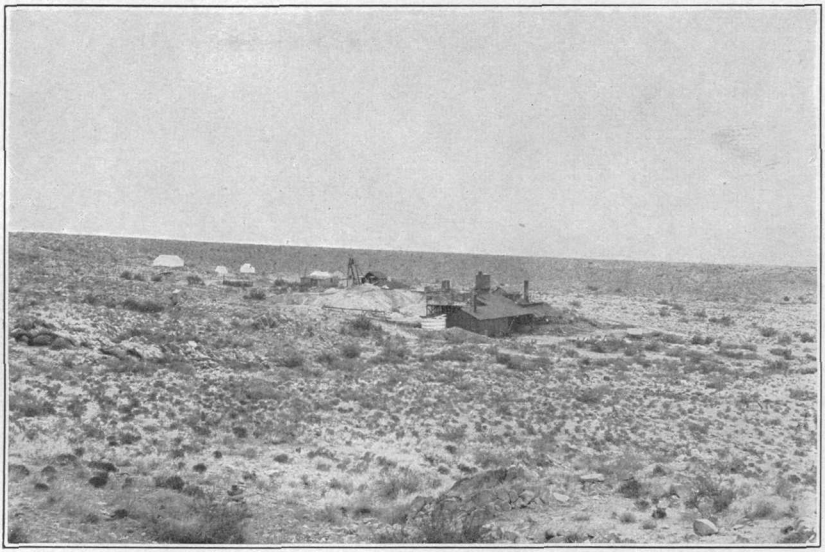
The Pinkham mine (Pl. VI, *A*), perhaps the most important copper mine of the region, is about 2 miles southeast of Chloride and about three-fourths mile east of the Towne mine. It is located in the open border of Sacramento Valley, near the foot of the range, at about the same elevation as Chloride.

The mine was located about 1896, but production began only recently. It is owned by Skee Brothers, of Santa Monica, Cal. It was recently bonded to the Union Smelting and Refining Company, of Los Angeles. The company began operations in March, 1906, and installed a 60-ton oil smelter and a coke smelter, both of which, it is stated, owing to improper processes and fluxes, failed to successfully extract the ore. The matte, however, is reported to have averaged 40 per cent of copper from 2½ per cent raw ore.

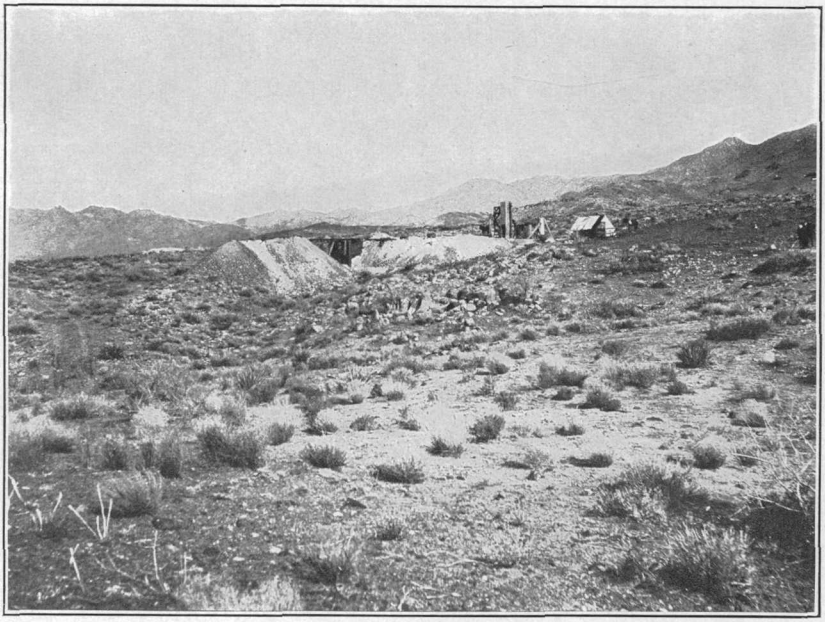
The company then proceeded to mine and ship the ore, which ran about $300 per car, and the property is now producing on a moderate scale. The mine is developed principally by a main 240-foot shaft and five levels, aggregating about 1,200 feet of underground work. It contains some water. The levels are located at about 50, 85, 110, 140, and 230 feet below the surface. The work is distributed approximately as shown in figure 10, which has been prepared and kindly furnished by Mr. H. L. McCarn.

The country rock is the pre-Cambrian complex, and it is intruded by microcline granite and diabase dikes near by. The vein strikes N. 40° W., but varies as shown in figure 10, and dips at angles ranging from 65° SW. to vertical. It is reported to be the same vein that starts from the east side of Congress "ledge" in Mineral Park Wash, near Mineral Park, nearly 2 miles distant, and to be traceable by its croppings all the way from this point to the Pinkham mine.

The croppings consist of rust-brown, iron-stained, crushed and recemented quartz and silicified rock about 3 feet in width, rising 2 or 3 feet above the surface. Underground the vein is on the average about 12 feet in width, with a local maximum width of about 30 feet. It is composed principally of a gangue of crushed quartz and crushed and altered granite, with locally some irregular streaked or banded ore.



A. PINKHAM MINE AND SLOPE OF SACRAMENTO VALLEY, LOOKING SOUTH-SOUTHWEST.



B. MIDNIGHT MINE, LOOKING NORTHEAST.

The ore contains principally copper and silver, with some gold and a little zinc. In the oxidized zone near the surface carbonates and oxides prevail, but in the deeper part of the mine sulphide ore begins, with a quartz and calcite gangue. This ore is said to average about 3 per cent of copper and 18 ounces of silver per ton and contains about 8 per cent of lime. The ore minerals are pyrite and chalcopyrite, with some bornite. Some of the ore shows a secondary growth or enrichment of chalcocite.

The ore occurs in lenses or elongated kidneys and in chimneys. The principal source of the ore thus far mined is a large chimney extending from a point near the shaft westward on the first and

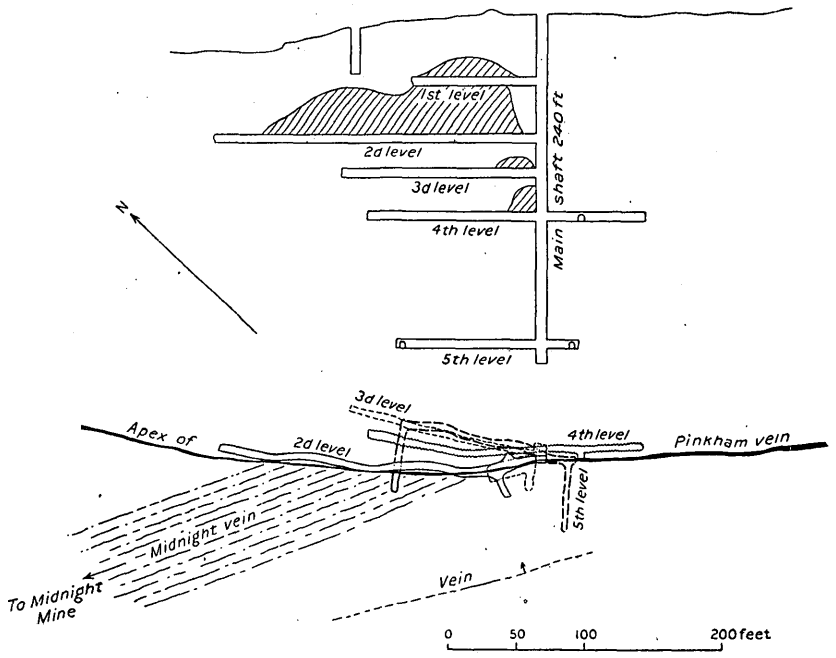


FIGURE 10.—Plan and longitudinal section of the Pinkham vein.

second levels. It has a width of 14 feet. A sample taken across it, including everything, is reported to have given a total assay value of $24 a ton. Much ore of this kind appears to be in sight here. The enlargement and enrichment of the vein at this locality seem to be due to the Midnight vein coming in obliquely from the northwest, as shown in figure 10.

Where work was being done on the second or 85-foot level at the time of the writer's visit in 1906, the stopes showed a width of 3½ feet of rich ore, mostly chalcocite and bornite, extending horizontally for a distance of about 40 feet, and the face of the drift at about 200 feet north of the shaft showed 5 feet of good ore, some of which averaged about $100 a ton and showed secondary deposition or enrich-

ment of chalcocite on the pyrite and chalcopyrite. The vein at this point stands about vertical or dips very steeply northeast instead of southwest, its normal direction.

Later a fine body of high-grade copper sulphide ore, 18 to 24 inches in width, was opened in extending the drift northwestward on the fourth or 140-foot level. This ore averaged about 9 per cent of copper and 60 ounces of silver to the ton.

On the fifth or 230-foot level, which is practically the bottom of the mine, the vein dips about 70° SW. and is from 4 to 6 feet in width. The face of the drift, 100 feet northwest of the shaft, shows a width of 8 feet with the foot wall not yet in sight. Here the vein consists of coarsely streaked or irregularly banded ore, crushed quartz, and altered country rock, all pretty soft and containing 4 to 6 inch gouge seams.

South of the shaft the vein is mineralized for a width of 20 feet or more, and at the end of a 40-foot crosscut into the hanging wall there is a good looking small vein 1½ feet wide, which dips steeply to the northeast.

MIDNIGHT MINE.

The claim of the Midnight mine practically joins that of the Pinkham mine on the northwest, as shown in Plate III, and, like the Pinkham, is situated on open, gently sloping ground. (See Pl. VI, *B*.) The mine was discovered prior to 1866. The original owner was a pioneer named Carpenter, who in early times hauled some of the ore to the Mineral Park mill. Later the mine was owned by Heimrods, McDuffee & Gilleland, and still later by the partners Darius Brown, Robert Gibson, James Boyd, and John St. Charles. Finally, about 1898, John St. Charles and his brother Keene became the sole owners. They alone have done most of the development, and have shipped ore from the deeper levels.

The mine is developed principally by inclined shafts, drifts, and crosscuts, and is equipped with a gasoline hoist. The main shaft is 200 feet deep, and the drifts, crosscuts, and stopes aggregate several hundred feet of workings.

The same country rocks prevail as in the Pinkham vein, being principally pressed and crushed microcline-biotite granite, and this is also intruded by the same classes of diabase and granitic dikes in or near the mine, the diabase apparently being the later of the intrusives (fig. 11). The vein or lode is less well defined than the vein in the Pinkham mine. As shown in figure 10, it strikes in general about N. 65° W. and on the southeast seems to join the Pinkham vein. It has a width of 50 to 75 feet and contains much low-grade ore. As seen in the mine, it contains two main veins or ore bodies, of which the principal or south one strikes about northwest and dips irregu-

larly southwest at angles of 35° or more. The second vein strikes about N. 80° W. and dips steeply to the north.

A large amount of good ore is shown in the mine, but it contains much zinc, and considerable disturbance, including lateral faulting, has taken place, by reason of which further development is needed before the structure can be worked out. The ore contains silver, copper, gold, zinc, and iron. The silver occurs mostly in chalcopyrite, the rule being the more chalcopyrite the more silver. Some bornite is present. The gold is found principally in the pyrite. The zinc blende, though more or less mixed with the ore, occurs also in a relatively pure 3-inch shoot on the hanging wall in the northeastern part of the mine.

For some years past the mine has been shipping copper ore in a small way. This ore was rich and averaged about $1,500 a ton, but some of it contained 5 or 6 per cent more of zinc than the 10 per cent allowed by the smelters and was accordingly penalized. It seems probable that by the use of a suitable magnetic separator the zinc could be extracted and profitably marketed as zinc ore. In certain parts of the mine the ore contains 30 to 40 per cent of zinc, and is so low in other values that it will be shipped as zinc ore. A recent carload shipment of the ore averaged 66 ounces in silver and $2.50 in gold to the ton and 4.5 per cent of copper. Under the present management the mine has produced about 300 tons of ore, with a total value of about $7,000. The ore is reported to mill about 5 to 1.

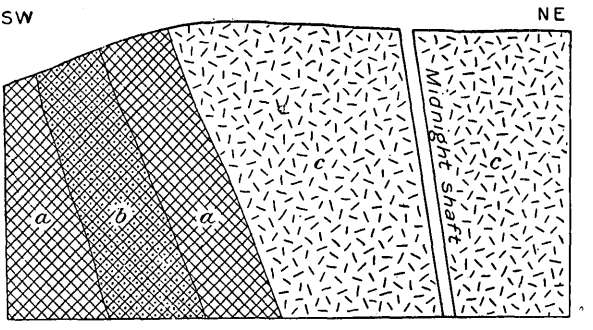


FIGURE 11.—Diagram showing intrusions near Midnight shaft. *a*, Aplite; *b*, diabase, intrusive into aplite; *c*, granite.

SILVER HILL VEIN.

The Silver Hill vein is located on Silver Hill, a prominent elongated ridge just southwest of Chloride and rising about 150 feet above it. It extends southward nearly to the railroad station. The ridge trends about north and south, is about three-fourths of a mile long and one-eighth of a mile broad, and is composed almost wholly of dark amphibolite schist. A coarse granititic rock appears to be intruded in its western base, and it is locally traversed by dikes and stringers of the garnet-bearing aplitic granite and also by a coarse pegmatitic granite. The schist dips about 60° E. and is cut by a well-marked sheeting that dips about 35° W.

As shown by openings and croppings, the northern or main half of the ridge is traversed longitudinally just west of the crest by a well-marked vein or mineral zone, varying from 2 to 12 feet or more in width, whose croppings, hardly rising above the surface, consist of brownish, yellowish, or greenish stained quartz, and seemingly altered dike material, which in places is calcareous and brecciated. The foot wall consists of a bowldery or brecciated schist.

The vein strikes N. 7° W. and dips steeply east. It is opened at intervals along its extent by five or six inclined shafts, some of which attain a maximum depth of about 100 feet. The work was done mostly in pioneer times, as this was among the first veins worked in the district. The ore contains silver, lead, and gold and is reported to carry about 2 ounces of gold to the ton, but the principal production is stated to be a small amount of lead.

JUNO MINE.

The Juno mine is situated in the low foothills about three-fourths of a mile northwest of Chloride, and is supposed to be located on the northward continuation of the Silver Hill vein. It is one of the early locations and was worked intermittently until about five years ago, when the shaft caved in, since which time work has been suspended. It was developed to the depth of 600 feet and equipped with a steam hoist. It is owned by E. T. Lloyd and B. Miller.

The vein dips steeply to the northeast. It is said to have been large on the surface, and the ore on the whole is rich. The surface ore was treated by a leaching process. The mine is stated to have produced much good ore and is regarded as a good property. Several operators have derived good returns from it.

MERRIMAC MINE.

The Merrimac mine is situated about a mile west of Chloride, at the border of the foothills and the Sacramento Valley, on open ground. It is one of the early discoveries and is owned by the Minnesota-Connor Mining Company. It is developed to the depth of about 200 feet and is equipped with a hoist and concentrating mill, but has not been worked for some time. The concentrating tables have been removed from the mill, and the mine has the appearance of being abandoned.

The country rock is pre-Cambrian coarse porphyritic gneiss. It is traversed by numerous veins or stringers, which are opened by prospect pits and shallow workings. The vein on which the mine is located seems to trend about N. 60° W. and dips to the northeast. The gangue is hard quartz and the ore contains silver and gold associated with pyrite. Much of the ore is banded and hard. The

high-grade ore contains ruby silver with a small amount of gold. Difficulty is said to have been encountered in concentrating the low-grade ore. A large dump shows that much work has been done, and the mine is reported to have produced considerable good ore.

TUCKAHOE MINE.

The Tuckahoe mine, one of the early discoveries, is 1½ miles west of Chloride, on the main road to White Hills. It is located on open ground, like the Merrimac mine, at an elevation of about 3,900 feet and in about the same class of porphyritic pre-Cambrian granite, which a few hundred yards east of the mine is cut by a diabase dike. Some basalt débris is strewn upon the surface. The mine is developed by a 45° inclined shaft, 200 feet deep, sunk upon the vein, and is equipped with a windmill hoist. It is owned by John Barry.

The vein strikes about N. 25° W. and dips about 45° NE. Certain irregularities suggest that other associated veins or stringers may be present near by, as at the Merrimac mine. The gangue is hard quartz and a mixture of quartz and country rock, locally crushed and recemented in the form of a breccia or conglomeratic mass, with many of the rock fragments rounded or pebble-shaped. The ore contains principally silver values, but some gold and galena are also present, all in association with iron pyrite.

The mine has produced a considerable amount of good ore. It was worked some years ago by the hyposulphite leaching process and $10,000 is said to have been extracted in one year. The latest ore shipped is stated to have averaged $10 in gold and 75 ounces of silver to the ton, and 17 per cent of lead. The mine is now producing in a small way.

TINTIC MINE.

The Tintic mine is situated on open ground in Sacramento Valley, about 1½ miles west of Chloride and half a mile south of the Tuckahoe mine. It is said to be located on a nearly flat-lying vein, which dips to the northeast and is from 2 to 10 feet thick. Water is said to be encountered at a depth of 40 feet below the surface.

The ore values are almost exclusively in gold and are said to average about $150 a ton in carload lots. The production is reported to be many thousand dollars, most of which has been obtained within a distance of about 200 feet, extending horizontally along the vein.

OTHER MINES.

Besides the mines already described there are in the district probably a score or more of small mines and promising veins, such as the Century group, Bobby Burns, Roger Boy, Goldback, and others, concerning whose locations and character data adequate for descrip-

tion are not at hand. Some of these properties are reported to be developed to the depth of 200 feet or more and contain several hundred feet of drift.

MINERAL PARK DISTRICT.

GENERAL DESCRIPTION.

The Mineral Park district practically joins the Chloride district on the south. Mineral Park, the main camp and post-office, situated near the middle of the district at an elevation of 4,200 feet, is about 4 miles from Chloride. The district trends about north and south, with a length of about 5 miles, which but slightly exceeds its width. It lies mainly in a basin several miles in diameter between the elevations of 4,000 and 5,000 feet. Some of the deposits on the north, however, extend nearly to the top of Cherum Peak, whose elevation is about 7,000 feet. The topography surrounding the basin is mountainous, but for the most part not rugged. The drainage issues westward into Sacramento Valley, mainly through Mineral Park Wash. Open groves of scrub pine and cedar occur in the hills.

The principal supply point is Chloride, but ore and heavy freight are hauled direct to the railroad, 3 miles to the west. The first location made in the district was the Mayflower, in 1870. It was soon followed by the Keystone No. 1 and No. 2, and then by the Lone Star. Considerable ore was soon taken out and shipped to the Selby smelter at San Francisco at a cost for freight of $125 a ton. Some ore was also freighted eastward by oxen over the old government trail to New Mexico.

The Keystone mill, which is still standing, was built at a reported cost of $125,000 and started in 1876. Operations continued more or less actively until the price of silver began to decline in 1882, and during that time the district was one of the heaviest producers and shippers of rich gold and silver ore in the Cerbat Mountains. Since 1882, however, the production has been small, only a few of the mines being worked. One of the reasons seems to be the fact that many of the mines are owned by the original locators or men who have not the means to work them below water level, which in a greater portion of the district is encountered at a comparatively shallow depth. Several springs occur in the district.

The Keystone mill contains a crusher, five 1,000-pound stamps, with pans, a Bruckner revolving reverberatory furnace, and a 25-horsepower engine. In the early days it received most of the ore from the Cerbat Mountain region, including the Chloride, Cerbat, and Stockton Hill camps. The treatment charges are reported to have been very heavy, but, on the other hand, the operators found it difficult to extract the values from the ore.

GEOLOGY.

The country rock is the pre-Cambrian complex, and comprises gneisses and schists as well as gneissoid granite. The structure or schistosity strikes a little west of north, with nearly vertical dip. The complex is extensively intruded or broken through by masses of the later, probably post-Carboniferous coarse granite porphyry, and is cut by dikes of rhyolite, diabase, and minette. In the northeastern part of the district, on the slope of the range between Mineral Park and Cherum Peak, the schistosity and sheeting in the pre-Cambrian rocks trend N. 65° E., with vertical dip, and a secondary sheeting trends N. 20° W. and dips about 80° E.

The district on the whole is well mineralized, and its mineralization seems to be largely due to the porphyry. Remote from the intrusive masses this granite porphyry is locally associated with the veins as dikes. It forms the upper part of a prominent foothill or knob on the northwest, known as Niggerhead. It also constitutes a considerable portion of the mountains on the opposite side of the wash, to the south, and extends interruptedly throughout the greater portion of the basin eastward for 1½ miles into the slope of the range. Its structure or jointing, which also penetrates the underlying pre-Cambrian rocks, is well shown across the northern part of Mineral Park district. It dips westward at angles of about 35°.

ORE DEPOSITS.

The deposits contain gold, silver, lead, and copper in fissure veins or lodes, some of which are unusually large. The strike of the veins is N. 37° to 60° W., and the dip is steep to the northeast or the southwest. There are also a few cross veins striking northeast or east and west. The gangue is quartz, with pyrite, chalcopyrite, arsenopyrite, galena, and zinc blende as the principal ore minerals. Especially in the upper levels there are also secondary argentite, native silver, copper, horn silver, and cerusite. The oxidized zone does not extend to a great depth.

The mines, numbering about twenty, are small, few of them exceeding 300 feet in depth or containing more than 1,000 feet of underground work. The principal ones are the Rural, Buckeye, Ark, Queen Bee, Tyler, Keystone, Fairchild, Metallic, Accident, Lady Bug, Standard, and Golden Star. They are nearly all reached by wagon road. The most important producers at present are the Keystone, Tyler, and Queen Bee.

KEYSTONE MINE.

The Keystone mine is situated on open ground about one-fourth of a mile east of Mineral Park and about 200 feet higher. It was located

by Charles E. Sherman, a well-known pioneer, in 1870. Its surface ores were very rich and carried high values in gold as well as in silver, by reason of which it soon became the first important producer, its ores being shipped to Swansea, Wales. It was later worked by the Mineral Park Mining Company, and the ore was locally milled in the Keystone mill. Later it was owned by James Uncapher, of Mineral Park, by whom it was sold to the present owner, the Keystone Mining Company, of Greensburg, Pa. The production of the mine to date is reported to be about $50,000.

The mine is developed mainly by a shaft 450 feet deep and 500 feet of drifts, mostly down to the 150-foot level, above which the greater part of the ore is worked out. The principal surface equipments are a steam hoist and a 5-stamp mill.

The principal rock at the mine is the granite porphyry. There are two veins. The vein on which the mine is located strikes N. 60° W. and dips about 80° NE. The gangue is quartz in which the ore shoots occur mainly in the form of lenticular streaks about a foot thick. The ore contains pyrite, chalcopyrite, and zinc blende, with silver and some gold. The silver is present as argentite, in part. The better grade of ore runs about 200 ounces of silver to the ton, 2½ per cent of copper, 8 to 10 per cent of zinc, and 12 per cent of iron. Toward the outside of the lenses it is irregularly and closely banded. It is richest where the vein pinches. Elsewhere it may be distributed in a thickness of 3 feet of quartz gangue, but it is good concentrating ore and is said to average $12 to $15 a ton, and by reason of its low grade should be milled on the ground. Some of the ore, however, runs considerably higher. That averaging $20 or more a ton is now shipped to the Humboldt smelter. None lower than $20 ore is now handled. The present rate of output is about 20 tons a month.

About 50 feet northeast of the vein on which the mine is situated and lying about parallel with it is a second or smaller vein, which looks well and whose ore is reported to be nearly all of shipping grade.

TYLER MINE.

The Tyler mine is situated in the southeastern part of the district, 2¾ miles southeast of Mineral Park, near the summit of the range, on a steep northeastern slope, at an elevation of about 5,300 feet, or about 1,200 feet above Mineral Park. A good wagon road extends nearly to the mine, with which connection is made by a good trail of easy grade. The mine was discovered by Stephen A. Tyler, the owner, in 1901. It began to ship ore in 1905, but only necessary assessment work is now done.

The mine is developed mainly by two crosscut tunnels and drifts, mostly situated within a vertical range of 100 feet, principally on the Gold Eagle claim.

The country rock is pre-Cambrian medium-grained gneissoid biotite granite. The vein strikes N. 37° W. and dips about 75° SW., into the mountains. It has a width of about 40 feet and seems to consist mainly of an altered and partly replaced crushed and recemented aplitic dike. The entire width is claimed to be low-grade ore, but the values occur chiefly in the first 6 or 7 feet of the hanging-wall side of the dike and are best near its contact with the granite. The hanging wall also carries 6 inches to 2 feet of slickensided gouge, between which and the country rock occurs quartz breccia containing some ore.

The mine produces gold-silver-lead ore. The principal ore minerals consist of galena and cerusite. The last carload shipped at the time of the writer's visit averaged gold 3.16 ounces to the ton, silver 8 ounces to the ton, and lead 17.5 per cent. At last accounts the mine is reported to be sold to a Los Angeles company.

LADY BUG MINE.

The Lady Bug, an old mine, is about half a mile southeast of the Tyler mine, close to the Tyler camp, at an elevation of about 5,000 feet. It was located in 1886 by Isaac Conkey, the owner, now residing at Mineral Park. It is developed principally by a 63-foot shaft, 100 or more feet of drifts, and a number of surface openings on the vein.

The country rock is pre-Cambrian biotite granite, the same as at the Tyler mine, and it is to a considerable extent intruded by the granite porphyry of Mineral Park. The vein is reported to be 7 to 8 feet thick. It lies nearly parallel with the Tyler vein, but differs from it in being composed of a gangue which is mainly quartz. The ore contains principally silver chloride and gold with a little galena. A considerable portion of the ore mined is reported to have averaged $300 to $500 a ton. The production is reported to be $6,000.

RURAL AND BUCKEYE MINES.

The Rural and Buckeye mines are in the northeastern part of the district, 1½ miles northeast of Mineral Park, near the south base of Cherum Peak, at an elevation of about 5,000 feet. They are reached by wagon road. They are situated but a few hundred feet apart on the same vein, the Rural being on the west and the Buckeye on the east side of the same gulch. The Rural is owned by E. F. Thompson, of Kingman, and the Buckeye by C. E. Lovett and others, of Denver, Colo.

The Rural is developed principally by a 200-foot shaft, about 100 feet of drift, and a winze. The drift extends westward, its face being about 110 feet distant from the shaft. The shaft contains some water. The Buckeye is developed principally by about 750 feet of drift, extending in an easterly direction. Toward the face of the drift the vein is faulted off to the northeast by a lateral throw of about 75 feet.

The country rock is medium-grained gneissoid biotite granite and associated schist. It is intruded by dikes of granite porphyry. The deposits occur in a fissure vein which is 2 to 4 feet in width in the Rural and attains a maximum of 8 feet in the Buckeye. In the Rural it dips about 80° S. and in the Buckeye about 70° N. In both mines it is associated with a dike of the granite porphyry, masses of which occur to the northeast near by. The gangue is quartz and is generally "frozen" to the walls. It shows ore shoots ranging from 4 to 20 feet in width, which consist mostly of pyrite and chalcopyrite, with parallel streaks of arsenopyrite, black oxide of manganese, gray chert, and quartz, the quartz being more prominent in the Buckeye than in the Rural mine.

The ore contains silver, gold, and copper, with high silver and gold values. The display of ores from these mines, containing masses of solid silver and beautiful specimens of wire silver, is said to have been awarded the silver medal at the Louisiana Purchase Exposition.

The production, exact figures of which are not available, is reported to mount well into thousands of dollars in silver and gold, and much good ore is said to be available in the mines.

WINDY POINT MINE.

The Windy Point mine is in the northeastern part of the district, about a mile northeast of Mineral Park, on open sloping or hilly ground, at an elevation of about 4,800 feet. It is owned by the Arizona Gold Mining and Metallurgical Company, with headquarters at Kingman. It is developed mainly by a 105-foot shaft and a small amount of drift. The shaft starts in gneiss, but soon enters the granite. The mine is newly equipped with a gasoline hoist and electric drills.

The country rock is the pre-Cambrian gneissoid biotite granite and black amphibolite schist. The granite is less dark and micaceous than at the Rural and Buckeye mines. The structure or sheeting strikes N. 85° W. and dips about 75° S. Both the granite and the schist are more or less sericitized and impregnated with pyrite and arsenopyrite near the vein. About 50 feet from the vein, on its

foot-wall side, the country rocks are cut by a peculiar greenish-gray porphyritic dike rock, which seems to be minette, and is apparently younger than the intrusive granite porphyry. The latter is also present in outcrops near by, and some of it was recognized in the dump débris derived from the mine.

The deposits occur in a fissure vein which strikes N. 42° W. and dips about 77° NE. It is 2 to 4 feet wide, and the pay streak or ore shoot ranges from 3 to 24 inches in width and favors the hanging-wall side. The values are in silver, gold, and copper. The minerals are principally pyrite, arsenopyrite, and chalcopyrite. The last shipment of the ore is reported to have averaged 3 ounces of gold and 486 ounces of silver to the ton and 2½ per cent of copper.

GOLDEN STAR MINE.

The Golden Star (formerly Lone Star) mine is in the northeastern part of the district, about a mile northeast of Mineral Park, a short distance below the Windy Point mine, at an elevation of about 4,700 feet. It is situated on open, sloping, somewhat hilly ground. The mine was located in 1870 and soon became an important producer of rich ore. It continued to be prominent till 1902, when the ore seems to have fallen off in grade. The mine is now dismantled of all surface equipments. Its output during much of this period is said to have been the largest in the region.

The mine was first owned by W. F. Grounds, now of Hackberry, who took out much rich ore. It was later owned by Fred Harter and Isaac Conkey, of Mineral Park. The present owners, besides Mr. Conkey, are W. G. Blakely, C. D. M. Gaddis, and Doc. Hamilton, all of Kingman.

The mine is developed principally by a 300-foot shaft and two levels, each containing about 300 feet of drift, and the ore is said to be stoped out from the surface down to the first level.

The country rock is principally black amphibolite schist, mica schist, and gneissoid biotite granite. The fissure containing the deposits is 2 to 4 feet in width, all of which is said to consist of low-grade ore. It strikes in general west northwest and dips about 65° S. At the shaft the strike is east and west, but a short distance east of the shaft the vein curves to the north and is said to split. At the surface west of the shaft it is 2½ to 3 feet thick, is dark and iron-stained, is parallel streaked or banded, and, like the Windy Point vein, is very arsenical.

The ore, like that of the Windy Point, is sulphide ore. It contains argentite, ruby silver, native silver, gold, and a trace of lead, all in association with arsenopyrite and pyrite. The ore shoot ranges from a few inches to 20 inches in thickness. The ore is mostly of

high grade, but that in the deeper part of the mine is reported to be too base or refractory to be handled advantageously with methods employed a decade ago. In former times some of the ore was shipped to Swansea, Wales.

STANDARD MINE.

The Standard (formerly Blue Bird) mine is about 200 feet southwest of the Golden Star mine. It is owned by Gaddis, Perry & Co., of Kingman. It is developed principally by a 100-foot shaft and two levels containing about 200 feet of drift.

The country rock is pre-Cambrian gneissoid granite and schist. The vein strikes N. 80° E. and dips about 70° S. The ore contains silver and gold.

QUEEN BEE MINE.

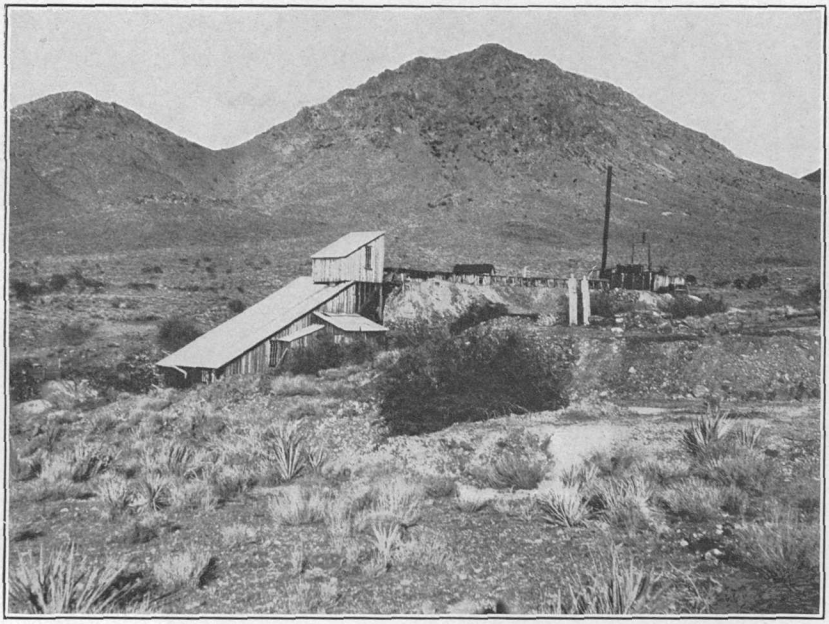
The Queen Bee mine is in the northwestern part of the district, in the foothills just north of Niggerhead, at the head of a gulch that drains westward into Sacramento Valley. It is close to the cut-off trail leading from the Chloride road across the foothills to Mineral Park.

The mine was discovered in 1876 and worked by chloriders. It has been leased intermittently, mostly at a royalty of 25 per cent. Surface improvements, including a hoist, were installed in 1904, after which steady work, including sinking and drifting, was carried on for some time. Early in 1905 the mine was leased to the Queen Bee Mining Company, of Philadelphia. It is now owned by James Uncapher. The production is estimated to have been $35,000, mostly in high-grade ore. The mine is developed by a 435-foot shaft and about 900 feet of drifts.

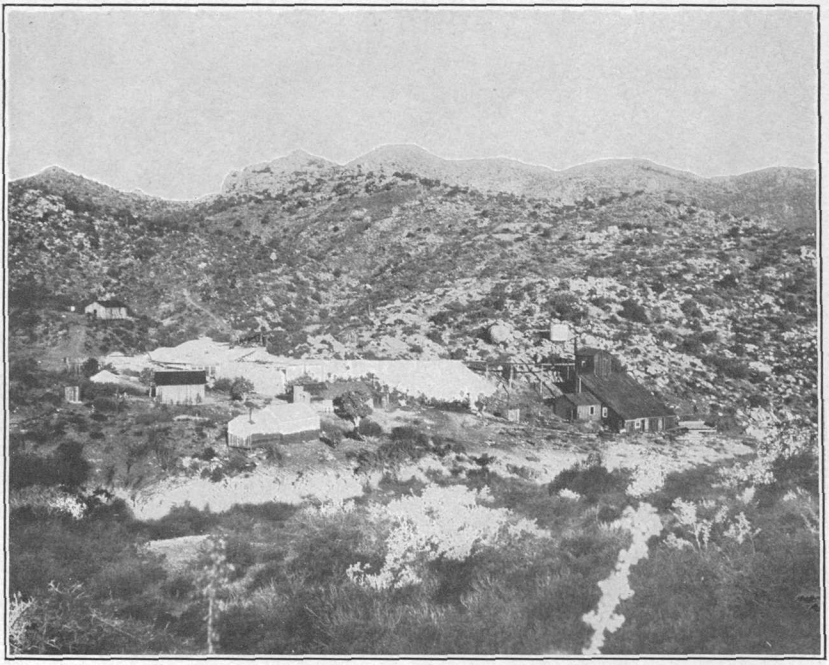
The country rock is altered pre-Cambrian mica schist. It is intruded by the granite porphyry, a dike of which 200 feet thick is associated with the vein on the hanging-wall side. The deposit occurs in a fissure vein about 4 feet in width. It strikes about N. 40° W. and is nearly vertical or dips to the east at angles of about 80°. It seems to extend southward to Mineral Park Wash, about half a mile distant. The pay streak is reported to average about a foot in width and is located mainly on the foot-wall side of the vein. The ore contains gold and silver in pyrite, arsenopyrite, galena, and chalcopyrite. The best ore yields 200 ounces of silver and 2 ounces of gold to the ton and contains native silver, hornsilver, or argentite.

ARK AND SAN ANTONIO MINES.

General statement.—The Ark and San Antonio mines (Pl. VII, *A*) are located in the southwestern part of the district, about two miles



A. ARK MINE AND MILL AND TURQUOISE MOUNTAIN, LOOKING NORTHEAST.



B. BANNER GROUP MINE AND MILL, LOOKING NORTH.

southwest of Mineral Park, in low foothills at the western base of the range and the border of Sacramento Valley, at an elevation of about 3,800 feet, in what is commonly known as Ark Basin. The mines are on adjoining claims, but on separate veins. (See fig. 12.) They are owned by the Ark and San Antonio Mining Company and have been worked for many years. Many of the owners are Mexicans residing in Mohave county. Much of the ore produced was rich and was shipped to mills and smelters.

The country rock is the pre-Cambrian gneissoid complex.

Ark mine.—The Ark mine is developed mainly by a 250-foot shaft, three levels, drifts, stopes, and winzes, aggregating about 1,500 feet of underground work. The levels are located at 50, 110, and 210 feet below the surface. They contain, respectively, 380, 400, and 500 feet of drifts. The mine is stoped from the surface to the 210-foot level. It produces considerable water. The principal surface equipments are a steam hoist and a Dodge pulverizer octagon revolving mill having a capacity of 40 tons of soft ore or 16 tons of hard ore a day.

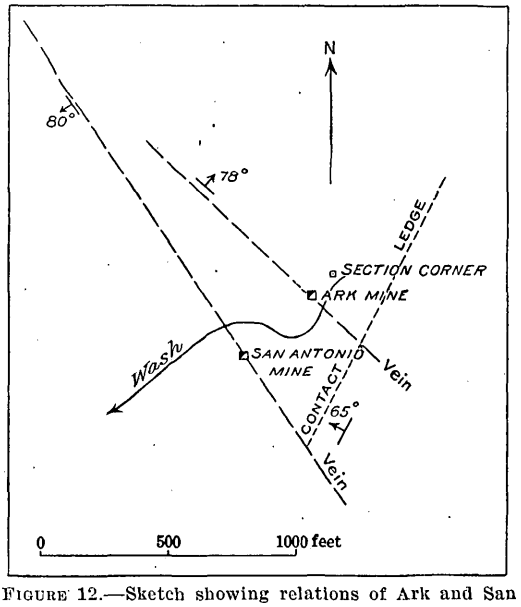


FIGURE 12.—Sketch showing relations of Ark and San Antonio veins.

The deposits occur in a fissure vein, which, as shown in figure 12, strikes about N. 50° W. and dips about 78° NE. It is 5 to 6 feet in width, is locally accompanied by 6 inches to 1 foot of gouge, in which are said to occur native copper nuggets as large as a man's hand. The foot wall is pre-Cambrian (?) medium-grained biotite-microcline granite. The gangue is quartz and somewhat silicified, crushed, and recemented granite. The sulphide ore contains pyrite and chalcopyrite with silver and gold, and the best yields about 175 ounces of silver and several ounces of gold to the ton. A 30-inch ore streak is reported to have netted $600 a ton. The production of the mine is reported to be about $150,000.

San Antonio mine.—The San Antonio mine is developed by a shaft 210 feet deep and by drifts. At the 60-foot level the drift extends 70 feet from the shaft to the northwest, and from this point up to the surface the vein was stoped out by O. F. Kuencer.

The deposits occur in a fissure vein, which is about 4 feet thick. As shown in figure 12, it strikes about N. 35° W. and dips about 80° SW. The gangue is quartz, and the ore occurs in shoots near the foot-wall side. The oxidized portion of the vein resembles crushed and recemented altered quartz and rock. It is stained brown and black by iron and manganese. The unoxidized portion consists mainly of dull-gray quartz imperfectly banded and locally with comb structure. It is porous or honeycombed and in places carries bands of pyrite an inch or more in width. The values are in silver and gold. No copper seems to be present. Of the ore mined by Mr. Kuencer 114 tons are stated to have averaged 174 ounces of silver and 3.15 ounces of gold to the ton. The production of the mine is reported to be about $75,000.

Cross vein.—About 300 feet southeast of the Ark and San Antonio mines, as shown in figure 12, is a third vein, which might well be referred to as the cross vein, for, roughly speaking, it lies nearly at right angles to the Ark and San Antonio veins. It strikes about N. 30° E. and dips about 65° NW. It extends from the San Antonio vein beyond the Ark vein and seems to be younger than the Ark vein, which does not cut it. It is a shear zone from 2 to 50 feet in width and is reported to carry low-grade gold ore with a trace of copper.

METALLIC-ACCIDENT MINE.

The Metallic-Accident mine is in the northern part of the district three-fourths of a mile north of Mineral Park. It was discovered by T. J. Christy, under whose ownership it produced handsomely. It is now owned by Henry Lovin, of Kingman. It is an old mine on which relatively only a small amount of work has been done, the developments not extending below a depth of 60 feet, where the vein is reported to become broken and to contain some copper.

The production is said to be about $54,000, all in ore containing chiefly chloride of silver with some gold; much of this ore was very rich.

FAIRFIELD MINE.

The Fairfield mine is about half a mile northeast of Mineral Park, on open, sloping hilly ground. It is reported to be developed principally by an 80-foot shaft and a tunnel nearly 1,700 feet long, known as the Hardy tunnel. The ore is reported to be principally of low grade.

WOOD CHOPPER'S RELIEF MINE.

The Wood Chopper's Relief mine, owned by J. W. Haas, of Mineral Park, is about 1½ miles southeast of Mineral Park on the south

side of the valley, in a steep northeastern slope of the mountain, at an elevation of about 4,500 to 4,700 feet. The country rock is the dark pre-Cambrian granite porphyry, extensively intruded by a light aplitic granite. The vein strikes nearly east and west and dips about 75° N. The mine is developed mainly by two tunnels, aggregating 500 feet in length and 200 feet of drift. The tunnels are situated 100 feet apart vertically; the lower one trends S. 16° E. for a distance of 350 feet to the vein. Here in the face of a 33-foot drift to the east the vein contains 2 feet of quartz with pyrite, intrusive aplitic granite on the hanging wall. The vein looks well, but is said to carry only a little gold, with a trace of copper and silver.

The upper tunnel, situated on the same vein as the lower, lies mostly in the granite porphyry and in the oxidized zone. It contains 160 feet of drift that runs toward the west. Here the vein is 4 to 6 feet wide and consists mainly of iron-stained, streaked, and banded brecciated material. It has yielded considerable good ore, some of which averaged $500 in silver chloride and $4 in gold to the ton.

KATIE MINE.

The Katie mine, owned by C. E. Sherman, of Mineral Park, is reported to have been a producer of rich silver ore since pioneer times.

OTHER PROPERTIES.

Among the other properties in the district are the Annie, Blue Martin, Kenney, Estella, Estella-Bronco, Flora, and Congress. They are all in the prospect stage; all but the last named are east or southeast of Mineral Park and are owned by J. W. Haas.

The Annie prospect is one-eighth mile northeast of Mineral Park. It is developed by a 25-foot shaft and smaller openings. The deposits consist of a "ledge," or mineralized zone, from 10 to 50 feet in width. It trends N. 70° W. and is located on the southwest contact of a rhyolite dike several hundred feet wide, erupted through the pre-Cambrian amphibolite schist and granite. The schist is traversed by numerous veinlets of fresh iron pyrites. The deposit, however is oxidized. It is reported to carry silver, gold, and copper.

The vein of the Blue Martin prospect strikes N. 60° W. and dips about 75° SW. It is about 3 feet thick and is composed mainly of crushed quartz, containing principally dark manganese-stained chalcopyrite ore with some malachite, the ore being reported to run about $30 in copper to the ton. The country rock is a medium-grained gray granite, sparingly impregnated with small crystals of chalcopyrite.

The Kenney prospect vein consists of 2½ feet of crushed or partly brecciated iron-stained quartz and rock, which contains lead values. The country rock is the dark granite.

The Estella prospect has six veins, which are mostly small, some of the larger being about 2 feet thick. They strike mostly about N. 60° to 70° W. and dip steeply southwest. They consist principally of quartz and other oxidized material and are said to have produced good silver chloride ore, and some that contained values of $25 in gold to the ton.

The Estella-Bronco vein, to judge from the croppings, is about 4 feet thick and has an extent of at least 200 feet. It dips northeast at angles of about 80°. Its ore contains iron pyrites and green silver chloride. The vein of the Flora prospect is 20 to 30 inches wide. It dips about 30° NE., and contains two 3 to 5 inch streaks of oxidized galena ore, which is reported to average about $30 in lead to the ton. The deposit is associated with the contact of the aplitic intrusive with the older granitic rocks.

The Congress prospect, also known as the "Great Bronco," is situated in Mineral Park Wash, about three-eighths of a mile west of Mineral Park, mainly on the south side of the wash. It is owned by James Uncapher. It is a mineralized shear zone, or a fault zone, with an observed width of 300 feet and a reported width elsewhere of 600 feet. It trends N. 50° W., is in alignment with Ithaca Peak and Niggerhead, and is reported to be the same "ledge" on which the Queen Bee mine is located. It is probable that the Queen Bee and Pinkham veins and the Congress ledge are all associated in this locality, but their direct connection was not traced. The deposit occurs mainly in the granite porphyry at or near its contact with the pre-Cambrian complex. It consists of more or less silicified and in part altered and iron-stained gray porphyritic granite, with pyrite and chalcopyrite forming the principal part of the ore, disseminated more or less throughout. The deposit, where best exposed and opened in the wash by shallow workings extending more or less across it, is reported to average about $5 a ton in copper, silver, and gold. Here conspicuous patches and areas of malachite and azurite resulting from recent oxidation occur on the surface and basal slopes of the workings, and much of the surface diggings is stained yellowish and greenish. The deposit has received the consideration of some of the largest companies in the Southwest. Whether values will be found in depth seems doubtful.

The McDonald prospect, situated within a few hundred feet of the top of Cherum Peak on the south side, is on a ledge that dips steeply north and is reported to contain tungsten ore.

The Argo prospect, said to be located at an elevation of about 6,000 feet, is reported to have shipped some high-grade ore running from 200 ounces up in silver and containing good lead values.

The Swift claim is said to have produced and shipped some ore containing good values in gold, silver, and lead.

The ore shoot of the Sabbath Bell vein, opened by a 90-foot shaft, is reported to contain about 2 ounces of gold and 40 to 50 ounces of silver to the ton.

CERBAT DISTRICT.

GENERAL OUTLINE.

LOCATION AND HISTORY.

The Cerbat district extends southward from the Mineral Park district for about 4½ miles and from the border of Sacramento Valley on the west to the crest of the range on the east, with a maximum width of about 3 miles in the southern part.

Cerbat, the principal camp and post-office, is situated on Cerbat Wash in the foothills at an elevation of about 4,000 feet, 3 miles from the nearest station of the Arizona and Utah Railroad on the west and 14 miles north of Kingman. Its origin dates from the early sixties, when the Golden Gem, Cerbat, Idaho, Twins, Champion, Vanderbilt, Eureka, Flores, Esmeralda, and Columbus mines were discovered or opened. It has always been a producer of high-grade ore and is reported to have produced more than $2,000,000.

A small smelter was operated here in the so-called Indian days, in the middle of the sixties, but for want of proper fluxes, for which tin cans and scrap iron were substituted, the process was not very successful, the lead being turned out in an extremely crude state.

TOPOGRAPHY.

The district ranges in elevation from 3,000 feet in the foothills on the west to 5,000 feet on the east. Stockton Hill, on the opposite slope of the range, is reached by trail only. (See fig. 16.)

The southern part of the district is drained mainly by Cerbat Wash, which leads westward across the district into Sacramento Valley. Its principal tributary from the south is Charcoal Canyon, which is several miles long and joins it just below Cerbat.

The northern part of the district is drained principally by Long Wash, which leads northward and westward into Sacramento Valley. The nearest railroad station to this part of the district is Mineral, about 3 miles to the west. Several small depressions which open into Long Wash from the east are known as Union Basin, Todd Basin, and Lane Springs Basin.

GEOLOGY.

The country rock is the pre-Cambrian granite, gneiss, and schist complex. It is intruded by dikes of minette, granite porphyry, diabase, rhyolite, basalt, and other rocks, some of which are associated with workable veins and are too greatly sericitized for determination. The complex is also flanked on the west by masses of the Tertiary volcanic rocks, principally rhyolite.

Probably the best exposure in the Cerbat Range is in Charcoal Canyon southeast of Cerbat. The canyon cuts across the beds diagonally and exposes most of the pre-Cambrian rocks, including granite, gneiss, pegmatite, schists, and syenite, together with veins and dikes occurring in the complex. The series is cut by faults, some of which now contain ore bodies.

The schistosity strikes north-northeast, with dip mainly west-northwest, varying from 70° to vertical, and the jointing trends west-northwest, with steep dip to the northeast.

Prominent among the dikes is the well-known "great white dike," so called from the fact that it weathers light buff. It extends throughout the greater part of the canyon and is associated with workable ore deposits. It is 40 feet or more thick. It crosses Cerbat Wash near the mouth of Charcoal Canyon, underlies the Gross ranch to the northwest, and is reported to extend much farther. It is a dark greenish basic rock, which is now altered and sericitized beyond adequate determination. Though profusely jointed and sheared, it seems to be younger than the granite porphyry intrusives with which it comes into contact.

THE DEPOSITS.

The ore deposits of this district contain principally gold, silver, and lead. They occur in fissure veins, which in general have a northwesterly trend and a steep northeasterly or southwesterly dip. Those situated north of Cerbat Wash are chiefly gold-bearing; those to the south contain principally silver and lead. The gangue is mainly quartz and the values usually favor the hanging wall. The principal minerals are pyrite, chalcopyrite, galena, zinc blende, stibnite, and native gold. Near the surface native silver, horn silver, argentite, and ruby silver appear, but the water level is only about 80 feet deep, and consequently primary sulphide ore comes in at relatively slight depth.

The deposits are opened by about thirty mines, a sketch of some of which follows. The most important mines, nearly all of which are now producing, are the Golden Gem, Vanderbilt, Champion, Oro Plata, Paymaster, New London, Idaho, Cerbat, St. Louis, Flores, Twins, Columbus, Alpha, Night Hawk, and Rip Van Winkle.

MINES NEAR CERBAT WASH DRAINAGE ON THE NORTH.

GOLDEN GEM MINE.

Location, history, and production.—The Golden Gem mine is located at Cerbat, on the hillside which slopes to the west. The mine was discovered and began to ship ore in 1871. Subsequently it lay idle for some time until it was acquired by T. L. Ayers, who shipped a very large amount ($200,000 reported) of rich (5-ounce) gold ore. He also hauled some of the ore to the C. O. D. mill, and left over

2,000 tons of second-grade ($24) ore on the dump, much of which still remains. Later the property was bonded to the Golden Gem Mining Company, of New York, of which Senator Warner Miller was president. This company sunk the shaft deeper and drifted, but as the ore on the 300-foot level fell off in grade, the mine was closed in 1904. It remained idle until 1906, when it was sold for $75,000, and is now owned by the Golden Star Mining and Milling Company.

A 40-ton mill with four Nissen stamps, recently installed, is now daily turning out about $350 worth of concentrates from the ore formerly left on the dump. Twenty per cent of the gold is collected on the plates. Preparations are being made to unwater and retimber

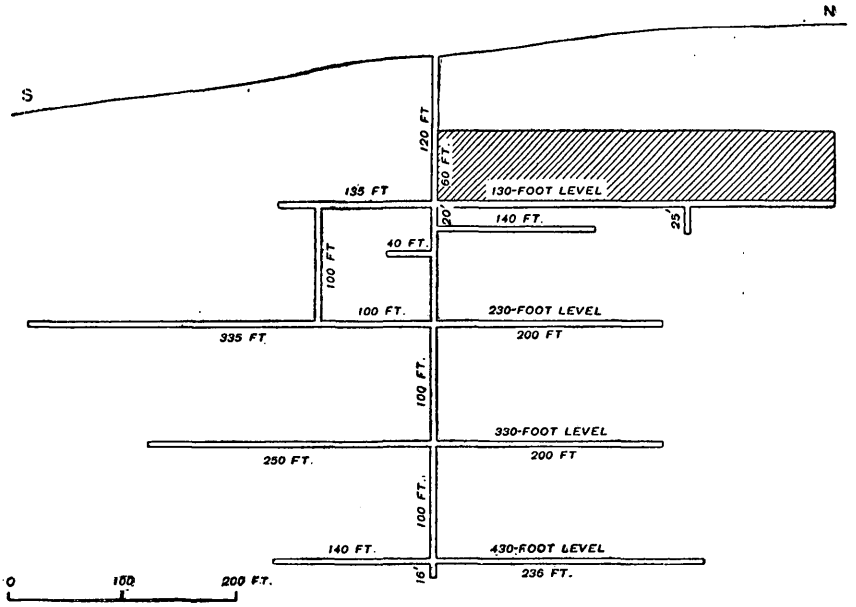


FIGURE 13.—Longitudinal section showing development of Golden Gem mine.

the old shaft of the mine, which at the time of visit was filled with water to the 200-foot level. This mine has produced good ore from the surface down, and the total production is said to have amounted to $190,000.

Development.—The mine is developed principally by a two-compartment shaft, 435 feet deep, and four levels containing about 1,200 feet of drift, winzes, and stopes. The levels are located at 130, 230, 330, and 400 feet below the surface. The first level contains 350 feet of drift north and 135 south from the shaft; the second level 200 north and 355 south, the third level 200 north and 200 south, and the fourth level 246 north and 140 south. (See fig. 13.) The only stopes are on the 130-foot level. They extend 66 feet horizontally and from 62 to 81 feet vertically.

The principal surface equipments are the 40-ton mill above mentioned, a 34-horsepower hoist, and distillate engines, aggregating 79 horsepower, for operating the plant.

Geology and ore deposits.—The country rock is the pre-Cambrian granite, gneiss, and schist complex. Fine-grained iron-gray gneissoid schist usually forms the hanging wall of the vein. The structure trends north-northeast and the rocks are intruded near by by diabase and granite porphyry or monzonite porphyry dikes. The much-altered diabase occurs in association with the vein.

The vein strikes about N. 40° W. and dips about 78° NE. It ranges from 6 to 14 feet in width and usually carries from 2 to 6½ feet of pay ore running from $10 to the ton upward. The ore shoots are reported to be more regular in the deeper part of the mine than near the surface.

The gangue is chiefly quartz and altered rock and is imperfectly banded. Some of the quartz is similar to the Gold Road type described on page 158. The ore contains chiefly gold, but carries also silver in places as high as 60 ounces a ton. The ore minerals are galena (5 or 6 per cent), zinc blende, pyrite, and stibnite. The vein is banded and shows evidence of intradepositional faulting. The values usually favor the foot wall, but vary in position, and locally rich ore streaks 2 feet wide occur on both sides of the vein.

Southeast of the mine the vein is about 6 feet in width and, as shown by croppings, extends about one-fifth of a mile to Cerbat Wash, where there are some indications that it may be split. So far as opened in the mine and two surface prospects beyond, the ore is reported to run about $20 to the ton.

On the 130-foot level, 270 feet northwest of the shaft, the vein is faulted off diagonally along the schistosity on the south or foot-wall side of a 4-foot band of dark schist. The ore shoot from the shaft to this point looks well and is reported to average high in gold.

The face of the drift extending south of the shaft on this level is reported by the foreman who had charge when the mine was suspended to contain a 24-inch streak of $48 ore.

VANDERBILT GROUP.

General description.—The Vanderbilt group comprises the Vanderbilt, Idaho, and Columbus mines, situated near together in the foothills at Cerbat, just north of the Golden Gem mine. The group is owned by the Cerbat Mining Company, with headquarters at St. Louis. At the time of visit the company was installing a 25-ton mill to treat the low-grade ore from the upper part of the mines by calcination and amalgamation of the concentrates, there being a large

amount of low-grade ore, especially in the Vanderbilt. The ore from the lower levels, owing to its richness, is shipped direct to the smelter.

Vanderbilt mine.—The principal mine of the group is the Vanderbilt mine, located about half a mile northwest of the Golden Gem and a little above it, near the head of Flores Gulch, which drains westward into Sacramento Valley. The Vanderbilt is one of the oldest mines in the camp. It was located early in the sixties and is now producing. It is developed principally by a 300-foot shaft and 800 feet of drift and crosscuts.

The country rock (locally called syenite) is pre-Cambrian fine-grained gneissoid chloritic schist, and is probably derived from a diorite which has been greatly sericitized and otherwise altered. Associated with the vein on the foot-wall side is a "porphyry dike," which may represent the intrusive granite porphyry.

The deposits occur in a fissure vein, which, like the Golden Gem vein, dips about 80° NE. and is supposed to represent the northwestward continuation of the Golden Gem and Idaho veins beyond their point of junction.

The ore, as in the Golden Gem mine, contains chiefly gold values, but carries silver also. The ore minerals are pyrite, zinc blende, and stibnite. The ore occurs mainly on the hanging-wall side. The best grade is reported to average about $500 or more to the ton. Galena occurs from the surface down to the 200-foot level, below which no lead ore has yet been found.

From the upper levels the mine is reported to have produced $150,000, and it has also yielded considerable ore to the present company.

Idaho mine.—The Idaho mine is located at Cerbat, near the Golden Gem mine, on slightly lower ground in a gulch on the west. It is one of the early discoveries of the camp, its ore being worked by Mexicans in arrastres during pioneer days, and it has been worked in a small way since 1871. It is developed principally by a 110-foot shaft sunk on the vein and 275 feet of drift. The shaft is reported to be wholly in ore and to show in the bottom a width of 5 feet of solid ore, which averages about $20 to the ton.

The geology and the ore are similar to those of the Golden Gem mine. The vein strikes N. 20° E. and dips 80° E. It averages about 4 feet in width and its ore shoot about 2 feet. The ore contains principally gold, with some sulphide of silver, galena, pyrite, and a little chalcopyrite. The production is reported to be $250,000.

Columbus mine.—The Columbus mine is about one-fourth mile northwest of the Vanderbilt mine, near the upper side of Flores Wash. The deposits are contained in a fissure vein, which has been opened principally by two shafts reported to be 175 and 200 feet deep and by 500 feet of drift. The production is said to be several hundred tons of rich ore.

ROBERT EMMET MINE.

The Robert Emmet mine, situated north of the Vanderbilt mine, is reported to be on a large vein, which is said to contain good values in gold and to have been a producer of rich gold ore.

FLORES MINE.

The Flores mine is located in the foothills on the upper part of Flores Wash, a short distance below the Vanderbilt and Columbus mines, northwest of Cerbat, and about 700 feet above Sacramento Valley. The property comprises a group of four mining claims.

The mine was first located in 1871 by a party of prospectors from Nevada, but owing to the hostility of the Indians actual mining did not begin until 1875 or 1876. At one time the mine was known as the Five Forks mine, from the ramification of the north end of the vein into five parts.

One of the early operators was Charles M. Gross, sr., a resident of Mineral Park, who afterwards became owner of the mine. In 1888 it was acquired by the Flores Mining Company, of Philadelphia. This company at once installed a 14-ton double-rocker mill, hoist, and other machinery and worked the mine until 1893, when, owing to financial difficulties, the mine was closed and sold for taxes. It was bought by W. N. Gurley, whose widow still owns it. The mine has not been operated since 1893, and is now filled with water to the 100-foot level.

The mine is reported to be developed to a depth of about 300 feet, with but little stoping. The principal surface equipments are a 5-stamp mill and a steam hoist. The mill is equipped for fine crushing and amalgamating, as the ore contains free gold.

The production is reported to have been considerably more than $200,000.

The country rock is the pre-Cambrian granitoid schist, and the intrusive granite porphyry seems to be present near by. The deposit is in a fissure vein about 4 feet thick, which dips 80° to 85° NE., but at the surface, where the vein is crosscut by Flores Gulch, it locally dips in an opposite direction. The croppings are chiefly reddish and brown iron-stained quartz and crushed or brecciated rock.

Though some ore averaging as high as $1,000 to the ton has been produced, the ore is mostly of too low grade to ship. It is contained in an oxidized gangue, composed chiefly of quartz and altered rock.

The ore contains gold, with silver sulphide, some zinc blende, and galena. It favors the hanging-wall side of the vein. Mr. Gross is reported to have handled ore averaging $60 or more only, but the Flores Company, with the mill now on the ground, profitably handled ore ranging as low as $6 a ton.

ESMERALDA MINE.

The Esmeralda mine is located in low, gently rolling foothills about a mile west-northwest of Cerbat, at an elevation of about 3,750 feet. It is owned by the Ark and San Antonio Mining and Milling Company, of St. Louis. It is developed principally by a 200-foot shaft and two levels containing about 250 feet of drift, with some stoping near the surface. The 110-foot level extends 90 feet south and 30 feet north of the shaft. At the time of visit the shaft contained water. The principal equipment is a 10-horsepower steam hoist.

The production is reported to be $90,000.

The country rock is the pre-Cambrian complex, with schistose structure trending about N. 35° W. The rock is intruded near the mine on the northeast by a fine-grained granite porphyry dike, several hundred feet in width.

The deposit is a fissure vein, which strikes N. 35° W., parallel with the schistosity in the country rock, and dips about 75° SW. The vein is from 4 to 5 feet in width. Its gangue consists mainly of quartz and crushed and more or less altered country rock. Oxidation extends to the depth of 90 feet below the surface, below which the ore consists of sulphides and contains chiefly pyrite and chalcopyrite, with gold and silver. A carload of the concentrates that was shipped is reported to have averaged 13.42 ounces of gold and 40 ounces of silver to the ton. The ore usually shows a crude banding about parallel with the vein.

CERBAT MINE.

The Cerbat mine is about a mile northeast of Cerbat, and the Golden Gem mine, in the foothills, on a side gulch of Cerbat Wash and near the top of the ridge separating it from Long Gulch on the north, at an elevation of about 4,600 feet. This mine is one of the early discoveries. Two operators were killed in it by the Indians in pioneer days. It was opened in 1869 and was worked by a whim in 1875. About 1880 a large mill was installed in the gulch below the mine, but operations have now been suspended for some time. The mine is owned by the Cerbat Mining and Milling Company, of Minneapolis. It is credited with a production of about $300,000.

The mine is developed principally by a 180-foot shaft, drifts, and stopes. The principal surface equipment is the large mill above mentioned.

The deposit forms a fissure vein 4 to 10 feet wide, contained in the pre-Cambrian complex. The vein strikes north-northwest, with bold croppings locally rising 8 or 10 feet above the surface. The gangue is mostly quartz, with some crushed and recemented rock. The ore

contains chiefly gold, with silver and copper also. The copper occurs mainly in the form of chalcopyrite and carbonates. A conspicuous coating of malachite is now forming on the ore walls and surface of the workings in the mine. Most of the rich ore seems to have been taken out, but the mine is reported to contain a large amount of good milling ore.

BUNKER HILL MINE.

The Bunker Hill mine is located in the mountains, a short distance east of the Cerbat mine. It is owned by John Mulligan. It is said to contain two veins situated close together. The ore, some of which has been shipped to the Needles smelter, is said to contain high values in gold and copper.

MINES IN UNION BASIN.

Union Basin, comprising an area about 1 mile in diameter, is located northeast of the Cerbat mine, in the upper part of Long Wash, which heads to the north of the upper part of Cerbat Wash. The nearest railroad station is Mineral, 5 miles distant, reached by wagon road descending Long Wash. The basin contains about a dozen small mines and prospects, not all of which were visited. The most important are described in the following paragraphs.

PAYMASTER MINE.

The Paymaster mine is located in the southern part of Union Basin, at the head of Long Wash, about half a mile north of the Cerbat mine, at an elevation of about 4,500 feet. It is an old mine and was profitably worked in the seventies, when the cost of mining supplies and of the reduction of ore was many times what it is now. It is owned by the Victor-Paymaster Mining Company, of Los Angeles, and is now producing. The total production is reported to be about $200,000.

The mine is developed principally by a 230-foot 60° inclined shaft and about 1,200 feet of drift, with upraises and stopes. It produces considerable water. The principal surface equipments are a steam hoist and a pump. At the time of visit a gasoline hoist and new machinery were being installed for more expeditious work.

The vein is contained in the pre-Cambrian complex, strikes N. 70° W., and dips 75° NNE. Locally it attains a width of about 15 feet. The gangue is chiefly mineralized quartz, in which the ore occurs principally in shoots, ranging from 16 to 24 inches in width.

The quartz contains principally silver values, with some gold. Much of the silver is in the form of ruby silver. The ore is said to range from $50 a ton upward. Some of it contains about 500 ounces of silver to the ton.

ALEXANDER GROUP.

The Alexander group of mines is located just northeast of the Paymaster mine, on northwestward slopes between 4,400 and 5,000 feet in elevation. It comprises four claims, the Alexander Nos. 1 and 2, Lazy Man, and Granfield. The two former are situated on the same vein and the two latter on separate veins. The veins were discovered in 1880 by Captain Lane, of Lane Springs Basin, and located in 1890 by James Dundon, of Cerbat, who is the present owner. The production of the property is reputed to exceed $5,000, the main part being derived from Alexander No. 1 claim.

The Alexander No. 1 is developed by three shafts and drifts. The shafts are 60, 80, and 230 feet deep. The shaft of the Alexander No. 2 is 100 feet deep. The Lazy Man contains a tunnel 125 feet in length, and two small shafts. On the Granfield claim the vein is opened by two inclined shafts, 35 and 100 feet deep and 500 feet apart.

The country rock is the pre-Cambrian gneiss complex. The veins strike northwesterly and dip northeasterly at angles of 60° to 80°. They range from 2 to 4 feet in thickness and are oxidized down to water level, which lies at about 80 feet below the surface.

The gangue is mainly kaolin, with some quartz. It is hard in the oxidized zone, but soft below water level. The ore usually favors the hanging wall and is said to occur in a nearly continuous shoot, about 18 inches in width. It contains silver, gold, iron, and lead. In the oxidized zone it contains principally soft horn silver and gold, with a little oxide of iron and carbonate of lead, the silver in places averaging about 500 ounces to the ton. Below water level the ore is chiefly sulphide, the lead occurring in the form of galena and the iron as pyrite, and there is reported to be an increase in the amount of silver, with little or no decrease in the amount of gold.

OTHER MINES.

The Climax mine is located on rough ground in the eastern part or head of Union Basin. It formerly belonged to James Dundon, of Cerbat, who recently sold it to a stock company of Denver. It is developed by several shallow shafts and drifts. The vein dips steeply southwest or is nearly vertical. The sulphide ore contains gold, silver, pyrite, chalcopyrite, and galena. The values are chiefly in gold and silver.

The Silver, Eddy, and Tub mines are said to be located on the same vein or lode, which in the Silver mine attains a width of about 100 feet. The Silver mine, owned by James Mulligan, is said to be developed mainly by shallow shafts and several hundred feet of drift. The ore is of low grade, containing principally gold and silver values, and is said to concentrate well.

According to reports the Tub mine is developed principally by shafts and crosscuts. Here the vein varies from 30 to 80 feet in width and widens downward. It is reported to show at a depth of 40 feet a 4-foot streak of galena, containing values in gold and silver, and at 60 feet below the surface an ore body about 20 feet in width, which averages about $10 in gold and 20 ounces in silver to the ton, and contains zinc, copper, and lead. The mine is known to have produced several hundred tons of lead carbonate ore, most of which averaged about 40 per cent of lead.

The Big Bethel mine is reported to be situated on a large vein containing a shoot of high-grade ore and is credited with a production of $10,000.

The Golconda mine, owned by E. F. Thompson and E. B. Smith, is opened by shaft, tunnel, and adit drift. It is reported to have produced from essentially surface workings several hundred tons of rich ore containing chiefly gold, silver, and lead values, with some copper and zinc. Some of the ore was treated at the old Empire mill in Todd Basin with good results. Recently the 300-foot level is reported to have been driven 200 feet on a 4-foot ore shoot that assays 50 per cent of zinc.

The Green Linnet mine is said to be opened principally by a 100-foot shaft and about 500 feet of drift and to have a good showing of ore.

Some of the mines of Union Basin are now said to be shipping ore to Iola, Kans., and Oklahoma for treatment. The ore is reported to average about 50 per cent of zinc, and to contain good values in gold and silver.

MINES IN TODD BASIN.

Todd Basin, a valley about 2 miles long, is situated immediately north of Union Basin and, like it, drains westward into Long Wash. The topography is generally rugged. The mines described in the following notes are the most important in this locality.

ORO PLATA MINE.

The Oro Plata mine, one of the heaviest and most continuous producers, is located in the eastern part of the district near the axis of the range and the head of the main gulch, at an elevation of about 4,300 feet. It is reached by wagon road. The mine was first located and owned by Mexicans, under whom it began to be worked early in the seventies. It was next owned by J. P. Lane, whom the tailings are said to have netted $70,000, but who, in 1882, sold it to a party of ranchers under the lead of H. Wilson. These men worked it and shipped ore to the smelters in Colorado, and finally sold the mine to J. W. Garret in 1895. In 1897 and 1898 the mine produced $150,000. Recently it has been purchased by the Oro Plata Mining Company, of St. Louis.

The mine is developed to a depth of 280 feet, principally by shafts, drifts, adit drifts, tunnels, and stopes, aggregating, it is said, about 7,000 feet of underground work distributed on three levels. The mine produces considerable water, ample for all milling purposes. The principal surface equipments are a 20-horsepower steam hoist and an air compressor. At the time of visit ground was being broken for a new mill.

The country rock is the pre-Cambrian gneiss, extensively intruded by coarse granite porphyry, a large dike of which crosses the gulch just below the mine. In the mine the granite porphyry seems to be associated with the vein, as does also a large 40-foot dike of finer-grained granite porphyry.

The vein, about 4 feet in width, normally dips about 80° NE. It is locally enriched by intersection with another vein. (See fig. 14.)

The ore, which occurs chiefly in a banded quartz gangue, contains principally gold and silver. There are small amounts of chalcopyrite, zinc blende, pyrite, and galena. The ore shoots are said to be richer and more regular in the deeper part of the mine than near the surface. The ore averages in gold 3 ounces and in silver 25 ounces to the ton, and in lead about 6 per cent. There is said to be good ore in the bottom of the mine, which carries about 7 per cent of lead. The value of the output of the mine from July 14, 1896, to February 18, 1901, as shown by the sheets of the Arizona Sampler Company, which bought the ore at Kingman, was approximately $206,000 (2,527 tons of ore, averaging $80 to the ton), of which about 75 per cent was in gold and the balance in silver and lead. The price paid in the recent purchase of the mine was based on the assumption that the ore on the whole averages $37 to the ton, including the large bodies of moderate-grade ore left in the mine above the 280-foot level during earlier work.

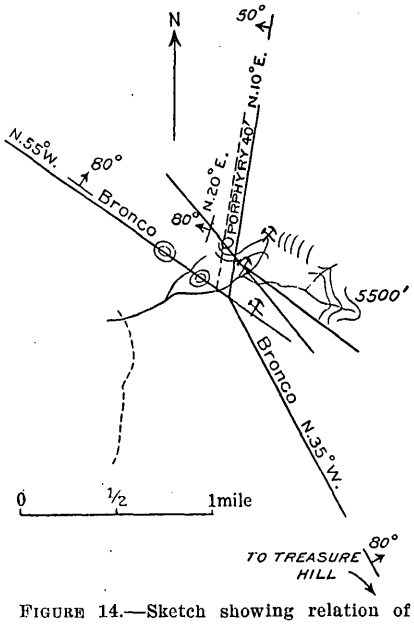


FIGURE 14.—Sketch showing relation of veins at Oro Plata mine.

The total production is reported to be about $500,000, and about 5,000 tons of second-class ore, said to average about $20 a ton, lie on the dump.

PROSPERITY MINE.

The Prosperity mine adjoins the Oro Plata mine, being located on the same vein where it ascends the mountain slope on the southeast. It was formerly owned by Cal. Wright and J. P. Lane, but is now owned by Owen McNally. It is said to be developed by about 700 feet of drift, mostly adit. The ore contains principally silver. Near the surface an ore body 9 feet in width is reported to have been a large producer and to have yielded considerable ore, which averaged $220 to the ton.

PRIMROSE MINE.

The Primrose mine almost adjoins the Prosperity mine on the southeast. It is owned by G. M. Bowers and T. E. Pollock. It is developed mainly by an adit drift, the breast of which is said to be in good ore, containing gold, silver, and copper. The mine produces much water and will require the installation of machinery for deep sinking.

BLACKFOOT MINE.

The Blackfoot mine, said to have been a good producer, is southeast of the Primrose mine, near the head of the gulch. It is owned by Byron Collins and Owen McNally. It is said to be developed principally by tunnels and shafts to the depth of several hundred feet. A proposed lower tunnel would cut the ore bodies at about 100 feet below the present workings. The vein is said to pinch in places, but in general increases in width with depth, and the ore shoot varies from 6 to 24 inches in width. The ore is reported to contain gold, silver, and copper, some of it running 180 ounces of silver and 3 ounces of gold to the ton and about 15 per cent of copper.

SUCCESS MINE.

The Success mine, located near the Oro Plata, is said to be opened by tunnels, drifts, and shafts on the vein. The ore is said to be sulphide and contains gold, silver, and lead. A lot treated years ago in the old mill in Todd Basin is said to have netted $27 a ton.

MEXICAN MINE.

The Mexican mine, located in the eastern part of the basin, is reported to have produced considerable ore that averaged about 9 ounces of gold and 312 ounces of silver to the ton.

MINES IN LANE SPRINGS BASIN.

Lane Springs Basin is a short, deeply cut side valley situated northeast of Todd Basin, from which it is separated by a prominent spur-

like ridge extending northwestward from the axis of the range. The basin contains six or eight mines, of which those described below are the most important.

ALPHA MINE.

The Alpha mine is located in the eastern part of the basin, at an elevation of about 5,000 feet. It is owned by Peter Cooper, Oscar F. Dennis, and Mrs. Smith. It is developed principally by two drifts, the upper one 400 feet and the lower one 200 feet in length, both of which trend about S. 30° E. along the vein, almost directly across the strike of the pre-Cambrian gneiss complex. The croppings are a prominent reef of black, iron and manganese stained quartz. The vein varies from 4 to nearly 20 feet in width, and consists principally of a gangue of imperfectly banded, fine-grained, sulphide-bearing quartz, in which the ore occurs. The ore contains silver sulphide, pyrite, galena, zinc blende, and chalcopyrite.

The mine is reported to have been a good producer. A consignment of 400 tons of ore is reported to have netted $125 a ton.

NIGHT HAWK AND RIP VAN WINKLE MINES.

The Night Hawk and Rip Van Winkle, two adjoining mines, are situated about half a mile southeast of the Alpha mine, both on the same vein in the steep northwest slope of the mountain, at an elevation of about 5,000 feet. The country rock is pre-Cambrian gneiss. The vein strikes northwesterly. In the Night Hawk it is reported to be developed principally by a drift 1,400 feet in length, whose face is located about 700 feet beneath the apex of the vein. The vein is said to be large and to contain a "pay streak" of sulphide ore ranging from 6 to 18 inches in width. The ore shoot in two localities has feathered out, and in both has been recovered with its usual values by cross-cutting into the foot wall. Much of the ore is rich; some of it is reported to have averaged $2,000 a ton in carload lots. According to record sheets of the Sampler Company, who bought most of the output from April, 1887, to January 20, 1900, the ore averages about 3 ounces of gold and 300 ounces of silver to the ton; the production during this period was 464 tons, containing values of about $244 a ton, amounting to about $113,000. The total output of the mine is reported to be $150,000, and was produced at intervals during the last seventeen years.

MINES SOUTH OF CERBAT WASH.

The principal mines situated south of Cerbat Wash are the Champion, New London, St. Louis, and Twins. As stated elsewhere, they contain chiefly silver and lead.

CHAMPION MINE.

The Champion mine is 1¼ miles southwest of Cerbat, on the west front of the range, 600 feet above and about three-fourths of a mile distant from Sacramento Valley, at an elevation of about 4,100 feet, near the head of a short wash that leads westward into the valley. It is reached by wagon road from the west. This mine is one of the early discoveries. It was fromerly worked by James Dundon, but is now owned by the Arizona-Mexican Mining and Smelting Company, of Needles, Cal. It is producing at a moderate rate. The mine is developed mainly by shafts and about 600 feet of drift to a depth of 70 feet, and it produces a little water.

The country rock is the pre-Cambrian gneiss, and it is intruded near the mine by granite porphyry and by diabase and minette dikes.

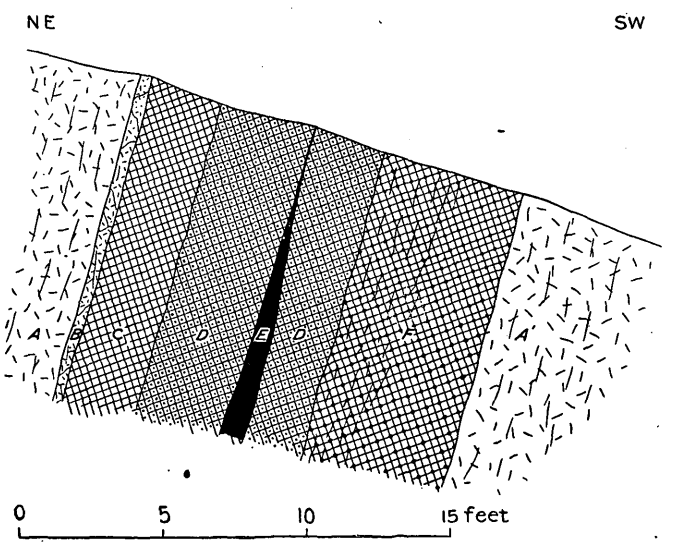


FIGURE 15.—Section of Champion vein. See text for explanation of letters.

One or more dikes are associated with the vein, which is about 12 feet in width and dips steeply to the northeast. A cross section of the vein, as sketched at the mine near the surface, is shown in figure 15. In this figure A represents country rock, consisting of alternately dark and light streaked granitic schist forming the hanging wall; B is gouge consisting principally of crushed granitic rock; C is brown, iron-stained ore; D is dark, earth-colored, fresh dike rock, which seems to be minette and contains biotite, augite, orthoclase, and andesine; E is a stringer of quartz and brown, iron-stained carbonate ore material, which widens at about 60 feet back from the face and is reported to have carried an ore shoot 1 foot in width, which, in the deeper part of the mine, becomes the main vein; F is reddish, coarse granite, or pegmatite, composed mainly of feldspar,

and toward D is sheared and cut by parallel lines produced by movement; A′ is dark granitoid schist, about the same as A, forming the foot wall. The ore is composed mainly of sulphides and contains principally lead, gold, and silver, the gold in some of it running about an ounce to the ton.

The mine has produced a large amount of ore, a considerable portion of which was high-grade surface ore. It now produces about 6 tons of ore a day, four-fifths of which is shipping ore. Only the best ore is mined. A large amount of milling ore is left in the mine and a considerable amount also lies on the dump.

NEW LONDON MINE.

The New London mine is located at the west base of the range, about one-fourth mile southwest of the Champion mine, at an elevation of about 3,800 feet, in an open wash, but little above the level of the neighboring Sacramento Valley. The mine was worked during the middle eighties, at which period it produced much good ore. It was closed about 1893 and is now dismantled of all surface equipments, but is regarded as a good property. The owners are Skee Brothers, of Santa Monica, Cal.

The mine is reported to be developed principally by two inclined shafts, drifts, and stopes. Though the deepest shaft is 150 feet in depth, the work is nearly all comprised between the 75-foot level and the surface and in a horizontal extent of 400 feet.

The vein containing the deposits is said to be similar to that of the Champion mine, but stronger, and to contain large bodies of ore. It strikes about N. 60° W. and dips 55° NE. The ore is said to average high in silver and gold, as well as in lead.

TWINS MINE.

The Twins mine is about one-fourth of a mile east of the Champion mine, in Twin Gulch, which trends northward and joins Cerbat Wash below the mouth of Charcoal Canyon. It is owned by the same company as the Champion mine, described above. It is opened by shafts and drifts to a moderate extent. It may develop into a zinc mine, for in the bottom of the mine the vein contains a shoot of zinc blende about 5 feet in width, which also contains from $7 to $8 a ton in gold. The mine is reported to have produced 300 tons of ore, aggregating a value of $10,000.

ST. LOUIS MINE.

The St. Louis mine is about half a mile east of Cerbat and the Gem mine and the same distance southeast of Cerbat Wash and several hundred feet above it. It is accessible by wagon road. The mine was discovered about 1865. It has been a producer on a

moderate scale, and is now producing under the present owner, the St. Louis Consolidated Mining and Milling Company, with headquarters at Los Angeles. This company acquired it in 1905. The property comprises 19 claims, but the developments are chiefly on the St. Louis Claim.

The mine is developed principally by adit drifts and tunnels, mostly within a vertical range of 340 feet, and contains about 1,000 feet of underground work. The shaft on the Knocker claim, however, is reported to be 110 feet deep.

Five distinct veins are reported to occur in pre-Cambrian gneiss. Several of the veins are said to converge near the southeast end of the St. Louis claim. Three of the veins trend northwest and dip 80° NE., and two trend about north and south and dip 85° E. The hanging wall of all the veins is said to be gneiss. The north-south veins are reported to have in most places a "porphyry" foot wall. These veins average about 5 feet in width and are said to be richer than the northwest-southeast veins and to contain more silver. The richest ore they contain is said to be steel galena. The ore occurs in shoots or bunches varying from 2 to 16 inches in width. It contains about $3 in gold and 12 ounces of silver to the ton and 55 to 75 per cent of lead.

The northwest-southeast veins are said to have a dark rock on the foot wall, with gneiss occurring locally on each wall. The largest of these veins is said to be 4 feet in average width, but it carries less ore than the smaller veins.

The two veins now being worked are known as Nos. 2 and 3. They are about 3 feet wide and the ore varies from 4 to 16 inches in width. In carload lots the ore is said to average about 60 per cent of lead and $2 in gold and 14 ounces in silver to the ton. Most of the ore thus far produced has been obtained within 40 feet of the surface. The management is now taking out shipping ore only and doing development work.

BLANKET VEIN PROPERTY.

The Blanket Vein property is about half a mile southwest of the Gem mine, just below the mouth of Charcoal Canyon. It is principally owned by the Golden Star Mining and Milling Company. The deposit is a gold-bearing quartz vein, resting on pre-Cambrian granite. It dips northeasterly at the low angle of about 30°, and is unique in being now bared, the granite having been completely removed from the upper surface by erosion over a nearly equidimensional area of about 500,000 square feet.

The vein is about 1 foot in average thickness and is said to contain about $8 in gold to the ton, or a total value of more than $90,000 for the area of the deposit thought to be in sight. Hornings and assays

show portions of the deposit to contain as high as $20 in gold to the ton. The gold is mostly free milling. The quartz also contains some iron, principally hematite and limonite, derived from pyrite by oxidation.

STOCKTON HILL DISTRICT.

GENERAL OUTLINE.

LOCATION AND HISTORY.

The Stockton Hill district joins the Cerbat district on the east, and is about parallel and coextensive with it north and south, being situated on the opposite slope of the mountains. It is about 4 miles in width and but little more in length. It ranges in elevation from 3,500 feet at the edge of Hualpai Valley on the east to 5,500 feet at the crest of the range.

The principal and oldest camp is Stockton Hill, situated in the foothills in the eastern part of the district, 10 miles north of Kingman, at an elevation of about 4,800 feet. It dates from early in the sixties, when the principal veins were first discovered and began to produce. In former days much of the ore was shipped to Swansea, Wales, but later it was treated in the Mineral Park and Cerbat mills and shipped to the smelters in San Francisco and to New Mexico. At present the ore is hauled by wagon to Barry or Kingman, whence it is shipped, mostly to Needles. The district is reported to have produced many million dollars' worth of ore.

TOPOGRAPHY AND GEOLOGY.

The topography, shown in part in the sketch map (fig. 16), is generally rough, but the mines are nearly all accessible by wagon roads, mostly of easy grade. The drainage issues eastward into Hualpai Valley, mainly through several short side valleys or transverse washes—the Canyon Station, C. O. D., I. X. L. (known as I. X. L. Basin from the width and open character of its middle part), Cupel, Treasure Hill, and Maywell. In their upper parts most of the washes contract into V-shaped gulches.

The country rock is the pre-Cambrian gneiss and schist complex. It is reddish brown and iron stained and is intruded by dikes of granite porphyry, diabase, and other rocks, mostly of basic character. The schistosity trends about N. 30° E. and dips usually vertically or at steep angles to the northwest. The dominant jointing or sheeting strikes northwest.

ORE DEPOSITS AND MINES.

The deposits occur in pre-Cambrian gneiss or schist, intruded in places by a later aplitic granite or by basic dikes. They are fissure

veins, which in general strike northwesterly and are vertical or dip at steep angles to the northeast. The gangue is quartz and the ores contain chiefly silver, with some gold, lead, and copper. Primary sulphide minerals are galena, zinc blende, chalcopyrite, and pyrite, but the district owes its reputation to the rich silver ores, such as native silver, cerargyrite, argentite, and ruby silver, which were found in large quantities in the upper levels. The water level is about 100 feet below the surface. Galena is often found above it, while rich silver minerals descend to a considerable distance below it. The greatest depth attained is 400 feet.

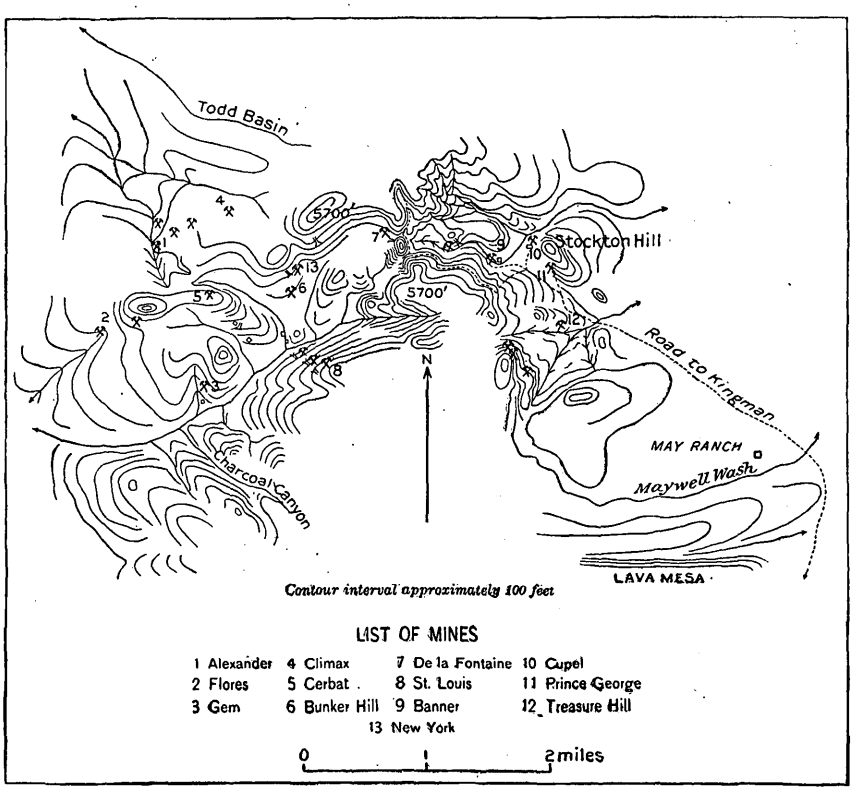
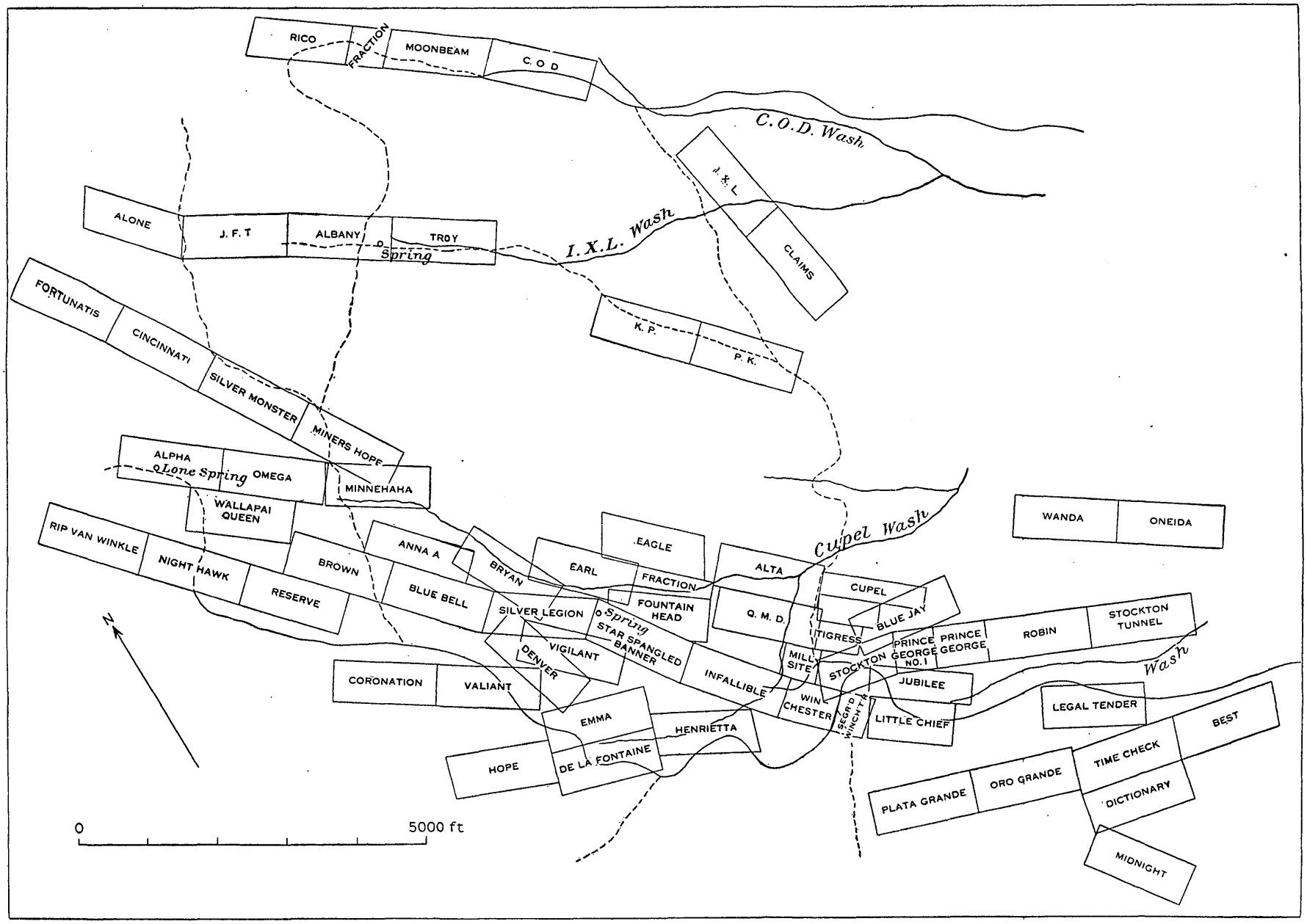


FIGURE 16.—Sketch map of Stockton Hill district and adjoining part of Cerbat district.

The district contains about 10 mines, of which the principal are the Banner Group, Treasure Hill, Little Chief, Cupel, Prince George, De La Fontaine, C. O. D., and Sixty-three. Their general distribution is shown on the accompanying sketch map (fig. 16). The principal locations made in the district are indicated on the claim map (Pl. VIII).

MINES ON STOCKTON HILL WASH.

The principal mines on or near Stockton Hill Wash are the Banner Group, Cupel, and De La Fontaine. Their situation in alignment on a nearly east-west line about 1½ miles in extent has led to the



CLAIMS IN STOCKTON HILL DISTRICT.

current belief that they are all on the same vein. They are perhaps in a general way in the same mineral zone, but as the strike of the veins at the different mines does not coincide with the trend of the mines and the veins have not been traced and do not seem to connect from mine to mine the single-vein theory remains to be proved.

BANNER GROUP MINE.

Location.—The Banner Group mine (Pl. VII, *B*) is about half a mile west of Stockton Hill, near the center of the district, toward the upper or gulch part of Cupel Wash at a point where it widens into a small basin at about 4,800 feet elevation. The property is said to comprise six adjoining claims, of which the most important are the Infallible (formerly Indian Boy) and the Star Spangled Banner. The principal mine openings are on the former, whence the workings extend northwestward into the latter. The property is owned and operated by the Arizona-Mexican Mining and Smelting Company, of Needles, Cal., where the large smelter owned and operated by this company is located.

Developments.—The mine is developed principally by adit drifts, stopes, winzes, and shafts, aggregating about 2,500 feet of underground work, including the tunnel or adit drift, 1,600 feet in length, on the vein. This drift has a greatest depth of 230 feet below the surface. Several shafts, mostly shallow ones, are located up to 1,050 feet from the mouth of the drift. At 800 feet from the mouth of the drift is a gasoline hoist and a 60-foot winze, reported to be sunk all the way in good ore. The property is equipped with a nearly new 40-ton mill supplied with concentrating tables.

The production is reported to be many thousand dollars in gold, silver, and lead, the zinc thus far being culled and left on the dump. The dumps also contain much second-class ore, which is said to be suitable for concentration. The mine now works about 20 men and produces about 30 tram-car loads of ore a day, of which one-fourth is shipping ore and three-fourths milling ore. The ore is shipped to the Needles smelter.

Geology and ore deposits.—The country rock is light to iron-gray fine-grained gneiss, in which the structure trends about N. 30° E. and dips steeply to the north-northwest. Toward the veins on the foot-wall side the rock is red from oxidized pyrite.

The fissure vein strikes N. 40° W. and dips about 80° NE. The croppings consist principally of leached reddish-brown quartz. The vein averages about 7 or 8 feet in width; the ore varies from about 1 foot to 3 feet in width and usually occurs on the foot-wall side of the vein. In the face of the drift at the time of visit it was 2½ feet

wide, and associated with it on the hanging-wall side was a foot or more of soft gangue composed principally of crushed and altered granitic material, which, on being removed by blasting, leaves the intact ore bared in fine condition for loading on the cars. The shoot contains parallel seams of light-colored material, which emphasizes the roughly banded character of the ore.

The ore consists in places of pure galena, but usually it contains also zinc blende, pyrite, and chalcopyrite. The gold in some of it amounts to several ounces a ton. The silver occurs in part as sulphide and native, as masses and wire silver, which locally interlaces adjacent parts of the ore shoot. The amount of zinc increases in the deeper, northern portion of the mine. Toward the northwest end of the surface workings occurs a large amount of reddish quartz ore, which seems to contain chiefly gold values. This probably represents the body of rich gold ore reported to have been found in the surface openings of the mine. A short distance north of this locality galena and zinc-blende ore with comb quartz and chalcopyrite seem to prevail.

CUPEL MINE.

The Cupel mine is situated in the foothills at Stockton Hill camp, on the south side of Cupel Wash. This mine is regarded as probably the oldest on Stockton Hill. It was located about 1863, and was worked intermittently from that date to 1891, being constantly a heavy producer. It is said to have yielded handsome returns to lessees in the seventies, and in the eighties it was opened up by an inclined shaft to the 400-foot level by Spruance, Stanley & Co., of San Francisco. From this shaft nearly half a million dollars in silver and gold ore is reported to have been taken.

The principal equipments are a steam hoist and an excellent 200-ton mill and plant of the Joplin type, recently installed. The mine is owned by the Stockton Hill Mining Company, with headquarters at Topeka, Kans. The mine is developed principally by a shaft 400 feet deep, a three-compartment shaft 150 feet deep, drifts, and stopes to a depth of about 400 feet, the workings being nearly all situated within 300 feet of the main shaft. The mine is said to produce about 25,000 gallons of water a day.

The production of the mine is conservatively reported to exceed $500,000, and is variously estimated at one to one and a half million dollars. From September 3, 1885, to May 1, 1890, according to the smelter sheets, the output was $131,405, and averaged approximately 150 ounces of silver to the ton and 20 per cent of lead, silver at that time being worth about $1 an ounce. It is stated that the mine contains much ore in sight and that the dumps contain about 2,000 tons of ore that is estimated to mill $6 or $7 net per ton.

The country rock is the pre-Cambrian gneiss and schist complex. Three veins, which strike northwesterly but are not quite parallel, contain the ore. They are known as the Cupel, Edward Everett, and Tiger veins. Several diagonal or cross veins or stringers are also present. (See fig. 17.)

The ore contains ruby silver and horn silver, together with argentite, but in places is rich in high-grade galena and carries about $5 a ton in gold. The bulk of the ore produced contains ruby silver, and some of it is said to have averaged 3,000 ounces of silver to the ton and gave to Stockton Hill and the Cerbat Mountains their early reputation. Most of the rich ore thus far produced is said to have been taken out within a horizontal distance of about 250 feet, extending principally from the shaft northwestward and from the surface to the bottom of the mine. Beyond this portion of the mine to the northwest the ore is said to contain principally galena and some gold.

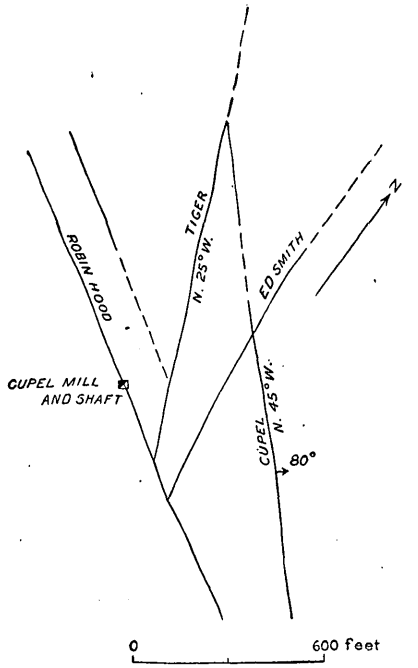


FIGURE 17.—Sketch showing relations of veins on Cupel claim.

PRINCE GEORGE MINE.

Location and history.—The Prince George Mine is located at Stockton Hill, about one-fourth mile southeast of the Cupel mine, at an elevation of about 4,600 feet. It is situated on steeply westward-sloping ground, near the head of a deep gulch that trends southward into Treasure Hill Wash.

The mine was worked principally in the eighties. After the installation of machinery the mine was operated by Mr. McKay, who soon suspended operations, since which time but little work has been done. It is now owned by the Stockton Hill Mining Company.

Production.—The production is reported to be $100,000, of which $90,000 was taken out in about ninety days, mostly from the large ore chamber.

Developments.—The principal developments are a 180-foot shaft and about 250 feet of drifts and stopes. The principal equipments are a coal or oil fuel hoist and pumps. The mine is said to produce about 20,000 gallons of water per day.

Geology.—The country rock is the pre-Cambrian complex, the prevailing phase being a medium-grained light gneiss, but next to the vein the rock is a coarse granite or pegmatite, some of which resembles graphic granite. The schistosity trends N. 30° E. and is paralleled by many small quartz stringers, none of which, however, are known to carry ore. Slickensiding in the mine indicates a nearly vertical movement.

Veins and ores.—The principal vein strikes N. 65° W. and dips about 80° NE. As shown in the mine at about 60 feet in from the mouth of the adit drift, the main vein is joined from the northwest by a second vein, which near the junction is 12 or 15 feet thick. At their junction the two veins seem to have formed an ore body 60 to 80 feet in diameter and extending to a depth of at least 50 or 60 feet below the surface. The upper portion of this ore body, particularly that in the oxidized zone, has been mined, leaving a large chamber where the ore has been removed.

The gangue is quartz and altered rock, and the ore in the unoxidized zone or lower part of the mine contains chiefly galena, argentite, and pyrite. The bulk of the ore mined from the chamber is reported to have averaged 60 per cent of lead and 300 ounces of silver to the ton, and the remainder 20 per cent of lead and 20 ounces of silver to the ton. The ore as a whole is reported to have averaged about $200 per carload, and most of the richest to have come from an ore shoot 13 feet wide.

The walls of the main vein are, as a rule, ragged, but the hanging wall of the second vein is well defined and smooth and contains a streak of ore 4 to 6 inches wide, reported to average about $600 a ton, on which the operators are now sinking. A rich 1-foot ore shoot is also reported to occur on the hanging-wall side of the main vein.

LITTLE CHIEF MINE.

The Little Chief mine is located about one-fourth mile southwest of Stockton Hill camp and about 80 feet above it, close to the main road. The mine has been worked on a small scale since the middle seventies, and has produced only high-grade shipping ore from the surface down. It is owned by the C. O. D. Mining Company. The production is reported to be more than $25,000.

The mine is developed to a depth of about 100 feet and contains about 1,000 feet of underground work, which includes a 400-foot crosscut tunnel, two 80-foot shafts, and 300 feet of drifting, the drift extending about 75 feet on either side of the two main shafts.

The country rock is the pre-Cambrian complex. To judge from talus débris on the surface at the mine, it seems to be intruded by diabase near by, and portions of a light-colored altered rock, which

seems to be the intrusive granite porphyry, are associated with the vein.

The vein trends N. 40° W. and dips steeply northeast. It is about 6 feet in width and is supposed to be the Banner vein of the Treasure Hill mine, described later. The gangue is quartz and crushed and altered silicified rock. The ore shoot locally coincides in width with the vein and is stained throughout with copper carbonate. The ore contains principally green horn silver, galena, and gold, is all of shipping grade, and is said to average about as follows: Silver, 350 ounces to the ton; gold, $5 to $10 a ton; and lead, 8 to 40 per cent.

DE LA FONTAINE MINE.

The De La Fontaine mine is situated at the west side of the district on the narrow crest of the range, at about 5,100 feet elevation, where the surface falls off steeply into Cerbat Wash on the west and Stockton Hill Wash on the east, the mouth of the adit drift or tunnel and shaft being located on the Cerbat side. The mine is owned by the Stockton Hill Mining Company. It is developed principally by a shaft 400 feet in depth and two levels comprising about 1,400 feet of drifts.

The country rock is principally a reddish fine-grained gneiss. Black amphibolite schist outcrops near by and is also present in the mine, particularly in the foot wall near the shaft on the 100-foot level. Back of the superintendent's house, a few hundred feet south of the vein, are prominent croppings of dark speckled medium-grained diorite from which the amphibolite schist has probably been derived.

The vein, which strikes N. 70° W. and dips about 80° NNE., is about 7 to 10 feet in width. The gangue is principally quartz, with some partly altered coarse granitic rock, but locally the fissure is occupied by greenish or reddish slickensiding gouge. The croppings consists of a 6-foot reef of quartz, stained by iron and manganese, and rising boldly 10 or 12 feet above the surface. The ore shoot is from 1 to about 4 feet in width. Good ore bodies of this width and of considerable extent are blocked out in the lower 300 feet of the mine.

The ore contains principally galena and zinc blende and a very little pyrite; it contains locally about $2 to the ton in gold, but the ore recently blocked out in the lower part of the mine is probably of a somewhat higher grade. The ore in sight in the mine is said to contain good values.

The company plans to treat such part of the ore as may be suitable in its mill recently installed at the Cupel mine and ship the balance to smelters.

MINES ON TREASURE HILL WASH.

The principal mines on Treasure Hill Wash are the Treasure Hill, Mocking Bird, and Sixty-three.

TREASURE HILL MINE.

Locaton and history.—The Treasure Hill mine is situated in the southeastern part of the district, in southward-sloping foothills at about 4,200 feet elevation. It was discovered late in the seventies and was worked on a small scale. From 1890 to 1900 it was owned by Lehorean Moore, who sunk five or six shafts to water level, about 65 feet below the surface, and is said to have stoped out very rich ore, some of which contained 15,000 ounces of silver to the ton. In 1902 the mine was acquired by the present owner, the Treasure Hill Mining Company, which has since sunk several shafts to the depth of about 110 feet and drifted on some of the veins, notably on veins Nos. 1 and 3. The property comprises four principal contiguous claims having a common corner and two extension claims on the southeast. The production is reported to be $100,000, of which one-half was high-grade silver ore from surface workings.

Developments.—The developments consist of a 140-foot tunnel, a 120-foot double-compartment 62° 30′ inclined shaft at the distant end of the tunnel, and a double-compartment 200-foot shaft, with drifts and crosscuts to nearly all the veins, in all aggregating about 1,000 feet of underground work. The principal equipments are a gasoline hoist, a Cornish pump with a capacity of 2,000 gallons, and engines. Heavier machinery is soon to be installed.

Geology.—The country rock is principally dark-bluish granite gneiss of pre-Cambrian age. The schistosity dips about 80° NW. The rock is intruded by a small stock of the granite porphyry. It constitutes the principal mass and upper part of the rough knob situated back of the mine and locally known as the Bronco, and it is in places associated with the veins in the mine. A schistosity is superimposed and is also older than the veins.

Veins and ores.—The veins are six in number. Beginning with No. 1, they are numbered consecutively from southwest to northeast. They average about 5 feet in width at the surface. In the southeastern part of the property they lie about parallel, strike northwest, and, except No. 4, dip for the most part steeply to the northeast. Northwest of the mine vein No. 1 curves to the left and outcrops on the southwest side of the intrusive aplitic mass, while the others lie to the east and northeast of the mass, the near ones curving out "to get past it," as the miners express it. Only the veins next to the intrusive rock are now being worked.

The gangue is principally quartz, in which the ore occurs in streaks or shoots from 100 to 200 feet long. The shoots usually favor the

hanging wall and are associated with clay gouge. The ore contains galena, with some pyrite and a little chalcopyrite. No zinc has yet been found on the property. The ore, so far as the experience of the present management goes, is said to average about 100 ounces of silver and $5 to $16 in gold to the ton, and from 7 to 10 per cent of lead, in both the oxidized and unoxidized zones.

According to reports of later (1908) work, 85 feet of drift run in the lower part of the mine, contains good milling values throughout its extent and width, and an unbroken small streak of high-grade ore.

SIXTY-THREE MINE.

The Sixty-three mine is located in the southern part of the district, about half a mile southwest of the Treasure Hill mine and several hundred feet above it, in the steep south side of a gulch which drains southward into Maywell Wash. The mine, which is one of the first discoveries, was found in 1863, from which date it is named. It at once became a heavy producer of very rich silver ore. After working the mine a few years, the first owners sold it to a San Francisco company, which worked it with good results and still owns it. Later it was also profitably worked by lessees. Subsequently the decline in the market value of silver and disagreement in the owning company are said to have led to discontinuance of work. The production is reported to be $500,000.

The mine is developed principally by adit drifts and tunnels to a depth of about 200 feet below the apex of the vein. The deposit is a nearly vertical fissure vein, about 3 feet in average width, in which the ore streaks average about 15 inches in width. The ore contains principally silver chloride and is mostly of high grade. Much of it is said to have averaged 3,000 ounces of silver to the ton. A considerable portion of the ore is said to have been treated in the Cerbat and Mineral Park mills and the rest was shipped to San Francisco. As there are no base metals in the ore, the mills are said to have extracted the values to a very high degree without roasting.

MINES IN I. X. L. BASIN.

I. X. L. Basin is an open basin-like area situated in the upper part of I. X. L. Wash, about 1½ miles north of Stockton Hill. It contains several small mines and prospects, about all of which are situated on the same vein or lode. The principal mines are the K. P. and the J. F. T.

K. P. MINE.

The K. P. mine is located in the southern part of the basin on open ground at about 4,700 feet elevation. The mine is new. It

is owned by Messrs. Kimberly and Potts, of Kingman. As the water level is at about 40 feet below the surface, the developments consist principally of shallow shafts and surface openings.

The country rock is the pre-Cambrian gneiss complex. The deposit forms a vein or lode about 65 feet in width, which dips about 75° NE., and is reported to have a horizontal extent of nearly 2 miles, many locations being made on it. The gangue or filling of the fissure consists essentially of crushed or brecciated vein quartz and crushed and altered coarse granitic quartz and feldspar. The croppings consist of similar material, locally silicified and stained reddish brown and black by iron and manganese oxides. The lode carries a width of about 7 feet of concentrating ore.

The ore is of low grade. It contains principally galena and is said to average about 60 per cent of lead. It contains also some gold, silver, and copper, the copper occurring as bornite and chalcopyrite.

J. F. T. MINE.

The J. F. T. mine, located in the upper or northwestern part of the basin, is said to be developed to a depth of about 200 feet. It is reported to have been a good producer, and its ore is said to contain copper, silver, and gold.

MINES IN C. O. D. WASH.

C. O. D. Wash is located about a mile north of I. X. L. Basin. Its principal mine is the C. O. D. mine.

C. O. D. MINE.

Location and history.—The C. O. D. mine is about 2½ miles north of Stockton Hill, in the upper or gulch part of C. O. D. Wash, at about 4,900 feet elevation. It is easily reached by a good wagon road. The mine was located about 1878 and was worked in a desultory manner until 1885, when active work was begun on the property. About 4,000 tons of ore was produced in the next seven years. Activities were renewed about 1900, with an output of several hundred tons of concentrates. In 1902 machinery and a mill were installed, immediately after which the mine and mill were operated for a period of six months, when, owing to decline in the market value of silver and, it is said, mismanagement and lack of proper machinery, the plant was closed. Later the Fletcher Mining Company leased the mine under bond and worked it for a short time, shipping the ore to Needles, but is said to have soon stopped operations for want of funds. The mine was closed again November 19, 1904, and operations have not yet been resumed.

The property is reported to comprise eight claims. It is now owned by the Taggart Mercantile and Mining Company, of Kingman. The mine is filled with water up to the first level.

Developments.—The mine is developed principally by a main shaft (No. 1) about 400 feet deep and by drifts and stopes on and between two main and two subordinate levels, aggregating about 2,500 feet of underground work.

From the second or 300-foot level to the surface the ore, except some of low grade, has been mostly stoped out for a distance of about 400 feet on either side of the shaft, especially on the east side, beyond which good ore is reported. The second level extends to a point 900 feet west of the main shaft, where connection with the surface is contemplated by a new double-compartment shaft (No. 2), which is now 96 feet in depth and on completion is to be used as a main working shaft of the mine. At about 1,200 feet west of this shaft a third shaft (No. 3) is sunk to the depth of 60 feet.

The principal surface equipments are a 50-ton concentrating mill containing rolls and three Bartlett concentrating tables, a 50-horsepower engine and boiler, and two rock crushers; a steam hoist with a 40-horsepower engine; a gasoline fan with a 10-horsepower engine, and a pump. The principal source of the power used is fuel oil. The mine is reported to yield sufficient water for operating the plant.

Geology.—The country rock is mainly dark-gray coarsely porphyritic gneissoid microcline granite. It is the dominant rock from Stockton Hill to a point beyond C. O. D. Gulch. Locally it is associated with dark fine-grained chlorite schist, in which the 60-foot shaft on the west is located. The rocks are cut by dikes of a greenstone or altered basalt. Schistosity and jointing strike N. 20° W., with vertical dip. A secondary system of joints trend N. 70° W. and dips about 80° S. and seems to be parallel with the C. O. D. vein, whose fissure probably belongs to the system.

Veins and ores.—The vein is well known as the "C. O. D." vein; it strikes N. 85° W. and dips about 80° N., and is reported to be more than a mile in length and about 6 feet in average width. The gangue is mainly quartz, in which the ore occurs in shoots and lenses which vary from 1 to 7 feet in width and are mostly of considerable extent. The narrow shoots are said to be usually rich, and the wider ones contain large bodies of milling and concentrating ore. At the 250-foot level the ore shoot is reported to vary from 3 to 7 feet in width and its ore to have averaged about $250 to the ton.

The ore contains principally silver sulphide and gold, with some galena, zinc blende, and below the 250-foot level a little chalcopy-

rite.[a] It is said to be less rich in the sulphide zone in the lower part of the mine than in the oxide zone near the surface. Its run of mine, roughly computed from a record of the output from October 10, 1885, to March 6, 1901, is about as follows: Silver 160 ounces and gold 2 ounces to the ton; lead, 12 to 20 per cent.

Production.—The production is reported to be $1,300,000, that of silver alone amounting to about $1,000,000; and several thousand dollars' worth of medium-grade ore are said to now lie on the dump. The output was mostly made between the autumns of 1885 and 1892. During this period 3,687 tons of ore are reported, according to smelter return sheets, to have contained about 402,000 ounces of silver, 1,180 ounces of gold, and 515,760 pounds of lead. Later, about 1900 to 1902, about 17,550 ounces of silver, 180 ounces of gold, and 114,360 pounds of lead are said to have been obtained from 330 tons of concentrates.

MINES OF CANYON STATION WASH.

In Canyon Station Wash, about a mile north of C. O. D. Wash, there are reported to be several small mines, of which the most important seem to be the Baden-Baden, King, and Queen mines, said to be owned by Lewis Davidson, of Kingman.

MINES IN "TOP OF STOCKTON HILL" AREA.

The "top of Stockton Hill" is situated in the northwestern part of the district, at the crest of the range, between the northern part of the Cerbat district on the west and the heads of I. X. L. and C. O. D. washes on the east. The mines include the Cincinnati, Miner's Hope, Blue Bell, Fountain Head, Brown, and others, the most important of which seems to be the Cincinnati. It is situated near the crest of the range about midway between Lane Springs and I. X. L. basins. It has not been worked for many years, but is regarded as a good property.

GOLD BASIN DISTRICT.

GENERAL FEATURES.

The Gold Basin mining district, of which Basin is the post-office, is situated in the eastern part of the White Hills (fig. 18). It extends over a hilly area about 6 miles in diameter, sloping to Hualpai Wash on the east, and ranges from 2,900 to 5,000 feet in elevation. The northeastern portion, where most of the mines are situated, is rugged, being marked by longitudinal fault scarps and scored by

[a] The mine is said to contain no copper above the 200-foot level, but in an opening about half a mile west of the mine and about 500 feet above it, on what is thought to be the same C. O. D. vein, the ore, which here occurs in a milk-white quartz gangue, contains chiefly bornite and chalcopyrite, with some zinc blende, and about $20 in gold to the ton.

several deep transverse washes, of which the principal ones are Banker, O. K., and Cyclopic, situated about 2 miles apart. The nearest railway station is Hackberry, 40 miles to the south, with which connection is made by stage line. Colorado River lies 16 miles to the north. Mineral was first discovered here early in the seventies, but remoteness from the base of supplies, together with scarcity of fuel and water, renders operations expensive and has materially retarded developments. Nevertheless, considerable progress has been made and much ore has been produced and worked in arrastres and mills.

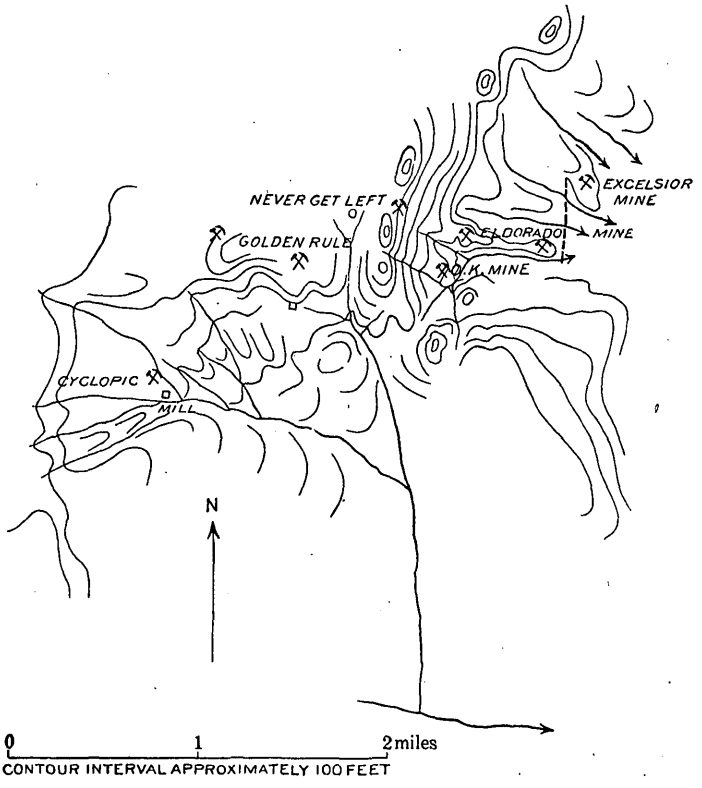


FIGURE 18.—Sketch map of Gold Basin district.

The deposits occur mainly in fissure veins in the pre-Cambrian crystalline rocks. The veins dip southeastward or northwestward, mainly at angles of 40° or 70°. The gangue is quartz, in places with siderite, and the metal is gold, mostly free milling, but it is associated with lead or copper ores, copper stain being a good indication of the gold values. Pyrite, chalcopyrite, galena, molybdenite, and wolframite are found, but the ore is largely oxidized, the water level not having been reached. Among the oxidized products are limonite, malachite, cerusite, and vanadinite.

The district contains about half a dozen small mines and about an equal number of good-looking prospects. The relative location of the most important is shown in the small sketch map (fig. 18). The principal mines are the Eldorado, Excelsior, Golden Rule, Jim Blaine, Never-get-left, O. K., and Cyclopic. The production of the district is given as more than $100,000, most of which came from the Eldorado mine.

ELDORADO MINE.

Location and history.—The Eldorado mine is located in the high foothills in the eastern part of the district, at about 4,000 feet elevation and 1,000 feet above Hualpai Wash, which is about 2 miles distant. The mine is reached by wagon road, over which most of the ore was hauled to the Basin or O. K. mill, 4 miles distant in Hualpai Valley. This mill, which was burnt while in operation in August, 1906, contained 10 stamps and a cyanide plant.

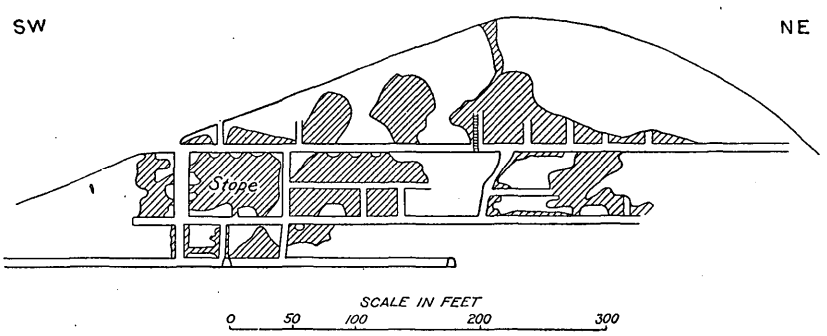


FIGURE 19.—Longitudinal section of Eldorado mine, showing stopes.

The mine was discovered late in the seventies and produced the first bullion taken from the district, much of its ore being at first worked in arrastres. It is owned by the Arizona-Minnesota Gold Mining Company, of Minneapolis. The production is reported to be $65,000, of which $5,000 was produced prior to 1902.

Developments.—The mine is developed principally by about 2,000 feet of tunnels and drifts and 40,000 cubic feet of stopes on three levels, aggregating probably about 90,000 cubic feet of underground work and distributed approximately as shown in the accompanying diagram (fig. 19). The lower tunnel trends about N. 33° E. and strikes the vein at about 200 feet in from the mouth. From this point the drift extends about 200 feet to the northeast.

Geology.—The country rock is a reddish schistose medium-grained granite. On the northeast, however, as shown at the surface and in the bottom of the mine, this rock gives way to a dark friable biotite granite. The contact between the two rocks dips about 30° W. It

is usually sharp and is probably a fault plane, which seems to cut off the vein on the northeast.

Veins and ores.—The deposit is a fissure vein, which strikes about N. 50° E. and dips 65° SE. It is continuous from the apex at the crest of the ridge to the contact in the lower tunnel of the mine and is stoped out through most of this extent. The walls are fair, but not regular. The vein averages several feet and the ore shoot about 20 inches in width. It contains iron-stained, free-milling gold-quartz ore, and is reported to average from $12 to $15 a ton in gold. The other associated minerals are malachite, lead carbonate, and vanadinite, the last occurring locally as incrustations of crystals one-fourth inch in maximum length. The principal mill treatment given to the ore was crushing, plate amalgamation, and cyanidation.

Just northwest of the apex of the vein above described and about 80 feet above it is the blanket vein, which is exposed for a length of 600 feet and a width of about 100 feet and which has contributed largely to the output of the mine. It dips about 25° E.

O. K. AND EXCELSIOR MINES.

The O. K. and Excelsior mines were discovered and located by three prospectors, Patterson, Rowe, and Fox, early in the eighties. They worked the ores in arrastres and hauled some to the 4-stamp mill at Grass Springs. In 1886 the O. K. was sold to a Kansas City company, which at once put up the O. K. mill in Hualpai Valley and ran it intermittently from 1887 to 1890. The mill burned down in 1893, but was rebuilt in 1896 and operated by lessees for a time, and then again shut down. It started once more early in 1902 and ran intermittently until 1906, when it burned down while in operation. The water used at the mills was piped from the springs or water tunnels in the upper part of Grand Wash Cliffs, 7 miles to the northeast. The mines are now owned by the Arizona-Minnesota Gold Mining Company.

O. K. mine.—The O. K. mine is about half a mile south of the Eldorado mine and about 100 feet below it, on the opposite side of O. K. Wash. The mine is developed mainly by adit drifts, winzes, and stopes on four levels. There is about 1,600 feet of underground work, distributed approximately as shown in the section (fig. 20). The production is reported to be about $25,000.

The country rock is a dark biotite granite, about the same as that which occurs in the bottom of the Eldorado mine. The strike is N. 30° E., with dip vertical. Slickensides pitch northeast-east toward the mouth of the drifts at angles of about 35°.

The vein trends N. 65° E., but curves to the north in its course and dips about 75° NW. It averages about 18 inches in width and is

composed mainly of seamed, gold-bearing limonite-stained quartz, said to average about $10 in gold to the ton. The hanging wall of the fissure is regular, but rough. Small faults 2 to 6 feet in throw occur, locally accompanied by overlap and enlargement of the vein. The ore favors the hanging wall, but where the vein overturns on the third level and the hanging wall becomes the foot wall the ore, nearly 1 foot thick, occurs in the foot-wall side.

The ore is free milling, but not so much so as the Eldorado ore, the gold being associated with cerusite. The principal other associated minerals are limonite, hematite, siderite, galena, molybdenite, and wolframite.

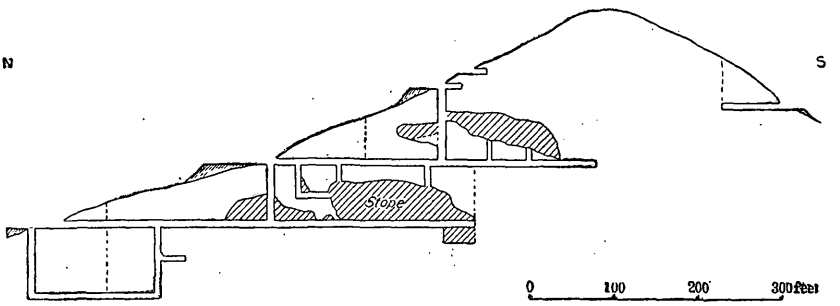


FIGURE 20.—Longitudinal section of O. K. mine, showing stopes.

Excelsior mine.—The Excelsior mine is about a mile northeast of the Eldorado and O. K. mines, in the low foothills near the edge of Hualpai Valley and about 500 feet above it, on the north side of O. K. Wash. The mine is developed to a depth of about 100 feet, principally by inclined shafts, drifts, and stopes, aggregating 500 feet of underground work. The production is reported to be $5,000.

The country rock is a coarse reddish granite associated with black amphibolite schist. The vein dips about 45° NW. It is from 1 to 4 feet in width and is locally occupied by gouge only. The ore shoot contains deeply iron-stained gold-bearing quartz or ore. It varies from three-fourths to 1 foot in width and occurs mainly on the hanging wall. The ore is said to be cyaniding ore, only a small percentage of the values yielding to amalgamation.

MASCOT MINE.

The Mascot, formerly the Old Homestake mine, is situated north of the Excelsior mine in the foothills at the edge of Hualpai Wash, and is said to contain a vein only 3 inches in width, which, however, is reported to be very rich. It is owned by the Arizona-Minnesota Gold Mining Company.

NEVER-GET-LEFT MINE.

The Never-get-left mine is located in the upper part of a cliff or fault scarp that overlooks the Eldorado mine on the east, from which it is but a few hundred yards distant. It is situated at about 4,500 feet elevation, or 1,600 feet above Hualpai Valley. It is owned by Henry Paully, of Basin, and is developed principally by an adit drift, shallow shafts, and open cuts, aggregating several hundred feet of work.

The country rock is dark gneissoid schist. The structure dips about 50° W., but the principal deposit dips about 80° N. It has a width of 6 or 8 feet and contains mainly iron-stained or copper-stained crushed gold-bearing quartz. The country rock is greatly disturbed by jointing, fracturing, and faulting, and its true character is somewhat doubtful. The mine has been a small producer for some years and was shipping ore in April, 1906.

GOLDEN RULE MINE.

Location and history.—The Golden Rule mine is about 1 mile west of the Never-get-left mine, at the extreme head of O. K. Wash, at about 4,550 feet elevation. It was discovered in the early eighties by Robert Patterson and Saul Rowe, who hauled some of the ore to the Grass Springs mill. Subsequently they leased the mine to Mr. Quackenback, and in 1900 sold it to the present owner, the Arizona-Minnesota Gold Mining Company. This company did but little development work on it till 1906. From May 15 to November 1 it was operated with a force of ten men, but was closed on the latter date. The production of the mine is estimated to be about $5,000, most of which came from the blanket vein.

Development.—The mine is developed by a 75-foot shaft, about 300 feet of drift, stopes, and a 25° incline about 100 feet long and 20 to 40 feet in width, the incline being on the south, where the deposits occur in the form of a blanket vein. The workings are contained within a horizontal distance of about 700 feet and a vertical distance of about 100 feet. The mine is handicapped by lack of water, which has to be hauled from the Cyclopic mine or from Basin, in Hualpai Valley.

Geology and ore deposits.—The country rock is the pre-Cambrian gneiss and schist. The fissure vein containing the principal part of the deposits strikes N. 20° E. and dips about 70° ESE. The croppings, which in part are prominent, form a reef of iron-stained, firmly cemented quartz breccia. The vein is best exposed in the north drift. It is about 2½ feet in average width and contains gold-bearing normal vein quartz, locally crushed, recemented, and iron-stained. Associated with it on either side is a sheet of pale grayish or whitish

gouge. The vein is said to yield good values throughout, the average being about $10 in gold to the ton, but the honeycombed quartz is the richest part of it.

At 120 feet in from the mouth of the drift the vein is abruptly cut off by a fault, immediately beyond which occurs a dark schistose rock that may be an intrusive. Near the fault the vein enlarges to about 12 feet in width, the enlargement being mainly on the foot-wall side and containing much honeycombed quartz, and the ore, greatly increased in quantity, is said to contain higher values. Some of it averaged about $100 a ton in a large chamber, from which much ore has been removed.

The fault hades north at an angle of about 10°. It is a normal one and the lost portion of the vein has risen toward the southeast. The amount of throw was not determined, but it is probably not very great. Beyond the fault the drift extends about 100 feet on the projected course of the vein which, however, has not been found.

On the south the deposits occur in a blanket vein, which is 3 to 5 feet thick, dips about 25° SE., and is probably a portion of the vein in the north drift, for it straightens up in that direction toward the top of the hill. The blanket portion has been mined over an area of about 100 feet along the strike and a breadth of 35 feet down the dip, and it probably produced good values.

CYCLOPIC MINE.

Location and history.—The Cyclopic mine is located in the southeastern part of the district, about 5 miles southwest of the Eldorado mine, near the head of Cyclopic Wash, at about 4,500 feet elevation, on open ground. It was discovered in the early eighties by Patterson, Rowe, and Glen, and about 1896 it was leased to a Seattle company. In 1901, with the Golden Rule mine, it was sold to Robbins & Walker, of Minneapolis, who milled some ore. The coarse tailings still on the ground are said to contain about $7 in gold to the ton. Since 1904 the mine has been owned by the Cyclopic Gold Mining Company, of Denver. A considerable amount of bullion is said to have been produced, but the exact amount was not ascertained.

Developments.—The mine is developed mainly by shallow, mostly inclined shafts, drifts, and crosscuts to a maximum depth of about 70 feet, but most of the workings do not extend below 30 feet. The developments probably aggregate about 1,000 feet of work.

As the mine is located in a broad wash, some of the workings have become filled with wash débris at times of flood. The principal equipments are an Ellspass mill, operated by a 26-horsepower engine, and a cyanide plant. The water supply is pumped by a small gasoline plant from the west side of the range, several miles distant.

Geology.—The country rock is a medium-grained coarsely porphyritic granite. It outcrops in association with the deposits and forms the foothills immediately on the southwest. Paralleling this rock, the wash, and the deposits on the northeast, and constituting the ridge on which the office and other buildings stand, is a fine-grained reddish granitic rock, with which is associated some of the same biotite granite that underlies the Eldorado mine. In contact with the deposits, particularly to the northwest, there is also a coarse red pegmatite.

Deposits.—The deposits are ill defined and not well understood. They consist of gold-bearing iron-stained breccias and sands of vein quartz, in a few places somewhat resembling conglomerate. This material is cemented by silica and iron oxide, but is in part loosely coherent. It trends from a point near the mill N. 57° W. up the wash and is contained in, and for the most part seems to occupy, an area three-fourths of a mile in length by about 200 feet or more in width. Prominent reefs of silicified iron-stained breccia several or more feet in width outcrop several feet above the surface. They are in practically all respects identical with the croppings of the Golden Rule and other veins that have been described. They do not, however, as a rule, continue in depth in the manner of a fissure vein, nor seem to have any definite fissure wall, but usually at a short distance below the surface give way to less firm material having an imperfect synclinal structure. In the northern part, the pseudovein croppings dip toward each other and their attitude suggests that they may be synclinal limbs of the same vein deposit.

From the principal openings near the mill in the southeastern part of the deposit the croppings representing the main or Cyclopic vein extend N. 57° W. They are continuous for the first 400 feet and are accompanied by some underlying vein quartz or ore and show ore in sight at both ends of the 400-foot excavation. Between this vicinity, however, and the northwest limits of the deposits, the croppings of the vein are interrupted, and some pits and cuts have failed to find ore there.

The croppings of the other vein extend without interruption from a point about one-fourth of a mile northwest of the principal opening for a distance of 350 feet to the northwest. They are nearly parallel with the main vein, from which they are about 350 feet distant.

The ore thus far has been derived mostly from these veins, but crosscuts 80 feet or more in length have been run in a considerable portion of the deposits between them and report fair values, which, however, seem to occur in lines or zones paralleling the deposit. Practically no mining has been done below a depth of about 30 feet. Near this level there is reported to occur a bed of red clay or gouge, which was formerly supposed to mark the lower limit of the ore, but

ore is said to have been found below it. The altered granite for a width of 100 feet or more bordering the deposit is also said to contain $2 to $4 a ton in gold.

The ore is of low grade, and is said to mill on the average from $7 to $8 a ton in gold, and to cyanide well. It contains also a little silver and a trace of copper, the latter occurring chiefly as malachite and not in sufficient amount to interfere with the cyanidation. The company is reported to have recently computed about 1,000,000 tons of ore in sight.

GOLD BELT MINE.

The Gold Belt mine is located on the southeast side of Banker Wash, at about 5,000 feet elevation. It is owned by Henry Paully. The country rock is an amphibolite schist, dipping about 30° W. At the western of the two principal openings the deposits are contained in a blanket vein of quartz 15 feet thick, inclining gently eastward, but thinning out in a distance of about 30 feet. The eastern opening shows two quartz blanket veins, each 2 to 6 feet in thickness, dipping gently westward and separated by a 4-foot dike of some volcanic rock that seems to be basalt, but is altered beyond identification.

The ore is said to be of two grades, the lower grade yielding from $4 to $7 in gold to the ton and the better grade from $16 to $20 to the ton and some as high as several hundred dollars a ton, that occurring in the porous or honeycombed quartz being the best. The deposit is reported to have produced a few hundred dollars' worth of ore.

SENATOR MINE.

The Senator mine is located some distance beyond the border of the Gold Basin district, about 7 miles northwest of the Eldorado and Golden Rule mines and about 7 miles south of Colorado River, on a low round hill at the southeast base of a prominent landmark known as "Senator Mountain." The mine was discovered late in the eighties by John Burnett, who in 1892 sold it for $14,000 to Senator Page, of Los Angeles, who in turn sold it to a Colorado company. The company at once installed a 10-stamp mill on Colorado River, 2 miles below Salt Springs, operated the mine and mill for about six months, and then suspended. Later the property was acquired by or leased to the Salt Springs Mining Company, which operated it about a month in 1903 and shut down, the ore being of too low grade to pay for its haulage to the mill, 7 miles distant, and for bringing supplies from Hackberry and Kingman, 50 and 60 miles distant, respectively. The mine is reported to have been abandoned since then.

The mine is developed principally by open work, cuts, and adit drifts. The deposits are said to be nearly flat lying and similar in character to those of the Cyclopic mine (p. 125), but they form a

larger body. The ore is said to be similarly low in grade, averaging about $3 in gold to the ton. According to Comstock,[a] the deposits exhibit structural features resembling those of "brecciated fusion" and "cooling lamination" and in origin seem to be associated with igneous intrusion.

DEPOSITS AT SALT SPRINGS.

The Salt Springs mine is about 7 miles northeast of the Senator mine and several miles south of Colorado River, in the first canyon west of Hualpai Wash. It is owned by the Salt Springs Mining Company, which is said to include members of the Arizona-Minnesota Gold Mining Company. The country rock is granite. The gold ore is said to occur sporadically in quartz bodies, and its downward limit is usually indicated by copper-stained quartz.

Other properties in this district are the Smuggler-Union group, the Eureka mine, and the Lutley group.

WHITE HILLS DISTRICT.

GENERAL DESCRIPTION.

LOCATION AND HISTORY.

The White Hills district is located about 28 miles north of Chloride, in the western border of the White Hills, at about 3,000 feet elevation. It comprises an area about 2 miles in diameter and is a part of the Indian Secret mining district, so named because the knowledge of the presence of its mineral was for a long time withheld from the whites by the Indians.

The first discovery of mineral in the district by white men was made by Henry Shaffer in May, 1892, through the aid of an Indian known as Hualpai Jeff, who exhibited a piece of rich silver ore at Gold Basin and showed Shaffer its source, where the Indians procured the supply of red iron oxide with which they adorned their faces. The locality is at the site of the Hidden Treasure mine.

After making several locations, Shaffer reported the discovery at Gold Basin and was soon joined by John Burnett and John Sullivan, who also located what later proved to be some of the best mines. The trio began work and were soon shipping very rich ore, some averaging $1,000 a ton. The camp soon became the largest in the region and reached its zenith in 1894, with a population of 1,200. Within a short time the camp was owned by one company, the White Hills Mining Company, of which the chief men were R. T. Root and D. H. Moffatt, of Denver. A 10-stamp mill was built early in 1904; in

[a] Comstock, Theodore B., Geology and vein phenomena of Arizona: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 1048–1049.

large part, it is stated, to work the dumps, which had grown huge. It was a complete success.

About 1895 the property was sold for $1,500,000, according to reports, to the White Hills Mining and Milling Company, an English concern, with headquarters at London and Colorado Springs. With only a moderate amount of ore in sight, this company installed a new, fully equipped 40-stamp mill, which was never worked to its full capacity and is still standing in good condition at the edge of the hills about one-fourth of a mile south of town; an electric-light system, and an elaborate water-supply system, including 7 miles of 7-inch wooden pipe line; a large reservoir and iron hydrants of city style, at a total cost said to exceed $150,000. As the company failed to make its final payment the property was put up at sheriff's sale and bought in by the former owners, Root and Moffatt, who are said to still own it.

DEVELOPMENTS.

The developments in the district, some of which extend nearly 1,000 feet in depth, consist principally of inclines, shafts, and drifts, aggregating probably considerably more than 10,000 feet of underground work. A plentiful supply of excellent potable water, ample for milling purposes, is usually reached at a depth of 400 to 600 feet and is now present in four of the mines.

While in operation the source of power used in the mills was coal hauled from Kingman, and the joshua trees, or yucca palms, supplied fuel for the steam hoists at the mines. The principal surface equipments of the camp now on the ground, besides the mill, hoists, trams, etc., at the mines, are a large concrete reservoir and numerous, mostly vacant, frame buildings, including offices, stores, dwellings, a church, and a schoolhouse—in all but a remnant of the former town. These are situated in the southern part of the district on White Hills Wash and mostly on Main street, which trends nearly east and west, as shown in the sketch map (fig. 21). The place now contains a store and the White Hills post-office, and regularly operates a stage and mail service with Chloride and with Eldorado Canyon, Nev., with which points it also has telephone connections.

TOPOGRAPHY AND GEOLOGY.

The surface is hilly but, except on the east, not rugged, and the district drains westward into Detrital Valley, mostly by small washes and their tributaries.

The country rock is principally light medium-grained gneissoid granite containing garnet with some associated dark amphibolite schist. The schistosity dips to the northwest but varies greatly, the

rock being folded and faulted. It is overlain on the east by the Tertiary volcanic rocks, which in turn are capped by younger basalt.

The gneissoid granite, in which all the deposits occur, contains principally orthoclase, quartz, microcline, and garnet. In many places the garnet is abundant, some of it occurring as large phenocrysts, and locally the rock is traversed by 2½-foot bands or zones, fully two-thirds of which are composed of garnets about one-fourth of an inch in average diameter.

The Tertiary volcanic rocks on the east consist principally of gray vesicular altered hornblende-augite andesite, or possibly latite, as they seem to contain much orthoclase and have a trachytic groundmass. They occur principally in an elongated ridge overlying the gneiss on the east and are about 600 feet in thickness. The upper 100 feet is principally a volcanic agglomerate. This rock is capped by dark vesicular normal olivine basalt, about 20 feet in thickness, which seems to cap also Senator Mountain, Squaw Peak, and other buttes in the vicinity.

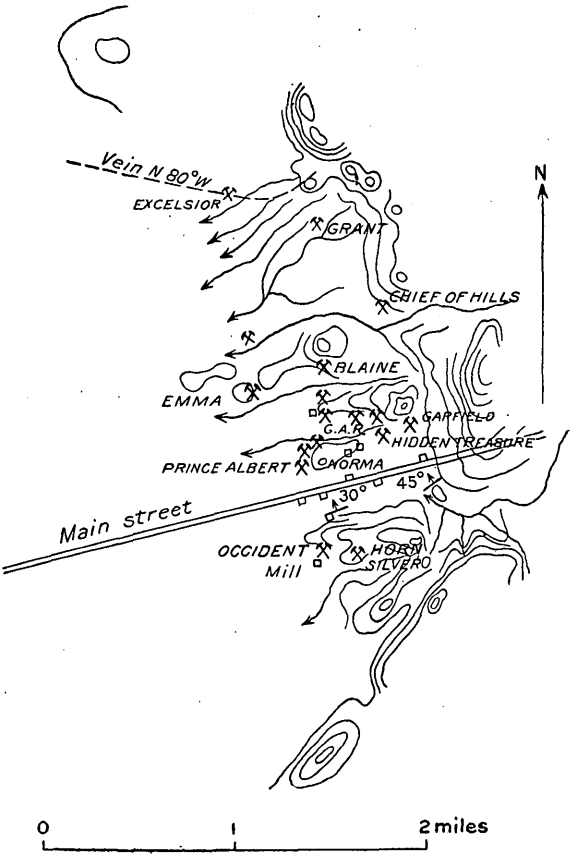


FIGURE 21.—Sketch map of White Hills district.

DEPOSITS.

The deposits are principally quartz veins, some of which are blanket veins or have a low dip. They average about 3 feet in width and in general dip to the northeast at angles of 20° to 80°. Associated with them locally are considerable manganese and iron oxide. The ore, which seems to be oxidized to the bottom of the mines,

contains chiefly chloride of silver with local values in gold, and is usually rich, being reported to average about $200 in silver to the ton. A 19-ton carload of the ore shipped to the smelter in 1894 is reported to have contained 29,000 ounces of silver and 80 ounces of gold. The miners report the best ore to occur in the "white porphyry," which seems to mean the light phase of the granitic gneiss.

The presence of yellow and brown material resembling the altered igneous rock in or associated with the veins suggests that the fissures, which the veins now fill, may formerly have been occupied by dikes of minette or vogesite that the veins have replaced. It is possible that these dikes may belong to the same period as the Tertiary volcanic rocks on the east, which at one time must have deeply buried the entire district, but it is more probable that they are very much older.

PRODUCTION.

The production of the district, which is known to be large, is reported to be about $3,000,000. Prior to the acquisition of the property by the White Hills Mining Company many lessees are reported to have made fortunes ranging from a few thousand dollars to $25,000, each from surface workings. During the first fourteen months of its ownership the White Hills Mining Company is reported to have shipped ore that netted at the Denver smelters $242,000, and throughout the period in which it operated the property large shipments of bullion are reported to have been regularly made.

MINES.

The district contains about 15 mines, of which the most important are the Prince Albert, Norma, Grand Army of the Republic, Occident, Horn Silver, Hidden Treasure, Good Luck, Excelsior, Garfield, Daisy, Bryan, Chief of the Hills, West Treasure, African, and Grand Central. They are nearly all situated within three-fourths of a mile of the camp (fig. 21) and were all discovered about the same time. A brief sketch of some of them follows. Only a few of the smaller ones in the northern part of the district are now being worked. The Occident and Horn Silver mines are situated in the hills south of town and the remainder are to the north of it.

GRAND ARMY OF THE REPUBLIC MINE.

The Grand Army of the Republic mine is located on Grand Army Wash, on open ground about three-fourths of a mile north of Main street. It is extensively developed to a depth of 700 feet, mainly by inclines, drifts, stopes, and shafts distributed on five levels, in part approximately as shown in fig. 22, the inclines being descended by tram tracks, which, together with the hoists, are still in place. Water level is reached at a depth of about 600 feet. The immense dumps indicate that much work has been done.

The country rock is gneissoid granite and schist. It is very highly altered and iron stained. The deposits are contained in two nearly parallel veins, situated about 30 feet apart, the main one being the lower. At the mine the veins strike N. 62° W. and dip about 23° NE., and the country rock seems to dip with them, but is much disturbed. At a point 150 yards southeast of the mine, however, the dip of the veins increases to about 75°, and farther on, about one-fourth of a mile from the mine, the veins appear in the West Treasure shaft, to which openings show that they are continuous from the G. A. R. mine.

In the G. A. R. mine the ore is free-milling, and much of it is very rich, some being said to average 6,000 to 7,000 ounces of silver to the ton. The mine is reported to have produced much rich ore from all its five levels. During a considerable portion of the Root-Moffatt régime the main force of the miners worked here, sometimes more than 100 men stoping at once.

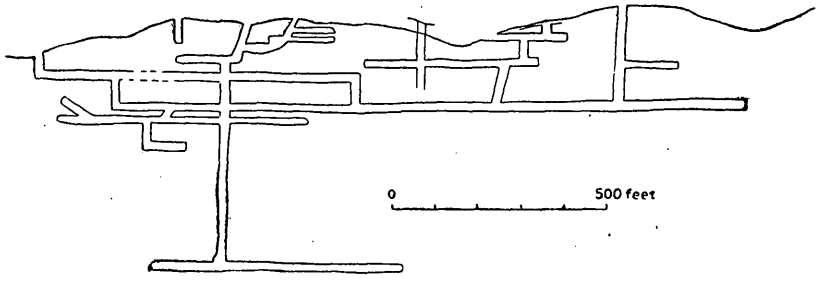


FIGURE 22.—Longitudinal section of G. A. R. mine.

WEST TREASURE MINE.

The West Treasure mine is located near the head of Grand Army Wash on the G. A. R. veins, especially on the upper vein, which is here about 20 feet distant horizontally from the lower vein and dips 65° N., while the dip of the lower vein is about 55° in the same direction. The veins seem to join each other at no great depth, and their junction has probably enriched the ore body in this mine. A large dump shows that much work has been done and the mine is reported to have been productive.

HIDDEN TREASURE MINE.

The Hidden Treasure mine is northeast of the West Treasure mine, immediately north of White Hills Wash and the upper part of town, in the east slope of the ridge, on the same G. A. R. vein. Here the vein strikes N. 80° E. and dips about 70° N. It is about 3 feet thick and is accompanied by 2 inches of reddish-brown oxidized gouge, between which and the rock wall of the fissure is an inch or two of greenish crushed rock gouge. The oxidized reddish-brown

iron-stained croppings were the source of the Indian face paint that led to the discovery of the district.

The country rock is amphibolite schist, which near the mine is greenish from the presence of epidote. It dips 20° NW.

The mine is equipped with a large steam hoist and a shaft house and has a deep shaft, but as the ore, according to report, is too base and refractory to be handled by the White Hills mill, the mine has not been extensively developed.

NORMA MINE.

The Norma mine is located in the same east-west ridge as the Hidden Treasure mine, immediately north of the town in the south side of the ridge, toward its east end. It is developed principally by shafts, drifts, and stopes to a reported depth of 600 feet. Its works, especially the tunnel, are said to extend through the ridge, coming out on the north side. In fact, a considerable portion of the ridge has been so undermined by the workings that it is said to stand on "stilts." The distribution of a part of the Norma workings is shown in the accompanying diagram (fig. 23). The dumps are large.

The country rock dips 35° N. The vein containing the deposits strikes N. 80° W. and dips about 70° N. It widens from 3 feet at the surface to 8 feet in the deeper part of the mine and contains much gouge or crushed and altered granite. The hanging wall is well defined and smooth. The production of the mine is reported to be large, but exact figures are not available.

AFRICAN MINE.

The African mine is north of the Norma mine, in the north side of the same ridge and seemingly on the same vein. It is said to be but a few hundred feet in depth and has not been extensively worked.

PRINCE ALBERT MINE.

The Prince Albert mine is immediately north of the town, in the western part of the ridge containing the Norma mine. It is developed to a depth of 300 feet or more, principally by inclines opened on the two sides and the west end of the ridge. It contains three productive, nearly flat-lying veins, which dip about 30° NNE. The two upper veins are about 75 feet apart and the lowest is 25 feet below the middle one. They lie in a dish or shallow syncline and are thought to connect with the Norma vein on the east. The veins, especially the two lower ones, descend nearly to the edge of the wash, and seem to converge on the African claim and near the Daisy mine.

The mine was a heavy producer in the hands of lessees. Its royalties of 20 per cent are reported to have amounted to $30,000 in

a short period. It seems to be mostly worked out so far as the oxidized zone is concerned, but is reported to contain much good ore still.

DAISY MINE.

The Daisy mine is located northeast of the Prince Albert mine, of which it is almost a continuation, in a flat of Grand Army Wash, where the converging Prince Albert veins seem to unite in a sag in the slope of the hill, with the Norma and the African situated just to the east. The vein strikes about east and west and is developed to a reported depth of 500 feet by shafts and other workings, which incline at angles of about 45° with the vein. There is a large dump of highly oxidized material. The production is said to be large and came in part from a very rich $300,000 ore shoot.

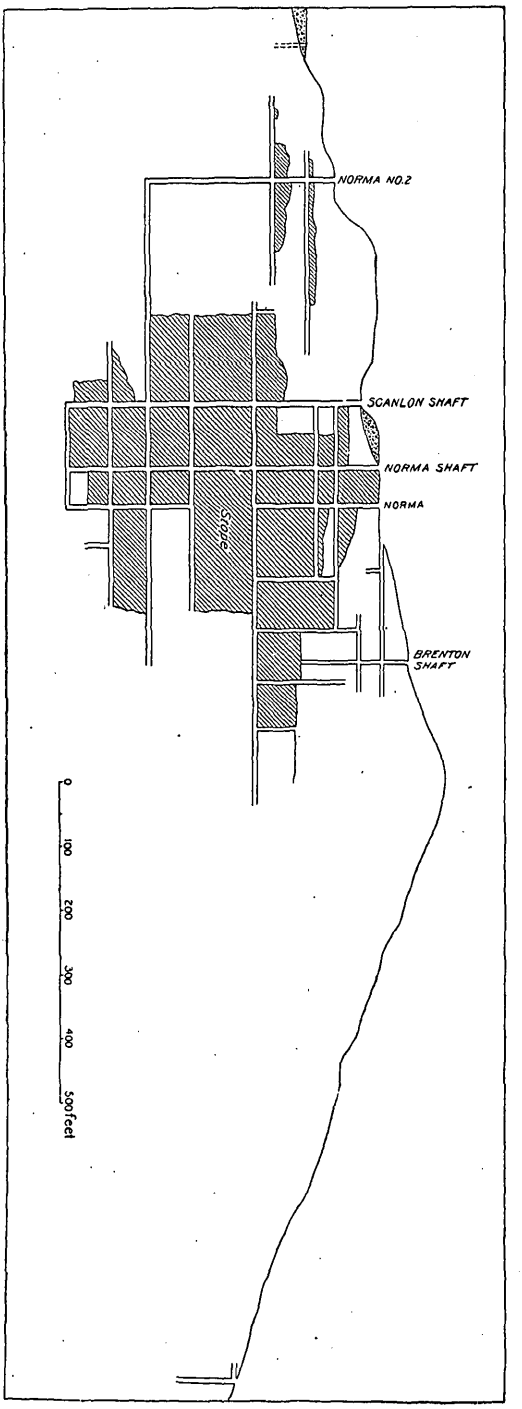


FIGURE 23.—Longitudinal section of Norma mine.

GARFIELD MINE.

The Garfield mine is located near the head of Grand Army Wash. Its workings are said to extend inward 150 feet. It was worked principally by lessees, who operated from the gulch and stoped upward. The production is reported to be about $60,000.

BRYAN MINE.

The Bryan mine is about a mile northwest of town. It is said to be developed to a depth of 240 feet. It has produced considerable rich surface ore and is reported to contain good milling ore all the way down.

CHIEF OF THE HILLS MINE.

The Chief of the Hills mine is northwest of the G. A. R. mine, near the head of the first wash north of G. A. R. Wash. It is said to be worked to a depth of about 200 feet, and has produced rich surface ore.

GOOD LUCK MINE.

The Good Luck mine, owned by A. L. McKesson, in the western part of the district, is said to have produced considerable ore. A few tons shipped in May, 1906, are reported to have averaged several hundred dollars a ton in silver and gold.

EXCELSIOR MINE.

The Excelsior, formerly the T. W. mine, is located in the northern part of the district, about 1½ miles north of the town, on open ground. It is one of a group of eight small mines or claims recently acquired by the Mohave Gold-Silver Company, with headquarters at Los Angeles. The mine is developed by a 185-foot shaft and drifts, but as the shaft had caved a new shaft 40 feet deep was being sunk at the time of visit. The dumps show considerable old work done, mostly of chloriders, who left much good ore.

The country rock is the gneissoid granite, deeply oxidized and iron stained. The vein containing the deposits is 3 to 4 feet thick, dips very steeply north or is about vertical, and seems to be about one-fourth of a mile in length. The ore usually occurs in a shoot about 7 inches in width and contains silver chloride and gold. It is all good milling ore and at the time of visit the company was planning to install a 10-stamp mill.

OCCIDENT AND HORN SILVER MINES.

The Occident and Horn Silver mines are about one-fourth of a mile south of town just east of the mill, mainly in the south side of an east-west ridge. They are situated near together on overlapping claims. They are both seemingly on the same vein, which is 2 to 4 feet in width, and contains chiefly reddish-brown iron-stained crushed and brecciated quartz or ore. It is steeper than the veins

north of town and dips about 60° N. The ore contains principally horn silver. Both mines are reported to have been heavy producers.

The country rock is the granitoid gneiss and schist complex. It dips about 30° N. At the Occident mine the rock is gneissoid granite; at the Horn Silver it is a gray schist.

The Occident mine is said to be 800 feet deep and to be extensively developed by drifts and stopes. A long drift to the west from the bottom of the shaft is said to penetrate much good ore. The mine produces a plentiful supply of good water. In the Horn Silver mine the vein flattens somewhat with depth and has been worked in part by inclines. Figure 24 is a section of the underground workings of both mines.

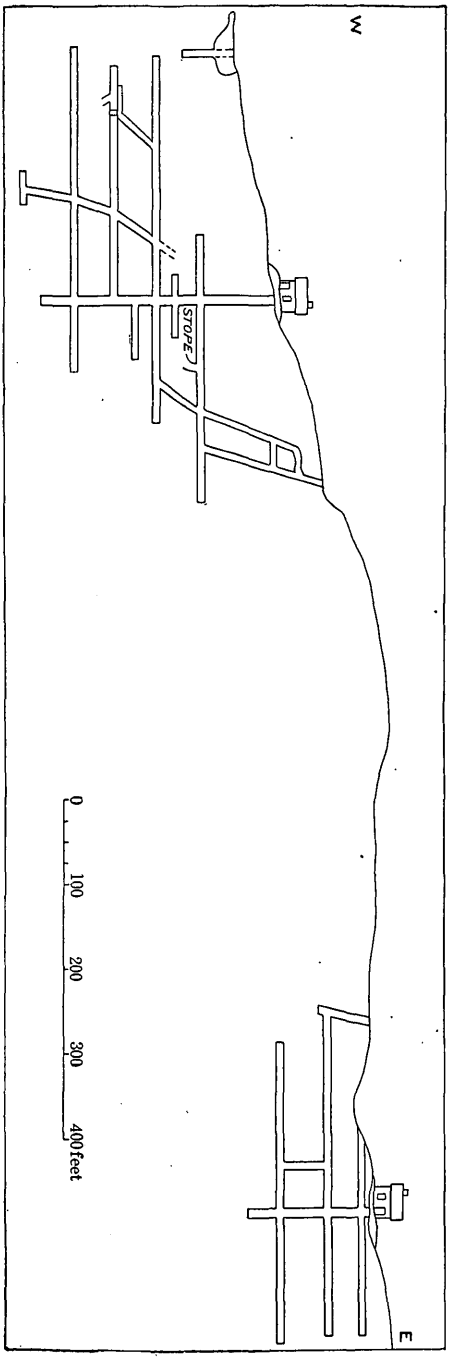


FIGURE 24.—Longitudinal section of Occident and Horn Silver mines. The Horn Silver is east of the Occident.

M'CONNICO DISTRICT.

GENERAL DESCRIPTION.

The McConnico district lies about 6 miles southwest of Kingman, southeast of McConnico station on the Santa Fe Railway, in the border of Sacramento Valley and the adjacent low foothills and scarp of Kingman Mesa, between elevations of 2,800 and 3,500 feet. It trends north and south and has a length of about 4 miles.

The country rock is principally pre-Cambrian granite, which in the valley portion of the district is covered by wash débris. The ore deposits are contained principally in gold-bearing pegmatite dikes and shear

zones, cutting the granite in a northerly direction and, in some places, are associated with later basic intrusives. The principal deposits are those of the Bi-Metal mine, the McKesson group, and the Boulder Creek group.

A good spring, Boulder Spring, occurs in the southern part of the district and water can probably be reached almost anywhere at the depth of a few hundred feet below the surface.

Specular iron occurs a short distance south of the McKesson mines. Titanite is reported in the country rock granite southwest of the Bi-Metal mine. Amethyst, associated with some stibnite and galena, is found about one-fourth of a mile northeast of Boulder Spring, in the foothills, probably as a vein pegmatite dike. This amethyst-bearing property is owned by Kinsman & Solomon. It is developed by a 65-foot shaft and has produced some good stones.

BI-METAL MINE.

Location and development.—The Bi-Metal mine, also known as the McGuire mine, from the name of its owner, who lives near by, is in the northern part of the district, about 3½ miles from Kingman, close to the railroad, in the basal west slope of Kingman Mesa. The mine is developed principally by about 250 feet of open cut, 130 feet of tunneling, and a shaft 80 feet in depth. From the mouth of the tunnel the slope of the surface is about 30°.

Geology.—The country rock containing the deposits is an altered and mineralized pre-Cambrian microcline granite. It occupies an area about 300 feet in diameter and locally seems to change into detrital masses, containing pebbles, cobbles, and bowlders of very dark to very light gray granite and schist ranging up to 2 feet or more in maximum diameter.

The structure, consisting of sheeting and cleavage, dips about 45° N., and has for the most part obliterated or obscured an older and more general north-south sheeting. Another system of jointing also dips westward about parallel with the surface slope, as shown in both the tunnel and the cut.

On the south the boundary of the mineralized area is marked by a dark-gray intrusive dike rock, which cuts the granite, contains inclusions or fragments of it, dips about 45° N. beneath the deposit, and is encountered in the bottom of the shaft. This dike rock is medium grained and consists essentially of a groundmass of plagioclase prisms containing pale-greenish hornblende phenocrysts, of which the largest are about three-fourths of an inch in length. The solutions which mineralized the deposits may have accompanied or closely followed the intrusion of this rock. On the west, toward

the railroad, the deposit is obscured by wash and débris. On the east the deposit seems to terminate above the mine at a point about where the slope steepens with overburden talus, but it may extend beneath this talus upward toward the top of the mesa and may possibly connect with a similar deposit about half a mile to the northeast.

Deposits.—The values contained in the deposits consist essentially of fine-grained free gold. As seen in the face of the tunnel and the bottom of the shaft, both the granite and the dark dike rock carry considerable iron pyrites and, according to reports, but very little gold. The same is true of the mineralized granite on the surface to the north and south of the deposit. In the oxidized and mineralized zone, however, this pyrite, particularly in the granite, has weathered out and given rise to the hematite and other forms of iron that so brilliantly stain the rock, and has left cavities or receptacles in which the gold now contained in the deposit seems to have become concentrated. Wherever this oxidized rock is crushed and panned or horned it yields a long string of fine, bright gold, and in some small gullies or lines of drainage within or at the border of the area, where further concentration by flowing water has taken place, several tablespoonfuls of mostly coarse gold, of which some of the largest nuggets contained about half a dollar each in gold value, are reported to have been panned. The gold is said to be of high grade, worth $19.50 an ounce.

The free gold to which the deposits owe their value seems to have been derived from a considerable thickness of overlying mineralized rock. As this overlying rock became disintegrated and was removed by erosion the fine gold liberated from it gradually worked into the underlying rocks in which it is now found. Below or outside of the oxidized zone of mechanical concentration probably only very low-grade ore occurs.

The mine is reported to have produced some gold, more than enough to pay for development, the gold being won principally by the use of rockers.

M'KESSON GROUP.

The McKesson group of mines is located near the middle of the district, toward its west side, on open ground in the border of Sacramento Valley, at about 2,800 feet elevation. The group comprises five or six openings situated on as many different claims within an area half a mile in diameter. The properties are all in the prospect stage and are developed principally by shallow shafts to a maximum depth of about 50 feet. They are practically all on pegmatite dikes that cut the pre-Cambrian granite. The dikes in general trend northerly, are from 2 to 10 or 12 feet in width, and contain gold in places. They also contain small bodies or stringers of quartz, some

of which is porous where its iron content has dissolved out. Whether the pegmatite, however, is primarily gold bearing or whether the gold has accumulated in its porous oxidized zone in the manner described in the Bi-Metal mine has not been satisfactorily determined. That such concentration of gold may represent the principal part of the values contained in the surface part of the deposits seems probable.

The principal deposits of the group are the McKesson "Ledge," the Santa Fe vein, and the Spot Cash prospect.

BOULDER CREEK GROUP.

The Boulder Creek group, consisting of eight claims, is situated in the foothills in the southern part of the district, at about 3,200 feet elevation. The topography is gentle and all the properties are accessible by wagon road of easy grade.

Traces of gold have been known in the region for many years and this property was discovered and located by A. L. McKesson about April, 1906, by dry washing or panning. It is now owned by the Grand Consolidated Gold and Silver Mining Company, of San Francisco. The property is developed principally by several shallow shafts and pits. Boulder Spring is located near by on the north.

The country rock is a pegmatitic granite, which is somewhat schistose and weathers into bowlders up to 60 or 80 feet in diameter. About half a mile to the southeast, 200 feet above the mine, the rock is capped by the dark lavas of Kingman Mesa.

The deposits are contained principally in two ledges, which are probably dikes, but may be merely mineralized zones in the pegmatitic granite. They lie at nearly right angles to each other and form a T-square, of which the top trends northwest-southeast and the stem extends to the southwest. The latter varies from about 100 to 1,000 feet in width, and has a known length of about one-fourth of a mile. Where opened on the northeast in the Baby Mine shaft to a depth of 30 feet it consists almost wholly of red oxidized pegmatite and is in places porous or honeycombed, where seemingly iron pyrites has been dissolved. More than half of all the material excavated from the shaft is piled up as ore and is said to contain from $3 to $100 in gold to the ton.

The northwest-southeast ledge likewise has a maximum width of about 1,000 feet and is reported to have a known extent of about a mile. It is composed of coarse granite similar to that in the Baby mine shaft. A considerable portion is stated to be ore. That from the openings on Baby Mine claim No. 2 is reported to average about $12 in gold and 20 ounces in silver to the ton, and contains also some galena and chalcopyrite.

MAYNARD DISTRICT.[a]

GENERAL DESCRIPTION.

The Maynard district is a large indefinite area in the Hualpai Mountains. The district is said to be easily reached from Kingman by a good road crossing the summit of the range via Wheeler Pass. Water can be derived from most of the mines, and pine timber suitable for mining purposes grows near by.

The first important discovery of mineral in the district was made about 1865 by a party of prospectors headed by John Moss. They located the mines known as the Pride of the Pines and the Florence, and named the district Wauba Yuma district. Soon after beginning operations they were driven from the mountains by the Hualpai Indians, then on the warpath, who continued hostile for several years following.

In 1871 Lieutenant Wheeler's party, of the War Department, in making a reconnaissance in the Territory, camped on what is now known as Wheeler Wash, on the east side of the mountains. A large party of prospectors from San Francisco soon camped near by, made locations, named the district the Maynard district after Lafayette Maynard, one of its pioneer members, and elected a recorder. The first location made was named the Wheeler lode. For a decade or more, beginning in the early seventies, the district furnished a livelihood to a considerable number of people, whose operations were confined to the rich surface ores in the oxidized zone.

The country rock is mainly pre-Cambrian red granite, said to be intruded by porphyry dikes. The zone of mineralization in which most of the deposits occur lies on the northern and eastern slopes of the mountain. In this zone the deposits are contained in strong and persistent fissure veins similar to those in the Cerbat Mountains. The width of the ore ranges from 1 inch to 3 feet. It contains principally horn silver and is usually rich, especially so where the green horn silver (bromyrite?) is present. Some of the deposits also contain copper. Among the most important of the veins are those of the American Flag, Enterprise, Great Eastern group, and Siamese group. They are mostly situated in alignment with the principal system of the Cerbat veins, agree with them in strike, and are probably contemporaneous with them in age and of the same general origin. The production of the district is reported to be fairly large.

Other metals reported to occur in the Hualpai Mountains are molybdenite, found in association with copper, and native quicksilver, associated with lead carbonate, the latter being on a claim owned

[a] Owing to lack of time this district was not visited by the writer. The account of it is compiled principally from statements found in the Mohave County Miner, verified and supplemented by verbal reports of pioneer citizens and men who have worked in the mines.

by Mr. Jackman. Just beyond, in the Aquarius Range, about 50 miles from Kingman, is a tungsten mine which annually produces 25 tons of tungsten ore, worth $400 a ton at Kingman, whence it is shipped.

AMERICAN FLAG MINE.

The American Flag mine is about 16 miles southeast of Kingman, on the eastern slope of the mountains, at about 5,000 feet elevation. It is reached from the wagon road near the summit by a 2-mile trail. The mine was discovered in 1874 by W. M. Shoulters, who is said to have sold it, after working it a short time, to John Pemberthy, William Richard, John Corin, and Joe Prisk for $25,000. These men developed it principally by adit drifts. The water level is said to lie at about 700 feet below the surface. The mine is now owned by a company of which John Pemberthy and H. H. Watkins, of Kingman, are members.

The country rock is granite. The main vein is from 1 to 4 feet in width, and the ore shoot is said to be relatively large. The ore contains principally antimonial silver, some gold, and a little zinc. Much of it is rich.

The production is reported to be about $400,000, sold from the mine, in ore that averaged more than $100 a ton. For 21 tons of the ore from the lower part of the mine shipped to Swansea, Wales, a net return of $11,500 is said to have been received.

GREAT EASTERN GROUP.

The Great Eastern mine is about 16 miles from Kingman, on the eastern slope of the mountains, about 3 miles north of the American Flag mine. It was discovered in the early seventies, and is owned by the Great Eastern Mining Company.

The deposits occur in several strong fissure veins, which strike northwesterly and are associated with a contact between the granite and "porphyry." The most important is known as the Great Eastern vein. It is opened by about 300 feet of tunnel and drifts with good results, the ore shoot being continuous for an extent of about 130 feet. The ore contains principally silver and galena, with small values in gold and copper.

ENTERPRISE MINE.

The Enterprise mine is located about east of Kingman, in the northeastern slope of the mountains a few miles north of the Great Eastern mine. The property comprises a group of six claims. It is owned by the Enterprise Mining Reduction and Improvement Company.

The mine is developed to a depth of 300 feet by a vertical shaft, drifts, and crosscuts, aggregating about 600 feet of underground work. The principal equipment is a steam hoist, capable of sinking to a depth of 1,000 feet. Water, and wood at $2 a cord, are available near by and timber suitable for mining purposes can be had about 3 miles distant.

The country rock is granite. It is intruded by " porphyry," which is also associated with the veins. The deposits are contained in several veins which strike northwestward. The principal vein dips steeply to the northeast, is from 6 to 14 feet or more in width, has well-defined walls, and, to judge from its croppings, which are prominent, and prospects, has a length of more than a mile. The ore shoots are strong and persistent. The ore contains principally galena, pyrite, and chalcopyrite, with good values in gold and silver. Small lots of about 1 ton each of sulphide ore treated at the Llewellyn test plant in Los Angeles, were concentrated 6 into 1 and gave values of $81.37, $62.29, and $57.08 a ton.

OLD HACKBERRY MINE.

In the northeastern part of the district are a number of mines of which the best known is probably the famous Old Hackberry mine. It is about 14 miles northeast of the Enterprise mine, in the eastern slope of the Peacock Mountains, an outlying range of the Hualpai Mountains, near the old town of Hackberry. It was for many years a heavy producer and is credited with a production of $1,000,000. The ores are said to have been treated by the chlorination process.

SIAMESE GROUP.

The Siamese Group mine is situated on the southern part of the east slope of the Hualpai Mountains, in the Cedar Valley district, at about 5,000 feet elevation. It is best reached from Yucca, from which it is 23 miles distant in a southeasterly direction. A wagon road extends to a point within 5 miles of the mine, with which connection is made by trail.

The property comprises nine claims. It is reported to make a very good surface showing and to be promising in copper. Since 1907 it has been owned by the Arizona-Southwestern Copper Company, with headquarters at Kingman.

The property is in the prospect stage and is developed principally by two 15-foot shafts, cuts, and surface pits. Water is present on the property, and water level is believed to lie at about 100 feet below the surface.

The country rock seems to be the pre-Cambrian granitoid complex. It is intruded by " porphyry " near by. The deposits are contained

principally in a large fissure vein, which strikes north-northwest, and the quartz croppings have a length of nearly 2 miles.

The gangue is principally quartz, and the ore contains copper, lead, silver, and gold. Average samples of the ore collected from an ore shoot about 4 feet in width in the lower part of the two shafts on Siamese claims Nos. 1 and 2 gave assay returns about as follows: Silver, 14 ounces to the ton; copper, 4 per cent; lead, 9 per cent; zinc, 2 per cent. Another test, made of a presumably select sample from the same shaft, though the manner of collection is not stated, is said to have given 10.5 per cent of copper, 16 per cent of lead, and 35 ounces silver and $1.60 in gold to the ton. The ore is said to be good concentrating ore.

GRAND WASH CLIFFS.

MUSIC MOUNTAIN DISTRICT.

GENERAL DESCRIPTION.

Location and history.—The Music Mountain district lies about 25 miles north of Hackberry, in the foothills of the Grand Wash Cliffs. It comprises principally an area about 3 miles in diameter, ranging in elevation from about 3,000 feet at the border of the valley to 4,000 feet on the east. The camp is located toward the southeastern part of the district, near the head of Camp Wash, at about 3,400 feet elevation.

Mineral was discovered here in 1879 or 1880, some of the discoverers and locators being Dave Southwick, Ed Burk, Bill Hatch, and Joe Prisk. Many of the claims began at once to produce. Most of the early work was done by lessees, the ore being treated in arrastres or shipped; later much of it was milled on the ground. The recent history of the camp is practically synonymous with that of the Ellen Jane mine. A chief drawback to the camp has been lack of water.

Production.—Concerning the production of the camp, figures of which are not available, the following data were gathered. Much rich ore was produced by lessees in pioneer times from nearly all the principal veins. At that time the Burk claim, now called the Golden Serpent, produced considerable ore that averaged from $300 to $400 a ton in gold and at present some of its ore contains 7 to 8 ounces of gold to the ton. The Ellen Jane mine in 1892 produced 165 tons of $32 ore, and later a smaller lot of $42 ore. The Lucky Cuss vein and the Marie E. vein are known to have produced considerable, all of which, together with what has been produced by the other veins, probably considerably exceeds $20,000.

Topography and geology.—The surface of the district in general slopes westward into Hualpai Valley (fig. 25). The topography is mostly rough, with several longitudinal ridges locally studded by

cliffs and separated by washes or gulches, some of which head several miles to the east near the summit of the cliffs and the Colorado Plateau.

The country rock is principally granite, which in part belongs to the pre-Cambrian gneiss and schist complex, while the greater portion seems to be younger. The pre-Cambrian rocks are best exposed where they form the core of the ridge just south of the camp. The supposed younger or post-Cambrian granite prevails throughout the greater portion of the district and is especially prominent in North Ridge, northwest of Camp Wash, where it

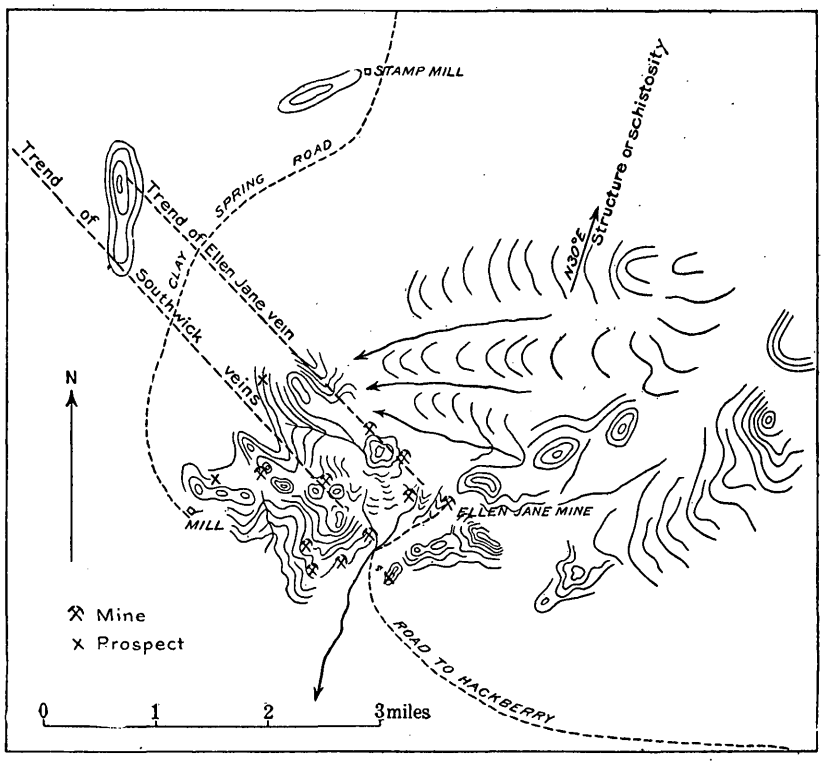


FIGURE 25.—Sketch map of Music Mountain district.

extends to the old mill at the border of the valley on the west. In the northern part of the district it is a relatively fresh-looking medium-grained gray biotite granite, allied to quartz monzonite. In the southern part what is thought to be the same rock is coarse or pegmatitic.

The older or pre-Cambrian country rocks have a well-marked schistosity, which trends about N. 30° E. and dips about 65° SE., and both classes of rocks are cut by a well-marked sheeting that strikes about N. 60° W. with dip about vertical and seems to be decidedly later than the schistosity.

The country rocks are intruded by dikes and masses, both basic and acidic. The most important of the basic rocks is a medium to coarse grained basaltic diabase, which weathers in coarse pieces and nodules and may be of two periods in age. As dikes it is associated with the veins, and as a mass, or possibly a sheet, about 150 feet in thickness, from which the dikes seem to be given off; it trends in a north-south direction across the middle portion of the eastern part of the district and dips eastward into the mountains at angles of about 25°. Remnants of it also in part cap the northeastern part of North Ridge and dip gently to the west.

The diabase-basalt is not affected by schistose structure but is older than the veins and probably also older than the sheeting. It contains fragmentary inclusions of granite and exhibits the other phenomena usually characteristic of an intrusive.

The most important of the acidic intrusives are a coarse granular granite containing much orthoclase, no bisilicates, and no microcline; a fine-grained microcline granite; and a medium-grained purplish-gray granite porphyry. The coarse granular granite is not affected by schistosity and is older than the diabase, probably also than the sheeting. The fine-grained granite is in part schistose, and is earlier than the sheeting, the veins, and the diabase. It may be pre-Cambrian. The granite porphyry is associated with the Lucky Cuss and Southwick veins. It has a micropoikilitic groundmass of quartz and orthoclase and contains phenocrysts of oligoclase, andesine, and biotite. It has no schistose structure and is earlier than the diabase. At the Lucky Cuss mine it seems to be earlier and at the Southwick mine later than the vein deposits.

Deposits.—The deposits are chiefly quartz fissure veins, which in the main dip steeply to the northeast. The principal ones are the Ellen Jane, Lucky Cuss, and Southwick. The Ellen Jane vein lies in the eastern part of the district and has a length of about a mile and a known vertical range of about 600 feet. (See fig. 25.) Its croppings range in elevation from about 3,430 feet in the head of Camp Wash to about 4,000 feet on North Ridge. The vein is best developed in the Ellen Jane mine. Some of the veins may be found to continue in a northwesterly direction underneath the heavy wash of the valley.

About 6 miles east of Music Mountain Camp, at the head of Clay Springs Wash, near the summit of the Grand Wash Cliffs and the Colorado Plateau, deposits of iron ore of considerable extent are reported to occur. The iron ore is locally stained by copper. These deposits seem to lie in the Carboniferous limestone.

ELLEN JANE MINE.

Location and history.—The Ellen Jane mine practically coincides in horizontal extent with the Ellen Jane vein; the main shaft is

situated on the southeastern part of the vein at the head of Camp Wash, about one-eighth of a mile east of Camp, at an elevation of about 3,440 feet. The Ellen Jane claim, on which the main shaft is situated, was discovered and located in 1879 or 1880 by Joe Prisk. It soon became a producer, being at first worked by lessees, and a little later it was owned by W. F. Grounds, of Hackberry, who about 1886 sold it, together with the Tomonotta adjoining it on the west, to the Gold Mining Company, of Washington, D. C., of which General Rosecrans was a member. The company at once became the moving spirit of the camp and installed a 4-roller 8-ton mill, which still stands at the foot of the mountains about 1½ miles west of the camp. The mill is stated to have saved about three-fourths of the gold, but left about $9 a ton in the tailings, owing to the fact that some of the ore was not free milling. About 700 tons of ore were

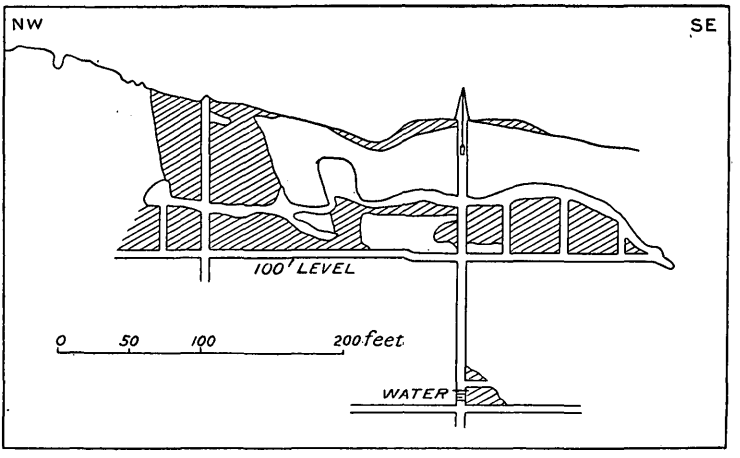


FIGURE 26.—Longitudinal section of Ellen Jane mine, showing stopes.

put through this mill and a considerable amount through the 4-stamp mill later installed by Mr. Grounds at Clay Springs, 2½ miles north of Camp. This mill is supplied with water from springs in the upper part of the cliffs.

Later the company was reorganized as the Washington-Meridian Company, repaired and improved the mill, mined some ore, and then temporarily closed in the spring of 1903. In the spring of 1904 operations were resumed, but as the water supply failed the company ran in debt, and the mine was sold to William Grant, of Hackberry, who in the spring of 1906 bonded the property, including seven of the most important contiguous claims of the camp, nearly all situated on the Ellen Jane vein, to P. C. Friend, of Philadelphia. Some gold has been produced during the last few years by lessees.

Developments.—The mine has about 1,500 feet of work (fig. 26). On the Ellen Jane claim it is developed to a depth of 200 feet, prin-

cipally by a main shaft and two levels containing about 300 feet of drifts; to the northwest, on the Tomonotta, Cleveland, and World's Fair claims, it is developed principally by adit drifts, shafts, winzes, and stopes, aggregating about 700 feet of work. The southern drift on the Cleveland is 300 feet long and the northern one on the same claim about 200 feet, its face being within 200 feet of that of the southern drift, but at a considerably lower level.

At about 400 feet below the top of North Ridge where the vein outcrops and the Cleveland workings occur, at the edge of the wash, a crosscut tunnel, known as the Wilsie tunnel, has been started to tap the vein at greater depth. This tunnel now has a length of 150 feet in solid granite and will have to be driven about 300 feet farther to reach the vein.

The main shaft near camp now contains water up to about the 180-foot level, and produces about 5 barrels of good potable water a day. Before water was encountered in the mine the supply for the camp had to be hauled, and during part of the time was brought from springs situated near the head of Clay Springs Wash, about 6 miles distant.

Deposits.—The Ellen Jane vein lies in granite, chiefly in the supposed post-Cambrian granite. It strikes about northwest and dips to the northeast at angles of about 80°. It varies from 2 to 7 feet in width, the average being about 4 feet, and is usually separated from the walls by a few inches to a foot or more of red and green, much slickensided gouge. A diabase dike is associated with the vein and shares its fissure.

The gangue is principally normal vein quartz, crushed and in part brecciated, together with highly crushed and altered granite and diabase, locally banded and all oxidized and iron stained to the bottom of the mine.

The ore is up to 3 feet and averages about 5 inches in width. It holds fairly constantly to the hanging-wall side of the vein and by mill runs is said to average from $10 to $42 in gold to the ton; the shipping ore runs as high as $500 a ton. A microscopic section of it shows principally granular quartz, iron, and limonite.

At the main shaft on the Ellen Jane claim the development is principally on the 100-foot level, on which the drifts extend about 130 feet to the southeast of the shaft and about the same distance to the northwest. The vein contains from 1 to 2 feet of breccia and a mixture of crushed granite and some diabasic material and quartz, all mashed together, on the foot-wall side, and about the same thickness of material, mostly of granitic origin, with some quartz, on the hanging-wall side, between which and the granite wall itself is from 3 inches to a foot of intervening gouge.

The diabase dike which, at the surface just southeast of the shaft, is associated with the vein on the hanging-wall side, is on this level on the foot-wall side and for the most part forms the foot wall with 1 foot or more of highly slickensided gouge intervening between it and the vein.

On the second or 200-foot level but little work has yet been done, probably owing to the fact that sulphide ore appears here; northwest of the shaft occurs a foot of ore that contains considerable galena and iron pyrites. This is the only base ore found in the vein. It averages about $18 a ton. About 10 feet above the floor of this level, in a small stope, the vein is about 3½ feet thick and is marked near its middle by a sharp line denoting the contact plane of its two facing halves, and along this line and locally diverging from it at sharp angles are ¼-inch to 2-inch seams of red ore, said to average $300 to $400 in gold to the ton.

On the whole the vein, so far as seen in the bottom of this part of the mine, does not look very promising. A generalized section of it is shown in figure 27.

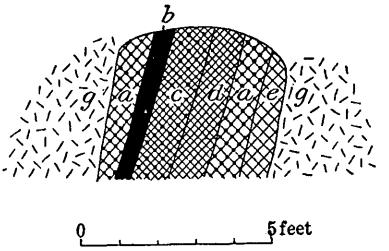


FIGURE 27.—Section of Ellen Jane vein at bottom of main shaft. *a*, Gouge, red, brown, and green stained; *b*, ore shoot, dark-red or light-gray carbonate; *c*, vein material of chiefly granitic origin and some quartz; *d*, vein composed of a mixture of altered country rock granite, leached diabase, quartz, etc.; *e*, diabase dike, foot wall; *g*, granite, country rock.

To the northwest, on the Tomonotta and Cleveland claims the south drift has a length of 300 feet. More or less throughout this extent the vein is associated with the diabase dike, which, just outside the drift in the cut along the tram track, lies for about 330 feet on the foot-wall side of the vein and is about a foot in width, but which enlarges in the drift. In the mouth of the drift the dike obscurely works across the vein to the hanging-wall side or vice versa. Locally, the dike and vein interlace and fine seams or stringers of ore occur in the dike overhead. The face of the drift, which is about 200 feet below the surface, is occupied largely by the diabase dike, which is here 2½ feet thick. On its hanging-wall side 1 foot of crushed or brecciated dike material carries the ore. This material is probably composed of crushed and altered granite and diabase with but little quartz, all altered almost beyond recognition.

Similar material, but with quartz disposed in narrow bands or stringers, also occurs on the foot wall, but, although it appears to be an important part of the vein, it does not carry much pay.

A cross section of the vein at the mouth of the drift, from foot wall to hanging wall, is as follows:

Cross section of Ellen Jane vein at mouth of drift.

	Ft.	in.
Brecciated gouge, composed of granitoid material, some quartz, and possibly altered diabase, all stained yellowish and reddish; it seems to carry the ore		9
Bands and stringers of material similar to the above, but less stained; at 4 inches from hanging-wall side a median seam, containing comb quartz	1	6
Diabase dike, sheeted longitudinally into slices ½ to 2 inches thick	1	
Dull-greenish altered diabase		1
Impure quartz		1
Sheared material at granite and diabase contact, more or less heavily stained		1–2

On the northern part of the Cleveland claim, near the top of the ridge, the Ellen Jane vein is joined by the Contention vein, which comes in from the south at an angle of about 30°. Although the Contention has not here its normal size, being wavy and locally pinched, it nevertheless very materially enriches the ore at the junction.

On the Tomonotta claim the ore mined in late years by lessees averages about 8 ounces in gold to the ton, while higher up in the upper part of the North Ridge portion of the Ellen Jane vein, including the Contention vein, the ore on the whole averages $100 in gold to the ton. Common shipping ore from the Ellen Jane vein now runs about $30 a ton, and it costs about $6 a ton to deliver it to the railroad at Hackberry.

CONTENTION VEIN.

The Contention vein is situated on the east top of the North Ridge, where it joins the Ellen Jane mine. It strikes about N. 30° W. and dips steeply to the west-southwest. It has been worked by shallow shafts on the Contention claim. Its surface workings are principally in a remnant of the diabase sheet, which is here 8 or 10 feet thick and in part caps the ridge.

MARIE E. VEIN.

The Marie E. vein is a small vein or stringer which lies about 200 yards northeast of and nearly parallel with the Ellen Jane vein and stands about vertical. It has been worked to a considerable extent, principally in the diabase, by cuts and drifts, to a depth of 150 feet. It consists for the most part of a thin sheet of reddish dense crushed and altered rock material, seemingly diabase, and a little quartz 5 or 6 inches in width filling a narrow fault fissure and containing $300

in gold to the ton. It is usually frozen to the walls of the country-rock diabase, where it leaves a ragged wall surface when broken off. It has been worked downward through the diabase and has about the same width and carries about the same values in the granite as in the diabase. The associated minerals are iron oxide and a small amount of calcite occurring in crystalline incrustations. The production of this small vein is considerable. At a point toward the west a claim worked by windlass produced several carloads of good ore.

LUCKY CUSS VEIN.

The Lucky Cuss vein lies southwest of and nearly parallel with the Ellen Jane vein. It is exposed on the Lucky Cuss claim, situated just southeast of the Ellen Jane vein, where it has been developed interruptedly for about one-eighth of a mile and locally to a depth of 150 feet. It lies chiefly in the red pegmatitic granite and seems to be stronger there than in the diabase, which it cuts in places on the southwest. On the north end of the claim the granite is intruded by a granite porphyry dike 8 or 10 feet in width, which is in contact with the vein or what may be a spur or stringer given off by it. The dike seems to be older than the vein. The vein strikes about N. 52° W., with dip steeply to the northeast or vertical, and is disturbed by a fault of about 25 feet lateral throw. It is 2 to 2½ feet thick and is composed principally of granitic material and quartz stained by iron and manganese, all more or less closely banded. The quartz shows comb structure.

The ore contains principally silver and some gold and is mostly of high grade. The production has been considerable on the Lucky Cuss claim, where the oxidized portion of the vein seems to be mostly worked out but is reported to contain still some good ore.

To the northwest the vein is supposed to cross Camp Wash beneath the camp, beyond which and where it ascends the south face of North Ridge it has been opened by a series of adit drifts and cuts. Here also it has produced low-grade ore containing considerable galena.

SOUTHWICK VEIN.

The Southwick vein is about half a mile southwest of the Ellen Jane vein. It strikes northwest and seems to extend about a mile. It is developed principally to the north of Camp Wash in the south slope of North Ridge, interruptedly for about one-fourth of a mile and locally to a depth of 100 feet within a vertical range of about 400 feet, extending from 3,100 to 3,500 feet in elevation. It lies in the granite and is associated with the granite porphyry and younger diabase dikes described on page 144. The vein appears best where adjoined by the diabase dike.

The gangue is usually iron-stained quartz and the ore contains gold, some silver, oxide of manganese, and considerable hematite.

LOST BASIN DISTRICT.

The Lost Basin district is situated in the most northern part of the region examined. It comprises the belt lying between Hualpai Wash on the west and Pierce Mill Canyon on the east, and extending from Colorado River at the mouth of the Grand Canyon southward through the Grand Wash Cliffs to a point 12 miles beyond Scanlon Ferry, near the latitude of Gold Basin. It has a length of 20 miles and a width of about 9 miles. It is reached by wagon road descending Hualpai Wash from Gold Basin to Colorado River at Scanlon Ferry.

The principal veins occur south of the middle of the belt, about 7 miles northeast of Gold Basin, where, between elevations of about 2,000 feet on the west and 5,000 feet on the east, they trend about east and west across the district for a distance of 6 miles.

They were discovered about 1886, and considerable ore has been taken out from time to time and treated in arrastres or milled, but the ground on the whole is but little more than prospected. This is probably due to the lack of water. The nearest water supply is Colorado River at Scanlon Ferry, 8 miles to the north, whence water is now hauled at a cost of $2 a barrel. The two points, however, could be readily connected by pipe line.

The ore could without difficulty be hauled to the river, with which the area is said to be connected by a good wagon road, but its transportation by water down the river, advocated by some, does not seem feasible, owing to the dangerous rapids that would be encountered and the impracticability of bringing barges or bottoms of any kind up the river and the great cost of bringing them overland.

The deposits are mostly owned by about half a dozen men. They occur mainly in the pre-Cambrian granitic rocks in well-defined, strong quartz fissure veins, of which there are two sets. Those on the west strike northward with dips vertical or steep to the east and are chiefly gold bearing; those on the east strike west-northwest and are chiefly copper bearing. The relative age of the two sets of veins has not been determined, but it is possible that the copper deposits may be in part pre-Cambrian.

The principal gold properties are known as the Scanlon-Childers mines and are owned chiefly by Mike Scanlon, of Basin, and Cy Childers, of Kingman. The veins average from 4 to 6 feet in width. Several of them are reported to be from 10 to 14 feet in width and from 1 to 2 miles in length. The croppings are principally brown and green iron and copper-stained quartz and are in part prominent.

Some of the veins are said to be exposed in the canyons to a depth of 200 feet or more and yield good shipping ore from the surface down to this depth. The ore contains principally gold and silver and a little copper, but no copper of commercial value and not enough to interfere with cyaniding.

The ore on the whole is fine in texture. It has been sampled and tested by Denver men and was found to be excellent cyaniding ore, and is reported to contain on the average $8 or upward in gold to the ton.

The copper deposits are said to extend from a point near the middle of the belt nearly to the summit of the Grand Wash Cliffs and Colorado Plateau on the east. They are owned chiefly by James Burrows and J. W. Mouat, of White Hills. Other owners are Messrs. Grant, Fielding, and Roseborough, of Hackberry. The pre-Cambrian complex is here more schistose than on the gold-bearing side of the belt, and some of the deposits on the extreme east are said to be associated with limestone. The copper-bearing veins, as indicated, strike west-northwest at nearly right angles to the gold-bearing veins. The croppings are large, and, as seen by the writer, consist principally of oxidized masses of brown and black quartz, with some malachite and azurite. The ore contains principally copper and carries also some gold and silver. Some of it is reported to have assayed from 17 to 20 per cent of copper.

The production of the district is reported to be many thousand dollars, chiefly in gold.

BLACK MOUNTAINS.

INTRODUCTION.

The deposits of the Black Mountains differ in most respects very markedly from those of the Cerbat Range. They occur chiefly in the Tertiary volcanic rocks. Their trend is west-northwest to northwest, the dip steep. Their gangue is mainly calcite and dolomitic carbonates, but these minerals have largely been replaced by quartz and adularia, a variety of orthoclase free from sodium and with characteristic crystal form. They are deeply oxidized and, as a rule, contain no sulphides, and their values are almost exclusively in gold, there being usually no base metals present. There is a general absence of fluccan or gouge, the veins being usually frozen fast to the country rock.

The districts in the Black Mountains, named in order from north to south, are the Eldorado Pass, Gold Bug, Mocking Bird, Virginia, Pilgrim, Union Pass, Gold Road, Vivian, and Boundary Cone. Of these the most important is the Gold Road district. The two first

named are in the Eldorado Pass mining district, the two next are in the Weaver mining district, and the Gold Road and Vivian in the San Francisco mining district.

GOLD ROAD DISTRICT.

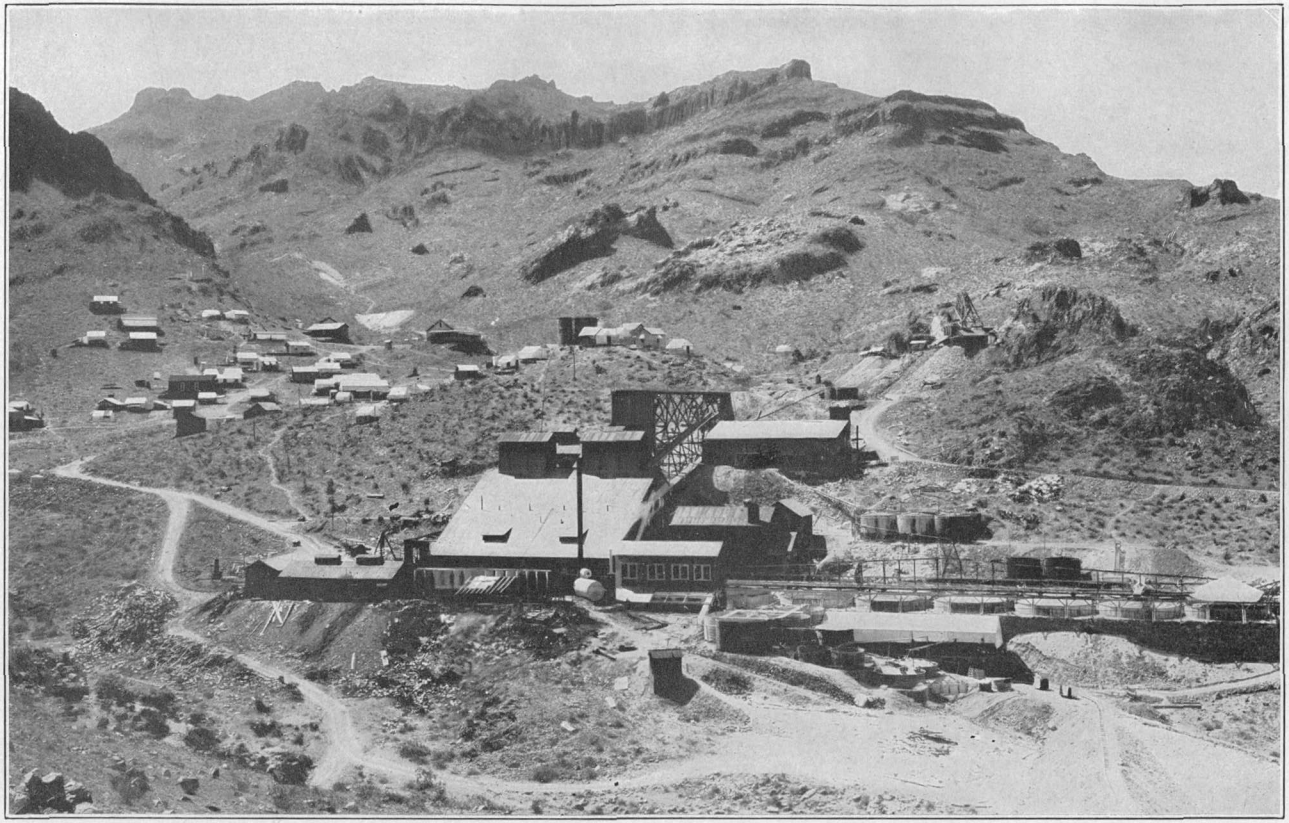
GENERAL OUTLINE.

Location.—The Gold Road district lies about 24 miles southwest of Kingman, mainly on the west slope of the mountains. It extends from Meadows, on Meadow Creek, at the east base of the range, northwestward to the Moss and Golden Star mines, about 6 miles beyond the crest. It has a length of about 10 miles and a width of about 4 miles. The principal camp, local supply point, and center of activity is Gold Road, situated on the western slope of the range, about 1 mile from the crest, at about 2,900 feet elevation and at the head of Silver Creek. It is 16 miles northeast of Needles, Cal., and is reached by wagon road from Kingman, via Gold Road (formerly Sitgreaves) Pass. Gold Road (Pl. IX) has a population of about 350. It is equipped with modern improvements, is well kept, and is plentifully supplied with excellent water pumped from Meadows.

History.—Mineral was first discovered in the district early in the sixties by John Moss and party, who found rich gold ore at what has since been known as the Moss mine, 4 miles northwest of Gold Road, near the old Camp Mohave trail. About the same time, or a little later, the Miller mine, formerly known as the Parsons mine, and especially as the Hardy mine, 2 miles northwest-west of Gold Road, was discovered, and for a long time these two mines were the principal properties in the district. They were at once worked and soon began to produce, the ore being at first shipped or milled in arrastres, and a little later some of it was treated in the Moss mill, which was built on the Colorado at the mouth of Silver Creek, about 7 miles west of the Moss mine.

A decade later, owing to the discovery of rich silver-gold ore in the Cerbat Range, the district became and for a long time remained quiet, until the decline in the market value of silver stimulated gold mining. The present activities began with the opening of the Gold Road mine and vein about 1902.

Topography and drainage.—The district ranges in elevation from 2,000 feet on the west and about 3,000 feet on the east to 4,500 feet at the top of the range. The range portion, which is about 3 miles in width, is rugged, particularly on the west, being marked by precipitous fault scarps, deep gulches, and canyons. Here in a horizontal distance of about 1½ miles the surface falls off from 4,500 feet elevation at the crest to 2,500 feet on Silver Creek just below Gold Road. The remainder of the area consists mainly of low, rounded, outlying



GOLD ROAD MINE, MILL, AND CAMP, LOOKING SOUTHEAST.

mountains or hills, open washes, and gravel-covered gentle slopes or mesas.

The principal outliers are the Hardy Mountains, a low group situated on the southwest about 3 miles west of Gold Road, to the south of Silver Creek. They are about 3 miles in diameter and rise about 600 feet above the surrounding country. Two miles north of the Hardy Mountains and Silver Creek is a much smaller group—the Moss Hills. On the east the drainage flows principally by way of Meadow Creek into Sacramento Valley, and on the west through Silver Creek into the Colorado.

Geology.—Tertiary volcanic rocks prevail, particularly in the eastern or range portion of the district. They practically constitute the range, and are in places covered by rhyolite and younger basalt. On the west occur also local areas of the pre-Cambrian gneisses, syenite, granite porphyry and micropegmatite, greenstone agglomerate, and overlying sheets of supposed Tertiary conglomerate and younger gravel and lava flows.

Deposits.—The deposits, which number about a dozen, are chiefly gold-bearing fissure veins or lodes. They occur in the lower part of the undifferentiated volcanic series, the green chloritic andesite, and the granite porphyry and micropegmatite described on page 31, and also along certain of their contacts, where rhyolite is usually the intrusive. They consist of two main types—those in which the gangue is chiefly quartz and adularia and those in which it is chiefly calcite. The former, which seem to be the older and carry the best values, occur mostly in the undifferentiated volcanic rocks and in granite porphyry and have a general northwesterly or northwest-westerly trend; the latter occur mainly in the green chloritic andesite and trend nearly north. The most important of the former type is the Gold Road vein; of the latter, the Pasadena and Mossback veins. (See Pl. X.)

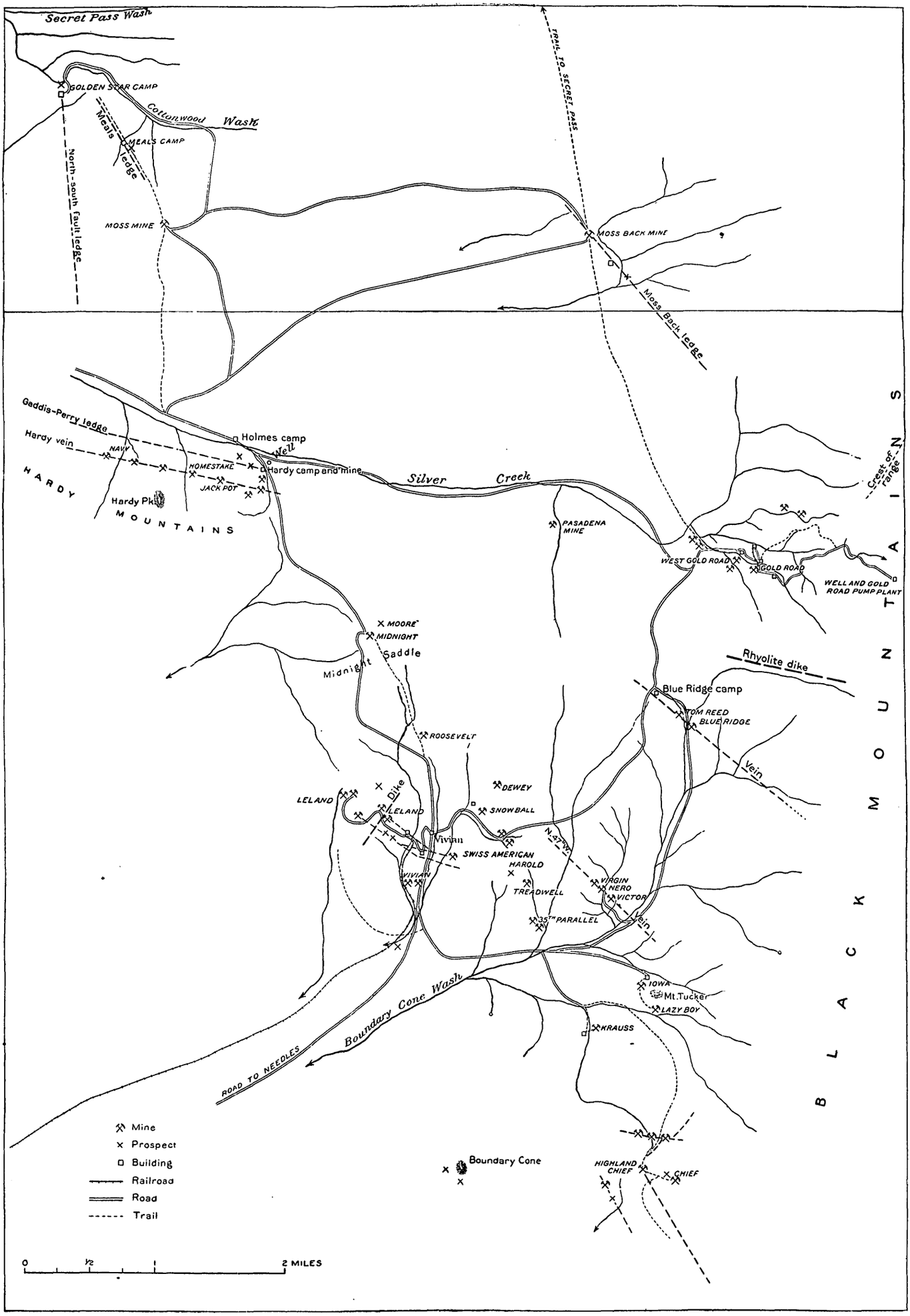
The veins in the green chloritic andesite in both the Gold Road and Vivian districts occur mostly in fissures, which seem to be peculiar to this formation and do not as a rule penetrate the underlying older andesite. The origin of the metallic contents was due to thermo-aqueous processes. In general the quartz and values favor the hanging wall, where the quartz feeds in by oblique stringers, and the spar or calcite favors the foot wall.

GOLD ROAD MINE.

Location and history.—The Gold Road mine, the most important in the district, 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 feet, on the western part of the Gold Road vein. From its

croppings the Gold Road vein has long been known, but the discovery of mineral values and the locations which resulted in the mine were made about 1902 by Joe Jeneres, a Mexican prospector, who was grubstaked to the amount of $13 by Henry Lovin, of Kingman. The discovery is reported to have been accidental. Jeneres in searching for his burros, which had strayed from camp, happened to pick up, near the present site of the Gold Road mine, a piece of quartz showing free gold, which led him to set up a monument and stake the Gold Road claim. Reports in Kingman that the specimen found by Jeneres and the croppings assayed 40 ounces in gold to the ton brought about a stampede to the district and the staking of many claims. Jeneres and Lovin did their assessment work and, with developments confined to a shaft 15 feet deep on the Gold Road claim, bonded the property to Los Angeles men for $50,000. Later the property was sold to Joseph Burkhardt, who worked it for some time and then sold it to Posey, Bailey, and McCormick for $275,000. Posey soon capitalized the property, enlisting the money of a French syndicate, which is currently reported to have paid half a million dollars for one-fourth of the stock. Work has been carried on systematically by this company, and the mill has been in operation about three years. The property, now including 12 or more claims, covering practically the entire known length of the Gold Road vein and distributed approximately as shown in Plate X, is now owned by the Gold Road Mining and Explorations Company, and is reported to have paid dividends of 5 per cent on a capitalization of $1,500,000. The company is incorporated under the laws of Arizona, with headquarters at Los Angeles and Paris. The company's annual reports are printed in parallel columns in English and French. It employs 180 men, of whom 75 to 80 work underground in three eight-hour shifts. Miners are paid $3.50 and machine men $4 a day. The company's pay roll is about $16,000 a month.

Developments and equipment.—The mine is developed to a depth of 800 feet by a main shaft and eight (1908) levels aggregating about 3,000 feet of drifts. Most of the ore has been mined for a distance of about 240 feet to the east and 640 feet to the west of the shaft, about as shown in the accompanying section of the underground workings (fig. 28). From the surface to the 300-foot level the shaft inclines at an angle of 85°, below which it is vertical and ends in a sump 35 feet below the 800-foot level. The levels are spaced 100 feet apart. The method employed in mining is a system of overhead stoping. The entire vein between the two levels is mined and the broken ore left in the stopes, from which it can be drawn as desired through chutes located 12 feet apart.



MINES AND VEINS IN THE GOLD ROAD AND VIVIAN DISTRICTS.

The mine produces about 12 gallons of water a minute. The water was first encountered on the 200-foot level in about the same amount it now occurs in the mine.

The principal surface equipments are a 50-horsepower steam hoist and a 200-ton gyratory crusher, located at the mine and run by separate engines; and a very complete milling plant, consisting essentially of six Huntington mills equipped with rollers, settling tanks, vats, laundries, filter presses, etc., and having a capacity of more than 200 tons of ore a day. The mill plant engines, including those that run the mills, compressors, and mine pump, and generate electricity for lighting the town and mine, aggregate about 500 horse-

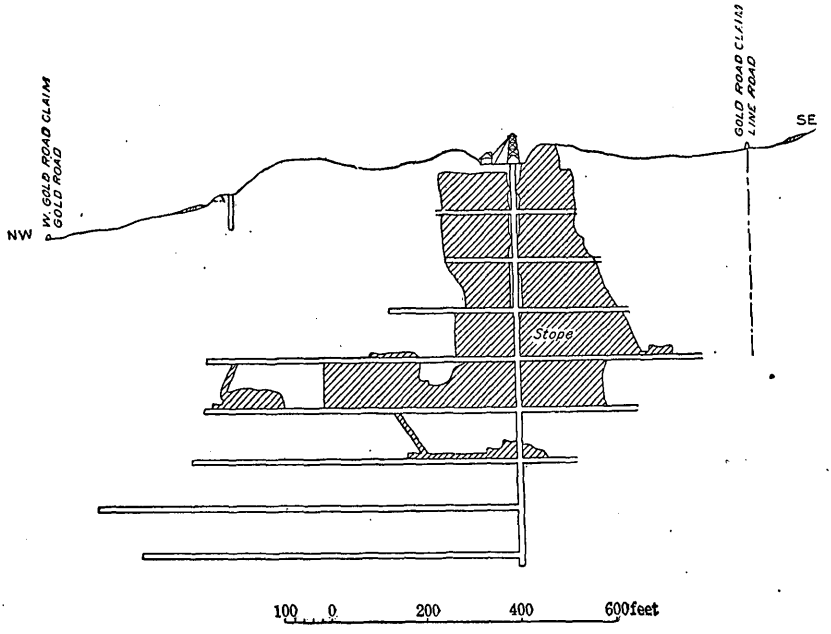


FIGURE 28.—Longitudinal section of workings on vein of Gold Road claim, Gold Road mine.

power. The mills and the pump are run by electric motors, with power transmitted from the generating plant in the engine room. In all, the engines of the mine and mill aggregate about 700 horsepower.

The principal source of the power, especially in the generators, is California fuel oil, freighted by wagon from Kingman and delivered at a cost of about $3.50 a barrel. Refined oil and gasoline used in some of the smaller engines are proportionately more expensive. The company's fuel bill for the year 1906 was $96,000.

The mine was closed at the end of 1907 on account of the high cost of power and the low grade of the ore. It was decided to open the east part of the property and connect it with the Gold Road claim by a drift on the 500-foot level. This drift has been extended 1,000 feet east of shaft No. 1. Shaft No. 2, to connect with this

drift, is being sunk at the junction of the Billy Bryan and Line Road claims. The total depth of this shaft will be 750 feet. It was lately reported that the Gold Road mines are being supplied with electric power by a large plant recently installed at Kingman, and that a 40-stamp 300-ton cyanide mill is being erected.

Ore treatment.—The ore is nearly all of milling quality, averaging about $10 in gold to the ton. The gold is extracted in the plant which has been described, the method of treatment being by Huntington mills and the cyanide process. Of the six mills five readily handle 180 tons of ore a day, one mill being usually held in reserve.

The ore is first crushed to less than 1½ inches in size in the gyratory crusher at the mine, whence it is conveyed by tram cars to the mill plant. Here it is further reduced by rolls to ¼-inch mesh or less before it goes to the Huntington mills, where it is ground in cyanide solution to less than 50 mesh, about two-thirds of the product being sand and one-third slimes, the slimes resulting chiefly from the calcite content of the ore. The sands are settled in vats and tanks and the slimes are filter pressed. The gold is precipitated on zinc shavings and refined at the mine.

The ore is easily milled and treated, although fine crushing is necessary as the gold is so finely disseminated in the quartz. Twenty-five per cent of the gold is liberated in two or three hours, and 85 per cent in ten days percolation. It is stated that by fine grinding 98 per cent of the gold can be extracted. The usual saving is said to be 91½ per cent of the assay value. The small residue left in the tailings is not entirely lost, for in the gulch below from $30 to $50 worth of gold is daily collected by precipitation from the seepage of the tailings dump. The output is shipped bimonthly in gold bricks worth about $45,000 each.

The ore is now said to be mined at a cost of $2.50 to $3 a ton and mined and milled at a cost of about $5 a ton, allowing $8 ore to be handled with a good profit. With the installation of cheaper power and a more efficient mill ore of much lower grade might be worked. The management hopes to reduce the cost eventually to about $3.50 a ton. Plate amalgamation was tried, but without much success.

The cheaper power might be supplied from a large electric plant at Kingman or by the installation of a large steam-power plant with engines of high efficiency, now considered by the Gold Road Company on its own ground. In this latter event the fuel oil now freighted by wagon from Kingman could be pumped from Meadows over the range much more cheaply than it is now freighted over.

The water used in operating the mill, besides that produced by the mine, is derived from the company's well at Meadows, on the east slope of the range, whence it is pumped by a 12-horsepower gasoline engine to the camp and mine. A small spring has been known at

Meadows since pioneer times, when the place was used as a station for the government's desert camel pack train, but the presence of water in copious amount was first discovered by the Gold Road Company by sinking a shallow well in the rhyolite where the Meadow Creek valley is crossed by a strong diabase dike. This seems to form a subterranean dam and raises the underground water to the surface as it percolates down the slope of the range through the rhyolite tuffs, producing in this locality a large supply.

About the only loss of water in milling is that which is hauled out in the tailings on the cars. The remainder, having brought the ore in solution through its several stages of treatment, is pumped back to the mill, whence it starts out with a new charge of fresh ore and thus moves in a cycle, being used on different charges of ore over and over again.

Production.—The production of the Gold Road property, including the Billy Bryan claim, to the end of 1907 is reported to be about $2,250,000, most of which was produced during 1905 and 1906. The production includes 110 tons of shipping ore, amounting to $110,000, derived mostly from the Billy Bryan claim. It was reported late in 1909 that there were in sight on the property 50,000 tons of ore averaging about $12 a ton.

Topography and geology.—The rough topographic features of the district are those characteristic of rapid erosion of heavy volcanic sheets. They consist in the main of broad and rugged westward-sloping, cliff-studded or stepped ridges separated by deep gulches that form the head of the Silver Creek drainage. The camp is situated mainly on one of these ridges and the Gold Road vein lies in the gulch adjoining it on the south.

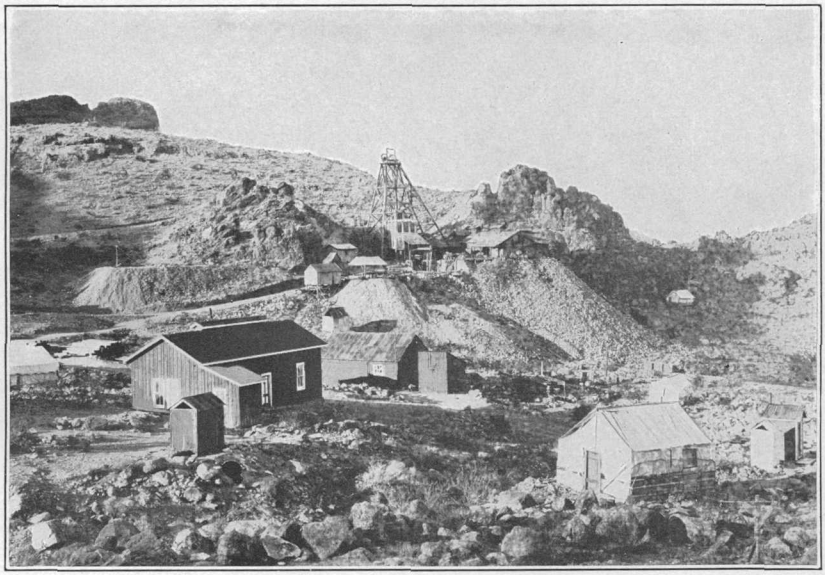
The country surrounding the mine is occupied by heavy sheets of volcanic flows. The series comprises andesite, trachyte, latite, rhyolite, and dacite, and is nearly 2,000 feet in thickness. This aggregation is difficult to separate and has been referred to above as the "undifferentiated" flows. It extends from a point about 1,000 feet west of the Gold Road mine 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 feet. 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 Gold Road mine. The structure is a very 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, varying from 12 to 50 feet in width, located about 600 feet south of the mine, is staked and much of it is said to average from $5 to $6 in gold to the ton, the values

occurring chiefly in stringers of quartz and calcite contained in the dike. Near by a portion of the dike is faulted laterally by a throw of 80 feet, which seems to affect the Gold Road vein also. Nearly a mile southeast of the mine, on the Railroad claim, what seems to be this same dike is in association with the vein, its cropping here forming a wall 20 or 30 feet high.

Deposits.—The Gold Road vein extends from a point about 700 feet west of the mine beyond the crest of the range, a distance of nearly 1¼ miles.

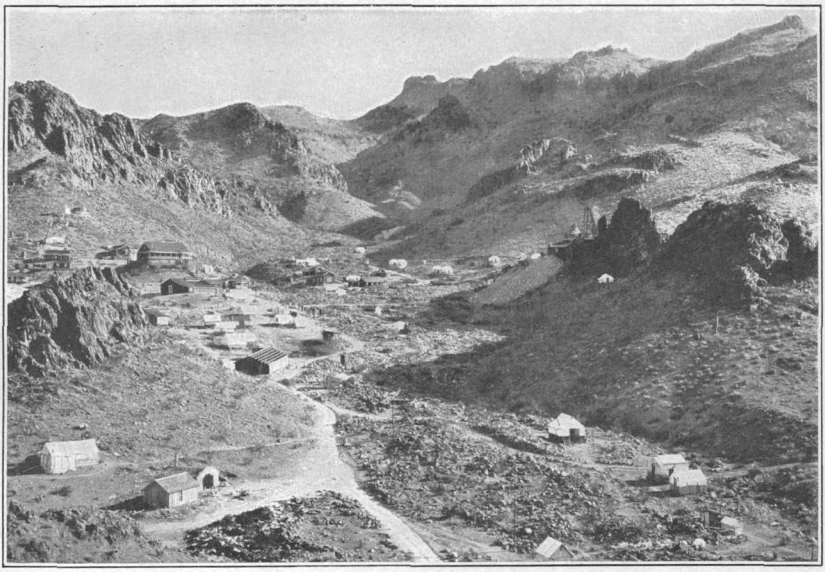
The vein strikes about N. 50° W. and dips about 80° N., approximately parallel with the close sheeting in the country rock. It varies in width from a maximum of 22 feet on the west to less than a foot on the east, where it seems to pinch. Between the bottom of the Gold Road mine and the crest of the mountains it has a known vertical range of about 1,850 feet, and its croppings, which, as noted, lie principally in the deeply cut Gold Road gulch, have a vertical range of about 1,300 feet. They consist essentially of iron and manganese stained quartz, silicified rock, and calcite. They are usually prominent, and in places form conspicuous buttes or knobs rising 20 or 30 feet above the surface, as at the Gold Road mine (Pl. XI). Here the hard silicified croppings on both sides of the vein have a lateral extent of 20 to 60 feet. The best ore usually underlies these prominent croppings, which seem to represent courses along which mineral-bearing solutions circulated more freely than elsewhere. The operators also report an intimate association of the ore and the present watercourses in the Gold Road mine. Where the croppings weaken or break down the underlying portion of the vein on all levels tends to become lean or barren, though the fissure and its walls and fillings continue unchanged. An exception to the rule, however, that the strongest croppings indicate the richest ore beneath them, occurs on the middle part of the Billy Bryan claim, described on page 165.

The vein consists essentially of quartz and adularia, with some calcite and brecciated rock, and is more or less banded. With small exceptions it is all good milling ore from wall to wall. The amount of waste, as shown by the small dump at the mine, is almost nothing. The gold, as seen microscopically, and in places by the naked eye, is very finely disseminated, principally in the quartz and adularia. The free gold is said to occur chiefly from the Line Road shaft eastward. The vein is strongest on the west, where, as developed in the Gold Road mine, it is uniformly about 10 feet in width. It is usually in sharp contact with well-defined firm walls of the country rock, consisting of andesite, trachyte, latite, or rhyolite. It is in general frozen to the walls and is locally enriched by oblique stringers that join it at acute angles from the northwest on the



A. GOLD ROAD MINE, LOOKING SOUTH.

Silicified lode croppings on both sides.



B. GOLD ROAD GULCH, LOOKING SOUTHEAST FROM UNITED STATES MINERAL MONUMENT.

Vein croppings in shade to the right.

hanging-wall side. As a rule hard and rough walls in this mine indicate good ore, and conversely soft and smooth walls are apt to correspond with lean ore. The ore consists chiefly of fine-grained, light-greenish quartz, much of it bladed or hackly and with a peculiar chalcedonic or drusy appearance (Pl. II). Many of the blades of pseudomorphic quartz are thickly covered with minute quartz crystals. Microscopic adularia is commonly intergrown with the quartz. Much of the quartz is clearly pseudomorphic after calcite. The quartz and adularia are locally present in equal amount, but more commonly in the ratio of about 2 to 1. As a rule no sulphides are present and but little limonite. Some pyrite occurs in the wall rock in the lower part of the mine, but no sulphides save that on the 600-foot level (see p. 162) have been found in the ore, nor are there indications that they were ever present.

In recent years the work in the Gold Road mine has mostly been below the 300-foot level. When the Gold Road Company acquired the property the shaft had been sunk to this level, but, except a few sacks of high-grade ore which had been shipped, no ore to speak of had been stoped. The lowest-grade ore yet taken out of the mine was obtained between the surface and the 300-foot level, where it fell to $5 a ton. The ordinary mill run, it is said, rarely falls below $8 or $9 and ranges from that up to $22 a ton. It averages about $10 a ton, but $100 ore and upward is occasionally encountered on the hanging wall, where all the high-grade ore occurs. The pinching of the vein on the 300-foot level about 1903 led to the apprehension that the mine was worked out and would have to be abandoned. A dry-crusher mill was accordingly installed to work out the ore then in sight to this depth. In the mean time, however, the shaft was sunk 100 feet deeper. The ore not only continued down, but improved with depth. Then came the demand for a better mill, and the present Huntington mills were installed because the dry crusher could be used in connection with them and the immediate demands more readily and cheaply met. A sketch of some of the more important features of the deposits noted on the principal levels follows.

On the 300-foot level the walls in the main are firm and the country rock is an andesite, that on the hanging wall being the more-altered variety. In both walls a younger intrusive andesite appears in places. This is also considerably decomposed and contains chlorite and calcite. Locally the foot wall is softened and the soft spots are mineralized and carry low values, while the firm walls are barren. On this level the vein contracts, and between this and the 400-foot level it pinches to but 2 feet in width and is not workable. The striations on the walls dip 65° SE. About 400 feet west of the shaft, at the upraise from the fourth level to this level, the vein is composite,

about 8 feet in width, and is constant and continuous from this point down to the sixth level. A section of the vein sketched on this level, in which the best ore-bearing portion is the green quartz, follows:

Section of vein on 300-foot level, Gold Road mine.

	Ft.	in.
Hanging wall, gray andesite with dip slightly abnormal.		
Crushed greenish quartz ore	2	6
Fine-grained dark andesite, dike (?)	1	6
Andesite with stringers of quartz ore	1	
Quartz ore containing strips of andesite	1	
Good quartz ore with some crushed andesite	2	
Foot wall, gray andesite, partly mineralized with some quartz.		

On the 400-foot level the country rock is altered and shattered chloritic andesite and, as shown in the hanging wall in the crosscut at the pump just north of the shaft, is cut by a network of stringers and veinlets of quartz. The hanging wall, as seen 300 feet west of the shaft, consists in part of more or less silicified, banded, altered reddish lithoidal rhyolite containing parallel veinlets of chalcedonic quartz and is typical of the rock that usually occurs in the hanging wall in association with high-grade ore throughout the mine. At 400 feet west of the shaft the foot wall includes an altered andesite containing epidote, chlorite, and pyrite, resembling that found in the bottom of the mine on the 700-foot level, above which, as currently believed and reported, no sulphides had ever been found. The pyrite is very fine grained and is profusely and evenly disseminated throughout the rock. On this level the vein is similar to that on the 300-foot level above described. To the west it is reported to contain three distinct shoots, and, as elsewhere in the mine, it is the greenish quartz and not the spar (calcite) which carries the gold. The calcite prevails toward the foot wall, and the quartz and consequently the values associated with it favor the hanging wall. Wherever the hanging wall straightens up or is slightly overturned and dips to the southwest or toward the foot wall it does not carry any values.

On the 500-foot level at the shaft the following partial cross section is shown:

Cross section on 500-foot level, Gold Road mine.

	Feet.
Andesite	15
Quartz-calcite vein dipping northeast	7
Andesite	5
Vein	8
Hanging wall containing rhyolite.	

At 75 feet west of the shaft the walls are vertical or slightly overturned, and the foot wall contains reddish-brown, brecciated, mineralized rhyolite similar to that described on the 400-foot level, but coarser and less banded.

At about 100 feet west from the shaft the 7-foot stringer exposed at the shaft landing gradually joins the vein at a sharp angle on the foot-wall side and doubles the values in the vein, and the walls and the vein here gradually assume their normal dip of 86°. Just beyond this locality the vein increases to 10 feet in width, and at about 200 feet west from the shaft it is about 22 feet wide, the entire vein being good ore. The width diminishes somewhat upward toward the 400-foot level.

At about 200 feet west of the shaft a 4-foot stringer leads off at a sharp angle to the west, and both stringer and intervening mineralized rock wedge are worked with vein to a point where the wedge becomes several or more feet in thickness. Here the stringer affected the values of the vein but little, but just beyond the junction of the stringer the ore gradually enriches to $80 a ton, and this value for the full 8-foot average width of the vein continues 100 feet westward to a fault or break, and with but slight decrease extends upward to the 400-foot level. On the whole the enrichment seems due principally to stringers feeding in from the ragged hanging wall at acute angles from the northwest along the structure or sheeting. In this rich $80 ore shoot, at 275 feet west of the shaft, the hanging wall is an altered pyritic bluish-green andesite, similar to that described on the fourth level, but it is extremely dense, and the pyrites are similarly so fine as to be almost invisible. The foot wall at this locality seems to be the altered red and brown stained lithoidal rhyolite.

At 400 feet west of the shaft the values cease, and the vein soon pinches down to 3 or 4 feet in width and presently disappears, the two fissure walls lying together for a distance of 90 feet. The rock in the hanging wall, notably at 400 feet west of the shaft, is the shattered chloritic andesite and contains veinlets of adularia and quartz, while the lithoidal rhyolite continues in the foot wall, and at 450 feet west of the shaft the two walls are separated by a 1-inch seam or dike parting of the rhyolite.

At about 500 feet west of the shaft ore again comes in and continues for 162 feet beneath the silicified rock and quartz butte croppings to a point beneath the Tozier shaft or extension winze. At 660 feet west of the shaft the vein rapidly splits up or gives way to country rock and continues barren, except for a small stringer. The vein matter and the walls are loose and barren and continue so to the end of the drift 300 feet distant at a point within 200 feet of the west Gold Road mine. Where the vein breaks up at 660 feet west of the shaft the hanging-wall rock is the andesite and the foot wall the rhyolite whose normal position is regarded as the hanging wall.

East of the main shaft the vein is 12 feet in width, and the rock wedge between the vein and the stringer is 10 feet thick. At 150

feet east of the shaft the stringer bears off to the south-southeast at an angle of about 40° with the vein, and vein, foot wall, and stringer are all worked for a distance of about 12 feet, beyond which the vein pinches down to 3 or 4 feet in width, with the ore running $16 to the ton. The walls are good. The hanging wall contains both the green chloritic andesite and the red rhyolite, while the foot wall consists principally of the silicified red rhyolite. Striations on the hanging wall dip 35° SE. At 200 feet east of the shaft occurs a break or faulting of the vein, the dip of the fault plane being 65° W. On looking southeast-east along the drift the vein is seen to have slid downhill about 40 feet, as shown also by surface croppings, and beyond this the vein is cut off and the drift or tunnel continues in "country rock," which is chloritic trachyte on the hanging wall and relatively fresh andesite on the foot wall.

On the 600-foot level the vein contains much more spar or calcite than on any other level and the ore shoot is reported to have an uninterrupted extent of 1,100 feet. 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. At the landing the foot-wall stringer described as occurring on the 500-foot level lies near the shaft. The walls are reddish oxidized andesite (?) and, as shown in the hoist station, the hanging wall is mineralized for a distance of 30 feet or more laterally from the vein. At 100 feet west of the shaft the ore consists principally of greenish quartz with adularia and calcite, and carries good values, and at 120 feet west the foot-wall stringer from the shaft, here about 20 feet wide and all good low-grade ore, comes in and joins the vein. A crosscut 30 feet in length from the hanging wall of the vein has not yet reached the foot wall of the stringer. The hanging wall of the vein here is coarse breccia, probably of andesite tuff, more or less soft, and is coated with downward-facing comb quartz and spar. Fresh striations on the hanging wall decline 55° NNW. The movement has produced 2 feet of fault breccia, which is cemented by quartz and spar. In the hanging-wall face of the crosscut the rock seems to be the lithoidal rhyolite and the rock in association with the stringer andesite. At 204 feet west of the shaft the foot-wall stringer, which from the shaft to this point is fairly good only and contains much spar, comes into the vein and greatly enriches it from this point westward, and the foot-wall rock carries some sulphides. At 312 feet west of the shaft the hanging wall is in places gash veined and partly mineralized, and the foot wall contains hard andesite breccia with some quartz-spar ore in large bunches frozen to it. Where the ore is thus frozen to the walls in the mine the wall has usually to be broken to get the ore. At 400 feet west of the shaft the vein is cut off abruptly by the same fault that cuts off the ore shoot on the 500-

foot level. Here the break is about 12 feet west of the point it occupies on the 500-foot level and the hanging wall is cross sheeted into slices from 4 inches to 1 foot in thickness, while on the 500-foot level it is smooth and the foot wall is brecciated rhyolite. Farther west the vein is represented by a barren stringer 1 foot or more thick, which seems to extend for a distance of 40 feet to a point where good stoping ore, consisting mostly of quartz with some spar and some brecciated angular fragments of country-rock andesite, comes in and continues westward for a distance of 162 feet. The maximum thickness of this 162-foot ore shoot is 16 feet, and here it carries the richest ore.

At 500 feet west of the shaft a 4-foot spur, vein, or stringer goes off at a short angle from the vein to the southeast-east in the foot wall. It dips about parallel with the vein and does not seem to affect its ore values. It has been mined for a distance of 15 feet. The face of the drift in it shows a gold-bearing black band, several inches in width, containing principally oxide of manganese. At 600 feet west of the shaft, in the face of the drift and beyond, the vein has pinched to a width of 2 feet and seems to narrow with depth.

East of the shaft the country rock is the reddish silicified andesite. The vein is split or composite and consists of alternating bands of stringers of quartz, calcite, and country rock. At 80 feet east of the shaft the vein pinches and almost entirely gives way to country rock. There is no sign of a fault, but the walls are rough and some barren vein material extends on to the face of the drift. At 140 feet east of shaft, where the vein is 4 feet wide, occurs the cross fault of the fifth level, which cuts the vein nearly at right angles. The country rock is a greenish-gray epidotized porphyritic andesite.

At the time of visit the 700-foot level was just being opened. About 35 feet northeast of the shaft a stringer or vein 2½ feet in width was cut, whose position, attitude, and other characteristics correspond to those of the Gold Road vein. Numerous small stringers and veinlets lie on either side, and the rock, which from the shaft to the face of the crosscut is in general massive, is here for a width of 6 or 7 feet on either side of the vein sheeted into slices down to 3 or 4 inches in width. Just above this locality, on the 600-foot level, the vein is reported to have split into three parts. The vein is frozen to the walls and composed of greenish quartz and calcite; it is imperfectly banded, brecciated, and in part iron stained and oxidized. It contains, according to assay returns, $11 in gold to the ton. In contact with the vein is greenish, dense, very hard andesitic rock, traversed by numerous veinlets of chalcedonic quartz and adularia. On the foot wall the rock is less dense and looks like an agglomerate.

Near the face of the crosscut occurs a 2½ to 3 inch stringer, which consists of nearly all quartz with a little associated dark calcite and is said to contain about $16 in gold to the ton. Its strike is more

northerly than that of the vein, with which it makes an angle of about 30° and which it probably joins a short distance to the east. The face of the crosscut is a medium to coarse grained dull-greenish propylitic trachyte. (See analysis, p. 39.) It is a totally different rock from the green chloritic andesite described on pages 34–37, which occurs elsewhere in the mine. It is intruded by a fine-grained reddish and greenish rock, probably andesite. In the landing and crosscut as a whole, however, particularly in the southern half, the prevailing rock is the massive dark sulphide-bearing green chloritic andesite, which seems to be the principal country rock and apparently indicates that the bottom of the mine, so far as the country rock is concerned, has practically reached the sulphide zone, although no sulphides have as yet appeared in the vein. Late in February, 1907, this level was reported to be showing good ore bodies, the values of which are said to be comparable to those on the sixth level.

The Tozier shaft, also called the west winze, is 600 feet west of the main shaft and starts on lower ground; it was being sunk at the time of visit and was then 90 feet in depth, having penetrated nearly to the projection of the 200-foot level in the main part of the mine. It here shows a good-looking 5-foot vein of ore said to run about $11 to the ton. The company expects, in case the ore body extends to the west, to connect its workings with the West Gold Road mine, 400 feet distant.

BILLY BRYAN MINE.

Location and development.—The Billy Bryan mine (see Pl. X) is located nearly half a mile southeast of the Gold Road mine, on the Billy Bryan claim in Gold Road Gulch, on the Gold Road vein, at about 3,300 feet elevation. Before it was acquired by the Gold Road Company, which now owns it, the mine was worked to a considerable extent by lessees. As shown in the section of underground workings, it is developed by about 2,500 feet of work, consisting principally of an adit drift 1,200 feet long and three shafts from 100 to 150 feet in depth. The adit drift, commonly known as the "Line Road tunnel," starts on the Line Road claim, lying between the Gold Road and Billy Bryan claims at about 3,200 feet elevation and extends to the southeast, where its face on the eastern part of the Billy Bryan claim lies about 250 feet below the surface. Beyond this point important surface workings extend interruptedly nearly to the east end of the Railroad claim, which joins the Billy Bryan on the east.

Geology.—The geology is essentially similar to that of the Gold Road mine. The country rock is the group of undifferentiated volcanic rocks, whose variations and phases are well shown in the large dump at the mouth of the drift. The principal rock corresponds more closely to trachyte than to dacite or rhyolite, and is in general con-

siderably altered. The rocks are locally faulted and are intruded by rhyolite and dikes of the young reddish-brown andesite.

The croppings of the Gold Road vein at the Billy Bryan mine are prominent and wall-like, but they probably do not represent the whole of the deposit. It is believed that the vein is split throughout the Line Road claim, the beginning of the split being at the mouth of the main drift. A stringer diverges here to the left, or north, and within a short distance enlarges to a side vein of fairly well-banded good-looking quartz 3 to 4 feet in width and carrying moderate values. After nearly paralleling the vein for 1,200 feet at a distance of about 100 feet, this stringer reunites with the vein near the east end of the deep works on the Billy Bryan claim, where good ore occurs at the junction and beyond. The area contained between the two veins is traversed by numerous parallel quartz stringers and veinlets. Just beyond the point of junction a similar side vein, not shown on the surface, is said to have been encountered by a deep crosscut 80 feet north of the vein.

The vein on the Billy Bryan claim varies from 1 to 20 feet 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; in places, however, quartz forms the principal part of the vein. Farther southeast, beyond the 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 and finely ribboned or banded, wavy, and crenulated, its structure resembling the fine flow structure of certain lavas.

In the Billy Bryan shaft the ore for the first 25 feet in depth is reported to be of small value. From 25 to 80 feet the values were good, but below 80 feet they are said to decrease. On the Line Road and Billy Bryan claims the gold occurs chiefly along the contact of the red jasper or jasperoid brown quartz and white or green quartz and along the bands in the glassy quartz that may be present. 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 in the surface workings, and it is under these workings, notably on the Billy Bryan and Railroad claims, that the Gold Road Company expects favorable results. Advices from the mine in June, 1908, stated that the company was sinking two shafts on the Billy Bryan claim to connect by drift with the Gold Road shaft and had encountered good ore as deep as the shafts extended.

In its extension eastward across the Last Chance claim and the crest of the range the vein contains some good croppings and openings, but it is split by horses at one or two points and locally narrows to unworkable dimensions. It may, however, be found to widen in depth as it descends in horizon in the Gold Road and Billy Bryan mines.

WEST GOLD ROAD MINE.

The West Gold Road mine is located in Gold Road Gulch, about 600 feet west of the main shaft of the Gold Road mine and on the projected course of the Gold Road vein; it has an elevation of about 2,800 feet, or 100 feet below the collar of the Gold Road shaft. Work was begun on the West Gold Road property in 1905. The property is owned by the West Gold Road Mining Company, with headquarters at San Francisco. The mine is developed principally by a shaft 455

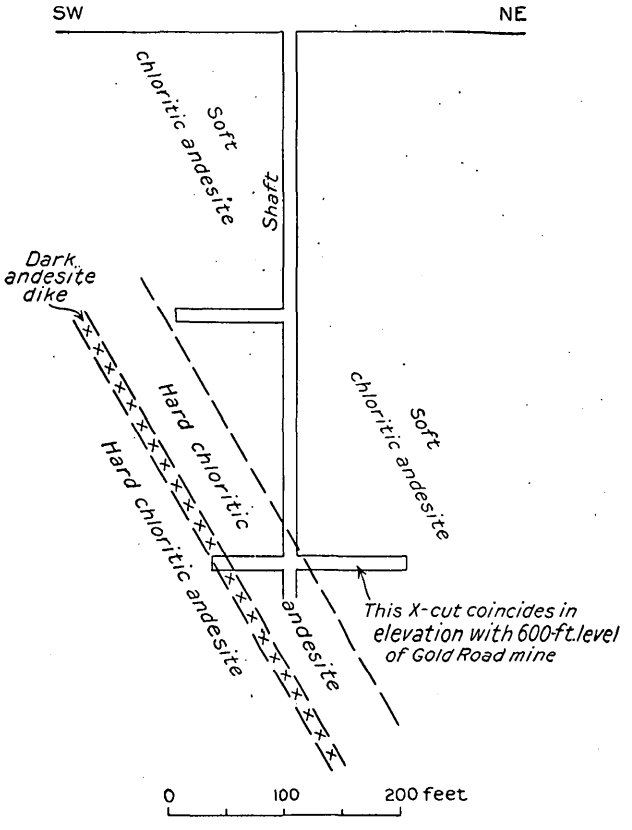


FIGURE 29.—Cross section of workings of West Gold Road mine.

feet deep and about 200 feet of crosscuts (fig. 29). On the 240-foot level the crosscut extends 45 feet to the southwest and on the 440-foot level, which corresponds to the 600-foot level of the Gold Road mine, the crosscut is driven 65 feet to the southwest and 100 feet to the northeast.

The country rock, and about the only rock encountered in the mine, is the green chloritic andesite. It is pyritic and contains quartz and chalcedony-pyrite veinlets. In the lower, southwestern part of

the mine the rock is less altered and is cut by a dike of younger dark andesite about 7 feet in width, dipping steeply to the northeast, nearly parallel with the vein, and encountered principally at the end of the crosscut to the southwest on the lower level.

The developments above cited were made in the hope of finding workable ore on the northwestern extension of the Gold Road vein, but the only deposit encountered is a ledge or vein of mixed bluish and drusy quartz and altered, slightly pyritiferous rock. This vein occurs in the crosscut to the southwest on the 240-foot level and probably represents the Gold Road vein; it is 5 feet wide and dips 86° NE. It is said to average about $2 in gold to the ton and the deposit is not workable at this point.

PASADENA MINE.

Location and history.—The Pasadena mine (see Pl. X) is about 1½ miles west of Gold Road, on open, gently sloping ground that drains northward into Silver Creek, at about 2,550 feet elevation. The mine was located about 1900 and had been working about two years at the time of visit. It is still in the development stage. The property comprises seven mineral claims, five being continuous along the vein and two being side claims. It is owned by the Pasadena Consolidated Mines Company, with headquarters at Pasadena, Cal.

Developments.—The mine is developed mainly on the Rhine Gold claim, principally by a shaft 318 feet deep, three levels containing about 100 feet of drifts and crosscuts, and by surface openings. A small shaft 55 feet deep is located 820 feet south of the main shaft.

The principal equipments are a gasoline hoist and a 2-stamp prospecting mill for testing the ore bodies in development work. The water supply is piped by gravity from Cottonwood Springs, 3 miles to the northeast, at Battle Mountain.

Geology.—The country rock is the green chloritic andesite, which here, particularly in the side of the gulch to the west of the mine and in the dump, is shown to vary in a very short distance, even in a hand specimen, from the soft, altered greenish chloritic phase to the fresh, hard black rock. A fuller description of the rock appears on pages 34–37. The rock shows characteristic propylitic alteration along the vein. Angular blocks of the rock a foot in diameter and many smaller fragments are inclosed in the vein.

The rock is intruded by dikes and masses of rhyolite and by dikes of a basic but quartz-bearing greenstone porphyry. One of these dikes, of greenish color, 20 feet in width, and trending east and west, is cut by the vein about 3,000 feet south of the hoist. The dike is here prominently cross sheeted parallel with the vein.

Veins and ore.—The Pasadena vein or lode varies from 10 to 140 feet in width. It strikes about N. 10° W. and dips about 70° W.

It is reported to extend throughout the length of 19 claims and to be continuous with the vein of the Tom Reed or Blue Ridge mine on the southeast; if this is correct it has a length of several miles.

To the north the vein does not seem to retain its development more than a few hundred yards beyond the mine and hoist. To the northwest, however, where the gulch from the south enters Pasadena Wash, a vein of calcite 2½ feet wide and striking northward is prospected, but is not proved to be a part of the Pasadena vein, which it may, however, join farther north.

The croppings consist essentially of reefs of iron and manganese stained quartz and some gray calcite. They show polished faces with horizontal striation. In the Pasadena mine the walls are reported to be firm, well defined, and regular and to stand well.

The vein consists essentially of calcite and quartz, the quartz increasing in amount with depth. Some of it is of the greenish Gold Road type and this carries the best values. The calcite or spar portion of the ore is said to contain its best gold values in the minute black specks and dendritic bodies of iron and manganese, which it carries widely disseminated.

The average values of the ore are reported to be about $10.50 a ton and the ore is said to be suitable for the cyanide process. In the main shaft, which is on the west spur of the vein, the ore is said to average $11.20 in gold to the ton from the surface down, the ore shoot varying from 4 to 10 feet in width. At a smaller shaft 55 feet deep mill runs of ore are reported to have given results as follows: Surface, $5.56; at depth of 25 feet, $12.45; and at 55 feet, $24 in gold to the ton. The ore at these depths is reported to extend the entire width of the shaft, with only one wall in sight.

MOSS BACK MINE.

Location and history.—The Moss Back mine is situated 3 miles by trail northwest of Gold Road, in open country near the foot of the range, at about 2,400 feet elevation. It is near the upper edge of a bluff about 80 feet high overlooking a wash on the northeast. The property comprises three claims. It is reached by wagon from Gold Road in a distance of 7 or 8 miles by descending Silver Creek nearly to the Moss mine road forks.

The deposit was first located about 1863 by the Barry Mining Company as the Blanco ledge, so-called from the whiteness of its croppings and ore. It was relocated in 1864 and thereafter abandoned and finally it was again relocated in 1901 by Charles H. Burlock and wife, of San Diego, Cal., who still own a four-fifths interest in it, the remaining fifth being owned by the Moss Back Mining Company, of Los Angeles.

There has been no production, but about 900 tons of what is said to be good milling ore lies on the dump.

Development.—The mine is developed principally by a main shaft, drifts, and crosscuts to a depth of 330 feet. The workings also include a crosscut tunnel 150 feet in length on the southwest. The mine is said to produce a plentiful supply of water for ordinary milling purposes. The water rises within 170 feet of the surface. The mine is now dismantled of its hoist and surface equipments and the ladders have been drawn from the shaft. Besides the water produced by the mine a never-failing source of supply is a constant spring located at the foot of the range about a mile northwest of the mine and about 400 feet above it, with which there are pipe-line connections.

Geology.—The Moss Back deposit is geologically and mineralogically very similar to that of the Pasadena mine. The country rock is the green chloritic andesite; it is locally pyritic and is intruded by rhyolite dikes and masses and by fresh black basalt or basaltic andesite. The structure or sheeting trends about N. 80° E.

The rhyolite is also in part mineralized and is reported to assay from $2 to $3 a ton all over the surface; it contains veins or reefs of silicified rock, and is cut by diabasic basalt dikes. In the small hill east of the mine it contains a 1 to 2 inch rich gold-bearing stringer with much hematite.

Veins and ore.—The Moss Back vein or lode dips about 80° SW. and has a known extent of nearly half a mile; the width at the surface is at least 23 feet, and it is said to widen to 40 feet in the bottom of the mine. The vein consists essentially of a mixture of gold-bearing, medium to coarsely crystalline calcite, with a small percentage of fine-grained silica or quartz and probably adularia, which has seemingly replaced calcite. It also contains a considerable amount of the greenish mineralized country-rock andesite, which occurs in streaks or small bodies and carries low-grade values.

The croppings are more or less silicified portions of the vein above described, for the most part stained by iron and manganese oxides, and contain in places masses or clusters of quartz blades representing the replacement of calcite by the quartz along its crystal faces and cleavage planes. There is but a small amount of gouge, but the wall rock next the vein is usuall sheared, silicified, and veined by quartz or calcite.

The principal portion of the vein or main ore shoot, the part best defined at the surface, has a width of 12 to 15 feet and contains from 4 to 6 inches of gouge material consisting of sheared and crushed rock, calcite, and quartz on its foot-wall side.

The ore almost everywhere contains disseminated minute blackish specks of hematite, and these, particularly in the spar, are reported to carry the gold in very finely divided particles. The values rise

with increase in the amount of silica in the spar, the best ore being in association with the silica. Some small pockets of yellowish-brown "sugar quartz," which consists principally of colored spar, with an admixture of silica and limonite, are said to have contained up to $2,000 in gold to the ton.

A 17-foot crosscut from the main shaft to the southwest at a depth of 200 feet below the surface, which has not yet reached the hanging wall, is said to show good ore throughout its extent, running from $6 to $9 to the ton. In the shallow workings on the southeast a 10-foot width of the vein is reported to average $31 in gold to the ton.

MOSS MINE.

Location and history.—The Moss mine is about 4 miles northwest of Gold Road and 2¼ miles west of the Moss Back mine, to the north of Silver Creek. It lies in a well-mineralized area on the southeast slope of a group of outlying hills, the Moss Hills, which trend west to a point about 1½ miles beyond the mine. This mine, the original discovery in the country here discussed, was located in 1863 or 1864 by John Moss, who found much free visible gold exposed in the croppings about where the shaft is now sunk. On this spot, from a hole about 10 feet in diameter and depth, he took out $240,000 in gold, all of which he immediately spent in development work, much of which was ill advised. Moss died later in poverty.

The rich ore was contained in reddish-brown hematite or iron-stained quartz croppings, which Silliman[a] aptly describes as having the appearance of sulphide-bearing quartz that had been roasted. Much of it was covered with flakes, incrustations, and beads of gold from the size of shot or pea to that of a hazelnut. Two tons of ore taken from the outcrop of the vein is said to have netted $114,000 in San Francisco, and the exhibition of this rich ore led many men to brave the dangers of the desert and the Indians to reach the district.

The mine was worked principally in pioneer times, at first by the Moss Brothers. After the rich find a 10-stamp mill was built on Silver Creek just below the Holmes camp, where some of the ore may still be seen. Dahlgreen Black is said to have enlisted eastern capital and operated the mine after the Moss Brothers. The property, including several patented claims, is now owned by the Gold Giant Mining and Milling Company, with headquarters at Los Angeles. Some development work was done on the property in 1906. The total production is $500,000.

Developments.—The developments consist principally of a 230-foot double-compartment shaft and about 600 feet of tunnels and crosscuts. The shaft starts on the hanging-wall side of the vein

[a] Silliman, Benjamin, jr., Am. Jour. Sci., 2d ser., vol. 41, 1866, pp. 289–308.

and now contains some water. Much of the horizontal underground work is 8 by 10 feet or more in cross section and was done in the pioneer black-powder days at great cost.

The tunnel starts in a gulch about 100 feet south and 60 feet below the collar of the shaft, whence it extends diagonally to the northeast for a distance of about 250 feet, following a stringer in part nearly to the vein. It then parallels the vein westward as far as the shaft, with which it connects by a crosscut. Other crosscuts open the vein at intervals and extend into the foot wall on the north. Several shorter crosscuts also extend to the south on good-looking spur veins or stringers, but in no case more than about 30 feet, which seems to indicate that the values were too low to pay.

The principal equipments are a good gasoline hoist and a small mill at Hardyville, near the mouth of Silver Creek, on Colorado River, 7 miles distant.

Geology.—The country rock is a quartz syenite porphyry phase of the granite porphyry and micropegmatite described on page 30, but contains more hornblende and biotite. It forms a considerable part of the Moss Hills and underlies the younger volcanic rocks in the vicinity. Northward it extends for a distance of half a mile or more to a point about one-fourth of a mile beyond the Moss mine saddle and southward nearly to Silver Creek and the Holmes camp, probably connecting locally with the same rock in the Hardy Mountains. It weathers reddish brown.

Veins and ore.—The Moss vein as seen underground has a width of about 22 feet and a known extent of more than half a mile and a reported extent of about 4 miles, being held by some to connect with the Moss Back vein. It dips steeply to the south and is associated with considerable fault breccia on its foot-wall side. Both sides of the vein are frozen to the walls, and in consequence of this the walls are torn and ragged where the vein has been mined.

The croppings, which in large part are prominent and of the Gold Road type, consist principally of a surficially iron-stained mixture of quartz and crystalline calcite and probably adularia and silicified rock, which in part is porous or honeycombed and is cut by a cross sheeting or slickensiding.

In the underground and less-oxidized vein the quartz and calcite are present in about equal amount and the quartz seems to have replaced calcite, both minerals being usually fine grained and very intimately intermixed or intergrown. The quartz is mainly of a greenish hue, like that of the Gold Road vein, but a considerable portion is also pale rose-red, from which the vein has commonly come to be known as the rose-quartz vein.

Under the microscope a section of the ore shows coarse granular quartz, with coarse calcite grains, also acicular calcite in triangular

pattern and intervening finer-grained quartz; the quartz appears divided in sectors through the distribution of radial inclusions, probably mostly fluid. No adularia was seen in the section, but it is probably present in the ore.

East of the mine, at the wagon-road gap, where a good surface opening has lately been made, the vein has narrowed to a few feet in width, and in the most easterly crosscut on the level of the tunnel in the mine, about 100 feet east of the shaft, it is split into several parts or stringers by horses and inclusions of the country rock.

Nearly the whole production seems to have been obtained from very rich pockets or concentrates in the croppings and highly oxidized ore near the surface, for deeper work shows the deposit to consist principally of a large body of low-grade ore, much of it averaging about $4 in gold to the ton. Several tons of the ore are reported to have averaged $6,800; two tons $42,500 each in San Francisco; and a lot of about 100 tons, which was treated at the small mill at Hardyville, about $42 a ton.

Lying near the Moss vein on either side are one or more small veins or ledges, on which assessment work is kept up. The principal one on the north is about parallel with and 500 feet distant from the Moss vein, and contains much fluorspar.

RATTAN MINE.

The Rattan mine is 4 miles northwest of Gold Road and about one-fifth of a mile south of the Moss mine, in the south base of the Moss Hills. The property comprises two claims, the Rattan and Ruth, which have been patented since 1894, but it has not been worked for some time. It is owned by the Rattan Mining Company of Kingman.

The mine is developed principally by a 200-foot shaft, about 200 feet of drift, and considerable stoping on the 100-foot level. The principal equipments are a gasoline hoist and a 10-stamp mill; the latter being located 7 miles distant, on Colorado River at Hardyville. Several hundred tons of the ore were treated in this mill.

The country rock is a quartz syenite porphyry phase of the granite porphyry and micropegmatite, the same as at the Moss mine, except that here it is finer grained and contains considerable iron pyrite. It exhibits two structures which are variable, one trends N. 15° E. with dips steeply to the east and the other trends about east and west with dips steeply to the north.

The Rattan vein dips about 80° N. Openings on it extend interruptedly for about three-fourths of a mile to the east. So far as seen at the surface the vein is 2 or 3 feet wide, and the ore body is said to be up to 2 feet in width. It consists principally of calcite or spar, quartz, and crushed rock, and contains green fluorspar.

The vein in the bottom of the mine is said to be about a foot in width and to contain a shoot of $300 ore 1 inch wide. The ore differs from the Moss ore principally in containing pyrites. Some good ore has been shipped and a considerable amount has been milled. Several hundred tons were treated in the company's mill at Hardyville, but owing to its sulphide content a high extraction was not obtained.

GOLDEN STAR GROUP.

The Golden Star group of mines comprises seven or eight properties, mainly in the prospect stage, situated in the northwest corner of the district about 2 miles northwest of the Moss mine. They extend from the north slope of the Moss Hills northward mostly on open ground to Cottonwood Wash, a distance of about 2 miles.

The camp is located in the northern part of the area at about 2,200 feet elevation, just south of Cottonwood Wash and about 140 feet above it, near the point where the wash passes from open country into a canyon. It is reached by wagon road leading from the Moss mine northward, thence westward down Cottonwood Wash.

The group is owned by the Golden Star Mining and Milling Company, of Pasadena, Cal. The principal openings of the group are on the Golden Star, West Point, American Boy, and Red Bluff claims.

West Point prospect.—The West Point prospect is located in the lower west slope of the Moss Hills, on the West Point claim, about half a mile south and 100 feet above the camp, in gray andesite, which here contains considerable breccia. The vein is about 3½ feet in width. It strikes N. 65° W. and dips about 80° NE. It has very much the appearance of a finely sheeted or cleaved dike, subsequently silicified, and is said to contain the highest-grade ore in the camp. The ore is of the quartz-adularia type and its values are in gold. A microscopic section shows it to consist of quartz of variable grain, limonite, and a small amount of adularia.

American Boy mine.—The American Boy mine is about a mile south of the camp and 800 feet above it, in the upper north slope of the Moss Hills. It is developed by a 110-foot crosscut tunnel, 200 feet of drift, and a 60-foot shaft sunk to a level with the drift and tunnel.

The country rock is a medium-grained bluish-gray rock, which seems to be an andesite and is locally pyritic. It is cut by a cross sheeting that dips steeply north and a jointing that trends north-northwest. An east-west dike of coarse, porphyritic andesite crosses the mouth of the tunnel.

The vein dips steeply to the northeast. It varies from 6 inches to 2 feet in width and contains chiefly impure gray and dark, coarsely crystalline calcite with local bodies of dense greenish quartz about an inch in maximum diameter. It is tightly frozen to both walls. The

croppings are silicified country rock and spar, and some of the surface ore is said to have averaged about $100 in gold to the ton.

Golden Star mine.—The Golden Star mine is about a mile southeast of the camp, in the lower north slope of the hills, in a gulch that trends to the northwest (Pl. XII, *A*). The country rock is dark-gray pyritic andesite, which near by rests upon an older coarsely porphyritic green rock and locally upon the pre-Cambrian pegmatitic granite which here forms the core of the hills. The vein is composed of calcite and quartz, the croppings of which are stained by iron and manganese oxide. It varies from 1 to 14 feet in width, dips 65° to 70° N., has a known extent of about a mile, and is cut by the Meals Ledge (see p. 176) on the east. On the hill slope west of the mine the vein is associated with thin, dense green porphyry dikes which parallel it.

The mine is developed by a 90-foot shaft. The vein here contains about 3 feet of good-looking calcite or spar, but is of too low grade to be workable.

Red Bluff prospect.—The Red Bluff prospect is just north of the camp, on the sides of a long, narrow north-south fault block, where it is crossed by Cottonwood Canyon, whose floor here lies about 140 feet below the neighboring surface. The fault block is about 50 feet wide. It dips 70° E. and extends into the Moss Hills, a distance of more than a mile.

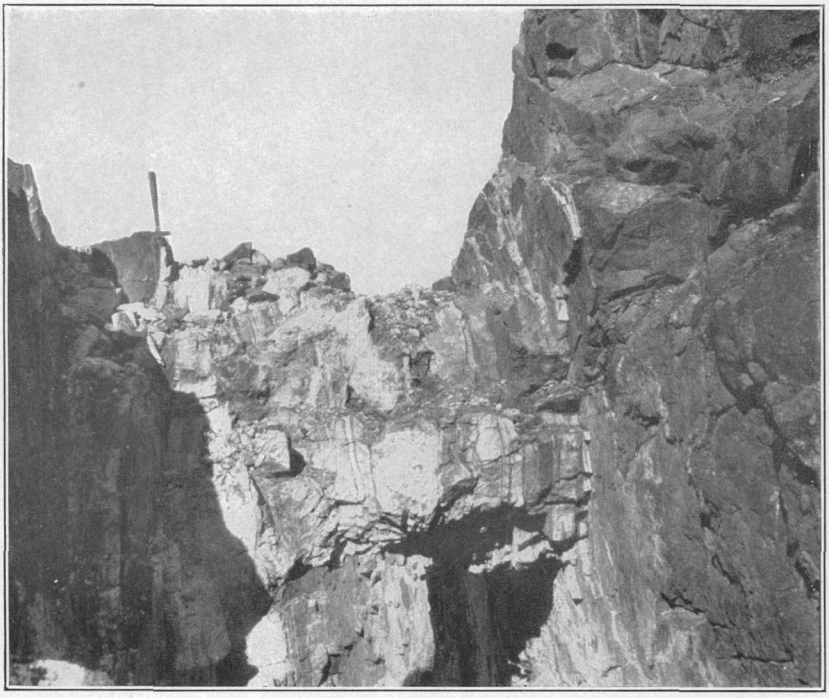
The country rock is a gray andesite, which rests upon the pre-Cambrian coarse granite or pegmatite that floors the canyon. These rocks are intruded by a granite porphyry dike 40 feet wide at right angles to the trend of the fault block. After the intrusion of the granite porphyry the dike was cross faulted, and the country rock on the west or foot-wall side of the fault block, including the dike, was carried by lateral throw about 150 feet to the south, to a point about west of the camp. The amount of movement along the fault plane of the fault block has been considerable and has produced from 1 to 14 feet of fault breccia, crushed rock gouge, etc., and here mineralization has taken place.

The best values occur in red, oxidized streaks, principally on the hanging wall, but also on the foot-wall fault plane, and are usually associated with or near by the granite porphyry.

The granite porphyry is a pink or reddish rock with a medium or fine grained groundmass containing phenocrysts of quartz. It contains no ferromagnesian silicates, and under the microscope shows some silicification and secondary growth of adularia.

The property is developed principally by a 45-foot drift and a 50-foot crosscut. The drift, starting near the bottom of the canyon, extends to the south on the hanging-wall fault plane, principally in fault breccia and pre-Cambrian granite, with granite porphyry on

A. GOLDEN STAR MINE AND FAULT BLOCK, LOOKING SOUTH.



B. GOLD ROAD VEIN AT EAST OF LINE ROAD CLAIM, LOOKING NORTHWEST.

its hanging-wall side. From its face the crosscut has been driven through the fault block to the foot wall, without encountering much ore. This deposit appears to warrant further prospecting.

VENTURE PROSPECTS.

The Venture prospects, owned by Thomas Patterson, of Gold Road, are situated in open, gulch-scored ground, just north of Cottonwood Wash. The country rock is a gray medium to fine grained fresh biotite andesite closely related to that in the Moss Hills on the south; on the north are old greenstone tuffs in which the sheeting dips steeply to the south-southwest.

The principal exposure occurs on Venture claim No. 2. Here the vein or ledge containing the deposits is vertical or dips steeply to the north-northeast, and, where open to the depth of about 8 feet, presents the following section, beginning on the hanging-wall side:

Section of vein on Venture claim No. 2.

	Ft.	in.
Country rock, somewhat crushed along face of hanging wall.		
Chiefly impure calcite with but little quartz, stained and mottled orange and greenish (principal part of the vein)	1	6
Yellowish-green talcose gouge		2½
Brecciated greenish rock spar and gouge material	1	
Foot wall, containing 1 to 3 feet of crushed country rock.		

The values, said to be fair, are contained principally in the firmest portion of the vein and in the heavy red or red-brown iron-stained rock along its sides. The croppings are mostly weathered calcite, some of which, as well as the surface ore, yield $6 in gold to the ton.

MEALS LEDGE.

The Meals ledge, a large gold-bearing calcite vein or lode of low-grade ore, is located east of the Golden Star group. With certain interruptions, it extends from the saddle in the Moss Hills near the Moss mine northward for a distance of nearly 2 miles, its general strike being N. 30° W. It is best developed in the open mesa country between Cottonwood Wash and the Moss Hills, where the principal locations are owned by W. H. Meals, of Gold Road. Here it varies from 10 to 60 feet in width, with an average width of perhaps about 40 feet, and dips in general about 65° ENE. It is composed principally of coarsely crystalline calcite, with usually a small amount of quartz, and locally contains, particularly in the croppings, much angular crushed andesite, quartz porphyry, and other rock.

The country rock forming the hanging wall of the vein for a considerable distance south of Cottonwood Wash is greenstone (altered andesite?) containing bowldery inclusions of the pre-Cambrian gran-

ite; the corresponding foot wall on the west is the normal country-rock gray andesite.

Southward toward Meals camp, which is located on the vein about midway between Cottonwood Wash and the Moss Hills, the vein seems to lie largely in the pre-Cambrian granite, with the country-rock andesite continuing for the most part as the foot wall; and slickenside grooves dipping 20° to 60° SSE. show considerable movement to have taken place. At Meals camp the granite continues on the east and the porphyritic andesite on the west. The principal claims in this vicinity are the W. H. Hearst, Jupiter, Rancon, Hot Times, and Yellow Spar Extension. Here the vein is 16 feet in width and is opened by 20-foot shafts on either side of the camp. It is composed principally of calcite or spar with a small amount of quartz and is reported to average from $6 to $8 in gold to the ton, the values occurring principally in association with the quartz and the firmer portions of the spar.

Near by the vein is joined by the Golden Star vein, here pinched to a mere stringer coming in from the west. South of the junction a porphyritic greenstone (andesite?) forms the hanging wall. Farther south, in the lower slope of the Moss Hills, about one-fourth of a mile north of the Moss mine saddle, the underlying quartz syenite porphyry of the Moss mine becomes the country rock, and in this rock the vein seems to pinch. In this syenite rock, however, which extends from this point beyond the Moss mine on the south, in the east side of the Moss mine saddle, along the course of the vein, occur several stringers, ranging from a few inches to a foot in width and contained within a width of 18 or 20 feet, which are commonly referred to as the Meals "ledge," but on neither the north nor the south slope of the hills was any exposure of the vein observed.

MILLER MINE.

Location and history.—The Miller (formerly the Parsons and the Hardy) mine is 2 miles southwest of Gold Road, on the south side of Silver Creek, mostly in a hill on the northeast slope of Hardy Mountains, an outlying group of the range, at about 2,200 to 2,400 feet elevation. The mine was discovered early in the sixties. It was worked by adit drifts, and some of its ore was shipped to San Francisco, some was treated in arrastre, and some in the old Moss mill on Silver Creek. W. H. Hardy, of Kingman, a former owner, states that he took out $80,000 worth of ore after a considerable amount had been mined and shipped by earlier owners. Later Frank Holmes became interested in the mine and soon began shipping ore; still later the mine was taken over by Col. Thomas Ewing, of Vivian, who sunk a 200-foot shaft on it, and drifted and crosscut the vein

with good results. The property is now owned by George Miller, of Gold Road, who has been connected with it since about 1892. It comprises six claims. The production to date is reported to be $100,000, of which $80,000 was stoped from a comparatively small space.

Developments.—The mine is developed to a depth of about 300 feet, principally by three shafts aggregating 500 feet, three tunnels and a drift amounting to nearly 1,000 feet, and about 200 feet of crosscuts. The principal surface equipment is a gasoline hoist. Good potable water, said to be plentiful for domestic and milling purposes, is derived from a well near the mine.

Geology.—The country rock is the granite porphyry and micropegmatite described on page 30. It is a medium to coarse grained rock and weathers pale purplish and brown; it contains many fine-grained magmatic inclusions or "schlieren," and, as at the Rattan mine, above described, it is, locally at least, pyritic, though no pyrite has yet appeared in the veins. It is sheeted about vertically north-south and east-west. It is intruded and in part overlain on the north by micropegmatite, which is to some extent altered and mineral bearing, and it is seemingly intruded by rhyolite on the east. It is also intruded by dikes of a dark greenish altered rock, probably a diabase.

Vein and ore.—The Hardy vein is reported to have a length of 4 miles. It strikes about N. 80° W. and dips about 75° N. Toward the west the Jack Pot, Homestake, and Navy Group mines and other openings are situated on it. (See Pl. X.)

The Miller mine is located on the east end of the Hardy vein, which here has an averge width of about 15 feet and a maximum width of about 30 feet, as shown by cuts and croppings at the east shaft. The croppings consist of quartz and silicified rock stained by iron and manganese. The vein is composed principally of quartz, a small amount of calcite, and some altered rock, which seems to be the younger micropegmatite. Much of the quartz, as shown in the deep workings and in the croppings, has replaced calcite, after which it is pseudomorphic. Plate II, reproduced from a photograph of a specimen collected in the main drift about 600 feet from the mouth and 200 feet below the surface, represents this ore. Some of the quartz is drusy, many of the vugs containing slender brittle quartz needles. The vein contains also considerable greenish crystalline fluorspar, which faces slabs of quartz a foot or more in diameter with incrustations one-half inch thick. Adularia is also present in the vein, along with the quartz of variable grain which replaces calcite. The occurrence of what seems to be altered micropegmatite in association with the vein suggests that the fissure now occupied

by the vein may formerly have been occupied by a dike of the micropegmatite, which the vein later replaced.

Beside the main vein above described there are also several smaller veins. In the middle east slope of the hill in which the mine is located the vein near its east end is intersected by a smaller north-south vein. This cross vein varies from 6 inches to about 3 feet in width and is younger than the main vein, which it cuts. It is otherwise similar to the main vein and has received considerable development in the mine, mostly to the north of the main vein, and has contributed materially to the production.

Also paralleling the Hardy vein and situated about 450 feet distant from it on the north is a small vein or stringer known as the McCullough ledge. It lies in the granite porphyry and micropegmatite, stands about vertical, and extends from Hardy Wash westward to a point beyond the Homestake mine, a distance of about a mile. It is prospected at several points and is said to carry good values in gold and silver.

The ore of the Miller mine contains chiefly gold, but carries also considerable silver—more silver, it is said, than any other ore in the district or southern part of the Black Mountains. The ore is reported to average about $6 a ton, but some very rich ore is also present.

JACK POT MINE.

The Jack Pot mine, owned by Maj. R. J. Holmes, of Gold Road, is about one-fourth of a mile west of the Miller mine, in the upper north slope of the mountain, at about 2,500 feet elevation. It is on the Hardy vein and in country rock of granite porphyry and micropegmatite. It is developed principally by a 160-foot shaft and drifts and is equipped with an 8-horsepower gasoline hoist.

HOMESTAKE MINE.

The Homestake mine, also owned by Maj. R. J. Holmes, is nearly a mile west of the Miller mine, in the upper north slope of the mountains, at about 2,450 feet elevation. It is on the Hardy vein in the granite porphyry and micropegmatite. It was formerly worked by Col. Thomas Ewing and is now bonded to the Gold Road Company. It is developed principally by drifts and shafts, the drift to the east being about 240 feet in extent, and is equipped with an 8-horsepower gasoline hoist. The vein varies from 2 to 20 feet in width, looks well, and is said to carry good values.

NAVY GROUP MINE.

The Navy Group mine (see Pl. X) is about 1½ miles west of the Miller mine, on the east slope of a north spur of the Hardy Moun-

tains, at about 2,300 feet elevation. This also is on the Hardy vein in the granite porphyry and micropegmatite.

It was located by R. E. Zuver, of Gold Road, by whom and his associate, Maj. R. J. Holmes, it was formerly owned. It is now owned by the Navy Group Mining Company, of Los Angeles. The croppings all the way up the mountain slope, several hundred feet in extent, are strong and are reported to continue so for a mile or more westward to the locality where the mountains fall off into the mesa country on the west.

The mine is developed principally by an adit drift 900 feet in length trending N. 82° W. At 500 feet in from the mouth of the drift the vein is cut off by a north-northwest fault, which should be worked out with care before deep and expensive workings are undertaken. Some seemingly useless work has been done, including 400 feet of drifting, on the projected course of the vein beyond the fault.

The principal part of the vein is from 2 to 4 feet in width and consists principally of quartz with bunches of white and gray crystalline calcite and green and red fluorspar. The ore contains principally gold with a very little silver. It is reported to range in value from $8 to $30 a ton, the best grade being associated with iron-stained quartz.

GADDIS-PERRY AND ANGLE LODES.

From Hardy Camp and the mouth of Hardy Wash on Silver Creek just north of the Miller mine a large dike or belt of micropegmatite, about one-tenth of a mile in width, described under the Miller mine, extends N. 75° W. about parallel with the Hardy vein for a reported distance of 3 miles. It seems to be intruded between volcanic greenstone agglomerate on the north and the granite porphyry and micropegmatite of the Hardy Mountains on the south. The contacts on both sides are zones of mineralization containing lodes dipping about 70° N.

The south contact zone is here called the Gaddis-Perry ledge, from the principal prospect on it, situated at its east end, and the north contact the Angle ledge, from its principal opening. The croppings of the ledges are iron and manganese stained quartz and silicified micropegmatite. They are in part porous and honeycombed, and both the croppings and the subsurface portion of the ledges carry good gold values.

The Gaddis-Perry ledge is simply a zone of quartz and silicified rock, principally micropegmatite, from 60 to 80 feet in width, with granite porphyry and micropegmatite forming the foot wall and micropegmatite the hanging wall. It contains several prospects, of which the principal one is that on the east end, owned by Gaddis & Perry, of Kingman. This prospect has several openings, of which

the most extensive at the time of visit was a crosscut driven to the length of 40 feet, showing good-looking gold-bearing quartz.

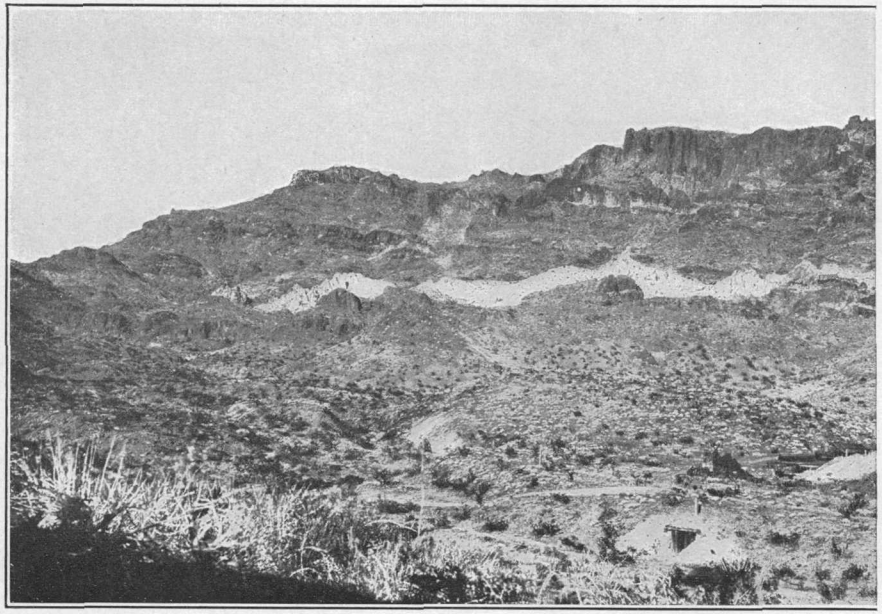
The Angle ledge is similar to the Gaddis-Perry ledge and several prospects are located on it, the most important of which seems to be the one owned by Mr. Angle, of Gold Road, situated about one-fourth of a mile northwest of the Gaddis-Perry prospect. Here the ledge is about 20 feet in width and is bounded by greenstone agglomerate on the hanging wall and micropegmatite on the foot wall, from both of which it is separated by 2 or 3 inches of whitish and reddish talcose gouge. It is opened principally by a 40-foot shaft and shows some good looking quartz, said to carry fair values in gold.

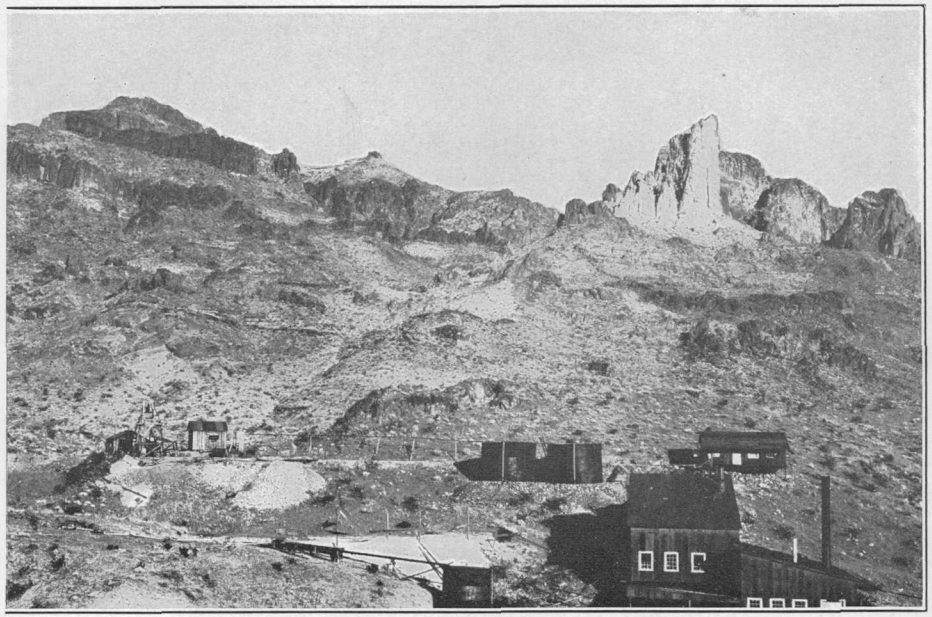
That the origin of the gold in these deposits is in some way connected with the micropegmatite seems very probable. Further support of this view is found in a somewhat similar occurrence to the north of Silver Creek, in the gulch just north of Holmes Camp. Here the country rock, volcanic greenstone agglomerate, is cut by an east-west 1 to 2 foot dike of the micropegmatite, which, like the ledges just described, dips steeply to the north. This dike has been prospected to a depth of 5 or 6 feet, and is reported to contain from $1 to $18 in gold to the ton. When followed eastward for about one-eighth of a mile the dike is found to narrow to 2½ inches in width, to lose its feldspar or rock character, and to become almost pure quartz. Parallel lines resembling flow structure traceable from the feldspathic-rock phase over into the quartz-vein phase in the same fissure.

VIVIAN DISTRICT.

GENERAL DESCRIPTION.

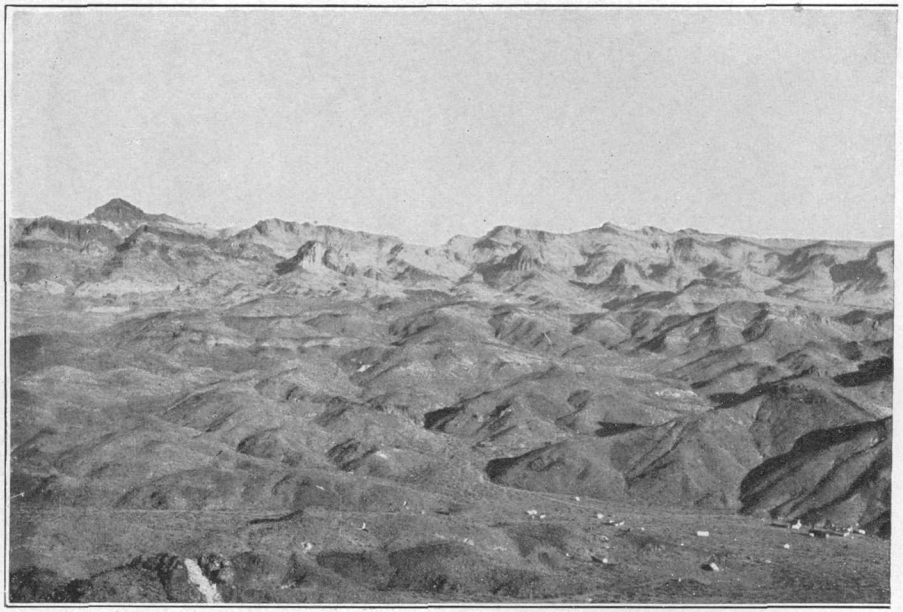
The Vivian district lies in the southwestern part of the region and adjoins the Gold Road district on the south, extending southward with a breadth of about 4 miles to a broad east-west wash, just north of Boundary Cone, a prominent landmark rising boldly 1,500 feet above the adjacent open country on the west. This wash may here be referred to as Boundary Cone Wash. In length the district extends from the crest of the range westward for a distance of about 5 miles, to the locality where the foothills give way to the open mesa country that slopes to the Colorado. Vivian, the principal camp, situated west of the center of the district in Vivian Wash at about 2,250 feet elevation, with a population of about 50 (formerly 150), is about 3 miles southwest of Gold Road and 14 miles northeast of Needles (Pls. X and XIII, *B*). Its water supply is piped by gravity, principally from Cottonwood Springs, located at Battle Mountain, 2 miles northwest of Gold Road.





A. TOM REED (FORMERLY BLUE RIDGE) MINE AND MILL, LOOKING NORTHEAST.

Dark volcanic rocks of range in background, intruded by light-colored rhyolite.



B. FOOTHILLS OF GREEN CHLORITIC ANDESITE, LOOKING EAST FROM LELAND MINE.

Mines of Vivian district in foreground; main range in background.

The district lies in the broad belt of eroded foothills between 2,000 and 3,000 feet elevation. The topography is hilly, but usually not rough (Pl. XIII, *A*, *B*). Nearly everywhere the washes form avenues of approach by wagon. The drainage is principally to the south by Blue Ridge, German American, Vivian, and Leland washes into Boundary Cone Wash, whence it issues southwestward into the Colorado.

But little was learned concerning the history of the district, which seems principally to date from the discovery of very rich gold ore about a decade ago in the Snow Ball mine, now included in the German-American group of properties.

Geologically and mineralogically the district is essentially a southward continuation of the Gold Road district. The country rock is principally the green chloritic andesite or latite (see p. 30), which on the southwest, below Vivian, gives way to the underlying older andesite, the basal member of the volcanic series. The intrusive character of the green chloritic andesite is well shown at the head of Leland Wash, just west of the Leland mine, where dikes from 2 to 20 feet in width given off from the main mass, extend one-eighth of a mile or more westward into the older andesite. The principal effect of the intrusion here seems to be silicification and hardening of the andesite along the contact.

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. The deposits occur in fissures, which are peculiarly well developed in the chloritic andesite, but as a rule are not productive in the underlying andesite. The ability to differentiate these two formations is, therefore, of great importance to the mine operator. They are best studied by observing the rocks along their zone of contact, which is well exposed crossing the ridge just southwest of the Vivian mine, beyond which it ascends Leland Wash northward to the west of the Leland mine and the west base of Leland Monument Butte, the high, dome-shaped knob about 2,000 feet in diameter situated just west of Vivian and rising nearly 700 feet above it, on which the Leland United States mineral monument No. 1679 is located.

The deposits occur in the chloritic andesite as fissure veins or lodes from 5 to 70 feet in width, composed principally of calcite, quartz, adularia, and country-rock breccia, and in general, as in the Gold Road district, those of more nearly westerly trend are of the quartz-adularia or Gold Road vein type and seem to contain the best values. The croppings consist principally of stained quartz and calcite and silicified rock.

The principal mines in which the deposits have been worked are the Leland, German American, Tom Reed, Victor Virgin, Midnight,

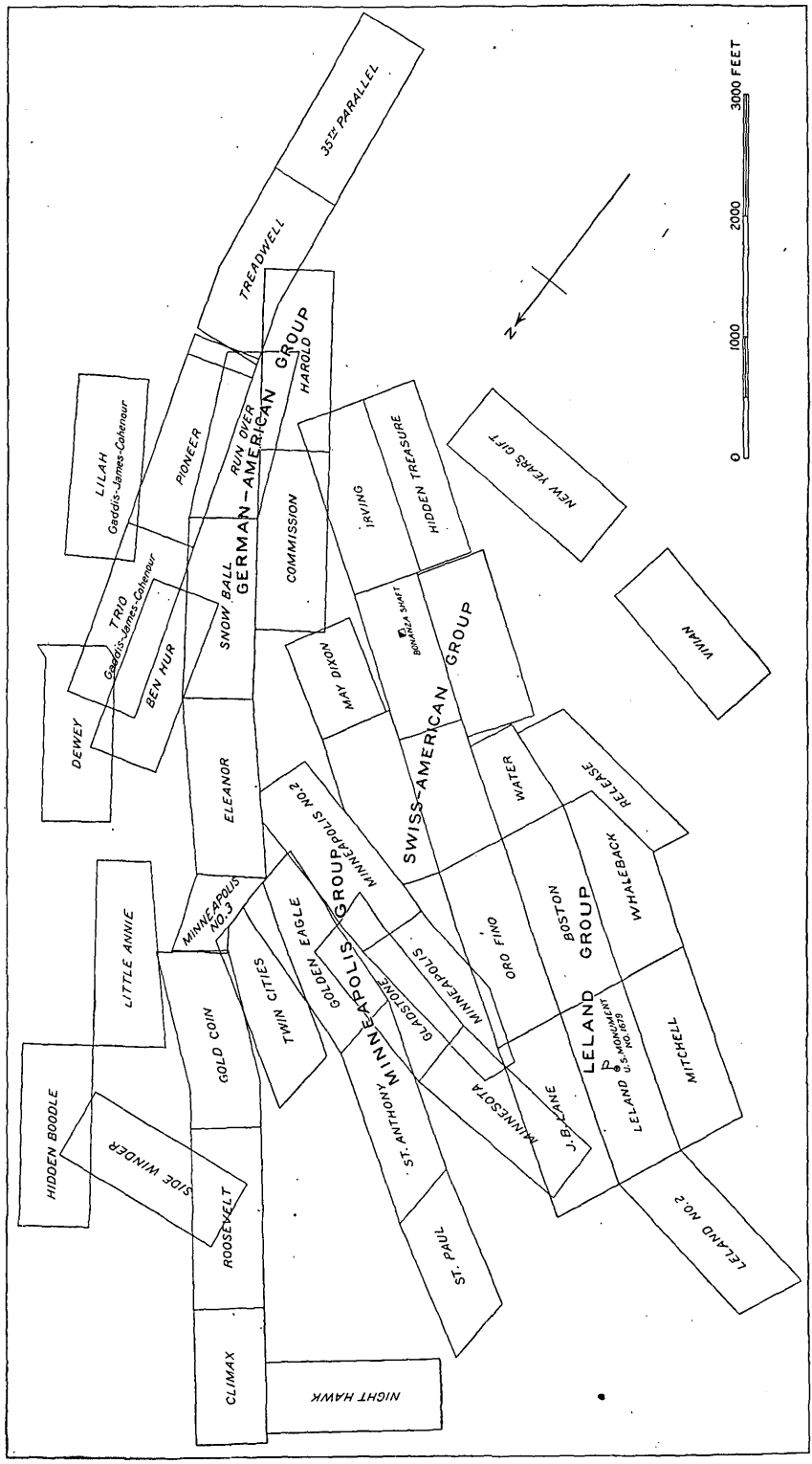
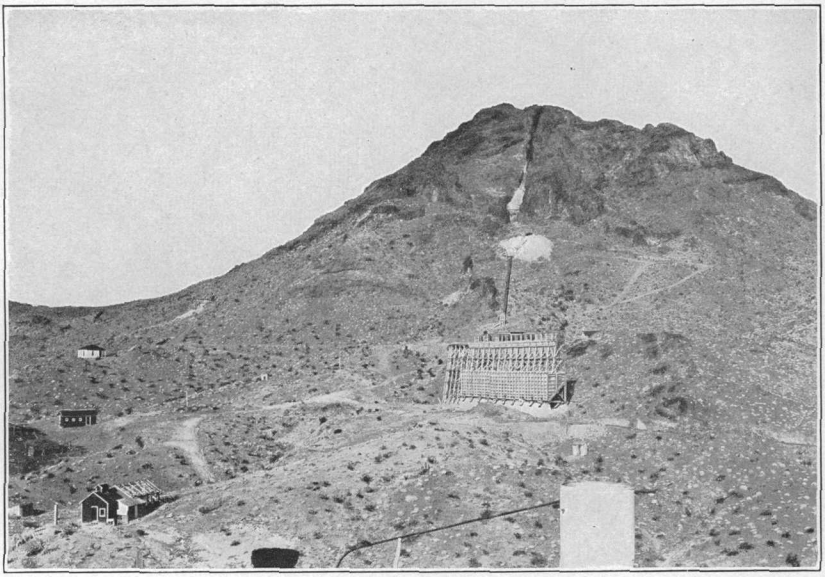
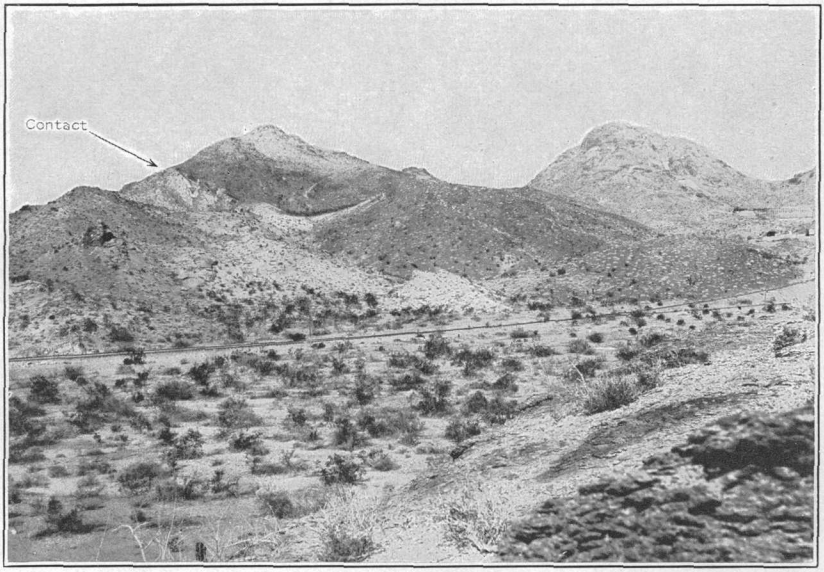


FIGURE 30.—Map showing location of principal claims in Vivian district.



A. LELAND MINE, EAST SIDE, LOOKING WEST.



B. CONTACT OF CHLORITIC ANDESITE WITH THE LIGHTER-COLORED, OLDER, UNDERLYING ANDESITE.

Ridge southwest of Vivian mine, Leland mine, and butte to the right, looking northwest.

and Vivian. Their general distribution is shown on the mine map (Pl. X), and the distribution of the most important claims on the claim plat (fig. 30), which also shows the position of the United States mineral monuments by which the properties are located.

LELAND MINE.

Location.—The Leland mine (Pls. XIII, *B;* XIV) is located just west of Vivian, on the western part of the Leland vein, in the upper part of Leland Monument Butte. The elevations vary between 2,400 and 3,000 feet.

History and developments.—The Leland property is reported to have been purchased from earlier owners in 1902 by Col. Thomas Ewing, who in 1903 sold it to the present company, the Mohave Gold Mining Company (which until January, 1907, was known as the Mount Mohave Gold Mining Company). Common reports give the price as $550,000. The property comprises a group of eight patented claims, of which the Leland and the Mitchell are the most important.

Immediately after the acquisition of the property the company began developments and operations on an unusually large scale. It installed a 12-chute ore bin at the mine at a cost of over $26,000 and a 40-stamp mill at a point which later became known as Milltown, 11 miles southeast of the mine, about 5 miles from the river, in the open, flat valley of the Colorado 6 miles from Spears Lake. It also installed a large pumping plant on the Colorado 2 miles below Needles, where, with a large Corliss engine, water was pumped through an 8-inch pipe line to the mill. In conjunction with these developments 17 miles of narrow-gage railway, the Mohave and Milltown Railroad, was built by an auxiliary company, it is said, at a cost of $268,000, from the east bank of the Colorado opposite Needles via Milltown to the mine. The freight and ore were taken across the river by ferry at Needles, where connection was made with the Santa Fe Railway.

With these equipments, installed at a cost exceeding $400,000, the company operated for a period of two years, principally during 1903 and 1904, and then closed down, mainly, it is stated, on account of failure to save the gold values in the ore at the mill. However, the company plans to resume operations in the near future, particularly in case the Midnight mine, which is now producing, continues to yield well.

The equipments above described remain at the mine. Of the 6 or 7 miles of railroad between Milltown and Needles, all but about 2 miles is said to be washed out by the flood water of the Colorado.

During the two years of operation a large amount of work was done in the mine and about 4,500 tons of ore was milled. The mine is

developed by adit drifts, tunnels, shafts, winzes, and stopes, aggregating about 3,000 feet of underground workings, distributed within a horizontal distance of about 3,500 feet and a vertical range of about 700 feet.

The most extensive part of the work is in the east side of Monument Butte, where the principal engines, ore bin, and railroad terminus are located. Here the tunnels or drifts on the lower tunnels exceed 800 and 700 feet in length and have tram connections with the ore bin. On the upper levels, toward the crest of the butte, in a vertical range of about 200 to 300 feet, extensive open-cut mining has been done and here the vein contains a width of 4 to 5 feet of very good-looking greenish quartz ore.

From the west side of the butte work on the two lower levels extends in about 600 and 500 feet, and this work is said to lack but about 125 feet to connect with that projected from the east. The portion of the vein contained between a level situated about 25 feet above the farthest 40 feet of the lower drift and the surface about 170 feet above it has been stoped out. The stoping apparently followed the richest ore only, much of which is reported to have averaged from $50 to $60 in gold to the ton.

The production of the mine was not learned, but of the 4,500 tons of ore milled a considerable amount is reported to have averaged $15 a ton and some from $50 to $60 a ton. Owing, it is said, to inefficient handling in milling a considerable amount of the gold values put through the mill was not saved.

Geology.—The country rock is the green chloritic andesite and latite, which in some parts of the mine is allied to quartz monzonite porphyry. A microscopic slide of a fresh black specimen collected in the lower east tunnel consists of a microcrystalline fine-grained groundmass of feldspar and a little quartz in which are embedded phenocrysts of orthoclase and plagioclase. In the lower part of the mine on the extreme west the chloritic andesite gives way to the underlying older andesite and is here intruded into it in the form of dikes, as has been described. A close sheeting, which seems to be the dominant structure, strikes N. 70° W. and dips 70° N. A secondary coarser sheeting or jointing strikes N. 22° E. and dips 70° E.

The black phase of the rock seems to contain considerable iron, which in some places on the upper northeast shoulder of Leland Butte renders the compass unserviceable.

Veins and ores.—The mine is located on the western part of a well-marked fissure vein, known as the Leland vein. This vein has a known extent of about a mile, strikes about N. 70° W., and dips about 75° S. At the mine it ranges from about 5 feet in width on the east to about 25 feet on the west. It is of the Gold Road type, being

composed essentially of pale-greenish quartz and microscopic adularia, locally accompanied by calcite or spar and country-rock fault breccia, and it is usually frozen to the fissure walls.

The vein is reported to contain more or less regularly throughout the mine a large amount of good ore averaging from $5 to $10 in gold to the ton. Locally the vein contains vugs lined with quartz crystals and black pulverulent oxide of manganese; many of these vugs carry much fine free gold.

The croppings of the vein consist of stained quartz and country rock containing stringers and veinlets of quartz and calcite; they are usually prominent, rising from 5 to 20 feet above the surface, and at the top of the butte they attain a width of about 40 feet, where they are locally split by a horse of the more or less silicified country rock 25 or 30 feet wide, which is traversed by stringers and veinlets of quartz and calcite and bounded on either side by 3 feet of vein quartz representing the vein, the portion on the hanging-wall side being the stronger and more persistent and direct in course. On a considerable portion of the western slope of the butte the hanging-wall side of the vein rises almost perpendicularly 60 to 80 feet above the surface and the vein is about 25 feet in width. At the west base of the butte, however, where it encounters the contact of the green chloritic andesite with the older andesite, this great vein almost abruptly ends, and it is not represented in its projected course or elsewhere in the older andesite beyond the contact. The contact, however, seems to be in part a fault contact as well as an eruptive one, as is shown where it is crossed by the lower tunnel on the west at about 100 feet in from its mouth.

East of the mine, particularly where the vein crosses the ridge on which the residence buildings stand, on the eastern part of the Boston claim, the croppings are 10 or 12 feet in width. They rise 5 or 6 feet above the surface and consist mostly of light-colored, more or less coarsely crystalline calcite or spar and quartz.

Another important vein at the Leland mine is the Mitchell vein. It is located about 400 feet south of the Leland vein, as shown in figure 30, and lies about parallel with it, but dips steeply to the north. It is opened at the south base of Leland Butte at about the same elevation as the lower drifts on the Leland vein by a 100-foot shaft and a 60-foot tunnel connected by tramway with the large ore bin. At the time of visit the shaft contained about 40 feet of water. The croppings at this point consist of a dark-stained "iron cap" of quartz, calcite, and rock several feet in thickness, resting like a detached cover on the underlying portion of the vein.

The principal opening is the shaft, but the tunnel shows some excellent examples of pseudomorphic quartz, which has replaced calcite. The vein consists of 7 feet of crushed and brecciated quartz, calcite, and country rock. The quartz is relatively pure toward the

hanging wall, but grades into a breccia of calcite, quartz, and seamed country rock. This vein, where sampled 60 feet below the surface, is reported to average about $8.50 in gold to the ton, or about the same as the Leland vein, while the rich streak of quartz on the hanging-wall side is claimed to average about $100 a ton.

Though no trace of the Leland vein occurs in the older andesite beyond the contact of the country rocks on the west, the Mitchell ledge seems to be represented there by sporadic croppings of impure dark-stained quartz or silicified rock and a little calcite, the quartz possibly being a replacement of calcite. Other croppings of a similar character occur near by, and most of them are associated with the intrusive green chloritic andesite dikes.

Although no sinking has been done to exploit the Leland ground below the lower workings above described, the ore on both the Leland and Mitchell veins, except in the extreme western part of the mine, very probably continues in depth coextensive with the green chloritic andesite to a level about 230 feet below the present lower level of the mine, or the drift commonly known as "Tunnel No. 3."

In the light of this conclusion the widely held theory that by sinking to a depth of 1,200 or 1,500 feet at a point midway between the Leland and Mitchell veins a large body of ore will be encountered at their junction should be accepted with caution, for the lower limit of the green chloritic andesite seems beyond doubt to lie at too shallow a depth for the veins to meet in this formation.

GERMAN-AMERICAN MINE.

Location.—The German-American mine (Pl. XV, *B*) is located in the southern part of the district about three-fourths of a mile east of Vivian and about 150 feet above it, in part on the German-American Wash and in part on the Vivian Wash drainage.

History.—The mine was discovered about 1896 and has been owned by the German-American Mining Company, of Los Angeles, since about 1900. The Gold Road Company, which had a bond on the property in 1902, drove the Thirty-fifth Parallel tunnel and did considerable work at the Thirty-fifth Parallel and Treadwell shafts, but most of the development was done during the years 1905 and 1906. The mine was still making weekly shipments of bullion in June, 1906, but was closed soon thereafter for lack of sufficient water to run the mill on a double shift, as it was not able to operate on a single shift with profit. The water at the time was piped from the Tom Reed mine. As the supply decreased, the mill was operated by two-hour runs only and at last shut down, but some of the property is still worked by lease. The mine produces only about 500 gallons of water a day, not nearly enough to supply the mill. For a long time before the plant was closed it was kept in operation without sinking by simply stoping from the surface and shooting the ore by gravity

to the drift and tunnel far below, as shown in the open works at the Thirty-fifth Parallel shaft.

The property comprises 12 claims, known as the Treadwell group (see fig. 30), aggregating about 200 acres, and extends through the length of about five claims nearly 1½ miles, the trend being a little west of north.

The production of the mine is about 2,700 tons of ore, which is reported and in part verified by mill records and United States Mint returns to average about $10 in gold to the ton. About 1,000 tons of the ore was produced in 1905 and 1,700 tons in 1906. A large dump at the mouth of the Thirty-fifth Parallel tunnel is reported to consist of good milling ore.

Developments.—The property is developed at various points, principally by shafts, drifts, and tunnels, to a maximum depth of about 300 feet and contains probably about 3,000 feet of underground work. The most important of the workings are at the Treadwell and Thirty-fifth Parallel shafts, which are situated about 1,200 feet apart on the vein and are connected with the mill by tramway.

From the Thirty-fifth Parallel shaft, which is 235 feet deep, and is intersected by a crosscut tunnel from the east at 170 feet below the surface, the drifts and workings extend laterally for 100 feet to the south and 120 feet to the north. From the Treadwell shaft (Pl. XV, *B*), which is 260 feet deep and sunk on the hanging-wall side of the vein, and in which the water rises to the 200-foot level, the drift on the 100-foot level extends for 160 feet to the south and 200 feet to the north; and that on the 200-foot level extends for 200 feet each way.

Pioneer shaft No. 1, the northern of the two shafts on the Pioneer claim, situated about 1,600 feet north of Treadwell shaft, is 240 feet in depth and contains several hundred feet of drifts and crosscuts on its two levels.

The principal surface equipments are a 10-stamp mill of 900-pound stamps, a cyanide plant, three steam or gasoline hoists distributed at the principal shafts, tramways, offices, and other buildings.

Geology.—The country rock is the green chloritic andesite, which in the southern part of the property, west of the vein on the foot-wall side near the tramway, is in contact with the older underlying andesite. The vein appears to lie on an eruptive fault contact of these two rocks. This older andesite extends from a point near the Thirty-fifth Parallel shaft northward to the North Pioneer shaft and the Snow Ball vein, and essentially constitutes the portion of the hills between the German-American vein on the east and Vivian Wash on the west, with small columnar cappings of the otherwise dominant country rock on the highest points. This rock does not seem to contain important deposits. At the contact of the green chloritic

andesite and the older andesite the transition zone from the unaltered stage of the one rock to that of the other is about a foot wide, the chloritic andesite being here dense, hard, and variously intruded into joint planes and fractures of the older andesite.

On the south faulting seems also to have taken place along the contact, as the eruptive rock occurs in the north face of the Thirty-fifth Parallel drift in the bottom of the mine, where it forms both walls.

The green chloritic andesite also occurs in the bottom of the Treadwell shaft, where it is somewhat altered, soft, pyritic, and traversed by calcite veinlets. The black, unaltered phase is also present, as shown in the dumps.

Veins and ores.—The German-American vein or lode extends practically continuously throughout the length of the Thirty-fifth Parallel, Treadwell, and Pioneer claims, a distance of nearly a mile, and contains free gold practically throughout its extent. Assays of $15 are said to be common and many samples yield up to $30 a ton.

The general strike of the vein is about N. 12° W. and the dip is about 85° E. The vein ranges from 1 to 60 feet in width and consists essentially of calcite, quartz, and adularia, with some brecciated country rock. The calcite is in part replaced by quartz.

The values favor the hanging wall and the best values are mostly associated with the quartz. A microscopic section of the ore shows it to be typical quartz, adularia, and calcite ore. According to a series of analyses of the ore throughout the vein, made by the company, the amount of quartz or silica present is about 17 per cent and calcium oxide (CaO) 27.9 per cent. Like the Gold Road ore this ore is easily mined and milled. An extraction of 92 per cent is reported to have been obtained by cyanidation. It is said that with electricity as power the ore could be mined and milled at a cost of about $2.50 a ton.

The croppings are prominent and where silicified locally rise 20 or 30 feet above the surface, as shown at the Treadwell shaft (Pl. XV, *B*). The following is a cross section of the vein north of the Thirty-fifth Parallel shaft, looking south:

Cross section of German-American vein north of Thirty-fifth Parallel shaft.

	Feet.
Smooth, glossy, slickensided hanging wall, of mottled, firmly cemented, and silicified fault breccia, 3 feet or more in width, composed of crushed country-rock andesite, quartz, and calcite ore; contains $2 or $3 in gold to the ton.	
Impregnated country-rock quartz and calcite ore; contains as a whole $4 to $6 in gold to the ton	8
Main vein chiefly calcite and quartz, somewhat banded toward center; contains $10 a ton	3–4
Greenish porphyritic andesite foot wall, rather freely traversed by stringers and veinlets of calcite and quartz.	

At the Thirty-fifth Parallel shaft the foot wall is usually well defined, solid, smooth, and slickensided. The vein is nearly everywhere frozen to the wall, which consists either of the solid country rock or of 6 inches to 2 feet or more of hard fault breccia composed of crushed rock, spar, and quartz. The hanging wall, on the other hand, is ragged, ill defined, and loose or less firm than the foot wall, and for 20 or 30 feet back from the vein is composed mostly of loosely cemented crushed rock containing veinlets of calcite.

On the 170-foot level, in the north face of the drift, about 200 feet distant from the shaft, the vein pinches to less than 1 foot in width and is not workable.

On the surface south of the shaft it splits or is shattered. A small stringer continues southward on the course of the vein, while the main portion of the vein is turned eastward at an angle of 20° to 30° from its normal course by a fold or small fault; prospects are opened on both parts on claims to the south.

At the Treadwell shaft the vein widens to a lode about 70 feet in width, which it maintains for a distance of about 600 feet. The lode is composed of rock, calcite, and quartz, and although it carries $2 or $3 a ton all the way across and contains several veins 3 to 12 feet wide, only an 8-foot vein on the hanging-wall side is workable. As exposed in a pit 160 feet south of the shaft, this 8 feet of pay ore consists essentially of coarsely crystalline or massive calcite, kidneys or small horses of red country rock, and a little quartz, and runs $9 or $10 a ton, retaining these values to the bottom of the mine. The quartz is of the pale-greenish Gold Road variety and carries the best values. Next to it in value comes the red or reddish iron-stained streaks in the spar. In the Treadwell shaft the vein gradually narrows in depth, the workable portion being only 2 feet in width in the bottom of the mine, 260 feet below the surface.

In Pioneer shaft No. 1, which is 240 feet in depth, the vein, 10 to 12 feet in width, is said to contain 1½ feet of $10 to $14 ore and about 5 feet of low-grade ore. This shaft is now being worked by lessees, who are shipping the ore to Needles. The shaft produces more water than the Treadwell shaft.

Just beyond a small gulch north of Pioneer shaft No. 1 the vein forks; the main or hanging-wall portion continues northward and seems to pinch out near the middle of the Trio claim, while the lesser or foot-wall portion curves to the left, extends northwestward, and forms the Snow Ball vein. In the Snow Ball shaft, which is 100 feet deep, it is said to contain a width of about 1½ feet of $25 to $30 ore and to have produced in pioneer days much very rich ore, some averaging 40 ounces of gold to the ton.

The Hidden Treasure vein, opened on the Hidden Treasure claim, is reported to be about 50 feet in width and to carry a streak of pay

ore on either wall and one in the middle; the latter is about 2 feet in width and is said to contain $60 ore.

VICTOR-VIRGIN MINE.

Location and history.—The Victor-Virgin mine (Pl. XV, *A*; fig. 30) is situated in the southeastern part of the district, 2 miles southeast of Vivian and a mile east of the German-American mine. The elevations range from 2,500 to 2,700 feet. The mine was discovered early in the sixties by Ben Speare, about the time that other mines in this part of the country were staked by the California volunteers then stationed at Camp Mohave on the Colorado. The property comprises two claims, the Victor and the Virgin, both patented. It was formerly owned by Charles Goodchild and is now owned by the Victor Gold Mining Company, of Denver. A small amount of rich ore has been shipped and much milling ore lies on the dump.

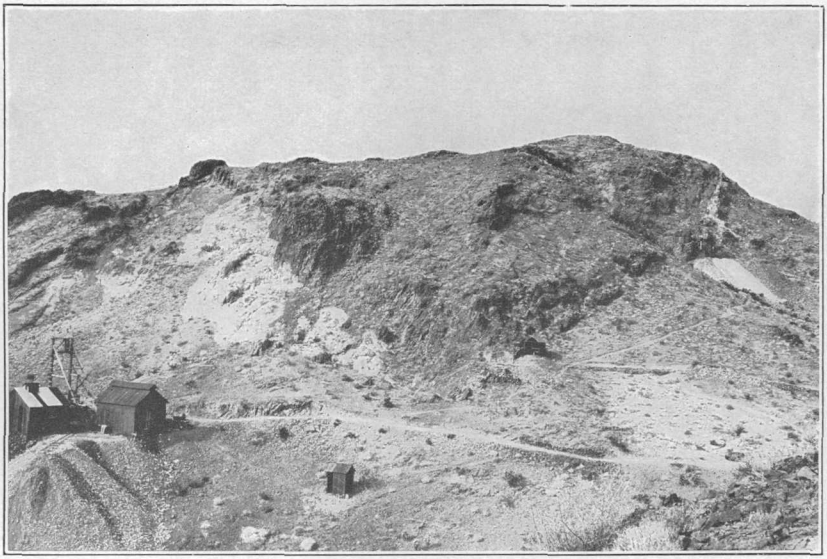
Developments.—At the time of visit (January, 1907) the mine was developed to a depth of nearly 300 feet, principally by two shafts and drifts. The shafts are known as the Victor and Virgin and are situated about 850 feet apart on the vein, the collar of the Virgin being about 100 feet above that of the Victor. Each shaft contains more than 300 feet of drifts. The Victor shaft produces some water, which was encountered in crosscutting to the vein 14 feet distant from the shaft on the 200-foot level.

At a point midway between the Victor and Virgin shafts, however, a new double-compartment shaft had just been started, and at present writing (June 22, 1908) is reported to have reached a depth of 500 feet; at this level the management is crosscutting to tap the vein.

The principal surface equipments at the time of visit were gasoline hoists at the Victor and Virgin shafts. Elaborate equipments, however, were then being added, including the installation of a 650-horsepower steam plant at Needles, 16 miles distant, the erection of a 20-stamp mill near the new shaft at the mine, and pipe-line connections between Colorado River and the mine and mill. The plant seems rather extensive for a mine of this size, in which the deposits have not yet been shown to extend to any great depth. The power plant at Needles will supply power and pump the water from the river to the mine and mill. It is expected that the power can be supplied at a cost of $6 per horsepower per month.

Country rock and veins.—The country rock is principally the green chloritic andesite, with the underlying older andesite occurring near by on the west. A little pyrite was observed locally in the green chloritic andesite, but none in the vein.

The Victor-Virgin vein lies chiefly in the green chloritic andesite and possibly in part on the contact between this rock and the older



A. VICTOR-VIRGIN MINE, LOOKING NORTH.

Victor shaft to the left, Virgin to the right.

B. GERMAN-AMERICAN MINE, LOOKING SOUTH.

Treadwell shaft to the right; Thirty-fifth Parallel shaft left of center. Boundary Cone shows through gap.

andesite. The vein strikes N. 47° W. and dips 80° NE. to 90°. It is reported to be more than 3,000 feet in length, varies from 1 to about 18 feet in width, and is locally associated with silicified country rock or breccia 100 feet or more wide.

The vein is of the Gold Road type, being composed principally of quartz and microscopic adularia with a small percentage of calcite and crushed rock. As seen in the Victor shaft and vicinity the calcite is usually best developed on the foot-wall side of the vein, where in places it is a foot or more in width.

The croppings are usually prominent and consist of the common dark-stained quartz, calcite, and silicified country rock, of which a cross section northwest of the Victor shaft follows:

Cross section of Victor-Virgin croppings northwest of Victor shaft.

	Feet.
(*a*) Dull greenish and purplish porphyritic hanging-wall green chloritic andesite, bearing amygdules and crystals of calcite and scattered amygdules of quartz; in the last 5 or 6 feet to the right stringers of chiefly calcite and some quartz, $\frac{1}{16}$ inch to 4 inches thick, trending nearly parallel with vein and feeding downward gradually into it	100+
(*b*) Silicified rock and impure quartz, brownish and greenish chloritic andesite, etc., traversed by some of the above-noted calcite-quartz stringers	3
(*c*) Breccia of greenish and reddish stained quartz, crushed and firmly recemented	1
(*d*) Andesite same as *a*, with crossing calcite veinlets $\frac{1}{4}$ to 1 inch thick	2–3
(*e*) Silicified calcite and fragments of country rock *a* or *d* and quartz frozen to foot wall	1½–2
(*f*) Country rock same as *a;* near vein is more silicified and finer grained and locally crushed and recemented; at 10 feet distant from vein carries a calcite-quartz stringer 1 foot thick and two smaller ones	100+

The section in the face of the west drift on the 200-foot level of the Victor shaft consists of about a foot of dull greenish-gray crushed and recemented quartz and calcite and 9 inches of brecciated gouge; it is usually frozen to the hard walls, the hanging wall containing stringers or veinlets of calcite that feed downward into the vein.

On the 100-foot level the vein is about 7 feet in width west of the shaft, while east of the shaft it is about 4 feet in width, and the hanging wall shows horizontal slickensides.

The ore shoots are reported to dip steeply to the southeast. The ore contains gold and locally shows copper stain, but no pyrite was observed in it. In the thin section the ore is seen to be a typical quartz-adularia ore with a few calcite grains present.

The ore is said to be mostly of medium grade, but it ranges from $9 to about $60 a ton. Some of the greenish quartz croppings near the Victor shaft are reported to have assayed $100 a ton.

TOM REED MINE.

Location and history.—The Tom Reed (formerly Blue Ridge) mine (Pl. XIII, *A*) is situated in the eastern part of the district, about a mile south of the Gold Road mine and about 200 feet below it and nearly a mile northeast of the Victor-Virgin mine. It lies on open ground in Blue Ridge wash near the base of the central part of the range, at an elevation of 2,700 feet.

The mine was discovered about 1900 and was soon after owned by Ely Hilty, Walter Fellows, Walter Hawkins, Jacob Anderson, and others. About 1901 the Gold Road Company sunk the two principal shafts on the property, the Ben Harrison and the Tom Reed, each to a depth of about 100 feet. The ore in the first 30 feet of the Ben Harrison shaft averaged $25 a ton and for the rest of the depth $12 a ton. About 1904 the mine was purchased from the Hilty party by the Blue Ridge Gold Mines Company, which installed a mill and operated the mine and mill for about a year and a half with about eighteen men, and milled on an average about 30 tons of $7 ore a day. As considerable gold remains in the tailings produced during this period the ore should be treated by cyanidation. In 1906 the Blue Ridge Company was succeeded by the present owner, the Tom Reed Gold Mines Company, with headquarters at Pasadena, Cal. In 1908 the mine was reported to be working steadily, sinking, and producing gold bricks regularly. More recently a body of $12 ore 12 feet wide is said to have been encountered on the 300-foot level.

The property comprises a group of eleven claims, adjoining one another end on and extending along the vein for a distance of about 3 miles. The production is reported to considerably exceed $120,000.

Developments.—The mine is located near the middle of the claim group on the Ben Harrison and Tom Reed claims and is developed to a depth of 185 feet, principally by the Ben Harrison and Tom Reed shafts. The developments aggregate about 600 feet of underground work, done mostly in 1904 to 1906. The shafts are located about 600 feet apart, on or close to the vein. The Ben Harrison shaft, whose workings practically constitute the mine, contains about 400 feet of drift, distributed on three levels 50, 100, and 150 feet below the surface.

The mine is said to produce about 5,000 gallons of good water a day, ample for operating the mill. The water level lies about 100 feet below the surface. A never-failing spring, the Olla Oatman, is said to occur on the property.

The principal surface equipments are a 40-ton 10-stamp mill (of 1,050 pounds per stamp), with an 85-horsepower Corliss oil-fuel engine and a 100-horsepower boiler, a 15-horsepower gasoline hoist, tramways, and necessary buildings. It was lately reported that 20 new stamps have been added and that the mine is being supplied with power from the plant at Kingman.

Geology and veins.—The country rock is the green chloritic andesite containing amygdules of calcite. The Blue Ridge vein strikes about N. 50° W. and dips about 70° NE. It lies nearly parallel with the Gold Road vein on the north and with 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, and it is said to continue as the Pasadena vein on the northwest, in which event it has a total length of about 4½ miles, being probably the longest vein in the district. At the Tom Reed mine it ranges from about 16 or 20 feet in width in the Ben Harrison shaft to about 35 feet in the Tom Reed shaft, with the fissure walls usually ill defined. It outcrops boldly for the length of two claims. The croppings consist principally of the usual dark iron and manganese stained quartz and silicified rock, calcite, and chert. On the foot-wall side they are markedly cross sheeted.

The vein is mainly of the Gold Road quartz-adularia type, with but little calcite present in the principal part of the mine. A considerable portion of it is reported to have run $25 in gold to the ton for the first 30 feet in depth and about $12 from that point down. Although gold only is produced, the ore contains also a little silver.

In the Ben Harrison shaft the vein shows a total width of 16 to 22 feet, and the only well-defined wall is the foot wall on the 50-foot level. This wall has about 1 foot of crushed rock and quartz as gouge and a 1½-inch band of silicified brown or red rock between it and the vein, which shows a thickness of about 3 feet of quartz ore and 3 to 4 feet more of intermingled crushed rock and quartz.

On the 100-foot level the vein consists of 16 feet of crushed quartz and rock with neither wall at all defined; but toward the hanging-wall side of the vein there is 6 feet of good-looking, more or less porous, clear quartz ore, as shown in the accompanying section.

Section of portion of Blue Ridge vein in Ben Harrison shaft on 100-foot level.

	Feet.
Crushed rock with some frozen quartz, but no foot wall.	
Massive quartz	2½
Rock horse, reddish brown	1½
Crushed rock	2
Crushed rock with quartz stringers	2¼
Partly crushed, porous, and honeycombed quartz ore, which somewhat resembles Gold Road ore	6
Crushed rock.	

On the 150-foot level the vein consists mainly of crushed rock, but the foot-wall side of the drift is in quartz; the hanging wall carries some vugs 6 inches to 1 foot in diameter, containing blackish, porous, and oxidized quartz ore.

In the crosscut at the bottom of the Tom Reed shaft, situated on the hanging-wall side of the vein, the following section is shown:

Section in crosscut at bottom of Tom Reed shaft.

	Feet.
Silicified andesite foot wall represented on the surface by the bold, dark croppings.	
Reddish-stained quartz and crushed rock containing, it is said, about $80 in gold to the ton	6
Crushed rock and spar	20+
Crushed andesite country rock and some spar with no definite hanging wall.	

A fine body of ore is reported to have been recently opened near the Tom Reed mine, on the Shuck & Darling property.

MIDNIGHT MINE.

The Midnight mine is situated in the hills 1½ miles northwest of Vivian, at an elevation of 2,500 feet, and is accessible by wagon road. It is owned by the Mohave Gold Mining Company, and has been producing moderately since about 1900. For some time it paid the running expenses of the Leland mine, which were large.

The mine is developed to a depth of 50 feet by inclined shaft, drifts, and stopes and is equipped with a gasoline hoist; the management has just begun sinking the shaft 300 feet deeper.

The country rock is the green chloritic andesite. It is intruded by basic and acidic dikes near by and is cut by a marked sheeting which trends N. 10° W. and dips 75° W. and by a close cross sheeting which dips steeply to the north. One of the basic dikes, a fine-grained greenish rock, about 40 feet in width, forms the foot wall. About 300 feet northeast of the mine, on higher ground, occurs a closely banded bluish to light-gray and greenish mottled 2 to 3 foot vein composed of fine-grained siderite containing some lime and manganese. It resembles rhyolite with banded or flow structure and may have replaced a dike in the fissure it now occupies.

The Midnight vein, which is the foot-wall member of a north-south lode, 100 feet wide, strikes N. 15° W. and dips 30° to 40° W. It is about 3½ feet in width and consists principally of quartz, with some calcite, fluorite, and adularia. Its foot-wall portion, for a width of 3 or 4 inches, contains crudely banded red and green fluorspar, and toward the foot wall the quartz becomes dark and dense, of a flinty nature, and contains a few crystals of pyrite.

The vein has been worked from the surface almost to the bottom of the mine and longitudinally for a distance of about 120 feet, mainly on the south side of the shaft, and in this extent has averaged about $18 a ton in gold. The production has been considerable for a mine of its size, that on one side of the shaft alone amounting to $18,000. Where now worked in the bottom of the mine the ore is of low grade, running about $7 in gold to the ton, and consists of a mixture of partly altered soft country rock traversed by stringers and veinlets of calcite and quartz.

VIVIAN MINE.

Location and history.—The Vivian mine is located on the Vivian claim about one-fourth of a mile below Vivian. It is west of Vivian Wash, on the Mohave and Milltown Railroad, at an elevation of about 2,200 feet. Its position and topography are shown in Plate X.

The mine was discovered about 1902 by Ben Paddock, a half-breed Mohave Indian, who in riding over the trail at the locality observed glittering free gold in rich croppings which had been disturbed by a recently passing wagon. He at once located a claim, later known as the Vivian, and took with him to Camp Mohave that day as much of the croppings as he could conveniently pack on his pony, from which it is said that he obtained about $500 in gold. Soon afterward a considerable amount of gold was extracted from the rich croppings and surface ore found on the claim. In 1903 the mine was purchased by Judge E. M. Ross and Col. Thomas Ewing, who developed it to some extent, and in 1905 sold it to the Vivian Mining Company, with headquarters at Los Angeles. The company continued to develop the property and installed a mill whose completion in the spring of 1906

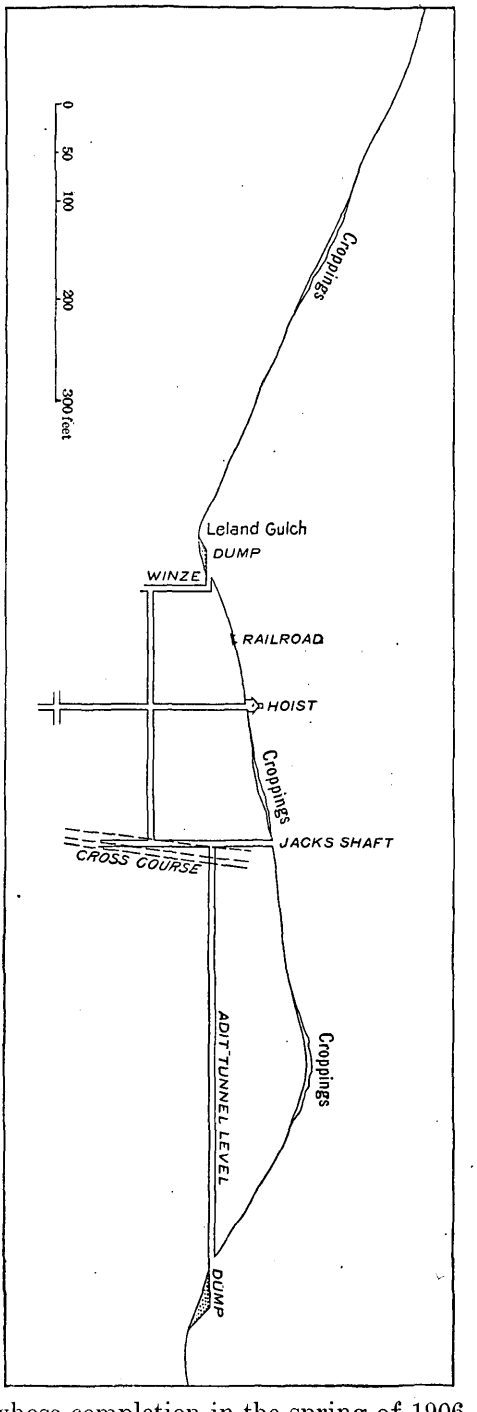


FIGURE 31.—Longitudinal section of workings of Vivian mine.

was followed by a run of forty days, after which the plant and mine were closed in July, it is said, for lack of water. The production is small.

Developments.—The mine is developed principally by three shafts and drifts to a depth of about 270 feet (fig. 31). The principal equipments, which, unfortunately, seem to have been prematurely installed, are new, of the best modern type, and very complete, and include an automatic 40-ton 10-stamp mill and cyanide plant, with a 200-horsepower Scotch marine boiler, Hamilton-Corliss engine, hoist with double engine, air compressor, ore crusher, bullion furnace, and commensurate attachments, to all of which may be added the advantageous location of the property on the railroad already mentioned.

Geology.—The country rock is the green chloritic andesite, which in the gulch just west of the mine gives way to the older andesite. The green chloritic andesite is probably intrusive in the older andesite, but the contact at the mine seems to be in part a fault plane. The older andesite rises about 40 feet above the gulch and extends from a point 200 feet above the mine to a point several hundred feet below it. The green chloritic andesite in the mine is pyritic and in part brecciated and somewhat altered.

Veins.—The Vivian vein strikes N. 75° W. and dips about 80° to 85° S. It has a known extent of about half a mile. It is 3 feet in average width, which is less than that of most of the veins in the district, and west of the mine it narrows to a mere stringer. It consists essentially of coarsely crystalline dark calcite and a little quartz.

The croppings have a thickness of up to 2½ feet of stained red and black quartz, rising to a maximum of 3 feet above the surface. A considerable amount of the quartz is pseudomorphic after calcite. The walls, especially the foot wall, are not well defined and contain coarsely crystalline calcite in the fractures and joints. A lack of continuity of vein and ore, which is said to be characteristic, is an unfortunate feature of the deposit. It is, however, very rich in spots.

The gold contained in the vein varies from very fine to coarse colors, wire gold, and small clumps, and occurs chiefly in pockets or bunches ranging from low to very high in value, as high as $9,500 a ton being reported. The higher values occur in the quartz and are best in the quartz that is associated with the dark spar.

The principal dumps show that the older and site has been encountered, from which it seems doubtful whether workable ore will be found at greater depths.

SWISS-AMERICAN MINE.

History and developments.—The Swiss-American mine is located at Vivian, in the base of the hills on the east side of Vivian Wash. The

mine was acquired from the locators by its present owner in 1891. Masses and fantastic forms of free gold are reported to have been found plentifully in its croppings and surface ore at the time of discovery and caused a considerable sensation. It is owned by the Swiss-American Mining Company, of Fremont, Ohio. This company is said to operate also a large silver mine and smelter in Sonora, Mexico. The production is probably small and has been obtained chiefly from the Bonanza shaft.

The principal developments are two shafts, the Ben Doran and the Bonanza. The former is 100 feet in depth and contains two 20-foot crosscuts to the north and to the south at the bottom. The Bonanza, situated 40 feet to the north of the Ben Doran, is but 16 feet deep. The principal equipments are a gasoline hoist.

Country rock and vein.—The principal country rock is the green chloritic and pyritic andesite, but the older andesite is also present.

The deposits are contained in what seems to be the eastward extension of the Leland vein, on whose course the mine and croppings are located, but at this locality the vein partakes more of the nature of a lode, shear, or compound fracture zone than of a simple fissure vein. To judge from the croppings the lode is about 200 feet in maximum width. It strikes N. 65° W., dips about 65° N., and is cut by a sheeting that dips steeply to the west and also a closer sheeting resembling cleavage that dips steeply to the east.

The lode is, in places, divided in two parts by faulting along its median line; for example, just south of the Ben Doran shaft the smooth slickensided hanging-wall side of the southern half of the lode, exposed for about 50 feet, contains 1½ to 2 feet of impure quartz and crushed rock.

The croppings of the lode consist principally of silicified rock and stained quartz. The most prominent of the croppings are comprised in a width of about 50 feet on the north or hanging-wall side. This portion rises about 20 feet above the surface of the wash and contains bodies of unaltered as well as silicified rock with stringers and veinlets of quartz and calcite, principally in the silicified rock. It contains also the workable and in part rich portion of the vein, which is reported to be about 13 feet in width, with principally quartz gangue frozen to the walls.

At a short distance east of the mine the lode is cut by a cross fault, which has seemingly carried the eastern portion 100 feet or more to the south and downward. Longitudinally, however, the croppings in general continue interruptedly eastward up the gulch and hill slope toward the German-American mine.

As the shaft was boarded up from the surface nearly to the bottom, underground observation was here restricted to the crosscuts at the bottom of the shaft, which lie in the older underlying ande-

site. A horizontal contact is reported between this rock and the green chloritic andesite 60 feet below the surface.

The only representation of the great Leland vein found here in the bottom of the mine is a stringer of partly vuggy quartz and calcite 1½ feet wide, containing very low values only, in the south crosscut and a 1 to 2 inch quartz stringer in the north crosscut, from which on the whole it seems probable that no workable ore occurs at greater depth. As stated on page 187, in the description of the German-American mine, there seems to be little prospect of any deep or important ore deposits being found between Vivian Wash on the west and the German-American vein on the east.

The Bonanza shaft, at the north or hanging-wall edge of the lode, is located on a small east-west shear zone, fault vein, or stringer, about a foot in width, consisting of altered silicified rock, impure iron-stained quartz, and calcite, and is associated with a parallel 10-inch dark dike rock. The ore of this little "vein" is reported to have contained free coarse gold in abundance, the richest being found in the iron-stained portion of the vein, but, as in the Ben Doran shaft and others, owing to the proximity of the older underlying andesite, it seems probable that the ore does not continue to great depths.

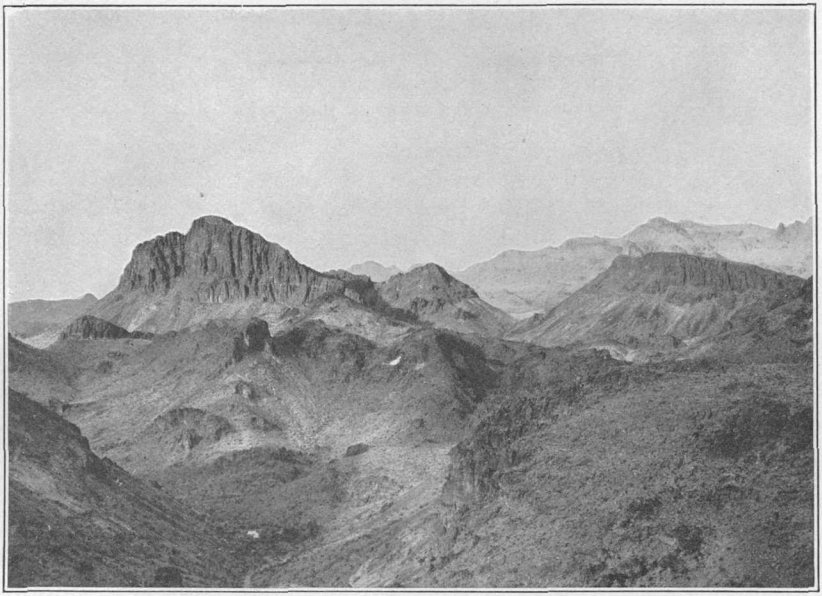
ROOSEVELT SHAFT.

The Roosevelt shaft is about three-fourths of a mile north of Vivian, in the hills on the upper drainage of Vivian Wash, on the Roosevelt claim, at an elevation of about 2,500 feet. The country rock is the green chloritic andesite. The deposits are contained in a calcite and quartz vein, which strikes N. 25° W., dips about 60° WSW., and is reported to be at least 30 feet in width where it is crosscut on the 100-foot and 200-foot levels. The vein is separated from the fissure walls by a well-marked sheet of talcose gouge. It is developed by a shaft 200 feet in depth. Both the country rock and the vein contain pyrite, which in the rock is finely disseminated, while in the vein it occurs in coarse sporadic crystals.

BOUNDARY CONE DISTRICT.

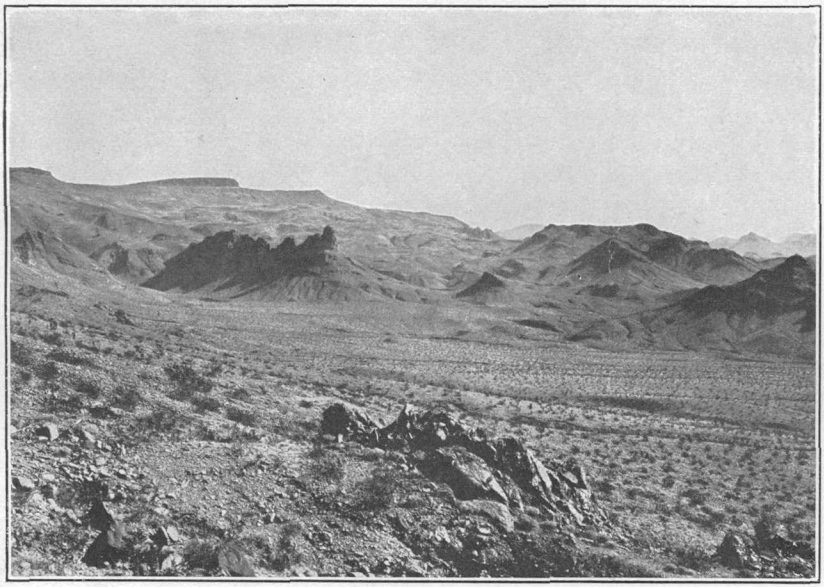
GENERAL DESCRIPTION.

The Boundary Cone district lies in the southwestern part of the region, just south of the Vivian district, from which it is separated by Boundary Cone Wash. It extends from the edge of the mountains at Boundary Cone (Pls. X, XVI) on the west, 3 miles eastward, nearly to the crest of the range, and from Boundary Cone Wash southward nearly to McHeffy Butte, about 4 miles distant.



A. TOPOGRAPHY OF ANDESITE IN NORTHEASTERN PART OF BOUNDARY CONE DISTRICT, LOOKING NORTH FROM POINT NEAR HIGHLAND CHIEF MINE.

Krauss camp and mine in foreground.



B. TOPOGRAPHY OF ANDESITE FLOWS IN SOUTHERN PART OF BOUNDARY CONE DISTRICT, LOOKING SOUTHEAST FROM BOUNDARY CONE.

The deposits occur principally in the northern part of the district. Here the topography is mostly rugged, of the type of eroded volcanic flows, with the mountains rising 1,500 to 2,000 feet above the intervening washes, through which the drainage issues northwestward into Boundary Cone Wash and thence westward to the Colorado (Pl. I). By means of the washes, which serve as highways, the properties are nearly all reached without difficulty, most of them by wagon.

The country rock is mainly a dense dark reddish-brown or purple andesite, locally known as "phonolite" from its metallic ring when struck, and is underlain principally by the earlier tuffaceous andesite containing agglomerates and breccias, below which the pre-Cambrian granite is exposed on the extreme west. These rocks are all intruded by rhyolite in the form of plugs and dikes, of which Boundary Cone is a typical example. The outer basal portion of the cone is composed of andesite tuff; the inner, upper portion, rising to a height of several hundred feet above the andesite, is a huge rhyolite plug, from whose periphery dikes radiate into the surrounding andesite, a good example being on the northwest slope, where a siliceous dike about 15 feet in width extends for three-fourths of a mile to the wash on the west. The andesite for a width of a few inches or a foot along the contact is altered and iron stained. The andesite is also cut by dikes of a younger andesite, derived from a magma the same as or similar to that of the country rock.

The structure in the country-rock andesite varies. In Mount Tucker, at the Iowa mine, in the northeastern part of the district, it consists principally of a sheeting which dips steepy to the south, a secondary sheeting which dips about 70° ESE., and a very marked cleavage, locally amounting to schistosity, which trends about N. 60° E. and inclines with low variable dips to the south-southeast.

The microscope shows the country rock to be a greatly altered andesite, composed principally of a fine-grained groundmass varying from trachytic to cryptocrystalline and containing small glassy or whitish feldspar phenocrysts. Fresh augite andesite was noted from the Highland Chief property.

The principal needs of the district are water and fuel. The chief source of the water supply at present is a few small springs located near the core or crest of the range.

The deposits are gold bearing and occur in two distinct types—as fissure veins in the purple andesite and as deposits on the contact of the rhyolite intruded into the andesite, andesite tuff, and granite. The gangue consists principally of fine-grained quartz with adularia and calcite.

The principal veins, five or six in number, occur in the northeastern part of the district. They strike in general west-northwest and

have steep dips. Some of the important properties or openings located on them are the Iowa, Lazy Boy, Krauss, Highland Chief, and Mountain Beauty.

IOWA MINE.

The Iowa mine, which is the most extensively developed, is situated in the northeastern part of the district at about 2,670 feet elevation, near the top of a nearly east-west ridge, about 140 feet above a tributary gulch on the northeast that leads northward into Boundary Cone Wash. It is about 3½ miles southeast of Vivian, the principal supply point, with which it has good wagon-road connections.

The property comprises three principal claims, the Iowa, Gold Cup, and Gold Nugget, known as the Iowa group. It was located in 1902 by Moore, Roberts, and Hunt, who still own it. Since 1904 it has been bonded to C. E. Hymer and S. W. Wood. It is developed principally by a 200-foot shaft and about 100 feet of drifts and crosscuts, distributed on three levels, and is equipped with a 6-horsepower gasoline hoist.

The country rock is the dense, reddish-brown, porphyritic andesite.

The deposits are contained in a fissure vein, which dips steeply to the south and is exposed by the croppings for more than half a mile. It ranges from 3 to 8 feet or more in width and consists principally of greenish brecciated quartz and a little calcite, with locally some rock breccia, and is traversed by veinlets of secondary quartz and calcite. The values, said to range from about $3 to $14 in gold to the ton, are found mostly within 3 feet of the hanging wall. Some faulting or displacement has occurred along the vein, where pronounced slickensiding shows the movement to have been normal.

On the 100-foot level at a point 10 feet west of the shaft the drift, including the 16-foot crosscut to the south in the hanging wall, shows the following section:

Section on 100-foot level in Iowa mine.

	Feet.
Andesite, crushed and sheared, forming foot wall.	
Crushed and brecciated quartz and andesite with veinlets, containing from $5 to $6 in gold to the ton	6
Horse of coarsely porphyritic andesite	9
Partly crushed and relatively clear quartz, probably with adularia, running about $3.50 in gold to the ton	7
Hanging wall of country-rock andesite.	

On the 200-foot level the crosscut, extending 12 feet to the south in the hanging wall, exposes the following sections:

Section on 200-foot level in Iowa mine.

	Ft.	in.
Andesite foot wall.		
Finely comminuted andesite and quartz containing $2 in gold to the ton		10
Crushed quartz and andesite, which is similar to the above, but on its hanging-wall side becomes a coarser and purer quartz and contains $14 in gold to the ton	2	
Partly crushed and sheared silicified andesite with fine stringers and veinlets of calcite and quartz	9	

LAZY BOY GROUP.

The Lazy Boy group, comprising four claims owned by F. L. Hunt and J. H. Moore, is on the opposite side of the ridge and about one-fourth of a mile southeast from the Iowa mine, at an elevation of 2,600 feet. It is reached by trail from the Iowa mine or from a tributary of Krauss Wash on the southwest. The property is now bonded to S. W. Wood. It is developed principally by a 43-foot shaft and an open cut.

The country rock is the dense, reddish-brown andesite characteristic of the district. The vein strikes N. 85° W. and dips about 80° S., nearly parallel with the Iowa vein. The cut exposes a width of about 6 feet of vein material, composed mostly of brecciated andesite and quartz, said to contain fair values in gold; in the shaft the vein contains several feet of excellent-looking greenish and iron-stained quartz or, which is in part brecciated, contains a little calcite, and probably adularia, and is said to average about $9 in gold to the ton.

HIGHLAND CHIEF AND MOUNTAIN BEAUTY PROPERTIES.

The Highland Chief property is located in the eastern part of the district, about 1½ miles south of the Iowa mine, in the heart of the range, at about 2,850 feet elevation, at the head of Krauss Wash, which drains northwestward into Boundary Cone Wash. It is owned by the Heck Mining Company, of which Casper Heck, of Vivian, is a leading member.

The country rock is andesite, and it is intruded by a similar somewhat younger rock. The vein strikes northwest and stands about vertical, but locally exposes a good foot wall dipping to the southwest at angles of about 70°.

The croppings are strong and bold, particularly to the southeast of the mine. They consist of stained, crushed, and greatly sheared quartz. The property is developed principally by a 70-foot drift,

in which the vein contains some good-looking greenish quartz ore, said to carry fair values in gold.

The Mountain Beauty property, owned by the same company as the Highland Chief, is located about half a mile northwest of the Highland Chief, at about 2,650 feet elevation, 1,000 feet above the main wash that issues westward south of Boundary Cone. The place is difficult of access. The vein, where examined at the head of a tributary wash on the north, strikes N. 80° W., is 12 to 15 feet in width, and consists principally of yellowish and brown iron-stained crushed or brecciated rock and quartz reported to contain fair gold values.

KRAUSS AND GOLDEN ERA PROPERTIES.

The Krauss and Golden Era properties, not visited in this work, seem from oral reports to be similar to most of those just described. The Krauss property, owned by Joseph Krauss, of Vivian, is about half a mile southwest of the Iowa mine, on Krauss Wash and the adjoining hill slope to the northeast, where the dumps show considerable work done. The Golden Era property is about 4 miles southeast of Boundary Cone, at about 2,500 feet elevation.

DEPOSITS AT THE ANDESITE-RHYOLITE CONTACT.

The deposits at the contact occur chiefly in the western part of the district. They are best exposed along the upper edge of the andesite collar encircling the rhyolite plug that forms the upper part of Boundary Cone. They occur mainly on the west and south sides of the cone, where at about 2,400 feet elevation they extend interruptedly for about a mile and are not usually accessible by wagon.

The deposits occur chiefly in a zone of greenish quartz located principally on the rhyolite side of the contact. The quartz zone is 6 to 10 feet in width. It locally contains from $3 to $17 in gold to the ton, with some $200 values reported, and some of the quartz shows free gold. The rhyolite for a width of 2 or 3 feet next to the quartz also contains values.

The Kyle property, opened to a depth of 10 feet on the west side of the cone, exposes a width of 6 feet of good-looking rhyolite and iron-stained, greenish, crushed or in part brecciated quartz with some intermingled rhyolite. Here the deposit dips inward toward the center of the cone at an angle of about 60° and is said to average $17 in gold to the ton. Similar openings also extend around the west and south sides of the cone.

The Warner prospect, reported to contain good values, is about half a mile southwest of Boundary Cone, in association with what

seems to be a rhyolite dike cutting the pre-Cambrian granitoid complex and remnants of overlying rocks.

UNION PASS DISTRICT.

GENERAL DESCRIPTION.

The Union Pass district (fig. 32) lies about 30 miles west of Kingman, mainly on the west slope of the range. It extends from Sacramento Valley and Union Pass westward to Colorado River at Pyramid, a distance of about 14 miles, and has a width of about 3 miles. It ranges in elevation from 4,000 feet on the east to 500 feet on the west. On the east the topography is rough and mountainous, of the type of dissected volcanic flows, with local fault scarps and deep gulches. On the west the district is composed of low hills, broad, open washes, and gravel-covered areas sloping toward the river. Important well-known landmarks are Union Pass on the northeast; Thumb Butte, a rhyolite needle, on the south, to which most of the claims of the district are tied; and Pyramid Rock, a survey benchmark at the river, on the west. A cross

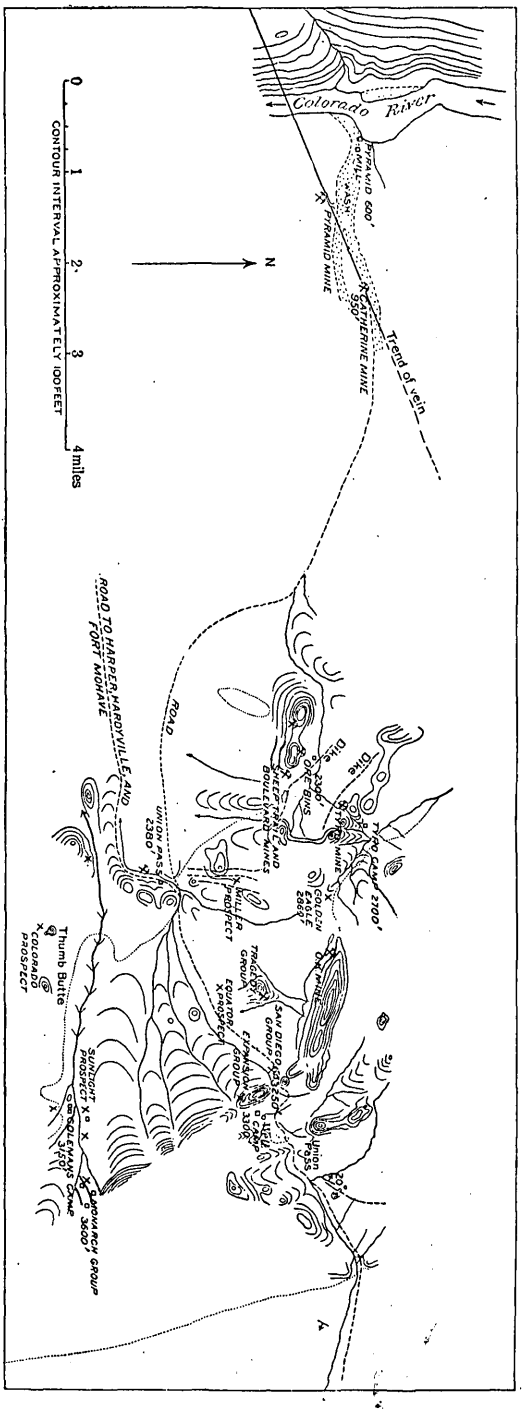


FIGURE 32.—Sketch map of Union Pass mining district.

section of the range at Secret Pass, southeast of Thumb Butte, is given in figure 33.

The water supply is scanty, except near the river. On the east it consists of a few springs or shallow wells in the mountains. The country rock on the northwest and on the south is the pre-Cambrian granitic complex, but in the remainder of the district, especially on the east, it is more or less deeply buried by heavy deposits of the Tertiary volcanic rocks, here consisting principally of rhyolite.

On the west the deposits occur in fissure veins in the pre-Cambrian granite. On the east they occur also as blanket veins, lodes, and irregular bodies and are found chiefly on or near the contact of the rhyolite and granite associated with diabase, a later intrusive, and in conjunction with one or more of these intrusives on fault planes.

The most important of the deposits on the west trend northeastward, those on the east northwestward, and those intermediate in position about midway between these two directions. The prevailing gangue is calcite, which is locally replaced by quartz and adularia.

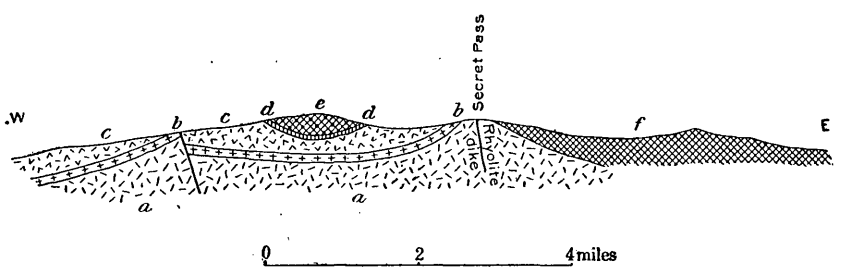


FIGURE 33.—Section across Black Mountains at Secret Pass. *a*, Granite; *b*, biotite andesite; *c*, andesite; *d*, andesite tuff; *e*, rhyolite; *f*, rhyolite and andesite (undifferentiated.)

The metal contained is gold. The deposits were probably formed by circulating thermal solutions, which accompanied and followed the invasion of the intrusives, especially the rhyolite.

MINES IN THE WESTERN PART.

The principal properties in the western part of the district are the Sheep Trail, Boulevard, Catherine, Pyramid, and Tyro. This part of the district has produced considerable ore, most of which has come from the Sheep Trail, Boulevard, and Catherine mines.

SHEEP TRAIL AND BOULEVARD MINES.

The Sheep Trail and Boulevard mines, a property comprising five patented claims and a mill site at the river, are situated near the middle of the district, about 7 miles east of the river, at an elevation of about 2,400 feet, in a group of outlying hills. The Sheep Trail mine was discovered in 1865 by Jack Mellen, a steamboat captain running on Colorado River. The group was later acquired by the

New Comstock Mining Company, which improved the property, installed a 20-stamp mill at the river, and milled about 2,000 tons of ore. In 1904 the Arizona-Pyramid Gold Mining Company, of San Francisco, took hold of the property and has recently milled much ore from the property, principally from the Boulevard mine.

The Sheep Trail mine is developed to a depth of 428 feet by drifts, tunnels, and shafts, aggregating, it is said, more than 5,000 feet of underground work, the lower tunnel being about 750 feet long. Its vein lies in a nearly east-west ridge of pre-Cambrian granite, rising several hundred feet above the adjacent open washes, with intrusive rhyolite near by. The vein dips about 60° S. The ore contains chiefly quartz and hematite as gangue, and is said to be rich. It is hauled to the Sheep Trail 20-stamp mill and cyanide plant, originally built for this mine at Pyramid. Several thousand tons of ore are reported to have been milled.

The ore of the Boulevard mine, whose production is considerable, is also reported to be very rich, some of it containing, it is said, about $50 in gold to the ton. The mine was a producer in 1906.

CATHERINE MINE.

The Catherine mine is about 1¾ miles east of the river and about 450 feet above it, on an open, gravel-covered slope about three-fourths of a mile from the hills to the south at an elevation of 950 feet. The mine was discovered by S. C. Baggs in September, 1900, and soon afterward some development work was done in taking out surface ores, mostly in the 60-foot incline. It was operated by the New Comstock Mining Company, under whose management it is said to have produced about 2,000 tons of ore, which was milled in the Sheep Trail mill at Pyramid. In 1904 the present owner, the Arizona-Pyramid Gold Mining Company, acquired the property, together with the mill at the river, and at once began more extensive development work. It installed a 22-horsepower gasoline hoist, compressor, and fan ventilator, deepened the shaft, and was soon mining and milling systematically. The source of power used is fuel oil freighted from Kingman.

The mine is developed principally by a shaft 225 feet in depth, several hundred feet of drifts and crosscuts, and about 20,000 cubic feet of surface work. The principal equipments are the Sheep Trail mill at the river and the gasoline hoist already mentioned, together with shops, offices, buildings, etc. The camp is at the river, where an ample water supply is available for all purposes.

The country rock is red, coarse pre-Cambrian gneiss or pressed granite and consists essentially of orthoclase, quartz, biotite, and microcline. The vein or lode containing the deposits strikes N. 64° E. At the mine it is about 75 feet in width at the surface, but gradually

narrows downward to 50 and 40 feet on the 100-foot and 200-foot levels, respectively. By reason of the overlying gravels, the vein is exposed for a length of only 150 feet. However, it is in alignment with and is probably a continuation of the Pyramid vein, which, beyond the edge of the gravel sheet, extends southwestward for a distance of several miles, a portion of it lying beyond the river about where the Homestake mill is located. The occurrence of similar ore in alignment on the northeast suggests that the vein may have an extent of nearly 5 miles. In the mine the vein is faulted in places and the fault planes are slickensided.

The vein consists mainly of quartz, mostly replacing calcite; the ore on the whole resembles that of the Gold Road mine, and consists of fine-grained quartz and adularia. Much of the quartz is of the bladed or hackly form characteristic of replacement after calcite.

A microscopic section of the ore shows quartz with comb structure deposited on a mass of granular quartz and adularia containing residual calcite. There are also grains of a black mineral which is probably argentite.

The croppings, which are in part prominent, consist of dark-brown or black iron and manganese stained quartz. Some of the ore is irregularly banded and cut by close sheeting striking N. 20° E. and dipping about 50° NW.

The greater portion of the ore is of low grade, ranging in value from $6 to $7 in gold and silver to the ton, but toward the north side the vein contains a streak of high-grade ore said to run from 4 to 5 ounces of gold and from 200 to 400 ounces of silver to the ton.

The ore is treated at the Sheep Trail mill at Pyramid. It is believed that under economical conditions the ore can be mined and milled at a cost of about $3 a ton. About 5,000 tons of ore have been milled.

PYRAMID MINE.

The Pyramid mine is near the river, about a mile southeast of Pyramid and about a mile southwest of the Catherine mine. It lies in an open country of low hills of pre-Cambrian granite, at about 700 feet elevation. It was discovered early in the sixties and a 30-foot shaft was sunk on it at that time, but little attention was afterwards paid to it until the discovery of the Catherine mine in 1900. It is owned by the Arizona-Pyramid Gold Mining Company. It is developed principally by a crosscut tunnel, a 60-foot drift, and several shafts.

At the apex of the croppings, which is considerably above the workings, the vein is 35 feet in width. It strikes about N. 70° E., being about in alignment with the vein of the Catherine mine, of which it is supposed to be a continuation, and is reported to have

been traced southwestward to a point 2 miles beyond the river, where it passes under the wash-covered mesa in the east slope of the Eldorado Range.

The croppings are similar to those of the Catherine mine and consist of dark iron-stained quartz and calcite. Dikes of rhyolite follow the croppings.

TYRO GROUP.

The Tyro group is located about 7 miles east of the river, just north of the Sheep Trail and Boulevard mines, in the same group of hills, at about 2,700 feet elevation. It comprises two and a half claims adjoining each other end on. Though the mine had previously been several times located, the first work on it was done by the present owners in March, 1902, about the time they located it. The owners are J. R. Russell, P. F. White, S. R. Davis, and S. W. Basanko, all of Kingman.

The property is developed principally by a 50-foot shaft, a 135-foot crosscut tunnel, and a smaller amount of drift and crosscuts. Water is scarce. The country rock is the pre-Cambrian red biotite-microcline gneissoid granite. It is intruded by rhyolitic dikes near by, which seem to be older than the vein, and the ore is reported to be better in value where the vein crosses the dikes.

The Tyro vein extends throughout the length of the claim group, a distance of nearly 4,000 feet, and dips steeply to the east. It varies from 15 to about 100 feet in width, the average width being about 30 feet. It is joined throughout its extent by imbricating stringers from the northwest and the southeast.

The veins contain principally calcite and a relatively small amount of quartz, which has replaced calcite. Some of the blades or plates of quartz replacing the calcite along the vein are 3 or 4 inches in diameter and occur in laminated masses 6 to 8 inches thick.

The vein on the average contains about $6 in gold to the ton and a little silver; some localities, however, are said to have yielded 11 ounces of gold and 53 ounces of silver. Owing to its general low grade, the ore could be worked only on a large scale.

MINES IN THE EASTERN PART.

The eastern part of the district, being relatively new, is yet for the most part in the prospect or development stage. It is being rapidly developed, however, and several mills are being installed. The deposits here, as already stated, are practically all associated with the contact of the rhyolite intruded into pre-Cambrian granite, with values occurring on both the granite and the rhyolite sides of the contact. The deposits locally form prominent hogback ridges, paral-

lel with the contact, and are associated with the faulting of the country rock.

The principal properties in the eastern and southeastern parts of the district are the San Diego, O. K., Expansion, Tragedy, and Union Pass groups. They are situated on the western slope of the range and are easy of access, being on or near the wagon road leading from Union Pass to Pyramid or Harpers. The deposits occur mainly near the contacts of the rhyolite, andesite, and diabase intruded into the pre-Cambrian granitic complex.

SAN DIEGO GROUP.

The San Diego, O. K., and Expansion groups are all located on what is commonly known as the "mammoth ledge." Starting from the crest of the range at a point about 2 miles southeast of Union Pass, at an elevation of about 3,700 feet, this "ledge" extends to the west-northwest for a distance of about 4 miles. It dips steeply to the northeast and is more or less prominently marked throughout the greater part of its course by southwestward-facing scarps or hog-back ridges several hundred feet in maximum height (fig. 34). To the southwest the country rock is the pre-Cambrian granite complex; to the northeast it is the Tertiary rhyolite.

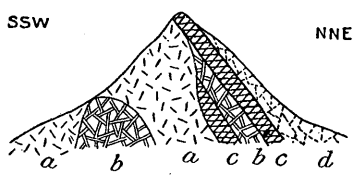


FIGURE 34.—Cross section of San Diego vein at San Diego mine. *a*, Granite; *b*, diabase; *c*, mammoth ledge of silicified gold-bearing rhyolite; *d*, rhyolite older than *c*.

The San Diego group is situated about a mile west of Union Pass, on the upper steep slope of the range, at 3,400 feet elevation. The property, which comprises about a dozen claims, was located about 1893 by F. J. Todd, from whom it was purchased in 1896 by the present owner, the San Diego Mining and Milling Company, of San Diego, Cal. The underground developments were small and consisted mainly of tunnels and crosscuts to the amount of 200 feet. There is also a shaft 75 feet deep.

At the time of visit a 10-ton mill was being installed.

A cross section showing the relation and attitude of the rhyolite and diabase intruded into the country-rock granite is shown in figure 34. The sequence of events that took place here seems to be as follows: Faulting of the country-rock granite (*a*) and its intrusion and flooding by the older rhyolite (*d*); faulting and intrusion of the diabase (*b*) along the contacts of *a* and *d;* faulting and intrusion of the younger rhyolite (*c*), which is akin to granite porphyry along the contacts of *a*, *b*, and *c*.

The intrusions were accompanied by crushing of the rocks and appear to have been followed by deposition of ores by solutions that

resulted in silicification of the rocks, particularly the younger rhyolite (*c*). The values favor the contacts, especially those of the younger rhyolite, but they occur also in the rocks themselves, in stringers and veinlets in the crushed diabase and the granite. They are contained in a quartz and adularia gangue, with a calcite residue. This gangue, in part, at least, is of the Gold Road type. It is also probable that values may be associated with the pyrites which occur in small stringers and disseminated grains in the diabase.

A large amount of ore is claimed to average from $12 to $15 a ton in gold and to contain a little silver. A shipment of a thousand pounds made to the Needles smelter in October, 1906, is reported to have averaged $56 a ton. Some bunches are said to run very high in values. The ore is believed to be suitable for the cyanide process.

O. K. GROUP.

The O. K. group lies about 2 miles west of Union Pass, at an elevation of 3,600 feet. It almost joins the San Diego group on the northwest, being situated on the continuation of the same hogback ridge, which here is several hundred feet high. At the time of visit it was owned by J. D. Richardson and heirs, of Kingman, but it is reported to have been acquired since by the Gold Pass Mining Company, of Los Angeles.

The property is developed mainly on the northwest, at the end of the ridge, which here falls off in steep slopes into a deep valley, beyond which the deposits have not been traced. The developments consist mainly of two tunnels driven on or near the contact of the intrusive rhyolite with the granite. The drifts are situated about 50 feet apart vertically. The upper has a length of 150 feet and the lower of about 250 feet. From the upper a winze descends to or near a crosscut in the lower.

The ore consists of iron-stained and pyrite-bearing quartz and altered rock, and locally contains also some galena. It is irregularly distributed or pockety. That taken from the upper drift, which looks better than the lower drift, is said to have averaged about $20 a ton in gold, and samples of the foot-wall granite taken 10 feet apart throughout the length of the drift are reported to have assayed from $1 to $4 a ton. Some high-grade ore occurs in small bodies of fine sandy material inclosed by the iron-stained lower-grade ore, quartz, and rock.

EXPANSION GROUP.

The Expansion group is situated about a mile southwest of Union Pass, at an elevation of 3,200 to 3,600 feet. It is owned by the Expansion Gold Mining Company, of Kingman, which acquired the property in October, 1905, and has operated it since April, 1906.

The property comprises six or more claims, situated along the contact zone. It is crossed near its middle point by a prominent gulch that heads near the pass and affords good exposures of the relations of the intrusive rocks to the pre-Cambrian granite. The portion to the southeast of the gulch lies along a contact scarp. That to the northwest is located on a prominent hogback. The camp is located on this gulch just above the hogback, and is amply supplied with good well water confined by an andesite dike intruded into the rhyolite.

The developments at the time of visit were a 220-foot tunnel near the crest of the hogback and a crosscut. Since then, however, it is reported that much work has been done and a 60-ton mill has been installed.

There are two lodes on the property. The more westerly is on the contact of the rhyolite porphyry and the pre-Cambrian gneissoid granite. Its silicified zone is about 200 feet wide and is traceable for a considerable distance in a northwesterly direction. It contains bands or belts of ore of varying width. The samples from the surface are stated to have given assays ranging from a few cents up to $90 a ton in gold, and contain also a little silver. The eastern lode is on the

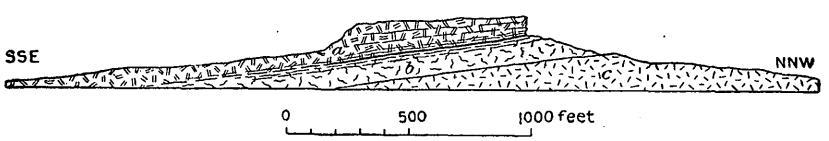


FIGURE 35.—Cross section of part of Tragedy vein. *a*, Rhyolite; *b*, older rhyolite porphyry and quartz; *c*, granite.

contact of andesite and rhyolite. Its surface values range up to $11 a ton, and the mineralization extends laterally a considerable distance into the rhyolite.

In the southeastern part of the property, which was being developed open by a tunnel at 100 feet below the croppings of the rhyolite-granite contact on the granite side of the contact, moderate values were reported in the granite. In the older orange-colored altered rhyolite that floors the valley just north of the camp fair gold values are said to occur over an area of 10 acres or more. This rhyolite is in part silicified and vuggy. All the Expansion ore is cyaniding ore.

TRAGEDY GROUP.

The Tragedy group is about 2 miles west-southwest of Union Pass and about a mile southwest of the San Diego group and "mammoth ledge," at an elevation of about 3,200 to 3,400 feet. It was discovered in 1900 and was first worked in 1903. It is owned by W. E. Sauls, O. D. M. Gaddes, and G. B. Ayres, of Kingman. It is located in a detached elongated foothill. A section of the rocks and the deposit is shown in figure 35. The exposures seem to represent the southern

limb of an eroded anticline of rhyolite flows, of which the section at the San Diego and O. K. groups, figure 33, is the northern limb. The structure is monoclinal, with the dip gently to the south.

The capping rhyolite is massive and white, but its lower 3 or 4 feet are streaked reddish. The older rhyolite porphyry is a highly altered reddish-brown iron-stained rock. It contains lime carbonate and much quartz, and in places it completely gives way to quartz. Its upper 3 or 4 feet is silicified and banded parallel with its contact with the rhyolite above.

The vein or ore bed, consisting of quartz and iron-stained altered and silicified rock containing the values, occurs in the upper 30 or 40 feet of the older rhyolite porphyry. The ore may have originally been deposited in this rock, but was probably subsequently enriched by circulation of thermal solutions that attended and followed the eruption of the younger rhyolite.

The developments consist of several tunnels or inclines and shafts driven 30 or 40 feet into this ore bed. Several hundred tons of good milling ore and some ore averaging $76 a ton are reported to have been produced.

UNION PASS GROUP.

The Union Pass group, better known as the Union Pass mine, is located about 3½ miles southwest of Union Pass, about 2 miles from the Tragedy group, and 5 miles east of Colorado River. It is situated on open ground at an elevation of about 2,400 feet, on the Harpers road about one-half mile below its junction with the Union Pass and Pyramid road. It was discovered about 1886 and is owned by the Union Pass Mining Company, of Philadelphia.

It is situated on a lode which follows a great fault plane between the pre-Cambrian country-rock granite on the west or foot-wall side and intrusive and effusive rhyolite on the east or hanging-wall side. The fault strikes N. 30° E. and hades to the east at angles of about 20°. It is normal with the upthrow on the west. The hanging-wall side of the lode is deeply slickensided.

The granite, a coarse porphyritic rock, is sheeted and made schistose along the zone of contact. The rhyolite is mostly agglomeratic and contains many bowlders or bowlder-like masses 2 to 3 feet in diameter. It is cut by a coarse jointing which approximately parallels the fault plane, and by a later sheeting having a southerly dip. Along the planes of the sheeting occur dikes of intrusive andesite and diabase or basalt and thin lentils or tabular bodies of a gray rock, apparently a limestone.

The lode, which in general is about 100 feet or more in width, consists mainly of a tabular body of fault breccia or agglomerate composed of rhyolite, andesite, granite, and quartz, and contains

veins of quartz and adularia, calcite, and silicified rock and lentils or tabular bodies of the gray rock resembling limestone, the latter being about 30 feet in maximum diameter and 7 or 8 feet in maximum thickness. Thin dikes or stringers of a later dark intrusive andesite are also present. The quartz and adularia and spar or calcite favor the hanging-wall or rhyolite side of the lode, and here in association with these minerals the values mostly occur. The croppings consist of brown and dark iron and manganese stained, silicified breccia and quartz, which in places is greatly crushed.

The property is opened at the foot of a fault scarp, rising steeply to a height of about 80 feet, forming the face of low hills on the west and overlooking a broad wash on the east. It is developed by a tunnel 120 feet long, a 100-foot incline winze or shaft, starting at 20 feet in from the mouth of the tunnel, and a 60-foot crosscut extending from the bottom of the shaft to the southeast under the wash. At the time of visit the shaft was said to contain 26 feet of water. It was reported that a 12-stamp mill and a pump were to be immediately installed.

Samples taken across the lode from the entrance to the face of the 100-foot tunnel are said to have given an average assay of about $4 a ton in gold. The best ore, however, occurs at the shaft in a 5-foot tabular vein composed of fairly pure quartz and adularia. It is said to average about $25 in gold to the ton.

To the south of the mine the croppings of the lode are prominent, and are said to continue so for a distance of 2½ miles from the mine, disappearing beneath a wash-covered mesa on the southwest.

A partial cross section of the lode as exposed at a point about one-third of a mile south of the mine, in the face of a prominent chimney-shaped cropping rising 25 or 30 feet high, is as follows:

Partial cross section of Union Pass mine lode exposed in croppings one-third mile south of Union Pass mine.

	Feet.
1. Rhyolite-andesite breccia, containing gold-bearing reddish-stained quartz	20
2. Breccia consisting of coarse bowldery agglomeratic rhyolite, granite, and quartz	15
3. Breccia, less coarse than No. 2, mostly granitoid and limy and containing veins of calcite and quartz with adularia	20
4. Breccia, granitoid, finer than No. 3	15
5. Metamorphosed semicrystalline "limestone"	5
6. Coarse porphyritic granite, country-rock foot wall.	

OTHER PROPERTIES.

Other properties in the district are the Monarch, New Chance, Sunlight, Coleman, Colorado, Miller, and Golden Eagle.

Monarch property.—The Monarch property comprises a group of six claims situated about 3 miles southeast of Union Pass, on or near the crest of the range, on open ground, at elevations of 3,600 to 3,700 feet. It is owned by J. S. Withers and Robert Brannack, of Kingman. It was discovered in 1904. The developments consist mainly of a shaft 60 feet deep, about all in granite.

The property lies just south of the point where the mineralized contact zone extending eastward from the Expansion property reaches the crest of the range and, curving to the south, loses its regularity and unity and is less well defined, portions of it occurring on either side of the crest. The country rock is the pre-Cambrian granite, with the usual intrusive irregularly present.

The shaft is sunk on a lode which seems to be a southward extension of a part of the Mammoth lode. Its upper 30 feet exposes a 10-foot vein composed mostly of quartz and light-colored clayey gouge with altered rock and calcite. It is stained in spots with malachite. The vein dips steeply to the east, with quartz forming the "foot wall," from which it is separated by 5 inches of red clay gouge, and granite forming the hanging wall. The ore is in streaks but a few inches in width, contained in the vein. It is reported to average about $40 in gold and $10 in silver to the ton, and contains a trace of copper. Below a depth of 30 feet, however, though calcite and quartz continue on the hanging-wall side, the vein becomes lean and consists mostly of argillaceous material.

New Chance property.—The New Chance property is located about 4 miles southeast of Union Pass, about a mile south of the Monarch mine, on the upper west slope of the range near the crest, between 3,600 and 3,900 feet in elevation. It was discovered about 1900 and is owned by Mike Redman, of Kingman. The developments are slight.

The general country rock is the pre-Cambrian granite, cut by a sheeting that dips steeply to the north.

The deposits occur in a lode contained in granite, rhyolite, and andesite and are reported to range from 20 to 30 feet in width. The strike is about N. 18° W. To the south of the gulch the lode stands about vertical, but to the north it dips steeply to the west. It is exposed for a horizontal distance of nearly half a mile and through a vertical range of 200 or more feet. The croppings, which are in part prominent, are dark iron and manganese stained quartz and silicified rock, which is chiefly rhyolite.

The ore is mostly contained in a vein about 2 feet thick, composed of quartz, calcitic brecciated rhyolite and andesite, and green fluorite. The ore streak in this vein, as shown in the shaft on the upper or south end of the property, where the vein is in rhyolite, with a greenish porphyritic rock similar to the andesite of the Vivian close by, is 8 to 10 inches in width, and is reported to average about $64 in

gold and 2 ounces of silver to the ton. The values are found mostly in the quartz-adularia portion of the vein, and are said to be best where associated with the fluorspar.

To the north of the gulch the ore, here also contained in a quartz-spar gangue, is fairly well developed along the rhyolite-granite contact, and at a point where the rhyolite is faulted off the ore continues for a distance of 200 feet in an extension of the fissure into the granite.

Sunlight property.—The Sunlight property, owned by J. D. Richardson, of Kingman, is about 1½ miles south of Union Pass and 3 miles west of the New Chance, on open ground, at an elevation of about 3,100 feet. The deposit is a 2½-foot vein of greenish quartz, adularia, and calcite, with some intermingled greenish or brecciated rock, and contains fair gold values. It dips about 60° E. and lies entirely in granite. It is opened by a 53-foot shaft and several smaller excavations. Near the bottom of the shaft the gangue becomes mostly altered granite, of which 1 foot on the hanging-wall side carries from $1 to $5 in gold to the ton, and is separated from the wall rock by several inches of clayey gouge.

PILGRIM DISTRICT.

The Pilgrim district, which is about 2 miles in length and trends northwestward, lies 9 miles west of Chloride, in the eastern foothills of the range, at an elevation of about 3,600 feet. The country rock is principally rhyolite and granite porphyry. The main opening is the Pilgrim mine, on the northwest. It was discovered March, 1904, by two prospectors, Dempsey and O'Dea, of Kingman, who still own it. Soon after it was bonded to Brockman, who developed it. It has a 12-horsepower gasoline hoist. This mine is situated on a contact vein between rhyolite breccia, with trachytic rhyolite, forming the hanging wall and granite porphyry in the foot wall. It is developed by inclined shafts, two levels, and drifts to a depth of 360 feet, and oxidation extends to the bottom of the mine. The vein is about 20 feet thick and about half a mile in length. It dips about 30° W. The gangue consists of quartz, with a little adularia and calcite. The ore is reported to average about $8 in gold to the ton, the gold occurring free. Twelve tons of $100 ore are reported to have been shipped, and about 1,000 tons of what is stated to be $6 to $7 ore lie on the dumps.

VIRGINIA DISTRICT.

The Virginia district, about 3 miles in diameter, lies 25 miles west-northwest of Chloride, near the middle of the west slope of the Black Mountains, 5 miles east of Colorado River and nearly opposite

the Searchlight district, Nevada, at an elevation of about 1,500 feet.

The country rock consists of the Tertiary volcanic rocks, with rhyolite and green chloritic andesite most abundant. The veins dip southwestward, usually have a calcite gangue, and locally grade into the country rock. The Red Gap vein, however, consists of more or less brecciated quartz, probably with adularia. It is similar to that in the Gold Road mine and carries good values.

The ore of the district is mostly free-milling gold. It averages about $7 to $8 a ton, and the best values are associated with specks of hematite distributed throughout the gangue, as in much of the ore in the Union Pass and Gold Road districts.

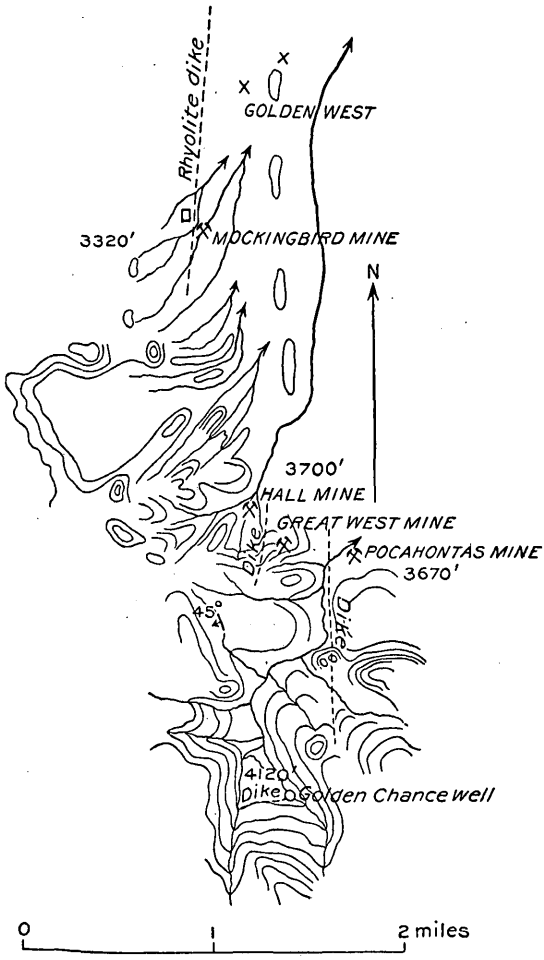


FIGURE 36.—Sketch map of Mocking Bird district.

MOCKING BIRD DISTRICT.

GENERAL OUTLINE.

The Mocking Bird district (fig. 36) lies 25 miles northwest of Chloride, in a reentrant parallel side valley in the east foothills of the range, at elevations between 3,000 and 4,000 feet. The valley is bounded on the east by a spur of volcanic rocks extending in a northerly direction from the flank of the range. The district trends north and south; it has a length of about 5 miles and a width of about 2½ miles. It is hilly on the south but open on the north, merging with the Sacramento Valley, which receives its drainage. Water is scarce, but some is encountered in the mines. The principal mines are the Mocking Bird, Hall, Great West, and Pocahontas. The Mocking Bird and Hall are now producing.

MOCKING BIRD MINE.

The Mocking Bird mine (fig. 37) is situated in the open northern portion of the district. Its principal developments are 12 or 15 shafts, ranging from 25 to 60 feet in depth, and about 500 feet of drifts. The vein lies nearly flat in a local sheet or flat-lying dike of altered and pressed minette, containing secondary epidote, calcite, and adularia. Other volcanic rocks near by consist of rhyolite tuff and latite. The vein is about 6 feet thick and consists of red and green quartz and breccia. The metal is gold with a small amount of silver. The gold occurs in a finely divided state, usually associated with hematite, of which much is present. The ore averages about $10 a ton. The production to date is reported to be more than $20,000; several times this amount of ore is said to be blocked out in the mine.

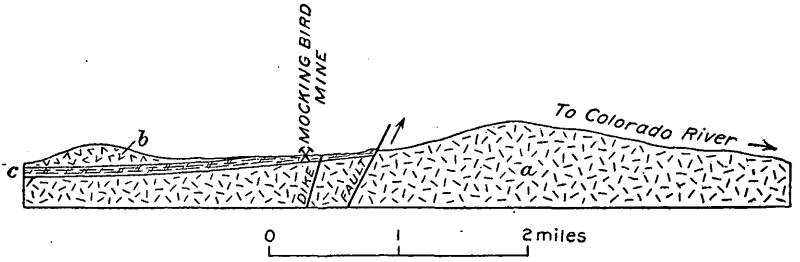


FIGURE 37.—Cross section of rocks at Mocking Bird mine. *a*, Pre-Cambrian granitic gneiss and schist; *b*, trachytic latite and rhyolite; *c*, minette.

HALL MINE.

The remaining mines are situated near together in the low foothills of pre-Cambrian granite in the southern part of the district. The veins here all dip steeply to the north. The Hall mine, which works the most northerly of the veins, is developed principally by a 210-foot shaft and two levels, containing about 200 feet of drifts. The vein ranges in thickness from a few inches to 2 feet, and is locally associated with diabase dikes. The gangue is quartz, some being of the honeycomb variety. Some of the ore is very rich, shows free gold, and is said to contain values of $10,000 or more to the ton. A 24-ton mill is operated at the mine.

GREAT WEST MINE.

The Great West mine is developed principally by adit drifts, shafts, crosscuts, and winzes to a depth of more than 200 feet. The vein is approximately 3 feet thick and consists essentially of gold-bearing, iron-stained oxidized quartz, reported to run from $10 to $80 a ton.

POCAHONTAS MINE.

The Pocahontas mine is developed by a shaft and drifts to a depth of 200 feet, and a new cyanide mill has recently been built to replace

the stamp-amalgamation mill formerly used. The value of the ore is in gold, which occurs mainly in pyrite contained in a somewhat stained and crushed quartz gangue.

GOLD BUG DISTRICT.

The Gold Bug district is situated near the summit of the range, about 3 miles north of the Mocking Bird district, 3 miles south of Eldorado Pass, and 30 miles northwest of Chloride. The only mine is the Gold Bug mine, which is developed by several shafts and drifts to a depth of 300 feet.

The deposits consist chiefly of two main veins situated about 22 feet apart in a doubtful volcanic rock, possibly a minette similar to that at the Mocking Bird mine. The veins dip steeply to the northeast. The ore is rich gold-bearing quartz, with a little silver, and favors the hanging wall, where in part it is associated with a diorite (?) dike. Much ore is said to remain in the mine.

Mr. H. J. Marmein, representing the Gold Bug Mining Company, has kindly given the following historical notes and account of recent development work:

This property consists of several patented claims. The first discovery of gold on these claims was made in 1892 by two Mormon miners, and the exceedingly rich ore taken out at the very beginning of work attracted much attention. In 1893 the property was sold for a large sum and was then worked in a desultory way for two years; during this time about 50 tons of selected ore was shipped, which netted $43,000, or about $860 a ton in car lots, after deducting all transportation and smelter charges. The owner erected a 20-ton Huntington mill on the banks of Colorado River, about 10½ miles from the mine, and 800 tons of the low-grade ore put through this mill, saving only 58 per cent of the assay value, gave returns on the plates of $12,000, or $15 a ton. Owing to lack of capital, the work was discontinued and the mine lay idle until March, 1908, when the present company began working the property.

The old workings consist of 15 shafts and open cuts, about 2,300 feet of underground work all told. The main shaft is now down 300 feet. Two shafts, each about 200 feet distant from the main shaft, on other veins, have been developed to depths of 100 and 140 feet.

As a result of operations of 1908 on the 290-foot level, which seems to be nearing the limit of the oxidized zone, it is reported that for the 70 feet of drift run the vein has an average width of about 5 feet and on either wall contains an ore streak which attains about 18 inches in maximum width. The ore of this streak averages from a few dollars to several hundred dollars in gold and from $1 to $60 in silver to the ton and shows coarse and free gold.

The quartz gangue of the vein is shattered, and the best values occur in its more shattered portions in association with iron oxide in the oxidized zone, and with pyrite and galena and vanadinite at greater depths, where sulphide ore is coming in and the ore bodies and values are becoming more regular.

ELDORADO PASS DISTRICT.

The Eldorado Pass district, an area about 2 miles in diameter, lies west of the White Hills at Eldorado Pass, on the road leading to Eldorado Canyon, at an elevation between 2,500 and 3,000 feet. The topography is one of gentle relief. The country rock is the pre-Cambrian granite, and it is intruded and locally overlain by the Tertiary volcanic rocks. The principal properties are the Burrows, Bagg, Young, and Pauly. They are in the prospect stage, but have produced some gold, the production of the Burrows being reported to be about $10,000. The metals of the three first named are gold and silver in quartz veins; the Pauly, which seems to be at the contact between the granite and the volcanic rock, contains principally copper.

NONMETALLIC MINERAL RESOURCES.

The principal nonmetallic mineral resources occurring in the region here discussed are building stone, cement rock, caliche(?), turquoise, and graphite.

Building stone.—The most important building stone in the region is the rhyolite tuff underlying Kingman Mesa. It occurs in abundance in heavy beds and is easily quarried in the scarps near Kingman. It is medium grained and fairly uniform in texture and dresses well. The most important buildings in Kingman are built of it.

Cement rock.—The main cement material of the region is a fine-grained pumiceous phase of the rhyolite tuff just described. It occurs in a deposit of considerable extent west and southwest of Kingman and probably elsewhere and is said to have been proved by experiment to be excellent for making cement. It requires no calcining. Briquets made with it are reported to have a high tensile strength and to stand salt-water test with excellent results.

It is also very probable that excellent materials for cement, brick, lime, and building-stone purposes occur abundantly in the Carboniferous and other Paleozoic limestones and shales of the Grand Wash Cliffs region, which, so far as learned, have not yet been exploited for these materials. The Carboniferous, which is strong here, has, as is well known, long been supplying these materials in enormous quantities for the above purposes throughout the Middle West, as well as in other sections of the country.

Caliche (?).—Calcareous deposits locally called "limestone" and "travertine" and used as flux at the smelters occur in Sacramento Valley, near Chloride, Mineral Park, and elsewhere. The deposits in place were not visited by the writer, but to judge from quarried material from them piled at the old smelter near the Chloride depot, where it had been used as flux, the deposits seem undoubtedly to belong to the class of subsurface calcareous deposits known to have a wide distribution in the hot, arid plains of Arizona and adjoining regions in the Southwest, and described by various authors under the names "caliche," "subterranean travertine," "tepetate," "tierra blanca," etc. In mineralogical, structural, textural, and other characteristics the material corresponds very closely with that described by Blake,[a] and in hand specimen it was readily identified by Dr. T. W. Vaughan, who is experienced with deposits of this class,[b] as being in all probability caliche.

The caliche deposits in the Southwest usually occur in more or less continuous sheets from 1 foot to 15 feet in thickness underlying the surface soil. They are formed not by hot springs, but by precipitation and concentration of calcareous material, through the evaporation of subsurface lime-bearing waters, which may be ascending, descending, or both, depending mainly on local climatic conditions.

Turquoise.—Turquoise is actively mined by several companies near Mineral Park, notably at Ithaca Peak, about 1½ miles to the southeast, and Aztec Mountain, about 3 miles to the south. It occurs in coarse altered granite porphyry in the form of veins and globular and irregular bodies, 1 to 8 inches in diameter, some of which are connected by stringers or mere seams and others isolated in the solid rock. The production is mostly shipped in monthly installments to New York, where it is sold chiefly in the rough for jewelry purposes.

A fuller account of the deposits, by Douglas B. Sterrett, is being published in the Mineral Resources of the United States for 1908.

Graphite.—Graphite, possibly of commercial value, occurs in the pre-Cambrian schists on the east slope of the Cerbat Range near the old government trail in Canyon Station Wash, a few miles southeast of Mineral Park.

Amethyst.—In the McConnico district, in a mineralized zone in the pre-Cambrian rocks, about half a mile north-northeast of Boulder Spring, amethysts have been found, one of which is reported to have been sold to the Tiffany Company for $59. The property is developed by several shafts, of which the deepest is about 65 feet deep.

[a] Blake, Wm. P., The caliche of southern Arizona; an example of deposition by vadose circulation: Trans. Am. Inst. Min. Eng., vol. 31, 1901, pp. 220–226.

[b] Vaughan, T. W., Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, p. 256.

WATER SUPPLY.

Throughout that portion of the area which lies north of the latitude of Kingman water is scarce, the only natural source of supply besides precipitation being a few small springs, found along the base of the ranges. In the pre-Cambrian rocks, however, particularly in the Cerbat Range, as shown in the mines, ample water of good quality is usually encountered at depths of 300 to 600 feet; and in the vicinity of Kingman in the rhyolite tuff a copious supply is reached at depths of about 130 feet, as shown by numerous wells. In the Black Mountains the best water-bearing formation is the rhyolite tuff, commonly known as the "water rock," extending in a belt of considerable width from Union Pass southward beyond Gold Road. It is the source of water used at Gold Road and other localities, and, as at Kingman, the supply seems inexhaustible. Water occurs in about all the shafts in the Gold Road and Vivian districts that are 200 feet or more deep.

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