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THE JARBIDGE MINING DISTRICT, NEVADA

WITH A NOTE ON THE

CHARLESTON DISTRICT

BY

FRANK C. SCHRADER

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ILLUSTRATIONS.

THE JARBIDGE MINING DISTRICT, NEVADA.

By Frank C. Schrader.

INTRODUCTION.

SCOPE OF REPORT.

In 1910, soon after ore was discovered in the Jarbidge district, a reconnaissance examination of the district was made, and a report thereon was published in 1912.[1] The present report is supplemental to the earlier report and aims to bring it as nearly as possible up to date. To this end two weeks was spent in the district in July, 1920. The material obtained was derived chiefly from underground examinations.

As time would not permit complete revision of the geology, the geologic and topographic map of the earlier report is here reproduced as Plate I. Fortunately an excellent large-scale topographic map covering about 60 square miles of the most important part of the district, on the west slope of the Crater Range, had recently been made by the Elkoro Mines Co., a subsidiary of the Yukon Gold Co., and by the courtesy of that company this map, showing also the location of the mines, is included in the present report (Pl. II).

The report contains much new material on the geology and ore deposits of the district but only a brief summary of the material on those subjects given in the earlier report, to which the reader is referred for a fuller account.

Valuable information and aid were generously given by the Elkoro Mines Co., the Jarbidge Buhl Mining Co., the Crater Mining Co., Benane Brothers, Claude C. Gillham, A. L. Rinearson, Patrick Donahue, William Van Alder, and other miners, prospectors, and citizens of Jarbidge.

LOCATION.

The Jarbidge district lies in the northern part of Elko County, in northeastern Nevada, near the Idaho State line on the north and about 60 miles from the Utah State line on the east. (See Pl. I and fig. 1.) It is included within an area about 14 miles square, extending a few miles west of Jarbidge River and east of the East Fork, with its center near latitude 41° 51′ north and longitude 15° 25′ west.

[1] Schrader, F. C., A reconnaisance of the Jarbidge, Contact, and Elk Mountain mining districts, Elko County, Nev.: U. S. Geol. Survey Bull. 497, pp. 1–98, 1912.

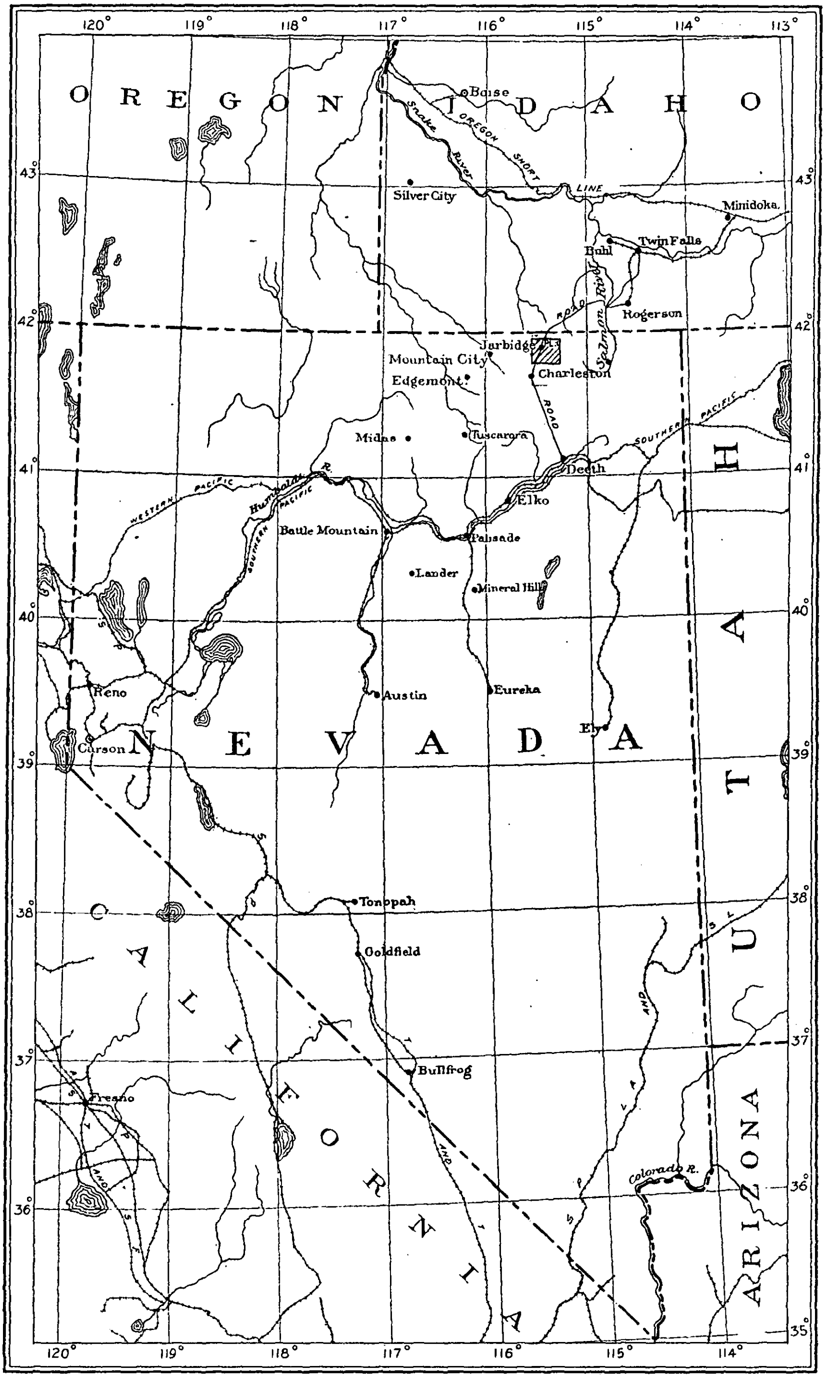


FIGURE 1.—Index map showing location of Jarbidge mining district.

It lies in the northeastern part of the physiographic region known as the Nevada Plateau, between elevations of 5,500 and 11,000 feet, on the upper north slope of the high east-west range that forms the divide between the Great Basin on the south and the Snake River valley on the north. To this range, or portions of it, particularly to the southwest of the district, the name Bruneau Range or Bruneau Mountains has locally been applied. Jarbidge, the town or camp (Pls. II and III), is in the northwestern part of the district, on Jarbidge River, at an elevation of about 6,200 feet.

On the southwest the district is bordered by the less known Charleston district. It is 15 miles from Mountain City, 20 from Edgemont, 25 from Tuscarora, and 12 from Charleston, all four camps west or southwest from Jarbidge.

The nearest railway stations in an air line are Rogerson, Idaho, 50 miles to the northeast, on a spur of the Minidoka & Southwestern branch of the Oregon Short Line, and Deeth and Elko, Nev., respectively 55 and 70 miles to the south, on the Southern Pacific and Western Pacific lines.

PREVIOUS DESCRIPTIONS.

Other than the report mentioned, the literature bearing on the district consists of some short papers, mostly by Winthrop W. Fiske, in mining journals that were current in the early years of the district. Most of the papers appeared in the publications named below, under some such heading as "Jarbidge, Nevada."

Salt Lake Mining Review: Jan. 30, Feb. 15 and 28, Mar. 30, June 15, July 30, Sept. 30, Nov. 15 and 30, 1910; Feb. 15, 1911.
Mining and Scientific Press: Apr. 30, June 18 and 25, Sept. 3, Dec. 31, 1910.
Mining World: Oct. 1 and 8, Dec. 24 and 31, 1910.
Engineering and Mining Journal: Oct. 15, 1910.
Reno Evening Gazette: June 2, 1913.

HISTORY AND PRESENT CONDITIONS.

A sketch of the district up to about 1912 appears in the earlier report. At that time most of the leading properties of to-day had been opened, many others had been prospected, and more than 500 claims had been staked and filed for record by nearly as many men. The Pavlak mill was being built, machinery for the Buster and North Star mills was on the way, and the problem of supplying the mines and mills with electric power was being considered.

At present the district contains about 90,000 feet of underground workings, mostly in about 10 mines, and has 8 mills. Most of the larger mines are supplied with hydroelectric power by the Nevada Power Co. from its plant at Thousand Springs, Idaho. The power is transmitted at 44,000 volts over a 73-mile line built in 1917 by the Elkoro Mines Co. at a cost of nearly a quarter of a million dollars. This company not only opened up a new epoch in the life of the district by bringing in electric power but made also a most important contribution in determining the process most suitable for treating the Jarbidge ores. Some of the mills have not been successful, owing chiefly, it is said, to failure to employ the correct process for the ores treated or to mismanagement. The power is supplied to the mines at the Idaho State rate of 1½ cents a kilowatt-hour, which renders low-grade material that would otherwise be unworkable at once of commercial value.

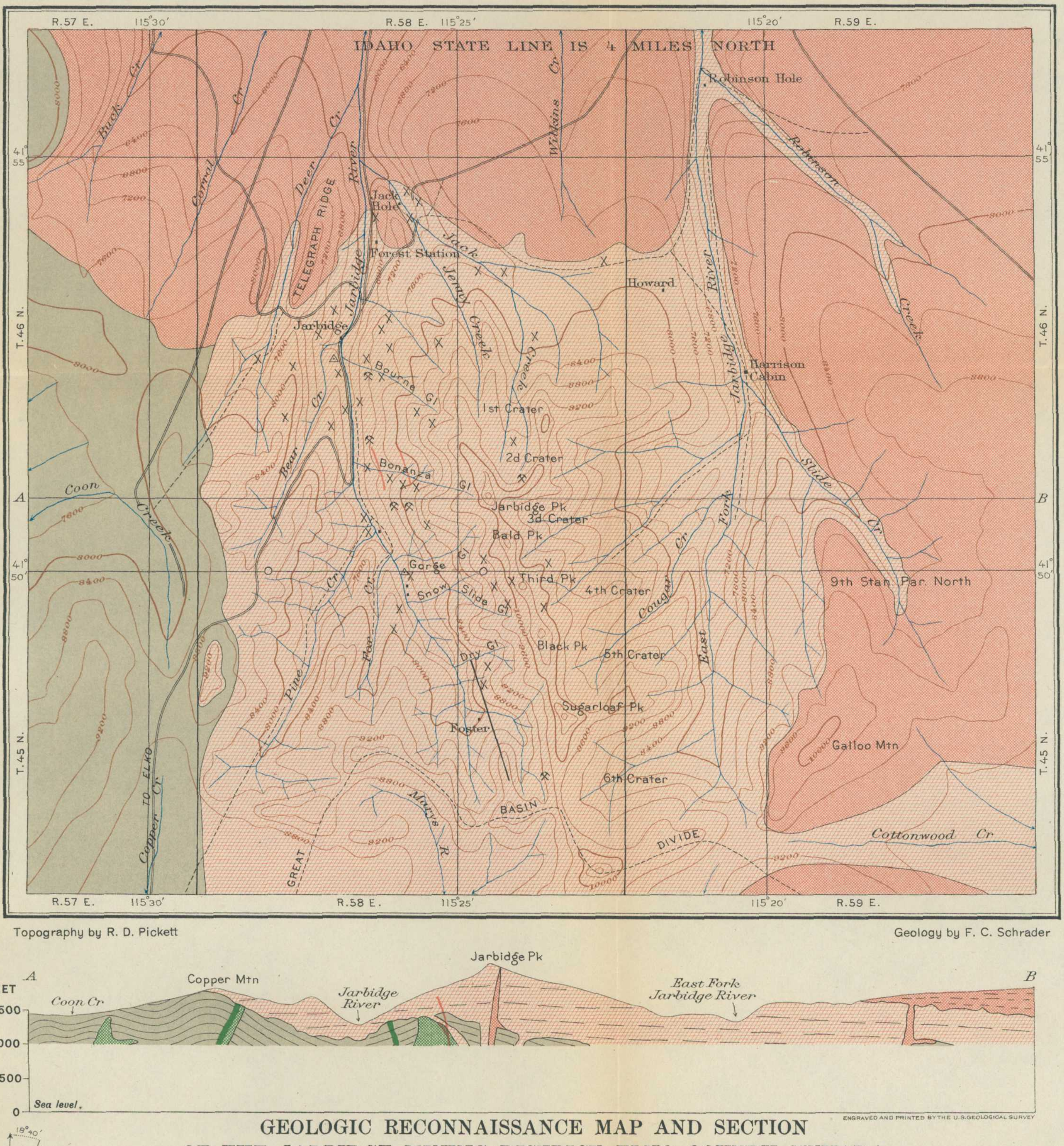
The most important development made in the district during the last decade is that of the Elkoro Mines Co. in the Long Hike and neighboring mines. The company began operations in 1916, and soon afterward it built the electric-power line and the 100-ton Elkoro mill, which has been steadily in operation since early in 1918.

Considerable development work has been done and is in progress by the Jarbidge-Buhl Mining Co., which, in addition to underground work, has extended the power line across the crest of the Crater Range and built a good wagon road up Jack Creek to its property. Much work has also been done in many other mines, among them the Starlight, Bluster, Pick and Shovel, Flaxie, Legitimate, O. K., Alpha, and North Star (formerly Bourne). In July, 1920, the population of the district was 250. Nearly all the men were working in the mines.

The town site of Jarbidge, which extends along the river from Moore Gulch nearly to Bourne Gulch (Pl. III), has been dedicated by the Government, and claimants now acquire deeds to their residence lots from the county judge at Elko.

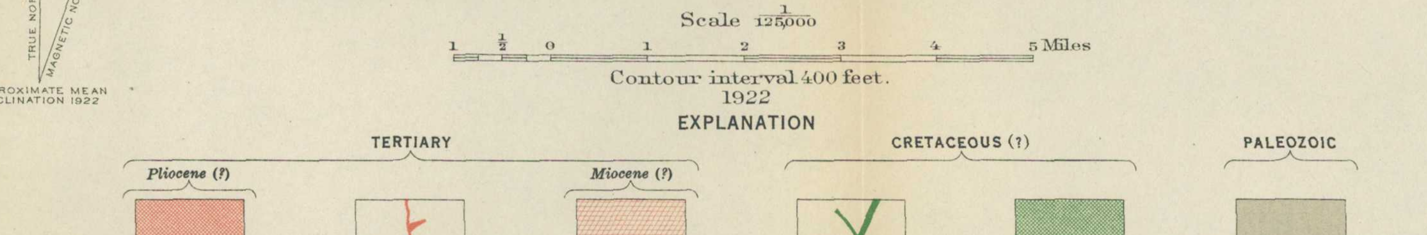
The wage scale of the district in 1920 for miners was $5.50 and muckers and trammers $5 a shift. The Elkoro Mine Co., which employs 80 men, furnishes them with good board at $1.50 a day. The cost of mining and milling is about $7 to the ton of ore.

Supplies are brought in from Rogerson, on the north, by team and autotruck at a cost of 1¾ cents a pound. With county aid a new road has been built along the river through the rim-rock canyon belt below Jarbidge. It is of easy grade, avoids Jack Creek Mountain with its snow drifts and other steep hills crossed in the last 6 miles of the old route, and is passable the year round. A triweekly mail and stage service is operated over this route. On the south the road from Elko and Deeth when in repair is suitable for passenger-automobile travel from the middle of June to October. As Deeth is a small place, without a hotel, most persons using the southern route start from Elko, the county seat, where living accommoda-



Topography by R. D. Pickett

Geology by F. C. Schrader



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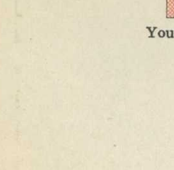
GEOLOGIC RECONNAISSANCE MAP AND SECTION OF THE JARBIDGE MINING DISTRICT, ELKO COUNTY, NEVADA



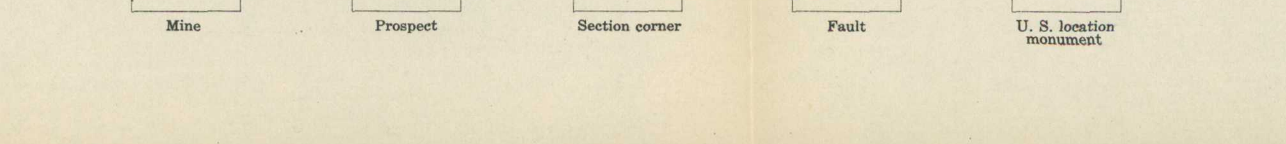
Scale $\frac{1}{125,000}$

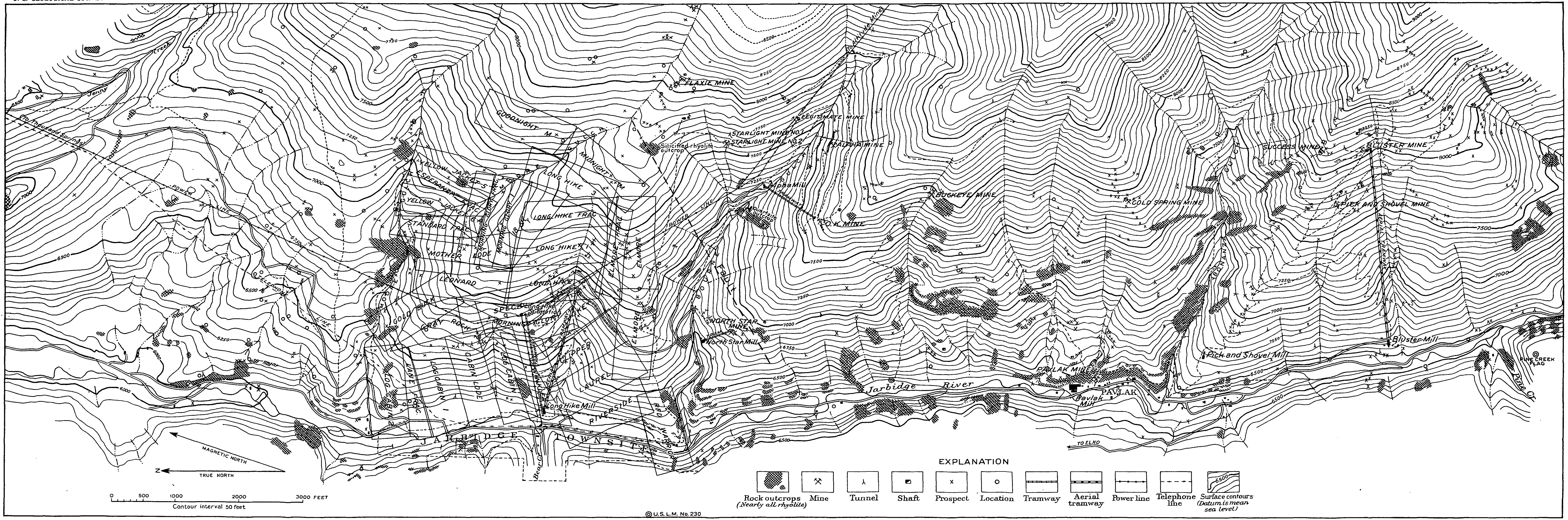
1 ½ 0 1 2 3 4 5 Miles

Contour interval 400 feet.

1922

EXPLANATION





TOPOGRAPHIC AND MINE MAP OF A PORTION OF THE JARBIDGE MINING DISTRICT, ELKO COUNTY, NEV.

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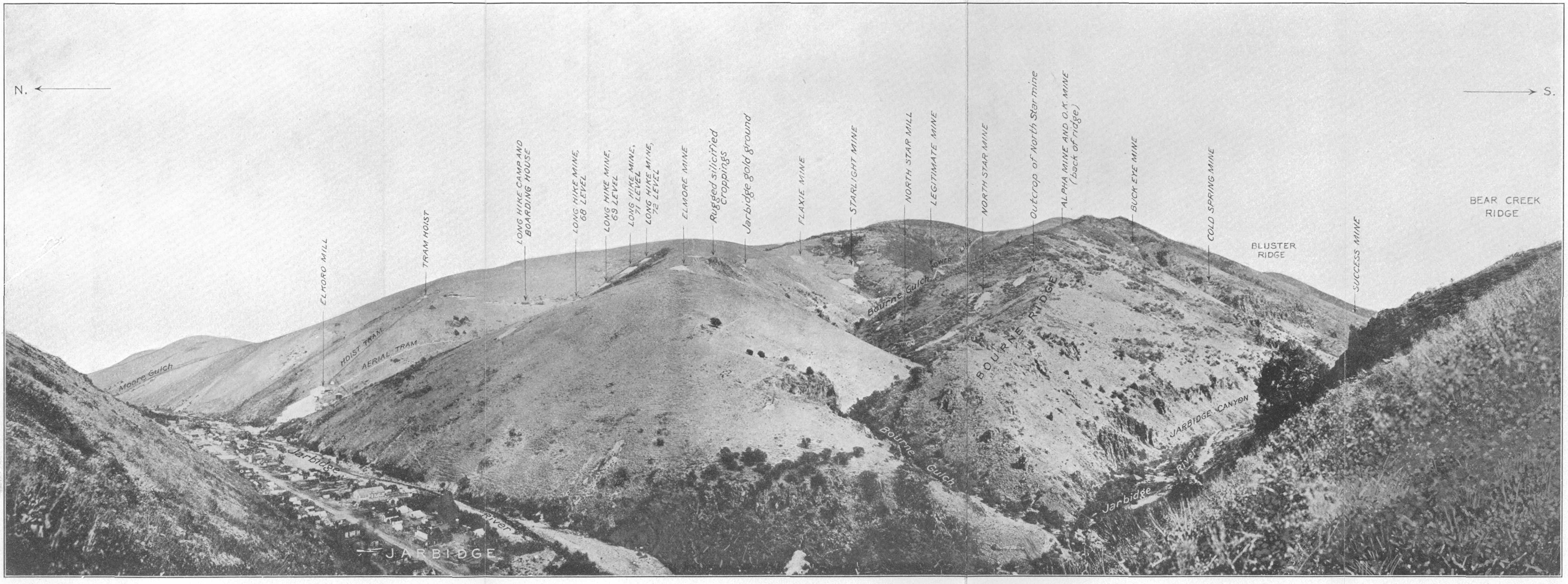
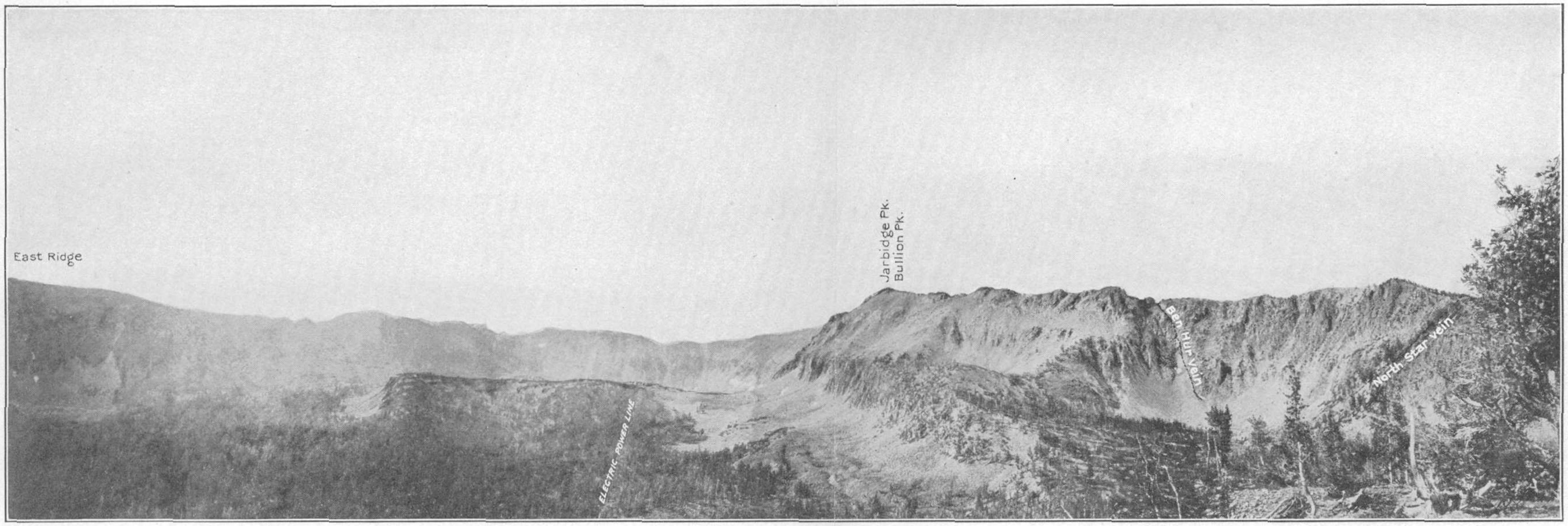


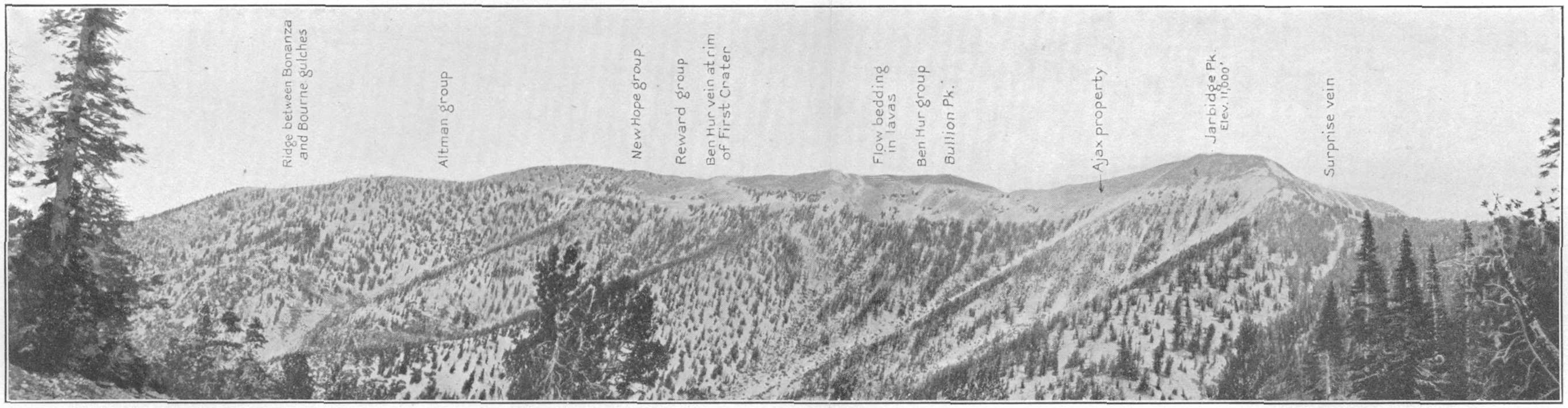
CRATER RANGE, NORTHERN PART OF WEST SLOPE, JARBIDGE, AND MINES.

Shows 3½ miles of the west slope of the range, looking east from Bear Creek Ridge opposite Bourne Gulch. Photograph by Claude C. Gillham.



A. FIRST CRATER.

Looking south from south knoll of North Mountain, shown in Plate XIX, *A*. *The "crater" is a huge cirque eroded in rhyolite. It measures* $1\frac{1}{8}$ *miles across its mouth from rim to rim.* The walls are nearly vertical and in places about 800 feet high. To the right the Ben Hur vein or its footwall is exposed through a vertical range of 500 feet. Photograph by Claude C. Gillham, taken in August.



B. HEAD OF BONANZA GULCH BASIN.

Looking northeast from Alforcus claim, above Bluster mine. The part of the basin here shown is semicircular and more than a mile wide. Photograph by Claude C. Gillham, taken in August.

tions and means of transportation are readily available. The biweekly automobile mail stage between Deeth and Charleston is used by some, who then proceed on horseback or afoot from Charleston over the remaining 24 miles of the route across the high mountains to Jarbidge. Charleston consists chiefly of a post office and a few stock ranches or farms.

PRODUCTION.

The reported production of the Jarbidge district at the end of 1921 was about $1,500,000 in gold and silver, of which about $1,250,000 was produced by the Elkoro Mines Co., mostly from the Long Hike mine. In 1919 Jarbidge produced more gold and in 1919, 1920, and 1921 more gold from gold ores than any other camp in Nevada.

CLIMATE.[2]

The climate at Jarbidge is similar to that of neighboring northwestern Utah and the Silver City region, Idaho, and in part to that of Great Basin on the south and the Snake River valley on the north. The summers are long and dry and there is great daily range between day and night temperatures. The days are warm, with abundant sunshine, but owing to the dryness of the air the heat is not oppressive. The nights are cool to cold. Frosts occur every month of the year. The annual precipitation is about 13 inches. It falls mainly as snow in winter, which ranges from 12 to 100 inches in depth at higher levels, and in places some snow remains throughout the summer. Fresh snow begins to accumulate on the mountains early in October and in the valleys late in November. Springs feed perennial streams by which the district is well supplied with wholesome water. In winter the temperature rarely falls below 20°. At Jarbidge milling operations are conducted throughout the winter with little or no artificial heat. The first warm weather of the year occurs early in June, when waters from melting snow greatly increase the flow of Jarbidge River and the other streams.

VEGETATION.

The area lies in the Humboldt National Forest and contains considerable timber at the heads of the valleys, well up in the mountains, and along the larger streams (Pl. IV). The principal trees are limber pine and alpine fir, and the better stands are on the east and northeast slopes. Much of the timber is suitable for mining, but the pine is the only tree suitable for lumber. Sawmills have been in

[2] The notes on climate and vegetation are in part supplied by the United States Forest Service.

successful operation at several points, and a mill is now running near the head of Jarbidge River.

Mountain mahogany, juniper, and aspen, mostly bushy trees of stunted growth, are plentiful and widely distributed and extend high up the mountain slopes. Favorable slopes extending from the foothills nearly to the top of the mountains are clothed with a fair growth of good forage grass and form an excellent sheep range.

PHYSICAL FEATURES.

GREAT BASIN PROVINCE.

The Jarbidge district lies on the boundary between two physiographic provinces—the Great Basin on the south and the Snake River valley or Shoshone Basin on the north. It has a relief of more than 5,000 feet. The chief features of the Great Basin consist of minor mountain ranges trending in a north-northeasterly direction and intervening detritus-filled valleys. In northeastern Nevada the ranges largely give way to irregular groups of hills that, increasing in altitude from foothills on the south, merge into the Jarbidge Mountains, which here form the north rim of the Great Basin. This portion of the basin is drained mainly by the headwaters of Marys River, which flows into the Humboldt, on the south, at Deeth.

SNAKE RIVER VALLEY.

Toward the north the Jarbidge Mountains slope down to the Snake River valley or Shoshone Basin, a vast, nearly level dissected area, 50 to 60 miles wide, surrounded by deeply sculptured mountains and extending in a curved course, concave to the north, entirely across southern Idaho.[3] The master stream is Snake River, which flows in a westerly course through the plain, here and there in box canyons. The plain ranges in elevation from about 3,000 feet above sea level on the west to about 6,000 feet on the east. It is mainly of constructional origin and is underlain by Tertiary and Quaternary basaltic lava flows and lake beds. Some of the more recent lavas are probably not more than 100 years old.[4]

A good partial section of the lavas is exposed in the right or north wall of the Snake River canyon just below the celebrated Shoshone Falls, and a less full section at the Salmon River dam and crossing of the Jarbidge road about 30 miles south of Twin Falls.

The Jarbidge region is drained mainly by branches of Bruneau River, which from its source south of Charleston, Nev., flows in gen-

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[3] Russell, I. C., Geology and water resources of the Snake River Plains of Idaho: U. S. Geol. Survey Bull. 199, 1902.

[4] Russell, I. C., op. cit., p. 61.

eral north-northwestward about 80 miles to Snake River. It crosses the State line at a point about 12 miles west of Jarbidge River, which joins it 22 miles farther north. The next main tributary to the Snake on the east is Salmon River, which flows about parallel with the Bruneau and crosses the State line 50 miles east of it.

From the convex southern edge of the plain, at an elevation of about 4,000 feet, between Salmon and Bruneau rivers, the surface rises in a long, gentle piedmont slope to the crest of the Jarbidge Mountains, the topography being on the whole in marked contrast with that of the rugged foothills on the Great Basin side, to the south. In the vicinity of the State line the elevation in general is about 6,000 feet; 6 miles farther south, at the foot of the high divide, it is about 7,000 feet. The highest ridges attain almost 11,000 feet. Near their headwaters the forks of Jarbidge River have cut deep trenches into the elevated volcanic plateau, which reaches its highest point south and east of Jarbidge.

The high ground extending northeastward from the Jarbidge district and mountains, usually mistaken for the Great Basin divide, is not the divide but a long spur ridge on the Snake River side.

JARBIDGE MOUNTAINS.

Of the mountains bounding the Snake River valley on the south, the Jarbidge Mountains are among the most conspicuous and lofty. The great watershed culminates in them at an elevation of nearly 11,000 feet. They are about 12 miles wide and trend in an east-west direction across the heads of the northward-flowing Jarbidge River and its East Fork. The mountains consist largely of a huge pile of Tertiary volcanic rocks. The main ridges in the Jarbidge district trend with the drainage, at right angles to the axis of the divide, as shown in Plate I. The trend is not wholly due to consequent drainage on a sloping constructional surface, as would at first appear, but seems in general to harmonize with the trend of the Great Basin topography on the south and probably owes its origin to lines of fissuring or faulting produced in connection with the igneous flows and uplift.

The lavas were erupted in at least two distinct and extensive epochs, separated by a considerable time interval, during which subaerial erosion scored the surface and developed a drainage system similar to that of to-day. Those of the first epoch, the old rhyolites, were erupted through and rest on a surface of low relief, ascribed to erosion during Cretaceous, Eocene, and part of later Tertiary time.

The lavas of the later epoch were more fluidal and resistant than those of the first epoch. For convenience they are referred to collectively as the young or rim-rock lavas. They were freely poured out, completely flooding the lower slopes of the region and burying a large part of the older lavas, in places to depths of nearly 2,000 feet. This second epoch of eruption left the Jarbidge Mountain region roughly in the form of a huge elongated east-west dome which rose perhaps 1,000 feet or more above the rocks that form the highest peaks of to-day and which, by reason of the fluidity of the later lavas, had a comparatively smooth surface. From the summit of the dome the surface declined in long, gentle slopes in nearly all directions, especially to the flat-lying Snake River Plains, about 20 miles distant on the north, and to the base of Elk Mountain, about equally distant on the east.

On this new constructional domal surface, at the end of the second epoch of volcanism, subaerial erosion resumed its work of denudation, and the present drainage system, with its main courses approximately parallel to the lines of the intervolcanic epoch, was established. The higher part of the dome, where the extremes of precipitation and temperature were greatest and where there were lines of weakness due to volcanism, including perhaps crater openings of considerable depth, was the most deeply dissected.

A notable and economically important feature of this process of denudation was the stripping off of the roof or cover of the dome, the great blanket of the younger lavas, which are now worn back to the east side of the East Fork valley on the east and beyond the Jack Creek valley on the north. The eroded edges of these lavas, rising nearly 1,000 feet above Jack Hole and Jarbidge River, form a steep inward-facing scarp or rim rock, which rests upon and encircles the slopes of the mountains on the north and rises to the 10,000-foot contour where it crosses the divide on the east. (See Pl. I.)

As soon as the young lava covering was worn through at or near the summit of the dome, erosion became concentrated along the contact of this covering with the underlying softer old lava, and it has been a controlling factor in determining the present dominant topographic features of the district.

Simultaneously and almost coextensively with the stripping back of the young lava covering, the main streams, in the process of down cutting along the contact and subsequently below it, shifted their channels laterally down the slope of the dome—Jarbidge River to the west, East Fork to the east, and Jack Creek to the north. This migration of the channels has produced precipitous inward-facing cliffs bounding these streams on the outer side of the dome—east of East Fork, north of Jack Creek, and west of Jarbidge River—and contrasting strongly with the long and comparatively gentle slopes on the opposite or inner sides, across which the streams have migrated. It has also resulted in the present occupation by East Fork and the Jarbidge of practically the same drainage lines that existed in the intervolcanic epoch, before the rim-rock lavas were poured out.

The denudation and dissection of the old lavas that followed the removal of the young-lava covering has resulted in two distinct types of topography. One type, shown in Plate III, is adolescent. It appears in the old-lava area that occupies the heart of the district and extends from a line west of Jarbidge River to a line east of East Fork. The other type appears in the young-lava or piedmont portion of the field and is young.

The old-lava area contains the dominant features of the district—the high, rugged north-south ridge between Jarbidge River and East Fork and the deep valleys of these two streams, which are sunk to a point below the 6,000-foot contour, or about 5,000 feet below the tops of the neighboring mountains.

Of the seven culminating peaks, which, as shown on Plate II, are about a mile apart, the most northerly and highest is Jarbidge Peak. This and the four succeeding peaks to the south, which nearly equal it in height, are conspicuous to the traveler approaching the district from the Idaho side, being visible at a distance of 90 to 100 miles on a clear day. They are commonly known as the Crater Peaks, or collectively as the Crater Range.

The Crater Range is the most striking feature of the district topographically, geologically, and economically. It exceeds in altitude the adjoining Great Basin divide. It is a huge mass of volcanic rocks and contains nearly all the mineral deposits of the district. It trends N. 20° W., as do also many of the veins, a fact which suggests that the orogenic forces which produced the range or determined its strike probably also produced the fissures containing the N. 20° W. veins. The west slope declines more or less uniformly at an angle of about 28° to Jarbidge River; the east slope is rugged and breaks off abruptly, as shown in Plates IV, *A*; V, *A* and *B*.

Near the middle of the area, from Jarbidge River to the top of the north end of the Crater Range, the surface rises about 4,300 feet in a horizontal distance of 1½ miles, or at the rate of nearly 3,000 feet to the mile.

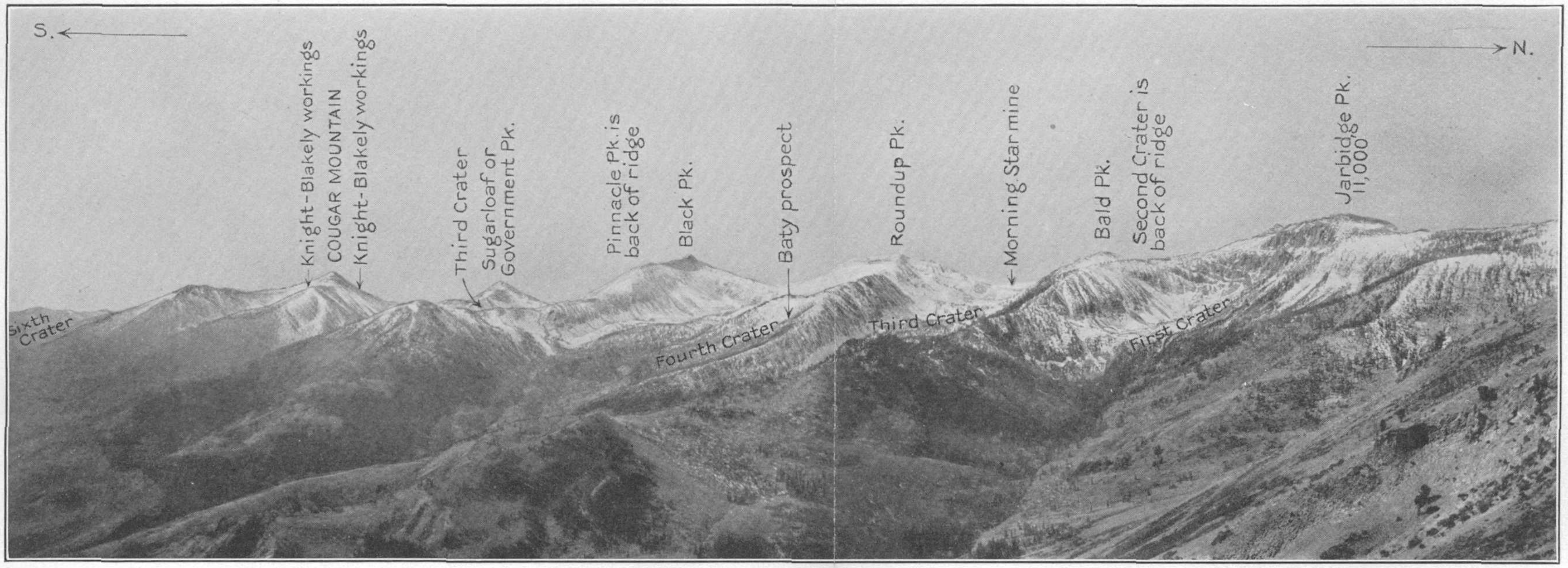
The topography of the old-lava area is of the type produced mainly by water erosion in an elevated country of horizontally deposited volcanic rocks. It is characterized by long, high, and in places narrow, though not usually sharp-crested ridges, with smooth or even contours, and correspondingly deep, mostly V-shaped valleys and gulches bounded by slopes that rise in many places for considerable distances at angles of nearly 45°. (See Pls. I and III.)

In portions of their courses even the main streams occupy steep-walled canyons, and locally, as back of the lower part of Jarbidge and west of Bear Creek, the uniformity of the mountain slopes is interrupted by vertical cliffs or scarps several hundred to a thousand feet in height, from whose bases long trains of talus or rock débris extend down toward the valleys. Some of the scarps are probably due to faulting.

On the east the Crater Range or, more exactly, its saddles, break off into steep-walled U-shaped cirques, amphitheaters, or basins, commonly known in this region as "craters," in which head most of the perennial tributaries of East Fork and Jack Creek. (See Pls. IV, *A;* V, *A;* VI, *A.*) There are six of these "craters." They are known in numerical order from north to south as First Crater, Second Crater, etc. Like the peaks with which they alternate, they are about a mile apart. They are separated by long sloping spur ridges, and some of them are confined by walls 1,000 to 1,200 feet high on the west. It is quite possible, to judge from tuff, breccia, and other volcanic débris observed in the walls, that some of them may really represent or be remnants of craters. In the main, however, they owe their general outline and probably their origin to former local or mountain glaciers that headed in them. They open toward the east or northeast, and in this direction their floors slope gently. The glaciated character of the valleys (U-shaped in cross section) into which they open is shown in Plate XIX, *A*. Since the disappearance of the glaciers the forms of the cirques have been modified by subaerial erosion, including that of snowslides or avalanches. Snow and ice now locally remain in some of them throughout the year, and the cliffs that confine them on all but the open side are flanked by belts of talus rising with steep slope usually about 200 feet above the floor.

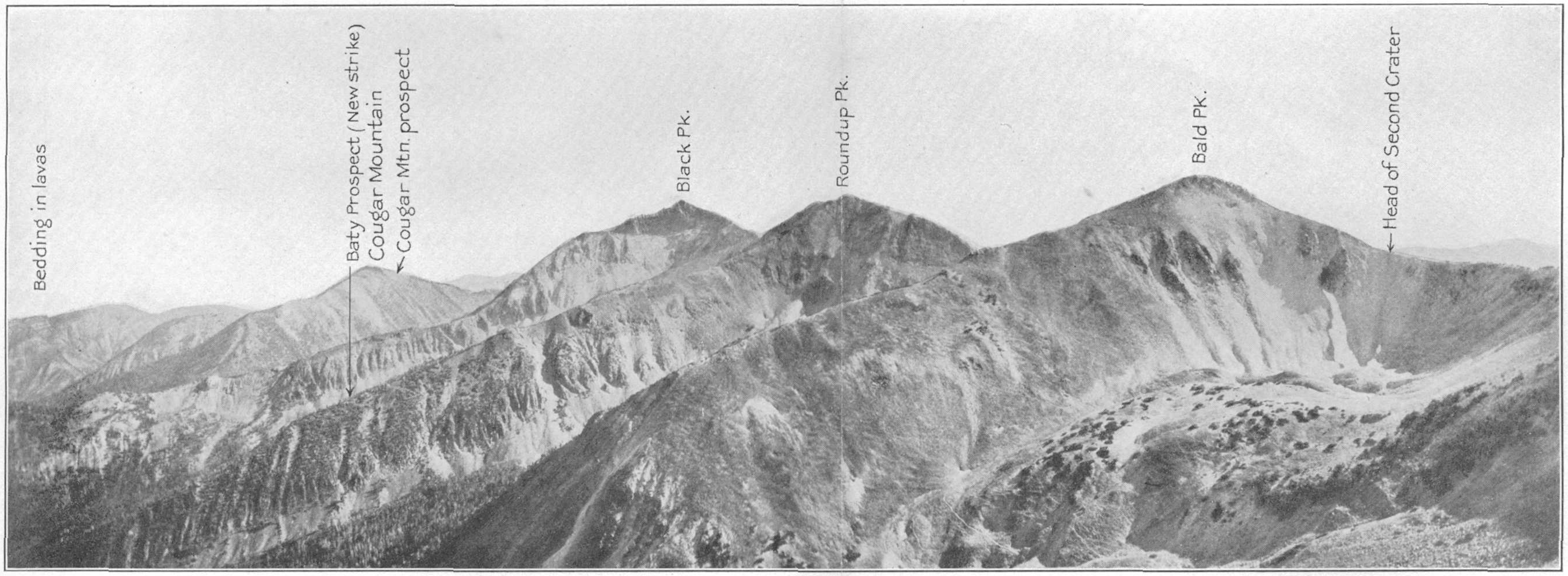
The determination of the position of the cirques on the east slope of the range and their erosion by snow and ice have been peculiarly favored by the local climatic conditions. Throughout the winter, including the periods of snowfall, the prevailing winds come from the west. They are generally violent and sweep the upper west slope of the range bare of fine talus or rock débris and snow, which they carry over the crest and deposit as huge cumulative drifts in the heads of the "craters." (See Pl. VI, *B*.) Here in glacial time the lower layers of snow under pressure of the superincumbent load congealed into ice. In the process of congealment the ice annexed on its under surface large angular blocks and lesser rock débris plucked from the cliffs and talus. This rock material held firmly in its grasp the glacier used as a powerful instrument of erosion as it slowly moved down the steep, rocky slope.

To this process of head erosion is due the steepness of the cliffs at the heads of the "craters." It captured some of the cols, as shown in the central foreground of Plate VI, *B*, and considerable portions



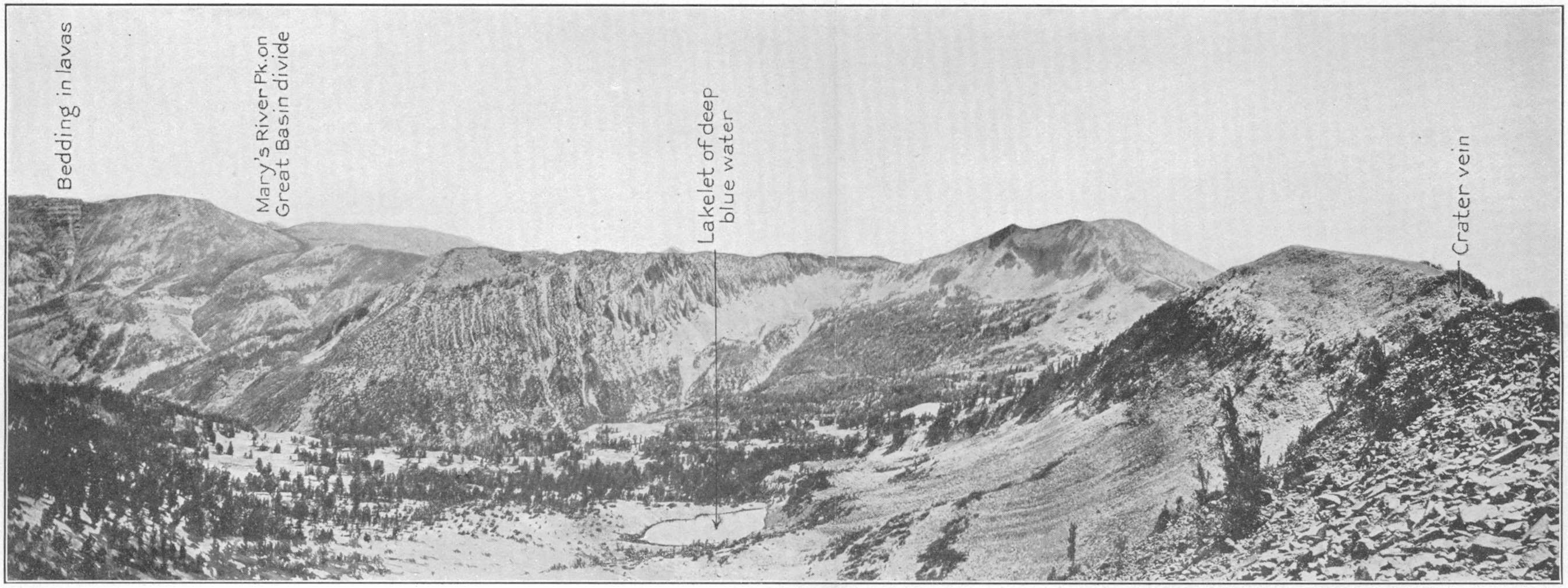
A. CRATER RANGE, EAST SLOPE.

Looking west from a point east of East Fork, 4 miles distant. Photograph by Claude C. Gillham, taken in October. The name Third Crater, at the left of Sugarloaf, should be Fifth Crater.



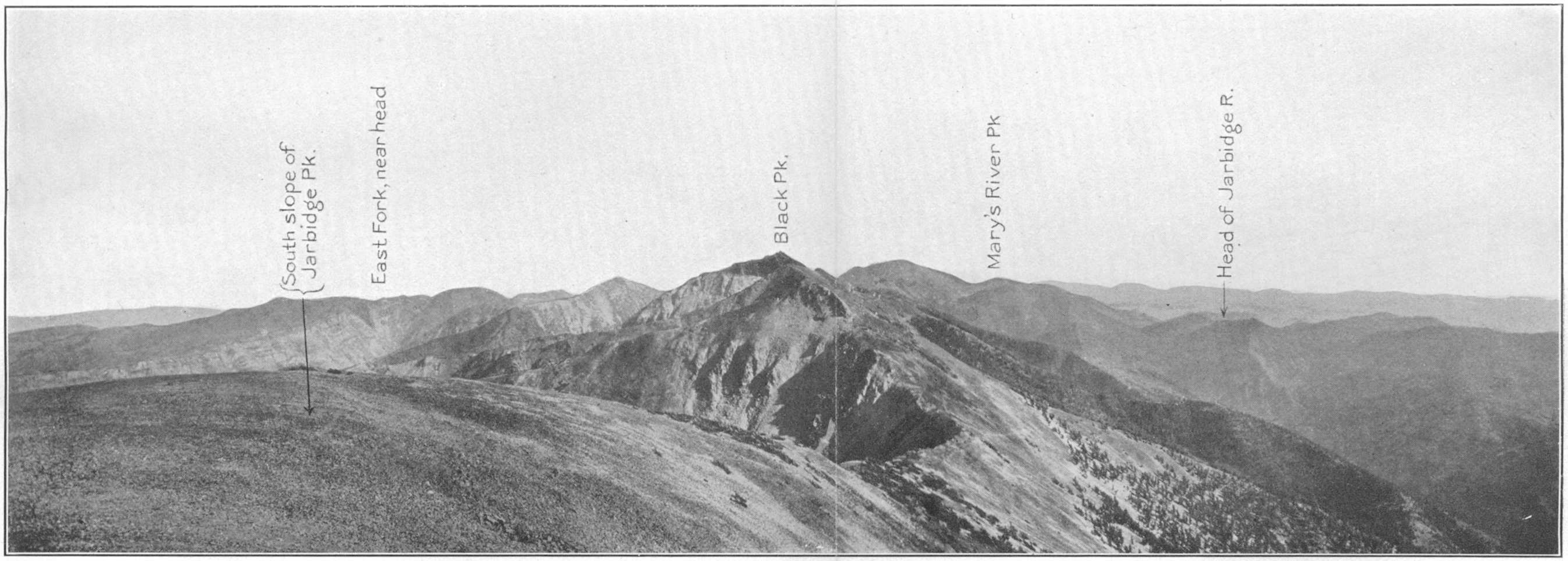
B. CRATER RANGE, PART OF EAST SLOPE.

Looking south from apex of Altitude vein on east ridge. Shows peaks, ridge, and gulch topography and flow bedding in lavas at left. Photograph by Claude C. Gillham.



A. SIXTH CRATER, HEAD OF EAST FORK OF JARBIDGE RIVER.

Looking south-southeast from south slope of Government Peak. Photograph by Claude C. Gillham, taken September 1.



B. CREST OF CRATER RANGE, MIDDLE PART.

Looking south from Jarbidge Peak. Rugged topography in old rhyolite at head of Jarbidge River in right background; heavy flow bedding in old rhyolite near head of East Fork in left background. Dark lava caps old rhyolite in Black Peak. Photograph by Claude C. Gillham, taken August 31.

of some of the most prominent peaks, as shown in Plate V, *B*. Head erosion in a much milder form than in glacial time is still in progress and will doubtless eventually destroy the picturesque crest of the entire range. The climate at the time the glaciers reached their zenith probably did not differ much from that of to-day.

The old-lava area on the whole is comparatively free from the impassable precipitous barriers that usually characterize a country of its scale of topography and class of rocks. It is mostly accessible to the pedestrian, and with slight detours a horse can be taken into almost any part of it.

The topography of the younger or rim-rock lava area contrasts strongly with that of the old-lava area. It resembles in its main features that of the adjoining Snake River Plains. The area consists in general of a gently sloping, rarely benched or scarped mesa or piedmont plain partly dissected by more or less parallel narrow, steep-walled box or V-shaped canyons. Its youthful character is due in some measure to the greater resistance of the rocks in which it is carved but mainly to the facts that its relatively dry climate essentially exempts it from the attacks of subaerial erosion and that the streams which rise in the moister mountain regions in crossing it erode only the bottoms of their channels, leaving the sides and upper edges of the valley walls intact.

Jarbidge River, the largest stream in the district, heads on the upper north slope of the Great Basin divide, in the angle formed by the junction of the divide with the Crater Range, at an elevation of about 9,000 feet. It flows in general nearly north through the western part of the district (Pl. I). After receiving the East Fork a few miles beyond the Idaho State line, it joins the Bruneau about 20 miles farther north, of which it is seemingly the largest tributary. It is difficult to ford during the spring and early in summer.

In the upper part of its course the Jarbidge receives numerous tributaries, the chief of which are Fox Creek and Pine Creek. In the remainder of the district its principal tributaries are Bear Creek and Deer Creek on the west and Bonanza Gulch, Bourne Gulch, and Jack Creek on the east. From Pine Creek nearly to Jack Creek, a distance of about 4 miles, it flows through a gravel-floored, locally terraced flat about 500 feet in width (Pl. III) and has a fall of about 160 feet to the mile. After entering the young-lava area a short distance above Jack Creek its course is mostly in a canyon.

Jack Creek, a fine stream, heads in the First Crater and adjoining territory on the southeast. It occupies in a sense a piedmont valley bounded by the old-lava mountains on the south and the young lavas forming the rim rock on the north.

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East Fork, which drains the eastern part of the district, is nearly as large as the Jarbidge, but its valley is more rugged. Its course through the young-lava area, which it enters in the northern part of the district, is mainly in a narrow canyon, whose walls have in places an almost sheer drop of 1,000 feet and can be crossed only by making a detour of several miles to the north by way of the Robinson Hole trail.

The extreme southeastern and south-central portions of the district, which are relatively unimportant so far as mining developments are concerned, drain, respectively, southeastward through Canyon, Cottonwood, and Camp creeks into Salmon River and southward through Marys River into the Humboldt.

GEOLOGY.

The Jarbidge district lies almost wholly in an area of Tertiary volcanic rocks resting on an eroded surface of folded and tilted sedimentary rocks, principally Paleozoic, which are cut by granitic intrusives. (See Pl. I.) The rock groups of the district, beginning with the oldest, are Paleozoic sedimentary rocks, post-Paleozoic intrusive rocks, early Tertiary lavas, late Tertiary lavas, Tertiary sedimentary rocks, and Quaternary deposits. The valuable mineral deposits occur in the early Tertiary lavas.

SEDIMENTARY ROCKS.

PALEOZOIC ROCKS.

Sedimentary rocks regarded as Paleozoic occur at the western margin of the Jarbidge district and extend southward across the divide into the Great Basin. (See Pl. I.) In this vicinity they constitute in part the high north-south ridge between the Jarbidge drainage basin on the east and that of Bruneau River on the west, whence they extend westward into what is locally known as the Quartzite Range and also as the Copper Mountain Range.

These rocks consist, in order of deposition, of quartzite, limestone, and shale. They have been considerably disturbed, faulted, tilted, and folded. They dip steeply to the north at angles of 60° and apparently exhibit a general thickness of several thousand feet. They rest largely upon gray, coarsely crystalline hornblende granite, which seems to be intrusive, and they are locally overlain or capped by thin flows of rhyolite. The limestone is also cut by dikes of granodiorite of about the same age as the granite, or slightly younger.[5] Some of these rocks on the southwest were casually observed by the writer along the Elko-Jarbidge road.

[5] Sweetser, N. W., Geology of the Jarbidge mining district: Min. and Sci. Press, vol. 101, p. 871, 1910.

Near the center of the Jarbidge district are outcrops thought to belong to these old rocks, notably on the west slope of the Crater Range. Here, protruding boldly above the surface of the surrounding rhyolite, a reef of brecciated quartzite, commonly known as the "quartzite dike," extends interruptedly for about 2 miles in a northeasterly direction diagonally across the mountain side above the North Star and Buster mines and just below the O. K. mine. It has an average width of about 200 feet. The quartzite is abundant in the Pavlak mine, and a short distance below the mine, at the foot of the bluff on the west side of Jarbidge River, occur large talus blocks of it, suggesting that the rock is probably in place in that vicinity also. These and similar data obtained elsewhere in the district indicate a thinning out of the overlying rhyolite toward the west and the presence of the underlying eroded surface of the Copper Mountain sediments sloping down eastward to a level probably not far below the bed of Jarbidge River.

On the northeast, where the quartzite reef crosses Bourne Gulch at an elevation of nearly 7,000 feet, it dips 80° NW. and shows on the hanging wall considerable fault breccia and a little black slate or chloritic and graphitic schist containing needles and lath-shaped bodies of sericite and other metamorphic minerals. The rock seems in general to be altered to a relatively massive quartzite by silicification, but where not altered it consists of medium-grained whitish or light-gray, very hard quartzite. Except for a few layers of parallel sheeting it is structureless. A specimen of the rock from the Pavlak mine was examined microscopically and found to be very fine and irregularly grained, greatly shattered, and recemented by secondary white silica. It also contains about 3 per cent of interstitial sericite or white mica in the form of foils and shreds and a little chlorite. The margins of the constituent quartz grains are sharply etched and embayed by corrosion. Most of the grains are glassy, but some are milky. Many of them are elongated and, being longitudinally oriented, give to the rock a structure resmbling schistosity. In the larger grains the extinction is wavy, owing to the destruction of the optical continuity by pressure.

About half a mile southeast of the quartzite reef, to the north of the Bluster and the Pick and Shovel mines, chiefly on the south side of Bonanza Gulch, pale-greenish siliceous shale or sericitic quartzite and conglomerate crop out through the rhyolite. The outcrops extend interruptedly westward down the gulch for about a quarter of a mile. These rocks appear younger than the quartzite reef, with which they are in marked unconformity and which has seemingly supplied much of the material in the conglomerate.

The conglomerate, of which about 80 feet is exposed, occurs toward the base or lower end of the croppings. It ranges from fine and arkosic to coarse and bouldery. It consists mainly of boulders and pebbles of quartzite, black massive argillaceous rock freely traversed by quartz veinlets, and some old basalt or diabase. It is overlain by impure sandstone or graywacke, which seems to grade upward into the shale. Both the conglomerate and the shale are cut by rhyolite dikes, one of which is about 30 feet wide. The shale is more or less massive and in part banded, and the banding apparently represents lines of stratification. The rocks in general dip gently southeastward, into the mountain. Their deeply buried portions are probably the source of crushed small masses and fragments of shale and other sediments found in the veins and associated fault gouge higher up in the mountains. Their outcrops on Bonanza Gulch indicate a thickness of at least 500 feet. At the upper end of Jarbidge, in the west side of the valley, at less than than 100 feet above the river, occurs black slate which appears to be upfaulted in the rhyolite.

The sedimentary rocks above described are referred collectively to the Paleozoic on account of their resemblance to known Paleozoic rocks observed in the surrounding regions.

There seems to be no doubt that the great pile of lava composing the Jarbidge Mountains rests upon an eroded surface that consists chiefly of these sedimentary rocks and is continuous beneath the lavas with that of the Great Basin on the south, Copper Mountain on the west, and Elk Mountain on the east.

The nearest locality at which the section of these Paleozoic rocks has been worked out in detail and their succession is well known is Eureka, Nev., 160 miles to the south. The section at that place appears in the earlier report.[6] None of these rocks in the Jarbidge district seem to have suffered deep-seated metamorphism.

TERTIARY (?) ROCKS.

MIOCENE (?).

In the Starlight, Altitude, and other mines in the upper part of the Crater Range and at the same general elevation at the surface near the heads of Bonanza and Bourne gulches occur small bodies of lignitic shale and dark slaty sandstone whose general similarity suggests that sedimentary rocks of this class may be locally interbedded in the old rhyolites. Wherever seen by the writer these rocks seem to have reached their present position by faulting or sliding as of talus. In the upper part of Bourne Gulch, however, on the Winner claim and adjoining ground, the rocks are reported to be in place, to crop out over a considerable area, to show a thickness of at least 20 feet, and to have a gentle dip.

[6] U. S. Geol. Survey Bull. 497, pp. 30-31, 1912.

Because of the probability that these rocks are interbedded in the old rhyolites they are provisionally referred to the Miocene.

PLIOCENE (?).

According to A. L. Rinearson and others, there occur on the lower part of Jack Creek a few exposures of deposits of whitish to gray friable sandstone or waterlaid volcanic ash similar to that reported by prospectors on the south side of the Jarbidge Mountains,[7] described in the present report in connection with the Charleston district (p. 81) and referred to the Humboldt formation, of middle Pliocene age. It is quite possible that some of these deposits may be interbedded in the rim-rock lavas.

QUATERNARY DEPOSITS.

The Quaternary rocks are relatively unimportant. They comprise glacial and snowslide deposits, talus, and alluvium.

In the "craters" and at the head of Jarbidge River occur deposits of bouldery clay which seems to have been formed by local glaciers.

The snowslide deposits occur mainly as crude fan-shaped accumulations at the mouths of some of the main gulches and craters, as at Snowslide Gulch. They consist of a heterogeneous mixture of angular rock débris, gulch-scour clay, and demolished timber, gathered and mixed pellmell by the avalanche. They reach 40 feet in thickness and a quarter of a mile in extent.

Trains or belts of talus, usually coarse, extend from the foot of the cliffs down toward the valleys, as in the head of Bonanza and Gorge gulches and in First Crater (Pl. IV, *A*).

Deposits of stream-laid gravel and sand floor the open portions of the main valleys, especially the Jarbidge Valley, from a point near Pine Creek nearly to Jack Creek, a distance of about 4 miles, with an average width of about 500 feet, as shown in Plate III. They consist mainly of old-lava pebbles that range from fine to coarse but are mostly above medium in size. Below Jarbidge, where they have been exploited, they have a thickness of more than 14 feet.

IGNEOUS ROCKS.

INTRUSIVE GRANITIC ROCKS (CRETACEOUS?).

The oldest igneous rocks consist of stocks and dikes of granular granitic rocks that intrude the Paleozoic sediments. The most abundant of them is a gray, coarsely crystalline hornblende granite that is extensively exposed underlying and intruded into the Paleozoic sedimentary rocks southwest and west of the district.[8]

[7] U. S. Geol. Survey Bull. 497, p. 31, 1912.
[8] Sweetser, N. W., op. cit., p. 871.

After the intrusion both the granite and the Paleozoic rocks were further intruded and cut by dikes of granodiorite. A small body of this rock crops out through the sediments and their rhyolite covering in the upper part of Bonanza Gulch, north of the Bluster mine. It is a red medium-grained rock composed essentially of soda-lime and alkali feldspars in about equal amount, hornblende, and quartz. It contains numerous roughly equidimensional dark or dull-green crystals of hornblende, of which the largest are nearly a quarter of an inch in length.

The intrusive granitic rocks are regarded as probably of Cretaceous age and very likely belong to the same general period of intrusion as the batholiths of California and western Nevada. They are of economic importance, because ore deposits found in association with them in the Paleozoic sediments in the adjoining Charleston district seem to be genetically connected with their intrusion.

It is quite probable that deposits similar to those of Charleston or Copper Mountain and of the same age occur in the Jarbidge district, more or less deeply buried under the rhyolite.

TERTIARY VOLCANIC ROCKS.

GENERAL FEATURES.

The intrusion, deformation, and erosion of the Paleozoic sediments were followed by the eruption of Tertiary lavas that more or less completely flooded the region. It was recognized by the Fortieth Parallel and other surveys that the Great Basin shows a variety of Tertiary lavas which are identical over wide areas and were erupted in somewhat the same succession. This succession in general is rhyolite, andesite, and basalt.

Among these rocks the most abundant and widely distributed are the rhyolites.[9] The volcanic rocks in the Jarbidge district, as shown by a comparison with the studies of the Fortieth Parallel and other surveys, plainly belong to this family.

Rhyolites are glassy igneous rocks which form surface flows and have about the same chemical composition as granites. They are the volcanic equivalents of the granites, having been produced by the consolidation of a granite magma under volcanic conditions. They are highly acidic, most of them containing free silica in the form of quartz. In color they are generally white, pink, purple, or dark brown. The dense, pasty groundmass may contain phenocrysts of orthoclase, quartz, and plagioclase, with small amounts of biotite, augite, and hornblende.

The rhyolites of Jarbidge were erupted in at least two distinct epochs, separated by a considerable interval of erosion, and they are

[9] U. S. Geol. Expl. 40th Par. Rept., vol. 1, 1878, p. 606.

accordingly described as the earlier or old rhyolites and the later, rim-rock, or young rhyolites.

OLD RHYOLITES (MIOCENE?).

OCCURRENCE AND DISTRIBUTION.

The economically most important and interesting of the volcanic rocks are the old rhyolites. On the eroded surface of the Paleozoic sediments they were poured out, mainly in successive broad flows, until they aggregated nearly 6,000 feet in thickness, measured from the floors of the old valleys to the tops of the neighboring mountains. They seem to have been erupted mainly along a fissure or series of fissures, inconspicuous craters or vents coinciding with the axis of the Crater Range, whence they spread widely in all directions.

At or soon after the end of the eruptions the rocks were fissured, in part, perhaps, by contraction due to the cooling of the individual flows and heated mass, but mainly by crustal movement attended by faulting, which was mostly normal. Most of the fissures thus produced are now occupied by the gold-bearing quartz veins of the district.

The erosive processes that followed eruption and gave the region its present surface relief are described on pages 7–11.

Except for a small area at the crest of the Crater Range, the present area of exposure of these rocks in the district, essentially as shown on Plate I, extends from the region beyond the Great Basin divide on the south to Jack Creek, Rimrock, and Robinson Hole on the north, a distance of 12 miles or more, and from the region west of the Jarbidge district to and beyond East Fork on the east, a distance of about 9 miles, thus occupying about 100 square miles. Beneath the young-lava covering they seem also to have a considerable extent to the southeast, where they are exposed mainly in the deeply cut valleys on the headwaters of Salmon and Marys rivers.

Measured vertically from the summit of the Crater Range to Jarbidge River, which is still sinking its bed into them, the old lavas, after having suffered two periods of erosion, still show a thickness of nearly 5,000 feet. On the west they have been largely removed by erosion and are represented only by thin outliers capping the Paleozoic rocks on the summits of the Copper Mountain Range. On the east and north they pass unconformably beneath and are buried by the younger lavas described on page 20.

As seen in the field, the rocks exhibit a great variety of colors, of which the prevailing is pinkish or reddish ash-gray. Greenish, reddish, and purple tints are also characteristic, and practically the whole northeastern part of the Crater Range is stained a bright brick-red by iron oxide.

The rocks occur in successive flows, probably a hundred or more in number, resting unconformably one upon another and ranging apparently from 30 to 40 feet to several hundred feet in thickness. The flows are thinner in the upper part of the section, toward the top of the mountains. (See Pl. VI, *B*.) In general they are ill defined, particularly in the vicinity of the veins and mines where rock alteration has taken place. Locally vegetation is helpful in differentiating them. They are best exposed on East Fork (see Pl. VI, *B*, left background), where at one point twelve or more successive flows can be differentiated.

The best exposure of these flows on Jarbidge River is near its head on the west side, downstream from the Ozark lode. Here the flows dip gently southwest, but on East Fork they dip gently to the southeast, the difference in direction of dip of the two localities being due to their position in diverging sectors of the domical uplift.

In some localities, as shown in the cliffs back of Jarbidge and along Bear Creek, the flows exhibit crude columnar structure caused in places by cooling of the heated lava flows individually and elsewhere by jointing. In places the columns weather into pinnacled forms (Pl. VII). Some of the flows are also cavernous, with grottoes as large as 7 feet in diameter, examples of which are conspicuous in the high cliffs on Bear Creek. Three-quarters of a mile above Jarbidge one of these openings, known as the Cave, having a floor width of about 20 feet and a height of 16 feet, extends some 60 feet into the mountain. The caverns were formed mainly by uneven congealment of the lava while yet in motion, and in some of them, as in the Cave, their forms have been determined largely by faulting and dissolving of the rock mass by circulating acidic solutions. Similar features on a smaller scale occur in hand specimens as druses, many of them lined with hyalite or opaline chalcedony.

The flows are in the main nearly horizontal. They include locally intercalated sheets of black and brown obsidian or glass and also, particularly in the upper part of the section, the usual coarser volcanic ejecta, such as ash, tuffs, breccias, agglomerates, nodules, bombs, and lapilli, more or less widely distributed. Nodular and bomb phases occur on and near the Ozark ground, near the head of Jarbidge River.

STRUCTURE.

The rocks show gentle folding and fault dislocations, particularly along the vein fissures, as on Bear Creek, in the Long Hike mine, and along the quartzite reef. The fault along the quartzite reef is probably one of the major faults of the district and is older than the veins.

The faults, including the vein-fissure faults, seem to be mostly normal. In general they strike about north-northwest, nearly parallel with the Crater Range. They occur roughly in two groups—the west group, mainly in the west slope of the Crater Range and along Jarbidge River, and the east or Crater group, mainly in the upper east slope of the range. Those of the west group mostly dip to the east, into the range; those of the east group strike more nearly north than those of the west group and dip steeply to the west, into the range and against the dip of the west group.

The faults probably represent in part prevolcanic deformation lines in the underlying rocks that extend horizontally far beyond the Jarbidge district, and they were subsequently extended upward through the lavas by widespread postvolcanic disturbances.

The prevalence of normal faulting, however, and the convergent dips of the two groups or systems from opposite sides of the axis of the range indicate that some of the fissures are probably also in part due to the subsidence of the axis of the Crater Range and the adjustment that followed the outpouring of the lavas. In places fissuring may have been aided by contraction of the heated lava mass or part of it in cooling.

The rocks are cut by rhyolite dikes, which are similar in character to the extruded rocks and were probably derived from the same general magma. Examples may be seen in Bonanza Gulch below the Pick and Shovel property.

The rocks normally consist of a fine-grained dense or aphanitic groundmass with equidimensional phenocrysts of quartz and feldspar 0.2 inch or less in diameter that give to the rock a porphyritic aspect. The quartz is the more abundant mineral. In places the phenocrysts are so plentiful as to give to the rock the appearance of a medium-grained granite, but in general the groundmass much exceeds the phenocrysts in volume. Banding or flow structure is locally present but not usually pronounced. The rocks in general are considerably altered. In some areas, particularly in the vicinity of veins and fissures, they are highly altered by metasomatic replacement, the chief changes being devitrification and silicification of the rocks almost as a whole, attended by the development of certain new or secondary minerals.

The feldspars, which are mostly orthoclase, are usually much weathered, kaolinized, or reduced to chalky spots of crystalline chlorite, sericite, and other minerals and where corroded out at the surface give to the pebbles in the river gravels and to long-exposed talus a pitted or pock-marked appearance.

CHEMICAL COMPOSITION.

The chemical composition of a normal specimen of the old rhyolite from the South Hill Top tunnel at the upper end of Jarbidge is shown in column 1 of the accompanying table of analyses.

Analyses of Nevada rhyolites.

	1	2	3	4
SiO_2	76.77	76.80	75.29	71.00
Al_2O_3	12.63	11.64	....	....
Fe_2O_3	1.13	.66	....	....
FeO	.27	.50	....	....
MgO	.07	Tr.	....	....
CaO	.21	.43	.71	....
Na_2O	.30	2.53	2.90	....
K_2O	6.43	6.69	5.34	....
H_2O-	.49	....	....	....
H_2O+	1.55	....	....	....
TiO_2	.18	....	....	....
P_2O_5	.04	....	....	....
	100.07	....	....	....

1. Specimen No. 33, old rhyolite, Jarbidge district. George Steiger, analyst.
2. Specimen No. 166, Fortieth Parallel Survey, typical rhyolite, Mopung Hills, Humboldt County, Nev.
3, 4. Specimens Nos. 1 and 57, young rhyolite, Jarbidge district. George Steiger, analyst.

The specimen represented by analysis 1 is a fine-grained purple-gray, slightly porphyritic rock with a glassy felsitic to microcrystalline spherulitic groundmass and contains small, irregular phenocrysts of reddish or pale wine-colored glassy quartz and dull, inconspicuous weathered kaolinized and sericitized orthoclase. It is closely banded with fluidal structure and contains a few small elongated macroscopic and microscopic druses and parallel veinlets or stringers of apparently secondary quartz, in association with which is developed considerable pyrite. Pyrite in small macroscopic and microscopic cubes and grains is likewise disseminated throughout the groundmass, as is also considerable fine hematite or ferritic material. Magnetite and apatite are present as accessories.

Comparison with analyses tabulated by H. S. Washington [10] shows that the Jarbidge rock is remarkably low in sodium and is classified in the quantitative system as bisbose (I.3.1.1″). It is evident, however, that in spite of the fresh appearance of the rock it has undergone much alteration, which would have a tendency to increase the percentage of silica and potassium and to reduce that of sodium.

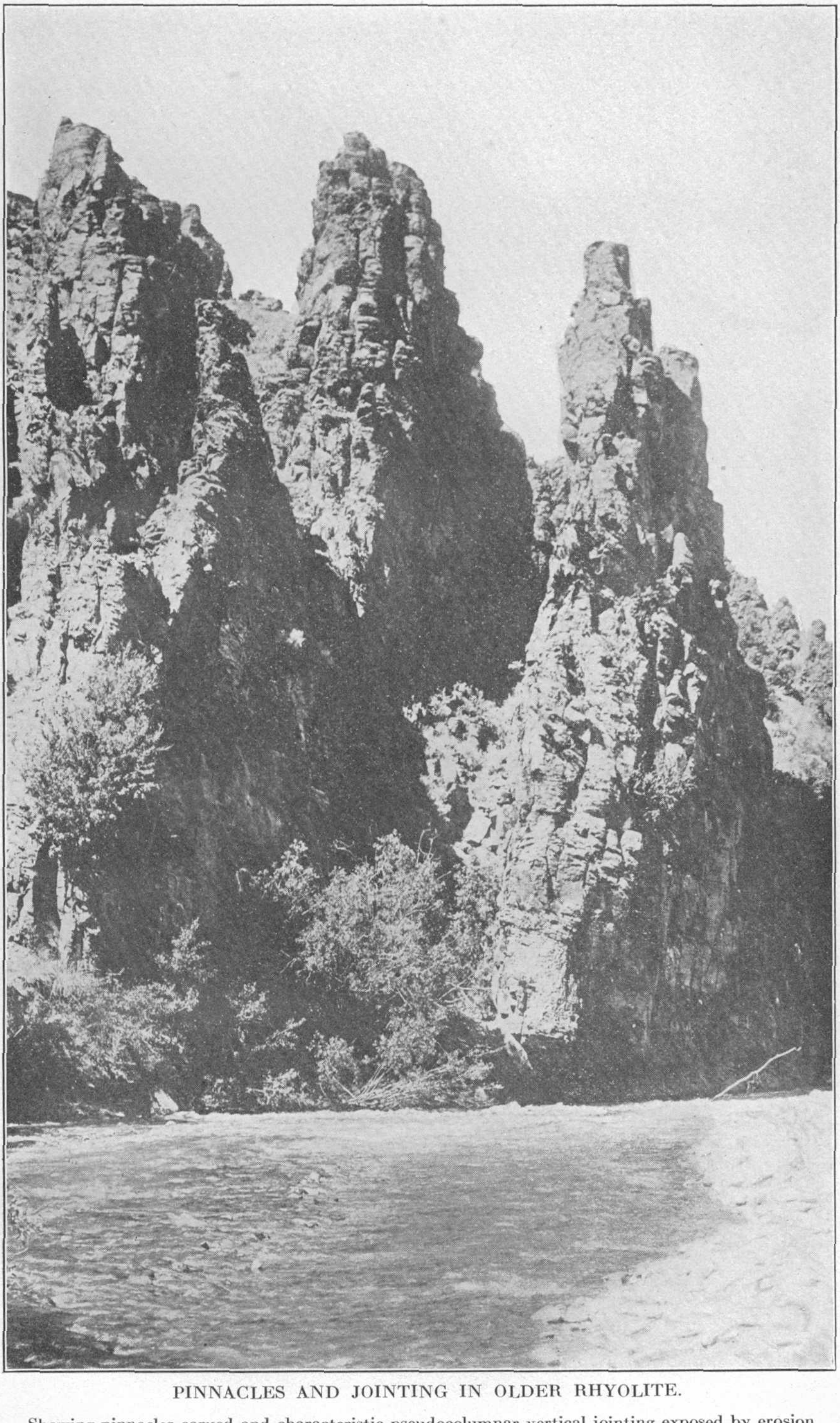
Analysis 2 represents the most siliceous of the typical rhyolites whose analyses are given in the report of the Fortieth Parallel Survey and is here quoted for comparison. The specimen analyzed came from the Mopung Hills, in western Humboldt County, Nev., and, to judge from the description given, is very similar to the Jarbidge rock of analysis 1. The analyses show a very close agreement between these two rocks in their most abundant constituents, silica and potash.

YOUNG RHYOLITES (PLIOCENE?).

OCCURRENCE AND DISTRIBUTION.

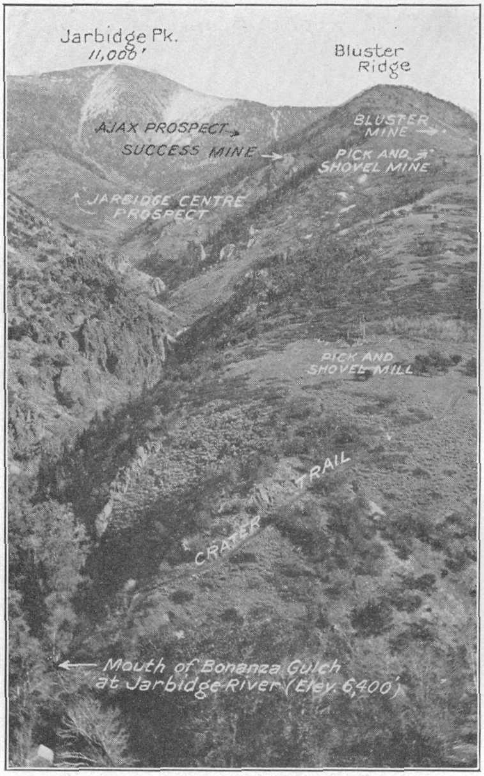
After a considerable interval of volcanic quiescence and vigorous subaerial erosion the young rhyolitic lavas were poured out from

[10] U. S. Geol. Survey Prof. Paper 99, 1917, p. 55.



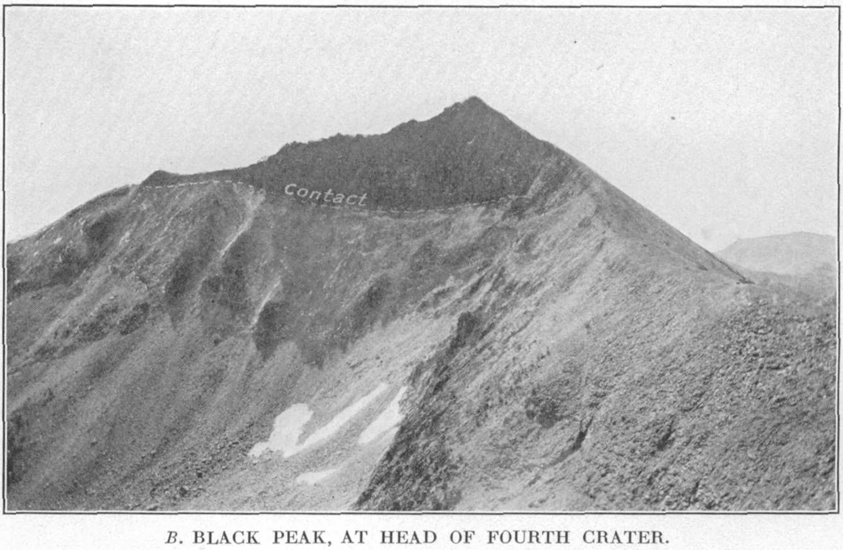
PINNACLES AND JOINTING IN OLDER RHYOLITE.

Showing pinnacles carved and characteristic pseudocolumnar vertical jointing exposed by erosion and weathering on Jarbidge River below Jarbidge, near mouth of Moore Gulch. Compare with Pl. IX, *B*. Photograph by E. C. Weyle.



A. BONANZA GULCH, JARBIDGE PEAK, AND MINES.

Looking east from Elko road, on opposite side of Jarbidge Valley. Photograph by Claude C. Gillham.



B. BLACK PEAK, AT HEAD OF FOURTH CRATER.

Looking southwest from south slope of Round Peak. Shows horizontal contact of vertical columnar dark young rhyolite with the underlying old rhyolite. Photograph by Claude C. Gillham, taken September 1.

essentially the same vents as the old lavas and covered their deeply eroded surface. The marked unconformity between the two formations is plainly seen in the northern and western parts of the district. (See Pl. I.) Here the young rhyolites form a gently outward-sloping piedmont plain, which, extending beyond the district, merges into the flat-lying Snake River Plains on the north and reaches the foot of Elk Mountain, 10 miles distant, on the east. They seem also to have a wide extent to the southeast and south, on the headwaters of Salmon and Marys rivers, respectively.

They were poured out at greater elevations than the old lavas; they were also more liquid, and, being erupted in successive flows conformably one upon another, they spread widely and reflooded the entire district more extensively than the old lavas, though not so deeply, and gave to the Jarbidge Mountains roughly the form of a huge east-west dome. On the outskirts of the district they rest in places upon the old eroded floor of Paleozoic rocks. Within the district they are best exposed on the north and east, where the eroded edges of their flows that terminate the surrounding plain form the inward-facing scarp or rim rock bounding Jack Creek valley on the north and East Fork on the east. Remnants of them seem also to occur in the crest of the Crater Range—for instance, capping Jarbidge and Black peaks (Pl. VIII).

In the valleys and low places the lavas attained a probable thickness of 2,000 feet, as may be inferred in the vicinity of the junction of Jack Creek with Jarbidge River, where they still show a thickness of more than 1,000 feet. At the summit of the dome and the rim of the "crater," however, by reason of their fluidity and the steeper slopes, their thickness probably did not much exceed a few hundred feet.

Owing to the unevenness of the floor on which the lavas rest and to later erosion, their contact with the underlying old lavas is very irregular, as shown in the northern part of the district from Jack Hole westward (Pl. I). After crossing Jack Mountain near the old wagon road the contact line descends into Jarbidge Valley to a point near the forest station and about 400 feet above the river; this figure approximately expresses the depth to which the river has at this point sunk its channel into the old underlying lavas during the present period of erosion. Here the contact line is sharply deflected to the north and crosses the river at a sharp angle about a mile farther downstream, near the 5,800-foot contour, whence it bends back on the opposite side and crosses Telegraph Ridge at a point 2 miles to the southwest, at an elevation of about 7,500 feet, between the old Elko wagon-road pass and the wireless-telegraph station, which stands upon the young lavas to the north of the contact.

STRUCTURE.

The young rhyolites occur mainly in homogeneous fine-grained flows conformably superimposed one upon another and dipping gently away from the mountains in quaquaversal manner. They are prevailingly dull reddish purple and reddish brown. They are as a rule closely though in places dimly banded by fluxion structure parallel with the flows and are comparatively free from volcanic ejecta. Locally, however, they contain intercalated sheets of finely tuffaceous and vesicular material which are drab, dull greenish, and black.

In places they are gently folded, slightly faulted, and vertically jointed and weather into castellated badland forms (Pl. IX, *B*), but compared with the old underlying lavas they have been on the whole not much disturbed or deformed. So far as observed, none of the dikes, veins, or fissures so freely traversing the old lavas occur in these rocks. From this it is inferred that the jointing and faulting in these young rhyolites are probably contemporaneous with the postvein faulting in the old rhyolites.

These rocks are lithoidal. They contrast strongly with the old rhyolites above described, having a much more basic appearance, and are locally known as basalt. In a few places they are medium grained or moderately porphyritic. They consist almost wholly of a dark-reddish or brownish-purple aphanitic groundmass, which usually is more or less closely banded by flow structure and grained and streaked by drawn vesicles. Macroscopic minerals are usually absent and if present are so few and small as to form a negligible percentage of the rock. The rocks have a more or less conchoidal fracture and weather purplish or dark reddish brown, owing mainly to oxidation of the iron content. They show none of the metasomatic or propylitic alteration occurring in the old rhyolite.

In column 3 of the table on page 20 is given a partial chemical analysis of a characteristic specimen of the young rhyolites. The specimen is a purple or dark reddish-brown aphanitic vesicular lithoidal rock, with small macroscopic drawn vesicles forming part of the generally closely banded fluidal structure, and contains very little quartz. It was collected from Telegraph Ridge, about a mile northwest of Jarbidge. The analysis shows a remarkably high percentage of silica for a rock of so basic an appearance, the silica being less than 1.5 per cent lower than that in the analysis of the old rhyolite, which is rich in quartz. It also shows that the silica must be contained almost wholly in the groundmas, either as tridymite or in some other form. In lime, soda, and potash content it stands close to analyses 1 and 2 and shows that in composition the rock on the whole is normal rhyolite.

Analysis 4 represents a specimen from the northeastern part of the district at a point about a mile southeast of Robinson Hole, where the trail in leading up out of the Robinson Creek canyon reaches the top of the rim rock and the edge of the plain on the east. The specimen is a medium-grained black rock of vitreous luster resembling pitchstone. It consists essentially of dark-gray glass, charged with feldspathic and augitic (?) microlites, the whole showing very perfect fluidal banding, with subordinate areas of spherulitic structure.

AGE OF THE VOLCANIC ROCKS.

Formations of known age fixing closely the age of the rhyolites above described do not occur in the Jarbidge district. Throughout eastern Nevada and western Utah rhyolites and tuffs developed on a grand scale are regarded as Pliocene by King[11] and Hague.[12] Also from evidence—such as rhyolitic ejecta contained in lake beds—furnished by detailed work in the area to the southwest, Emmons[13] concludes that the rhyolitic eruptions in this part of Nevada probably began in early Miocene time and continued through the Pliocene. The rhyolites that deeply flooded the Owyhee Mountains in the region about Silver City, Idaho, are referred by Lindgren[14] to the Miocene epoch and regarded as being erupted simultaneously with part of the great flows of the Columbia River basalt. Their deformational features, faulting, fissures, and ore deposits are similar to those of the older lavas in the Jarbidge district.

As the Mount Bennett rhyolite of Russell in the region near Mountain Home, Idaho, bears similar relations to the lavas of Snake River to those borne by the rhyolites of the Silver City region, and as it resembles and is correlated by Russell with the rhyolite underlying the Snake River Plains, as exposed at Shoshone Falls, which King[15] under the name trachyte refers to the Miocene, it seems probable that the rhyolites of Mount Bennett and Shoshone Falls are of the same age as those of the Silver City region and are probably Miocene. Therefore, to judge from the rhyolites in the surrounding regions, it seems probable that the rhyolites of the Jarbidge district range from the Miocene well into the Pliocene. The old rhyolites are regarded as probably late Miocene and the young rhyolites as middle Pliocene, or possibly later.

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[11] King, Clarence, U. S. Geol. Expl. 40th Par. Rept., vol. 1, p. 694, 1878.

[12] Hague, Arnold, Geology of the Eureka district, Nev.: U. S. Geol. Survey Mon. 20, p. 232, 1892.

[13] Emmons, W. H., U. S. Geol. Survey Bull. 408, p. 35, 1910.

[14] Lindgren, Waldemar, U. S. Geol. Survey Twentieth Ann. Rept., pt. 3, p. 116, 1900.

[15] King, Clarence, U. S. Geol. Expl. 40th Par. Rept., vol. 1, pp. 192–193, 1878.

MINERAL DEPOSITS.

OCCURRENCE AND DISTRIBUTION.

The mineral deposits that led to the discovery of the Jarbidge district in 1910 occur as tabular gold-bearing quartz fissure veins or lodes in the old rhyolites, with which, so far as this district is concerned, they are roughly coextensive. They are in general well defined, being more or less sharply separated from the country rock, and contain angular inclusions of rhyolite, sedimentary rocks, and seams of clay or gouge. Many of them have 1 to 8 inches of gouge on either wall. They seem obviously to belong to the group of propylitic veins, most of which were formed since the Miocene epoch. Among their characteristics is a peculiar alteration of the adjoining wall rock and a tendency to contain both gold and silver.

The veins are about 40 in number. They are in or associated with the Crater Range, the seat of volcanic eruption. They lie mainly between Jarbidge River and East Fork at various elevations between about 6,000 and 10,500 feet, or, in other words, they occur interruptedly through a vertical range of nearly 4,500 feet. Most of the veins lie within a belt about 4 miles wide, extending from a point near the mouth of Jack Creek on the north to and beyond the Great Basin divide and the head of Jarbidge River, 10 miles distant, on the south. Most of them are on the lower and middle west slope and the upper east slope of the Crater Range, and in general they have a north-northwesterly strike and a nearly vertical dip, as shown in figure 2.

They range from 1 to 30 feet or more in width and from less than 1,000 feet to several miles in length. Their outcrops, some of which are bold, prominent reefs rising in places 50 feet above the surface, extend interruptedly from an elevation of 6,000 feet to 10,800 feet, and some individual veins show a vertical range of nearly 2,000 feet. It seems probable that some of the veins may penetrate the underlying sedimentary and granitic rocks.

The veins in general consist of two main systems or groups, which, starting at the head of Jarbidge River on the south, gradually diverge northward into the western or Jarbidge River system and the eastern or Crater system; the two systems, however, are not everywhere sharply differentiated.

The veins of both systems occupy chiefly normal fault fissures, which seem to have been produced mainly by regional disturbances and in part by a sinking or parallel down faulting of the axial portion of the range that followed the first epoch of eruption, in consequence of which the fissures on either side dip in part steeply in opposite directions into the range—those of the east system to the west and those of the west system to the east. Some veins of the two systems accordingly converge downward, and it is probable that some of the fissures meet or intersect in the deeply buried axial portion of the range.

In the fissures produced by extensive regional faulting more or less regularity in strike, dip, and vein content is to be expected, but in those due to local postvolcanic sinking and adjustment of the range there should naturally be more variations, including probably in most fissures change in dip at the contact of the lavas with the underlying older rocks.

WEST VEIN SYSTEM.

The western part of the mineral belt, comprising the veins of the west system, crosses Jarbidge River obliquely near the mouth of Bonanza Gulch and the Pavlak mine, whence it continues north-northwestward across the lower part of Bear Creek nearly to Telegraph Pass.

This system comprises the wider veins and more valuable deposits, such as those of the North Star, Pick and Shovel, and Bluster, and the more recently discovered deposits of the Starlight and Long Hike mines, on which the most extensive development work has been done. These veins lie mostly between elevations of 6,000 and 8,000 feet. They are at a considerably lower geologic horizon than the veins of the Crater system. They also contain the most prominent croppings and are locally associated with conspicuous reefs of silicified wall rock. They are nearly all easily reached by wagon road or trail from the Jarbidge River valley. As shown in figure 2, they strike in general north-northwest and dip eastward into the mountains at angles of about 80°. They contain more brecciated material, and their walls are more irregular, less sharply defined, and show more extensive propylitic alteration than the veins of the east system.

The largest of these veins occur in a belt about 1 mile wide and 3 miles long, bounded on the west by Jarbidge River and extending from Moore Gulch on the north to Gorge Gulch on the south.

EAST VEIN SYSTEM.

The east or Crater system of veins, represented mainly by the Altitude, Windy, Ben Hur, and Ajax, occurs mainly on the upper east slope of the Crater Range, between elevations of 9,000 and 10,800 feet. From points on Jack Creek and Jenny Creek, a mile or more north of First Crater, they extend southward through the series of "craters" and their intervening ridges to and beyond the Great Basin divide, a distance of about 10 miles (Pl. V, *A*). They are reached by way of the Jack Creek and East Fork valleys or by trail from the upper part of Jarbidge River.

These veins in most respects contrast strongly with those of the west system. As shown in figure 2, they have a more northerly strike than the western veins, and some of them dip about 80° W., into the mountain. Their outcrops, which are usually inconspicuous, collectively show a vertical range of more than 4,000 feet. Their present exposures occur mostly at geologic horizons nearly 2,000 feet higher than the western veins, and accordingly they may be younger. They are narrower than the western veins, being usually from 1 to 4 feet in width, and are more persistent horizontally, some being said to have a length of 3 miles and to extend interruptedly for 6 or 7 miles. They are more sharply defined, with clean-cut walls that are free, and the footwall generally carries from 1 to 8 inches of clayey "talcose" gouge. The veins are closely banded, and some of the bands are separated by thin seams of gouge. These veins occupy mainly normal fissures produced in part by subsidence or down faulting of the axial mass of the range, with which they are nearly parallel.

CROSS VEIN SYSTEM.

Besides the two main systems above described there is a third or subordinate system whose veins strike northeast, almost at right angles to those of the other two. This third system, which for convenience may be referred to as the cross system, is represented along Jarbidge River by the Buster and Amazon veins; on the north by the so-called cross veins of Jack Creek, including the Moore vein; and on the south, toward the head of Jarbidge River, by the Jasper, Wonder, High Up, and Little Mud veins (fig. 2).

STRUCTURE AND COMPOSITION OF THE VEINS.

OXIDIZED ORE.

The economic metals of the deposits are gold and silver. They occur in the form of native gold, gold-silver alloy, or electrum, and the silver-bearing minerals argentite, cerargyrite, and naumannite. The primary metallization produced mainly sulphides, chiefly argentite and pyrite, but from the oxidized portions of the veins pyrite has practically disappeared.

The chief gangue minerals are quartz and adularia, and a common feature is their microcrystalline to cryptocrystalline character. The quartz is the more important, as its dominance or abundance favors the occurrence of the ore minerals, especially gold. Other gangue minerals and associated minerals are apatite, barite, calcite, chalcedony, chlorite, epidote, fluorite, hematite, hyalite, kaolin, halloysite, leverrierite, limonite, psilomelane, pyrolusite, marcasite, muscovite, opaline silica, orthoclase, pyrite, sericite, and talc. Four of these minerals—barite, naumannite, halloysite, and leverrierite—were first recognized in this camp in the present work.

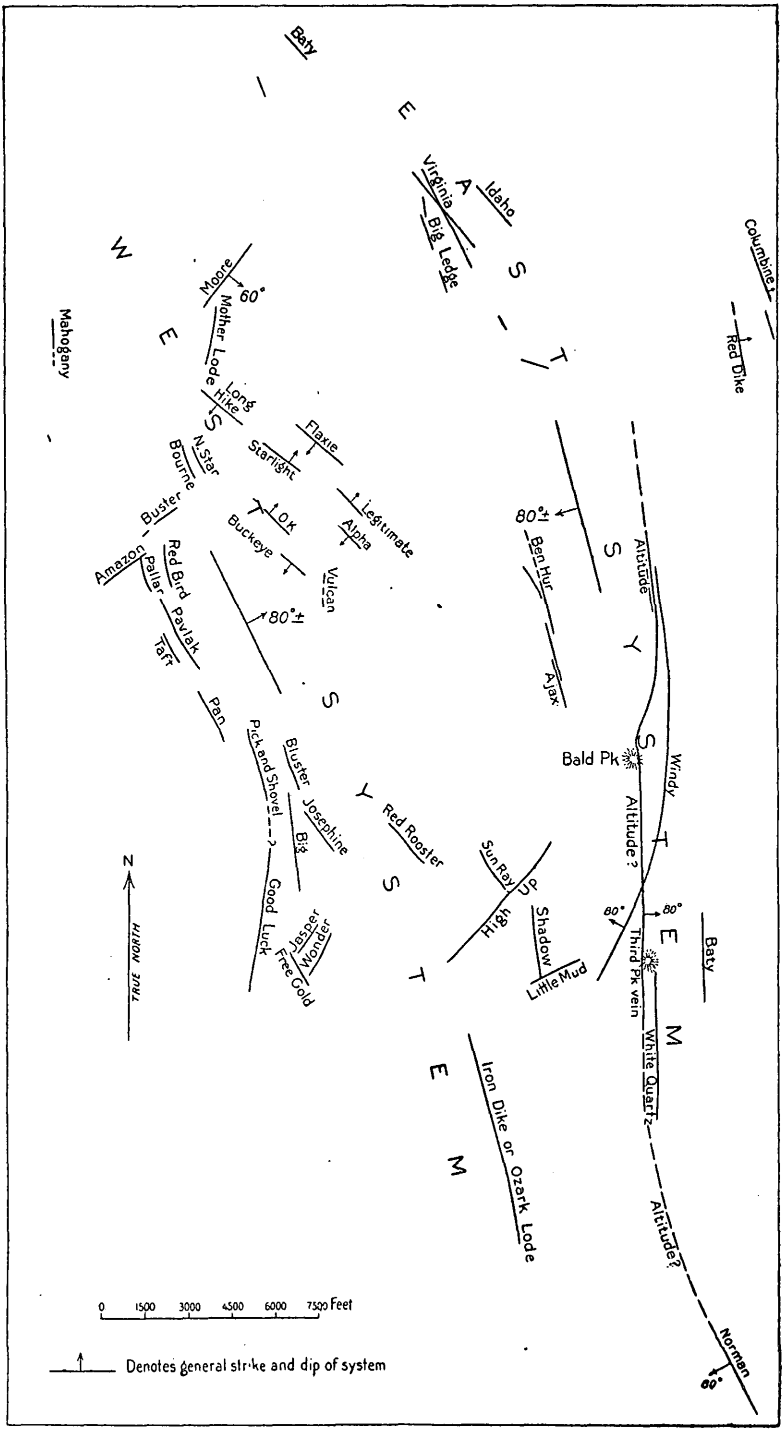


FIGURE 2.—Diagram showing trend and relative position of principal veins in Jarbidge district.

The veins are composed mainly of a characteristically laminated pseudomorphic milk-white quartz-adularia gangue (Pl. X), which in the croppings and surface workings is usually stained reddish brown to blackish and yellowish by iron and manganese oxidation products. Some of them, as the Pavlak and the Pick and Shovel, also contain considerable fault breccia or fragments of silicified rhyolite country rock, fragments and seams of the underlying shale, slate, or quartzite, and seams or stringers of halloysite and leverrierite resembling talc, from all of which it is inferred that more or less faulting or movement accompanied and followed the fissuring and subsequent veining. The ore occurs mostly in crushed and brecciated portions of the veins, and the veins to the north of Bourne Gulch are softer and more sugar-like than those to the south.

So far as present workings extend, to depths of about 800 feet, the veins are about all oxidized. Exceptions occur in the Alpha, Norman, Starlight, and Bullion mines, where, as described on page 32, a small amount of sulphide ore has been found. Extension of development work well into the sulphide zone on a few of the veins would be of material aid in rendering a forecast for the future of the district.

In the gangue quartz is on the whole the dominant mineral, but it is more or less profusely intergrown with adularia, and in some veins the adularia, although not visible to the naked eye, greatly exceeds the quartz and constitutes the bulk of the vein. Specimens from the west system show from 10 to 60 per cent of adularia, and some from the Crater system as high as 90 per cent. Adularia or vein feldspar is a variety of orthoclase free from sodium. It is semitranslucent and has characteristic crystal form (Pl. IX, *A*). It has a hardness of 6 and an index of refraction of about 1.524. It is mostly fine grained and is best studied under the microscope (Pl. XI, *A*). Its abundance in the Jarbidge veins is of unusual interest, especially as quartz is the almost universal gangue mineral of auriferous veins. Its presence and abundance indicate that the Jarbidge veins were formed at fairly high temperature and at depths of probably less than 2,000 feet.

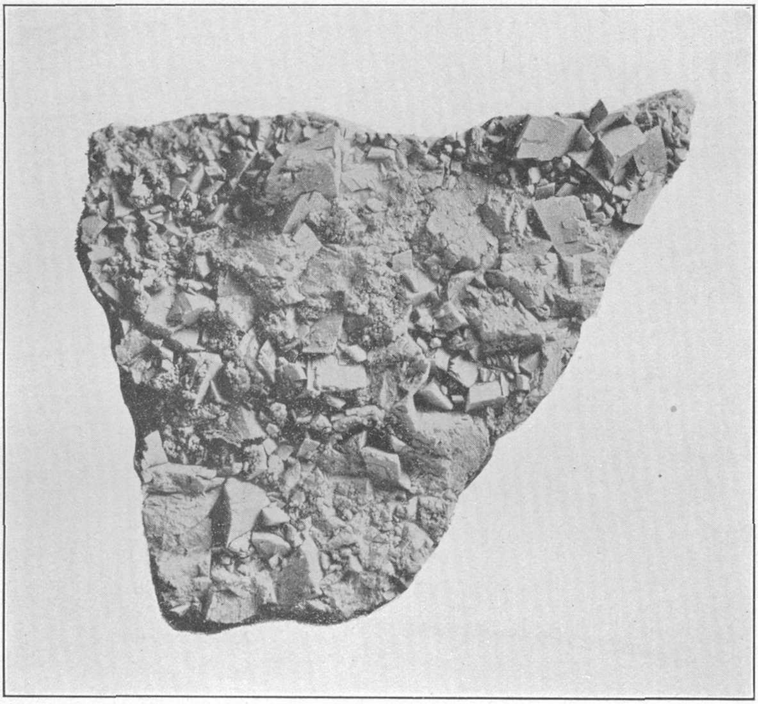
Only under the microscope does the proportion of quartz to adularia become apparent. The adularia occurs in individual crystals and grains intergrown with the quartz and only rarely shows cleavage. The crystals occur in several forms, of which the most plentiful and characteristic are small, thin tabular rhombic plates.

The following is a partial analysis of a normal specimen of ore from the North Star mine:

Partial analysis of ore from the North Star mine.

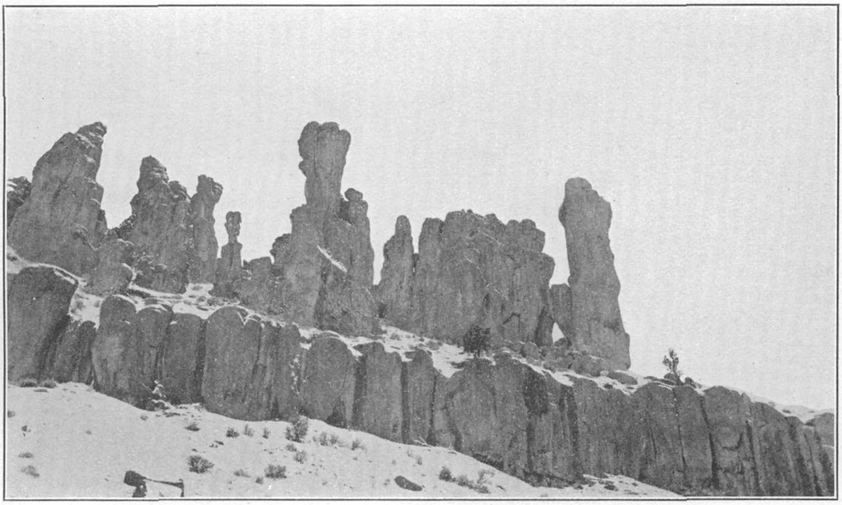
[George Steiger, analyst.]

SiO_2	72.28
Na_2O	.20
K_2O	11.84



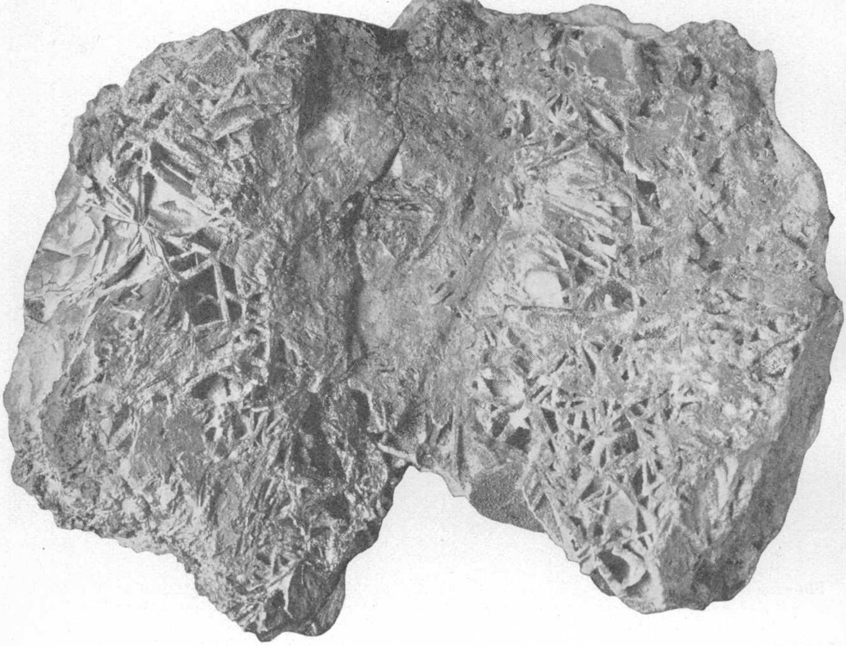
A. ADULARIA, OR VEIN ORTHOCLASE.

Incrusting joint planes and fissure walls in rhyolite horse in the 17-foot Bullion vein, in First Crater. The adularia forms a layer 0.1 inch thick. The areas that appear aphanitic consist also of adularia, but it is too fine grained to show its crystalline form on the scale of this photograph. Magnified 2 diameters.

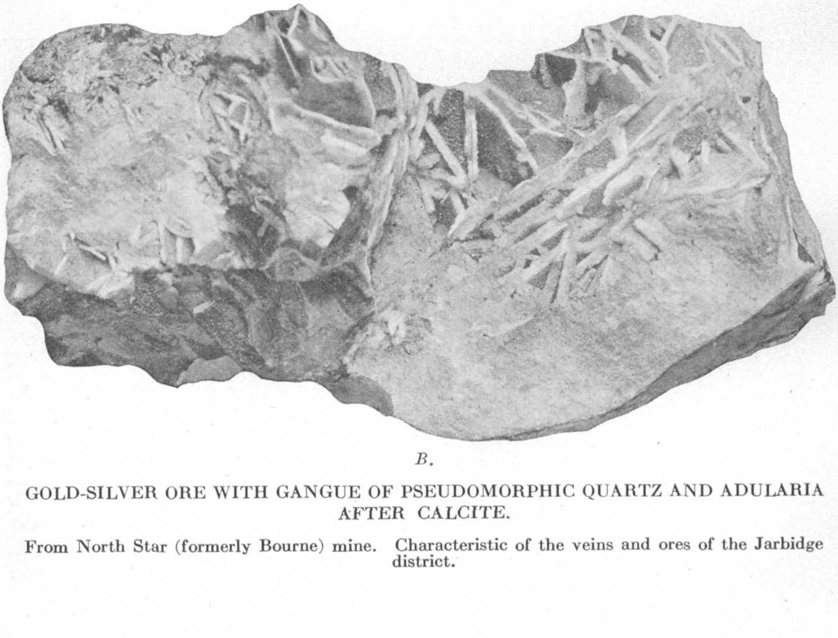


B. JOINTING AND WEATHERING IN YOUNG RHYOLITE.

Shows characteristic vertical jointing and castellated badland forms of polygonal cross section produced by weathering. View on Jarbidge River near mouth of Deer Creek and Idaho State line, looking north. (Compare with Pl. VII.) Photograph by E. C. Weyle.



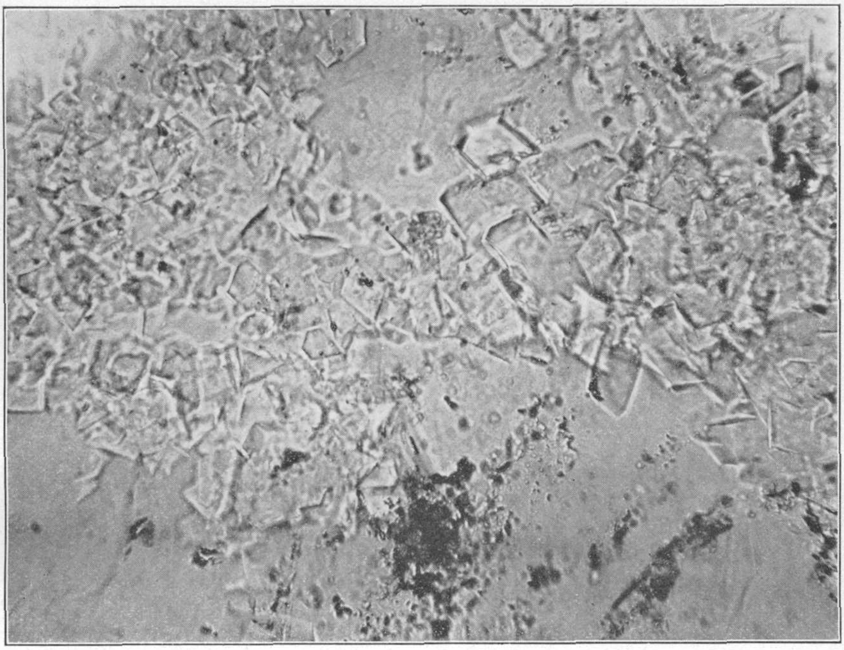
A.



B.

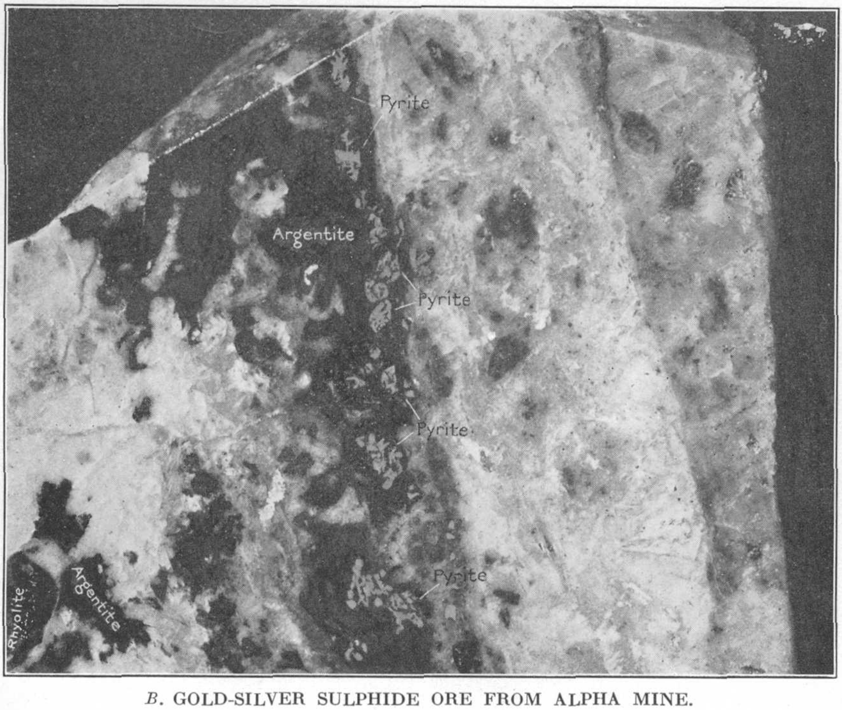
GOLD-SILVER ORE WITH GANGUE OF PSEUDOMORPHIC QUARTZ AND ADULARIA AFTER CALCITE.

From North Star (formerly Bourne) mine. Characteristic of the veins and ores of the Jarbidge district.



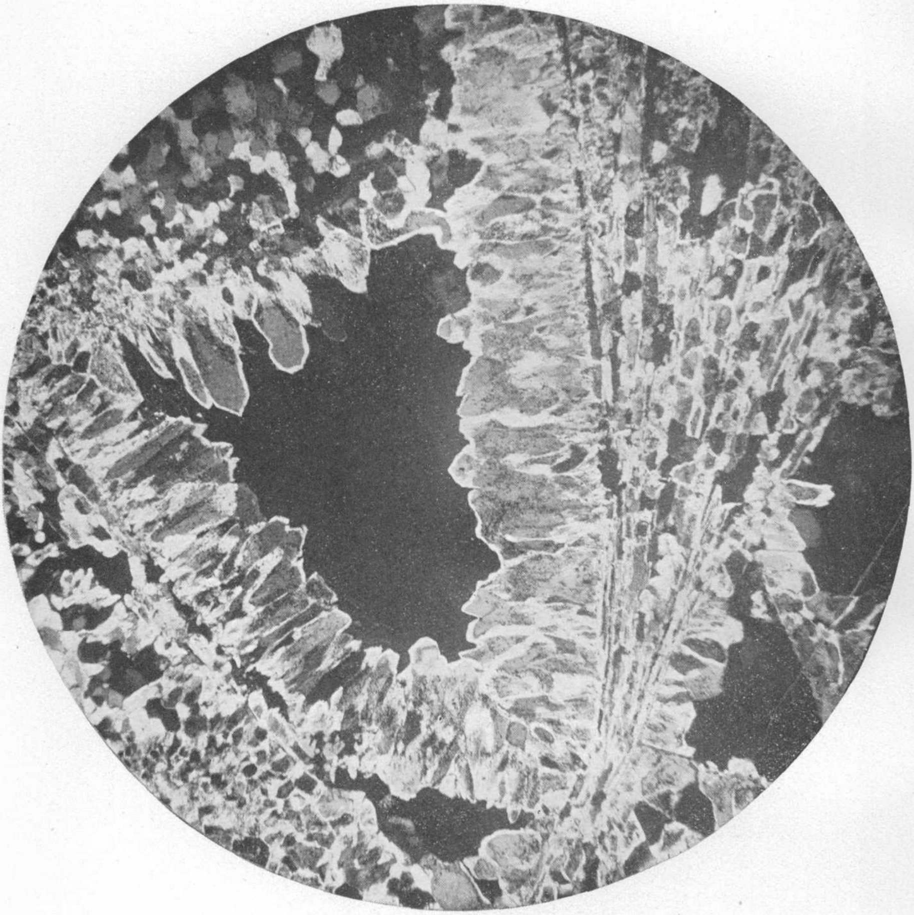
A. ADULARIA IN SILVER-GOLD ORE IN RHYOLITE.

Showing normal occurrence, crystallization, and habit. The smooth light-colored areas are quartz; the black areas are argentite and pyrite. Ordinary light; magnified 380 diameters.



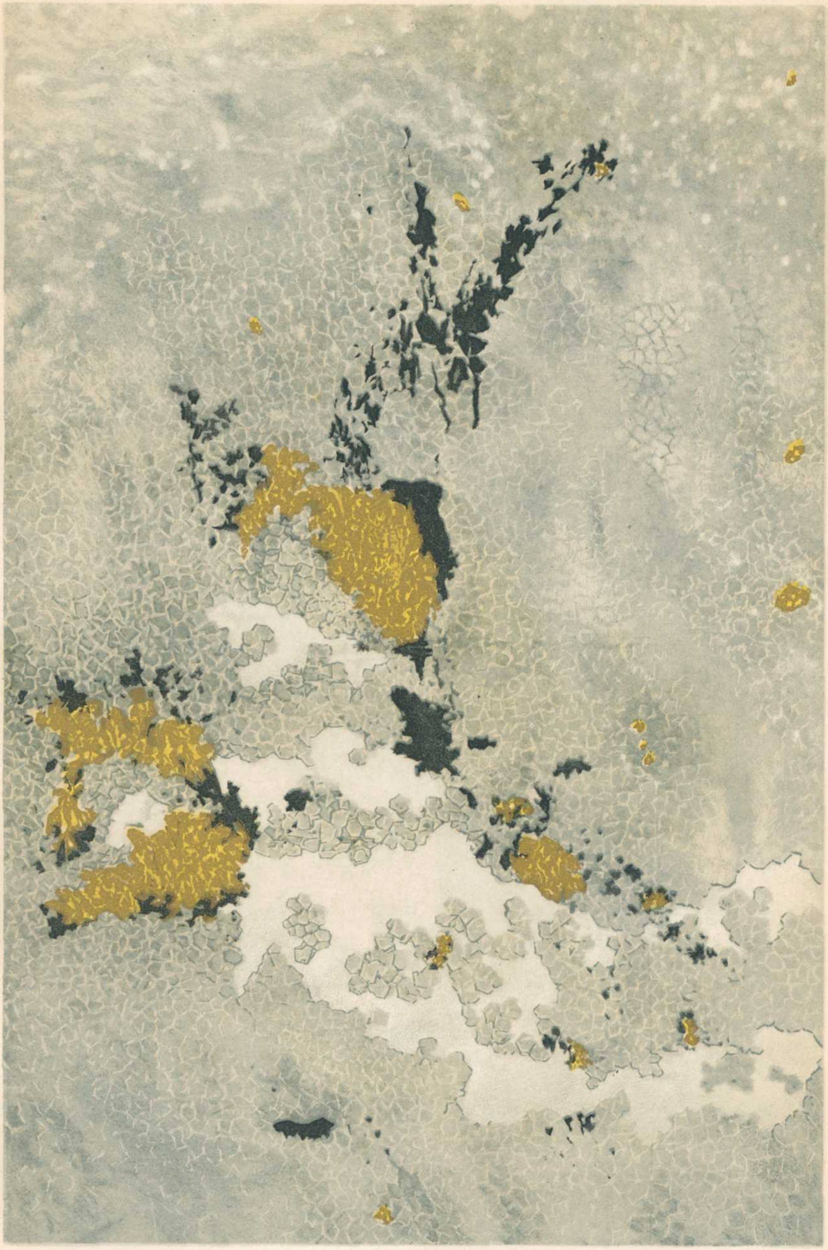
B. GOLD-SILVER SULPHIDE ORE FROM ALPHA MINE.

Showing banding and relations of argentite and pyrite in quartz-adularia-calcite gangue. The specimen contains a little native gold, which is not visible on this scale. Photograph of polished surface, magnified 3 diameters.



PHOTOMICROGRAPH OF QUARTZ AND ADULARIA PSEUDOMORPHIC AFTER CALCITE.

From Pick and Shovel mine, 100-foot level. Example of the cellular, drusy, radial, and bladed structure characteristic of the Jarbidge veins. Magnified 40 diameters.



A. Hoen & Co Baltimore.

PHOTOMICROGRAPH OF GOLD ORE FROM NORTH STAR MINE.

Shows character and manner of distribution of the gold in the quartz-adularia gangue (gray) and its association with argentite (black), characteristic of the Jarbidge district. The light area represents a hole in the thin section. Magnified 105 diameters.

A

B

A Hoen & Co Baltimore.

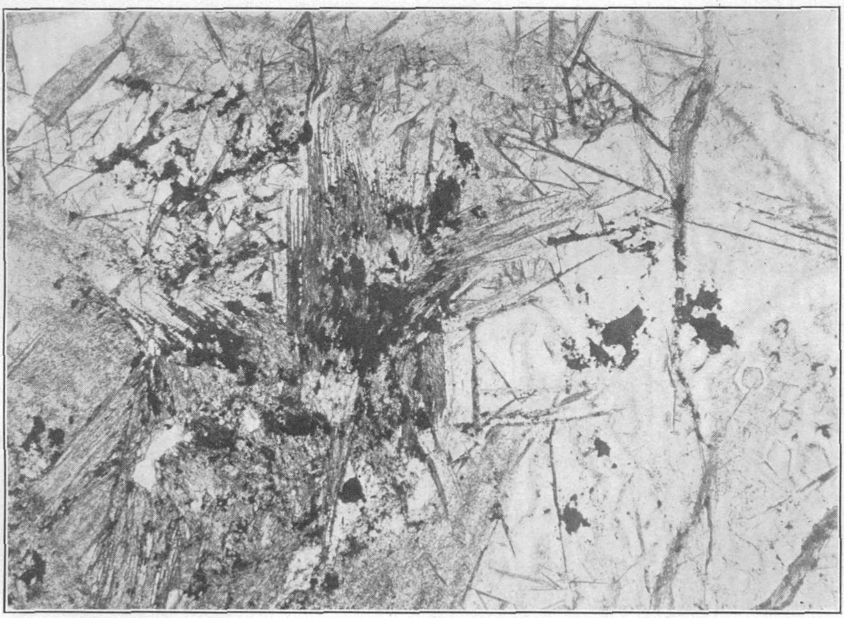
GOLD ORES.

A, "Blistery" phase, from Bluster mine.

B, Nodular or kidney phase, from Pick and Shovel mine.

Characteristic of certain ores in the veins of the West system. The gold occurs mostly along the dark lines and seams crudely encircling the nodular nuclei of rhyolite. The nodule marked *a* is rhyolite which peripherally has been corroded and metasomatically altered by the gangue solutions.

A.



B.

PHOTOMICROGRAPHS OF GOLD-SILVER SULPHIDE ORE FROM ALPHA MINE.

A shows lamellar fibrous calcite being replaced by quartz, adularia, chalcedony, pyrite, and argentite. *B* shows argentite replacing calcite along its lamellar partings. Both magnified 40 diameters.

From this analysis it is calculated that the amount of adularia present in the specimen is 70.65 per cent. The rest of the specimen consists of 13.67 per cent of free silica and 15.68 per cent of undetermined constituents, presumably for the most part alumina and other impurities. Except that it shows about twice the amount of potash the analysis compares favorably with that of the country-rock rhyolite given on page 20 (analysis 3). Comparison of microscopic sections of this ore with sections from the Crater veins indicates that much of the Crater ore probably contains more than 90 per cent of adularia and about 15 per cent of potash.

A striking feature of the Jarbidge gangue is its laminated or platy and bladed structure, in which innumerable contiguous or connecting laminae or plates and blades are variously arranged. This material is aptly termed by the miner "fish-scale quartz," from the plates partly overlapping one another. (See Pl. X.) Much of the pseudomorphic platy and cellular structure seems to be due to silicification and replacement of calcite along the parting and cleavage planes of the primary mineral. The plates range from those of minute size up to some nearly an inch in diameter and from the thickness of a knife blade to that of ordinary pasteboard. (See Pl. XII.)

As seen in thin section the dominant structure is the disposition of the minerals in sectors or long fan-shaped areas, each area composed of a number of similar subareas. There is much sericite, and veins of the west system contain also considerable fluorite.

Two of the most abundant minerals occurring both as gangue minerals and as gouge are halloysite and leverrierite, white hydrous silicates of aluminum that resemble talc and kaolin and are commonly so called by the miners. They are both secondary products derived from devitrification of the rhyolite and decomposition of feldspar or other aluminous minerals. Both have many of the properties of ordinary clay gouge and absorb much water. Halloysite is amorphous and contains considerable water.

Leverrierite[16] is a white micaceous hydrous silicate of aluminum. It is similar to halloysite and is closely related to kaolin, but it differs from halloysite in being crystalline and from kaolin in the ratio and combination of its constituents. It contains more silica, less alumina, and less water than kaolin and retains only 7 per cent of its water at 110°, whereas kaolin retains nearly all of its 14 per cent of water up to 400°. Leverrierite is easily fusible; kaolin is not fusible. In physical and optical properties leverrierite resembles muscovite, but its cleavage is less prominent. It is brittle when dry and very plastic when wet. Its index of refraction is approximately 1.58.

[16] Larsen, E. S., and Wherry, E. T., Leverrierite from Colorado: Washington Acad. Sci. Jour., vol. 3, pp. 208–217, 1917.

A specimen of the white gangue from the 6,400-foot level of the Long Hike mine, collected by the writer in the present work, was determined through chemical analysis by J. G. Fairchild to be halloysite. The loss of water at 110° C. was 1.12 per cent, and at the point of ignition 10.76 per cent. The specimen, though whitish, has a pale bluish to greenish hue and is in part stained pinkish or reddish with hematite and physically resembles alunite. As material similar to this specimen occurs in practically all the mines, it is inferred that halloysite and leverrierite are probably general throughout the district.

A specimen of fault gouge collected in the present work from the Starlight mine and examined by W. T. Schaller corresponds closely with the characteristics of leverrierite as originally described by Larsen and Wherry.

Manganese oxide, chiefly psilomelane and wad, occurs as black and dark-brown dustlike forms, small bodies or masses, and dendritic growths in the veins and on country rock, and locally it coats quartz druses and cements fine-grained quartz breccia.

A black mineral with metallic luster resembling argentite from the deep workings of the Long Hike mine, examined by Mr. Schaller, was found to carry plentiful selenium and is regarded as naumannite, a selenide of silver, Ag_2Se. As the mineral occurs in a normal specimen of ore, it is inferred that naumannite probably occurs also in other mines in the district. A good description of naumannite from Idaho is given by Shannon.[17]

Thin sections of ore from the oxidized zone show also considerable hematite disseminated as grains and dust and derived from the oxidation of pyrite. Owing to the generally porous character of the gangue and the plentiful supply of the percolating surface waters, this oxidation probably extends to considerable depths. The gangue contains also, mainly as filling, considerable gold and silver, the metals of the camp, described in detail farther on.

The gangue ranges from fine to coarse and from soft and friable to hard and siliceous, but owing to the prevalence of the pseudomorphic cellular structure the ore of the district on the whole is fragile and can be easily crushed and milled. It is of coarser texture and harder in the veins of the west system, where silicification has been more extensive. Here the veins are as a rule only coarsely and crudely banded to massive, and the laminated gangue occurs largely in bouldery bunches, the largest several feet in diameter. These veins also contain in places considerable fault breccia or fragments of silicified rhyolite country rock, from which it is inferred that more or less faulting accompanied and followed the fissuring and

[17] Shannon, E. V., Am. Jour. Sci., 4th ser., vol. 50, pp. 390–391, 1920.

subsequent vein formation. From the association of the silicified rhyolite the veins are often called " dikes."

Some veins, of which the Pick and Shovel is a good example, contain also fragments and seams of siliceous pale-greenish and blackish shale or slate supposed to be derived from the underlying sedimentary rocks.

In places the walls of the western veins are irregular and ragged or less sharply defined than those of the eastern veins and show the most extensive propylitic alteration found in the district. Here also occur the bold croppings. Some of the croppings are prominent reefs of the characteristically laminated quartz-adularia gangue and silicified rhyolite. They are commonly stained yellowish to reddish brown and blackish by iron and manganese.

In the eastern veins the gangue is composed of the same dominant minerals as that in the western veins, but in reverse ratio, the adularia constituting in the specimens examined 80 to 90 per cent of the vein. Though these veins show the same pseudomorphic structure as those of the west group, it is less pronounced and the texture is relatively fine. The veins are in large part closely and definitely banded and comby, and the bands are in places separated by thin slate-colored partings.

Both the croppings and the subsurface parts of the veins show free gold (Pl. XIII), which may be obtained by panning the crushed material. Good ground usually yields a long string of fine bright colors of gold in the pan.

With the gold in the veins is associated also silver, which occurs chiefly as argentite, as naumannite, as an alloy with the gold, and probably also in other forms. In many places there is black, sooty silver sulphide, which is characteristic of leached argentite. The quantity of silver is usually small, amounting to only about 2 ounces to the ton of ore, but in some ore as much as 90 ounces is reported. Tellurides of gold and silver have been reported with the richer ore, but the report is not known to have been verified.

In its widest distribution the gold shows as small bodies or specks, but parallel faces or slabs of the gangue, some larger than a man's hand, are plated with gold as thick as a knife blade. In other places large areas are incrusted with blebs of iron-stained quartz, freely sprinkled with specks of gold. (See Pl. XIV.) Most of the gold, however, is finely divided and not visible to the naked eye. It ranges from particles the size of a pinhead down to minute specks, which are usually associated with dark patches or specks of argentite, other silver-bearing minerals, and hematite (Pl. XIII). In most of the veins it is concentrated in streaks or pay shoots associated with fine dark streaks of silver sulphide and iron oxides. The gold content shows a wide range, the shipping ore of some veins being worth $600 to $1,000 a ton. The Bluster vein, 5 feet in width near the surface, was said to average $60 to the ton.

Another common form of occurrence of the gold is in nodules or reniform lumps formed by more or less finely banded concretionary growths of gangue, usually around an inclosed fragment of rhyolite which is generally corroded and metasomatically altered, or around a fragment of slate, as illustrated in part in Plate XIV, *B*. In these forms, which usually constitute rich ore, the gold occurs mostly along the dark lines associated with the circular banding above described.

The gold in the western veins is mostly of high grade; that of the Bluster mine, which has a deep-yellow color, seems to be among the best and is said to run about $20 or more to the ounce. In the eastern veins, however, the gold is mostly light colored, contains much silver in alloy or is electrum, and runs about $12 to the ounce.

SULPHIDE ORE.

Of the meager amount of sulphide ore which has been found, that in the Alpha mine is probably the most nearly characteristic of the district. A specimen of it from the 400-foot level is described below.

The ore in general is gray. It is crudely banded with alternate dark and light bands and streaks as much as an inch or more in width (Pl. XI, *B*). It is medium to fine grained and is slightly brecciated. It contains a few lustrous whitish spots of remnantal lamellar calcite and a few small round inclusions of reddish-brown oxidized rhyolite (Pl. XI, *B*), each kind 0.2 inch in diameter. The inclusions occur on either side of the rich ore shoot in the vein. Argentite occurs near or partly surrounds the largest rock inclusion but only slightly touches or penetrates it, if at all, being generally separated from it by a shell of the quartz-adularia gangue. There are also isolated beadlike bodies of quartz which seem to represent primary quartz phenocrysts derived from the replaced rock. The richest part of the ore is that of the dark bands, which in places consist chiefly of argentite and pyrite. In some ore, however, the richest part is in dark streaks and bodies irregularly distributed.

Microscopically the ore is seen to consist mainly of a microcrystalline gangue of quartz, adularia, and calcite in which is contained much sulphide, consisting of pyrite, argentite, and a little chalcopyrite, also some cerargyrite, pyrargyrite, and a little chlorite. Argentite, the black metallic ore mineral, though variously mingled with the pyrite, tends to be scattered as small bodies around larger bodies of pyrite. The ore also contains a little sericite, zircon, apatite, and barite. Portions of the gangue are cryptocrystalline and present a salt and pepper appearance.

Except the rock inclusions the calcite is the oldest mineral and is replaced by all or nearly all the later minerals, especially quartz, adularia, and the various sulphides. The dominant gangue mineral is quartz, which occurs mostly in small interlocking irregular anhedral forms associated with similar forms of adularia. The quartz is generally disposed in lamellar, radial, divergent, fan-shaped, and other anomalous forms pseudomorphic after calcite, which it has replaced. Some is marginally feathered, and some is flamboyant.

Most of the adularia occurs in small, well-developed, more or less definite rhombohedral crystals and allied forms and is plentifully distributed almost throughout the ore (Pl. XI, *A*). It is best seen in plain light when magnified about 200 diameters. In places it is very plentiful, and here and there it is the dominant mineral as along the edges and lamellar partings or blades of the calcite areas last replaced or not yet wholly replaced and separating wider belts of calcite and quartz, suggesting that some of the adularia is later than the quartz or most of the quartz-adularia gangue. This suggestion is corroborated by the occurrence of later veinlets of adularia traversing areas of the general quartz-adularia gangue; also by the fact that adularia was the last to be deposited in most of the bipartite comb-structure veinlets. Some of the adularia crystals show well-developed cleavage.

The calcite occurs largely in lamellar form in plates of considerable size and to a small extent in fibrous form (Pl. XV, *A*). All these forms in part show more or less of the fan-shaped structure with radial relief lines, etc., generally characteristic of ores of this class. The calcite now present is a mere remnant of that which formerly constituted the vein.

The replacement of the calcite by the other minerals has in large part occurred along the lamellar partings of platy habit in the calcite parallel to the basal pinacoid, as described by Adams,[18] and has given rise to the platy structure so characteristic in replacement quartz. (See Pl. XV, *B*.) Some of the oblique cleavage lines, however, were followed by replacement offshoots, branches, or bodies almost independent of the lamellar partings. (See Pl. XV, *A*.)

As seen under the metallographic microscope much of the ore shows a well-developed finely fibrous to felty texture, seemingly due to a very intricate intergrowth of quartz and adularia in the lamellar calcite along the cleavage and other planes as well as along the partings.

The ore is slightly cellular or vuggy, as is characteristic of pseudomorphic replacement ores, and the vugs are mostly irregular and lined with inward-projecting crystals of quartz and adularia (Pl. XII). The adularia is less plentiful in the inner or later growths than in the outer or earlier growths of the lining. In one vug, how-

[18] Adams, S. F., A microscopic study of vein quartz: Econ. Geology, vol. 25, p. 645, 1920.

ever, the lining shows two successive concentric bands of adularia alternating with those of quartz near the inner part.

ORIGIN OF THE VEINS.

From the universal occurrence of the laminated and other pseudomorphic structures of the quartz and adularia that practically constitute the veins it seems certain that the vein fissures have been mineralized during at least two distinct periods. After the eruption and fissuring of the old rhyolites there followed a period of mineralization in which the fissures were filled with material totally different from that which now occupies them. Just what minerals composed this first filling or what metals it may have contained is not definitely known, for so far as present developments in the district extend no trace or clue to them remains save the casts and forms shown in the pseudomorphic quartz-adularia gangue above described, remnants of calcite in the meager sulphide ore thus far found, and a little calcite which occurs here and there, seemingly as secondary filling, in some thin sections of the altered rhyolite.

From a study of these forms in connection with cabinet specimens of calcite and barite and similar deposits in other fields it seems certain that the first gangue mineral in the Jarbidge veins must have been calcite. The replacement of the primary calcite by the present gangue minerals seems to have been accomplished through the agency of ascending hydrothermal solutions. These solutions brought in the gold and silver content and probably contained several other minerals, but they were particularly charged with silica, potassium, and aluminum, and as they dissolved out the calcite of the original gangue silica was precipitated and quartz intergrown with adularia was deposited in its place, largely pseudomorphic after the structural forms or casts of the preexisting calcite, thus forming the present gangue.

In connection with the hydrothermal origin of the veins it may be also noted that the nearest hot spring is the Wilkins Hot Spring, about 10 miles northeast of Jarbidge. This spring doubtless owes its temperature to heated but gradually cooling volcanic rocks through which its water flows in depth.

Below ground-water level the ore may be expected to become sulphide ore, with probably a very material increase in silver and with the gold content held mainly in the sulphides, but little if any of it being free.

The depth at which the Jarbidge veins were formed is difficult to state. It seems probable, however, that the veins now exposed in the district were formed at a depth of not more than 2,000 feet below the surface, and the other deposits at a correspondingly greater depth.

It is not likely that many of the veins will be found to carry ore in the underlying sedimentary rocks. In the mines situated well up toward the crest of the range, however, the thickness of the ore-bearing rhyolite above the sediments is estimated to be from 1,000 to 3,000 feet. Of the sedimentary rocks limestone will probably be found to be the most favorable.

It is held by certain engineers that the workable deposits of the district are restricted to one or at most two flows of the rhyolite 500 to 800 feet in thickness, that to these flows alone are due the ore shoots found in the district, and that outside of these flows it is useless to search for ore. This view is not tenable, however, in the light of the fact that workable deposits have already been found interruptedly through a vertical range of more than 4,000 feet, a figure which approximately expresses the thickness of the rhyolites contained in the zone of mineralization. Doubtless some flows, owing to fissures, fractures, and certain soluble and replaceable constituents which they may contain to a greater degree than others, are more favorable for ore deposition. In the second place, not all and probably relatively few flows or eruptions of the rhyolite were accompanied or followed by ore-depositing solutions. It is wholly reasonable, however, to look for workable ore in any of the underlying or older flows and sedimentary rocks through which any ore-producing flow or its associated ore-bearing solutions passed in coming to the surface.

ALTERATION OF WALL ROCK.

In the walls adjacent to the veins and extending back from them 100 feet or more, particularly in the west vein system, the country rock has suffered more or less extensive alteration, in which the chief results have been devitrification and silicification of the rhyolite and in places the development of sericite in the feldspar, as well as of much pyrite throughout the rock. This process of alteration has left the texture and constituent minerals in an almost perfect state of preservation and given to the silicified rock a fresh and unaltered appearance. Elsewhere the rock is completely replaced or changed into massive quartz or veinlike gangue, in which all trace of the feldspars and other rock minerals has disappeared except the quartz phenocrysts, which by their wine color and other characteristics can be distinctly traced from the relatively little altered rock over into the gangue, where they apparently occupy the same relative position to one another which they held in the original rock. The rhyolite contains veinlets of quartz and adularia, which seem to be of the same age and to have been formed by the same solutions as the replacing gangue of the veins.

In the east vein system, where the veins are composed chiefly of adularia, denoting that the solutions that formed them were poor in silica, there is little if any alteration of the wall rock. On the whole, the degree of alteration of the wall rock seems in general to bear a more or less direct ratio to the acidity of the adjacent vein.

MINES AND PROSPECTS ON THE WEST VEINS.

The mining properties of the Jarbidge district, about 30 in number, consist chiefly of claim groups and mines located on the veins that have been described. On a score or more of them considerable development work has been done. A description of most of them follows. Their relative location is indicated on Plate XVI, which shows about 800 claims.

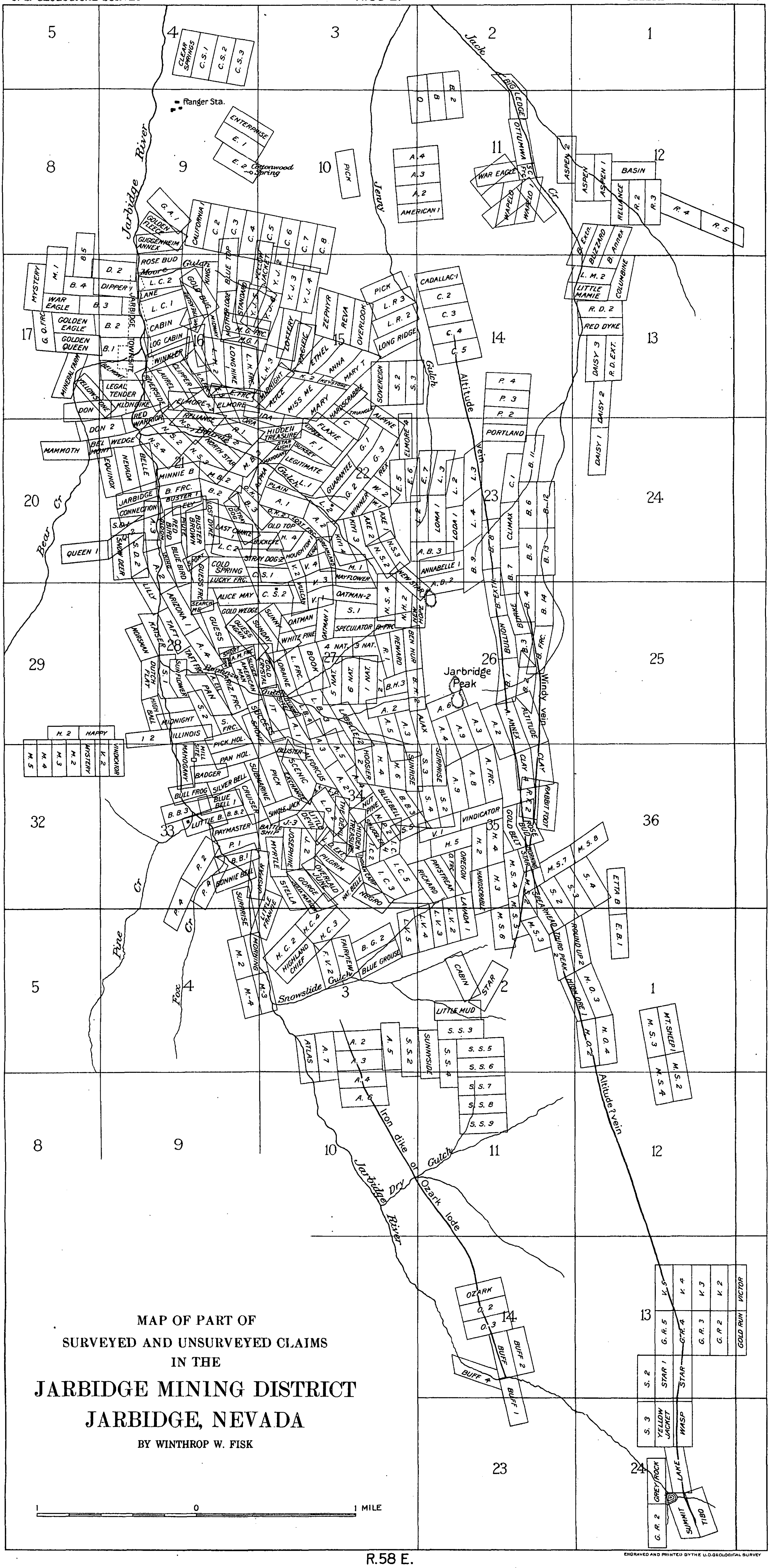
The properties on which the most development work has been done are on the veins of the west system. They number about fifteen and include the Long Hike, Starlight, O. K., Flaxie, Alpha, Legitimate, North Star, Pavlak, and Bluster mines. Their distribution is shown in Plates II and III.

Nearly all the maps and sections of the workings in the mines, as well as the topographic map forming Plate II, have been kindly supplied by the Elkoro Mines Co., whose engineering work seems to be very precise but whose elevations are based on an assumed elevation at Jarbidge, near the mouth of Bear Creek, of 6,100 feet, or about 100 feet lower than that of the map printed in the earlier report and here reproduced as Plate I. As the original elevations on the company's maps and sections are in current use and will render the maps and sections reproduced in the present report more readily useful in the field, they are retained throughout. Their retention accounts for a difference of about 100 feet in elevation shown between the two maps.

LONG HIKE MINE.

Location.—The Long Hike mine is a little to the northwest of the center of the district and east of Jarbidge, in the northwest slope of the Crater Range (Pls. II and III). Properties near or adjoining the mine are the North Star, O. K., Alpha, Legitimate, Starlight, Flaxie, Jarbidge Gold, and Elmore. The camp and main opening, which are on what is known as the 68 level, are at an elevation of about 6,800 feet, about 700 feet above the town of Jarbidge, at the mouth of Bear Creek. The property comprises a group of twenty-four claims. (See Pl. XVI.) It extends through a horizontal distance of 3,800 feet and a vertical distance of about 1,700 feet.

History and production.—Concerning the discovery and early history of the Long Hike mine, data are very meager. Some of the


MAP OF PART OF
SURVEYED AND UNSURVEYED CLAIMS
IN THE
JARBIDGE MINING DISTRICT
JARBIDGE, NEVADA
BY WINTHROP W. FISK
1 0 1 MILE
T.46 N.
T.45 N.
Jarbidge River
Jack Cr.
Jerry Gulch
Altitude vein
Windy vein
Jarbidge Peak
Bear Cr.
Pine Cr.
Fox Cr.
Snowslide Gulch
Dry Gulch
Iron dike of Ozark lode
Altitude? vein
Ranger Sta.
Cottonwood Spring
Moore Gulch
Bonanza Gulch
Jarbidge Townsite
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

ground now known as the Long Hike claims was staked under that name in 1910, as shown by the claim map of that date.[19]

In 1915 George J. Shoup, of San Francisco, enlisted capital and took an option on the property, and in 1915–16 he opened up a new ore body on it. In 1916, while the property was still in the prospect stage, the present owner, the Elkoro Mines Co., of Jarbidge, became interested in it, pushed development work, and soon began designing a treatment plant, which during the summer and winter of 1917–18 resulted in the building of the Elkoro mill. The company also simultaneously built the 73-mile electric-power line from Buhl, Idaho. The mill began operation in March, 1918, and has been running almost steadily ever since, treating daily about 100 tons of ore that averaged about $10 to the ton, and had produced by the end of 1921 nearly $1,250,000 worth of gold and silver. In June, 1919, the mine was the largest producer of gold in Nevada, and in 1920 it was the second largest, the mine of the Nevada Consolidated Copper Co. at Ely being the largest. In April, 1920, the company was said to have 40,000 tons of $10 ore developed in the mine. In July, 1920, it was roughly estimated that sufficient ore was in sight to keep the mill running for about five years, and in January, 1921, the company was estimated to have a reserve of at least 100,000 tons in the Long Hike, Starlight, and Flaxie mines. During the second quarter of 1922 the net operating profit of the company was nearly $58,000.[19a]

The company has also acquired or leased the neighboring Starlight, Flaxie, Legitimate, O. K., and Buster properties as prospective sources of ore. It employs 80 men and uses yearly more than 40,000 pounds of supplies, which are brought in from Rogerson. The mine timber is logged from Deer Creek, west of Jarbidge, and is sawed at the mine.

Development.—The mine is opened to a depth of 900 feet by about 8,000 feet of workings, including five adit tunnels, winzes, drifts, crosscuts, and stopes, as indicated in part in figures 3 and 5, which show approximately the stage of development attained by July, 1920. It is opened on 10 or more levels, which, contrary to the customary mode of designating mine levels, are enumerated in ascending order and are known respectively by the consecutive numbers 63 to 74 (70 and 73 omitted), denoting approximately the elevation, No. 63 standing for 6,300± feet, and so on. Thus, as shown in figure 3, the actual elevation of the 68 level, for example, is 6,825 feet. Most of the levels are spaced about 100 feet apart vertically.

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[19] U. S. Geol. Survey Bull. 497, pls. 12 and 13, 1912.

[19a] Eng. and Min. Jour. Press. vol. 114, No. 10, p. 431, Sept. 2, 1922.

Equipment.—The mine is well equipped with tram tracks, hoists, buildings, and electric power and light and has a sawmill at the portal. A 1,700-foot inclined tram connects the camp with the mill at the river side and Jarbidge, and the ore is delivered from the mine to the mill in aerial-tram buckets holding one-third of a ton each. (See Pl. III.)

The mill, which employs the cyanidation and counter-current decantation process, is a combination of the Marcy and Hardinge mills with Blake crusher and Dorr classifiers. It has a rated capacity of 100 tons in 24 hours but generally handles 120 tons with ease, as most of the ore is soft. A little ore that is mostly hard, refractory

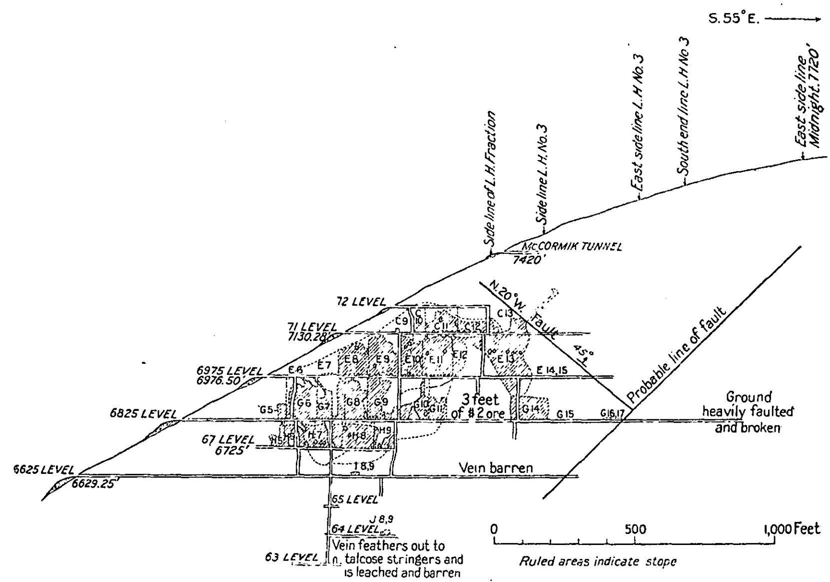


FIGURE 3.—Longitudinal section of Long Hike mine on plane of vein.

quartz, tending to cause undue wear in the steel lining of the ball mill, is crushed in a 5-stamp adjunct.

Since commencing, in March, 1918, the mill has operated almost continuously and has made exceptionally good recoveries, the average extraction being about 98 per cent in gold and 40 per cent in silver. At the time of visit the extraction in silver was about 50 per cent. Considerable difficulty was being experienced in the recovery of the silver, as the quantity of silver mineral is comparatively small, the metal content of the ore being approximately 1 ounce of silver to 1 ounce of gold. However, the company reported that much of the silver is reprecipitated in the process of treatment and that the recovery was improving. In 1922 the recovery was reported to be 99.5 per cent of the gold and 75 per cent of the silver.

The cost of mining and milling is from \$4.50 to \$7 a ton of ore, but \$4.50 ore, though it yields no profit, can be handled without loss, and even $4 ore if broken is milled. The ore milled in 1919 averaged $12 to the ton; that which was being milled in the summer of 1920 ran only about $10. As the Long Hike dumps contain considerable good-looking quartz and mineralized rock they will probably all finally be treated for their metal content.

Geology.—The country rock is the old rhyolite, most of which is highly oxidized, with the feldspars kaolinized, sericitized, and lever-rieritized, giving to the rock in general a light-gray color. In this light-gray groundmass phenocrysts and blebs of relatively dark or wine-colored quartz are conspicuous. In the lower levels the rock is typically the old rhyolite with wine-colored quartz phenocrysts and is more uniform in character than the rocks in the upper levels, which are of diverse character and in general of finer texture.

Variations of the rock occur from place to place on the different levels, as described below. In general, little or no differentiation of flows or beds is possible. The rock has been considerably faulted and crushed, and locally it contains inclusions of black shale or slate and dark sandstone. The sedimentary inclusions, which range from comminuted bits to masses several feet in thickness and 10 feet or more in extent, have reached their present position by faulting. A large fault, known as the main fault, extends almost longitudinally through the mine (fig. 3). It strikes about northwest and dips 75° SW. It is older than the vein.

Ore deposits.—The deposits are contained chiefly in the Long Hike vein and are valuable mainly for their gold content. The vein strikes N. 55° W. and dips about 75° SW. It ranges from 1 to 30 feet or more in width and has a known horizontal extent of about 3,000 feet in the Long Hike mine and a vertical range of 1,200 feet. As it narrows horizontally from the principal workings southeastward into the mountain and downward through the lower levels, where with increase in depth the rocks become tighter and accordingly less favorable for penetration by circulating mineral solutions, it does not seem to hold much promise beyond the limits of the present workings.

The deposits now worked are in large part the result of surficial enrichment caused chiefly by chloride solutions, iron sulphides, manganese compounds, and alkaline waters, much as described by Emmons [20] and others for other districts, the transportation agency being chiefly descending meteoric water. The deposits were probably also enriched in part by solution of the calcite and by solution and re-deposition of the gold.

However, as the present workings are all in the oxidized zone, if the vein or its fissure continues downward it would be reasonable to expect to find primary sulphide ore in depth similar to that in the

[20] Emmons, W. H., The enrichment of ore deposits: U. S. Geol. Survey Bull. 625, pp. 305–324, 1917.

Alpha mine (p. 32), though such ore at moderate depth will probably be of too low grade to work unless it occurs in considerable quantity. With one or possibly two exceptions the croppings are inconspicuous, so that in general cross trenching or underground work was required to determine the position of the vein. Approximately on the projected course of the vein to the southeast, on the neighboring Jarbidge Gold ground, near the Elmore mine, at an elevation of 7,800 feet, occur croppings which may represent in part the apex of the Long Hike vein. These croppings, which are rugged and rise 10 to 30 feet above the surface, consist mainly of more or less silicified rhyolite and quartz replacing rhyolite. However, present indications are that the vein or the silicified root of the cropping does not descend to the 68 level, or that if it does it dips more steeply than the neighboring fault.

The Long Hike vein, like most other veins of the district, is composed chiefly of a gangue of quartz, adularia, and altered rhyolite. In general it is so extensively oxidized that much of it presents a whitish limelike or chalky appearance, is relatively soft, and accordingly is easily mined and milled. The vein also contains, however, bodies of the relatively hard greenish replacement quartz and adularia characteristic of veins of this class found in the Oatman and other districts of the West. In places the vein is heavily stained reddish brown and blackish with oxides of iron and manganese.

The quartz-adularia gangue largely replaces the calcite, after which it is pseudomorphic, as shown by its lamellar and bladed structure. It has replaced also much of the included rhyolite and of the adjacent wall rock. Though much of the vein appears to be limy or chalky, it is noncalcareous, the limy properties of the calcite having been completely removed in the replacement or subsequently changed in the process of oxidation.

The vein contains considerable leverrierite, which occurs as a constituent of the gangue and as gouge in the fractures and on the vein walls. It seems to have been derived from the decomposition of the glassy groundmass or vitreous constituents of the rhyolite and the alteration of its feldspars. There is present also a little barite, some of which incrusting altered rhyolite was collected in the present work on the 69 level. The barite occurs in small macroscopic crystals and was probably formed contemporaneously with the quartz and adularia. Fluorite is present in small amount, and with it is associated considerable related sericite.

Except for considerable faulting denoted by slickensides, gouge, and sheeting, both within the vein and on the walls, the vein is mostly structureless or massive and shows but little banding or crustification. In places it is traversed obliquely by narrow, inconspicuous fault zones or seams resembling planes of movement. These zones are commonly known as cross slips and generally are accompanied by smaller stringers or bands of good ore, and some are filled with quartz and other gangue minerals. The ore of any one seam or streak is said to be generally continuous and to maintain its tenor entirely across the vein from wall to wall. Similarly, a lean streak is lean throughout.

The cross slips on the 68 and 69 levels generally continue without interruption from the vein through the contact into the wall rock, but at the contact they are deflected, as shown by the presence of quartz, slickensiding, shearing, and fault-drag material (fig. 4), indicating movement between the wall and the vein in approximately a horizontal direction between the time the seams were formed and the time of their filling by the quartz and ore. Slight movement has also taken place since the quartz was deposited. The differential of movement has been to the northwest on the footwall side and to the southeast on the hanging-wall side. The continuation of the seams from the vein into the wall rock is generally less difficult to determine on the footwall side than on the hanging-wall side. Faulting in the dip plane of the fault seems to be normal.

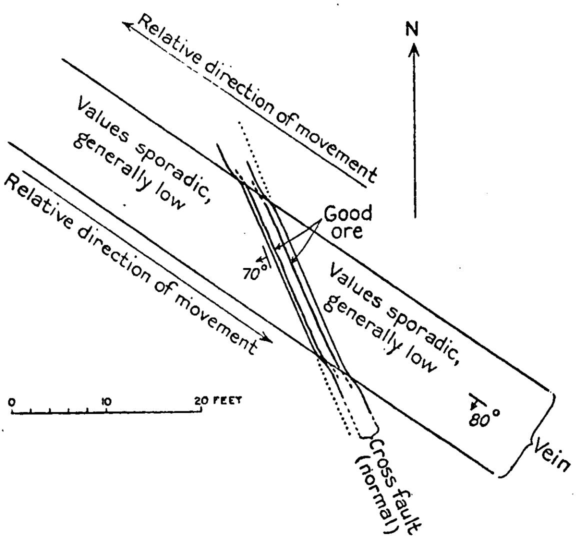


FIGURE 4.—Diagram of enriched cross slips or faulting in Long Hike vein. The heavy lines denote streaks or bands of good ore in the fault zone. Faulting in the dip plane of the fault zone seems to be normal.

The vein walls in general are ill defined. Some workable replacement deposits extend for a considerable distance laterally into the country rock.

The gold occurs disseminated in the quartz-adularia gangue and associated altered and replaced rhyolite. It is so finely divided that it is not visible to the naked eye and must be recovered by the cyaniding process. It is not uniformly distributed in the vein longitudinally, vertically, or laterally. Considerable portions of the vein are barren. The better ore is on the hanging-wall side of the vein. Of the replacement deposits in the wall rock, however, those in the footwall are much the better, as would be expected in deposits that are largely supergene.

The vein is opened to a depth of 900 feet on the 10 or more levels above noted.

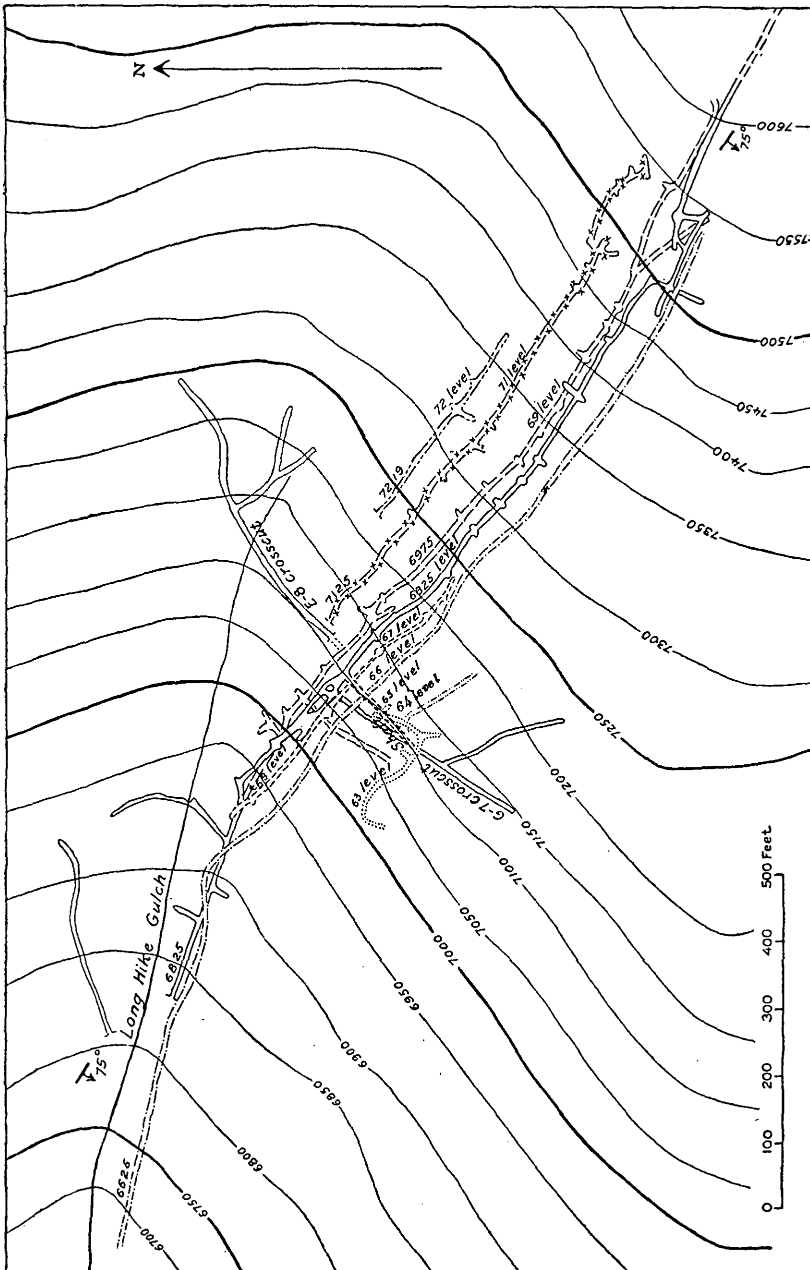


FIGURE 5.—Plan of Long Hike mine.

On the 68 level, which has a length of about 2,000 feet and extends to the side line of the adjoining Jarbidge Gold ground, the vein is from 5 to 10 feet wide and has produced about 4,300 tons of $12 ore, a larger tonnage than any other level in the mine. The good yield in ore is probably largely attributable to the fact that this part of the vein contains considerable of the hard lamellar replacement quartz. The quartz contains inclusions of altered and in part brecciated and mineralized rhyolite. The most productive stopes were G–7, 8, and 9 (fig. 3).

The deepest deposits of any importance were found at about 400 feet back from the face of the tunnel, in or near stopes G–16 and 17. They produced 800 tons of $20 ore. Beyond this point no ore of any consequence was found. At its face the level meets a fault, at and near which the ground is so intensely broken as to be of no promise. The fault strikes N. 20° W. and dips 45° W. In August, 1922, it was said that the main tunnel of this level was being extended to connect with the deep shaft of the Starlight mine, largely for the purpose of exploring at depth the block of intervening ground.

In the ground between stopes G–11 and G–14 and extending upward nearly to the top of the 69 level the ore was of low value, averaging only about $2 to the ton, and was confined essentially to a vein width of about 3 feet. Here the so-called north-south cross slips, which elsewhere almost invariably enriched the vein, contributed little or no value, although they contained quartz stringers.

The country rock, as shown in the hanging wall of stope G–7, is coarse grained or porphyritic, with dark phenocrysts, and its flow structure dips gently toward the vein. It is seamy and is largely altered by kaolinization and stained reddish or lavender and dark by iron and manganese oxides, which permeate it. Elsewhere it contains inclusions of dark slate, which apparently have not been altered by heat and are in part pyritic.

At stope G–6 the hanging wall consists of a sort of bluish-drab clay or mud-rock gouge containing small black carbonaceous or graphitic inclusions regarded as of sedimentary origin. Elsewhere the walls or gouge contain small lenticular bodies and streaks of black and white speckled quartz and quartz breccia firmly cemented by psilomelane.

On the 69 level, which is opened for a length of 1,250 feet, the vein is 4 to 9 feet in width and narrows as it extends southeastward into the mountain. It has produced 30,000 tons of $12 ore. The country rock at stope E–12, on the hanging-wall side, consists of lead-gray medium-grained highly altered rhyolite with a more or less platy or thin bedlike structure dipping toward the vein at angles of about 12°. The microscope shows it to be pressed, to be more or less schistose, and to contain rounded and subangular grains of primary quartz and much secondary muscovite or sericite, some of which has a divergent arrangement and radiates from feldspar and quartz crystals as nuclei. At about 500 feet farther in the mountain, in block E–16, the rock is similarly highly altered, lighter colored, and more highly mineralized and has a growth of barite crystals deposited on its joint planes and fracture surfaces.

The 71 level has a length of 875 feet, of which the inner 800 feet is on the vein, which extends to the N. 20° W. fault. From this level to the surface the vein has produced 3,400 tons of $15 ore and at the time of visit still contained 2,000 tons. The vein averages 3½ feet in width and consists chiefly of typical lamellar pseudomorphic replacement quartz and adularia with small inclusions of brecciated, altered, and mineralized rhyolite. It is thoroughly oxidized and is mostly stained pink or reddish by iron; where not thus stained it is whitish. It is microscopically drusy and in places shows specks and small bodies of argentite. The quartz-adularia gangue shows at least two generations or periods of growth. The phenocrysts in the rhyolite, especially those of quartz, are encircled by zones of secondary chalcedonic or metacolloidal silica, and locally the width of the zone equals the radius of the crystal. Around the feldspars the zonary growth is not so wide but is more crystalline. Slight stains of malachite and azurite suggest that before oxidation the vein probably contained a little chalcopyrite or that some of the pyrite now altered to hematite may have been cupriferous.

The 72 level is opened by a 350-foot adit tunnel. It contains the supposed apex of the Long Hike vein, which here is 3 feet in width and is exposed for 150 feet.

The 74 level, which is in ground adjoining the Long Hike No. 3 claim, is opened by a 150-foot tunnel, which does not show any mineralization.

The 67 level, opened for a length of 500 feet immediately beneath the productive part of the 68 level, has produced 18,000 tons of $12 ore.

The 66 level, which at the time of visit was opened by a 1,300-foot adit tunnel, has produced 550 tons of $8 ore. During the spring of 1921 the tunnel was extended 500 feet farther but without finding any ore. At the face this tunnel is the deepest working in the mine and has a nearly vertical depth of 900 feet on the dip of the vein.

The 64 level is developed mainly by a 250-foot drift at a depth of about 700 feet below the surface. The vein consists largely of thoroughly oxidized and mineralized rhyolite. From this level upward to the 67 level it is about 5 feet wide, and the portion extending up to the 66 level has produced 500 tons of $7 ore.

The 63 level, the lowest level of the mine, lies at a depth of about 700 feet. It is developed by a 200-foot drift. A pump stationed here drained the mine at the time of visit. In descending from the 64 level the vein narrows and locally feathers out, and on the 63 level it consists chiefly of a narrow leached and barren zone containing stringers of leverrierite, kaolin, or "talc." The country rock is only partly oxidized and for a distance of 20 to 90 feet from the vein contains considerable finely disseminated pyrite and psilomelane, apparently indicating nearness of the workings to the sulphide zone. The pyrite, however, is in part secondary; some of it fills cracks or small cavities in the feldspar and quartz phenocrysts, whence smaller stringers or veinlets extend into connecting fractures. A striking feature of the rock is the shattered condition of the quartz phenocrysts and the pyrite filling and cementing the cracks.

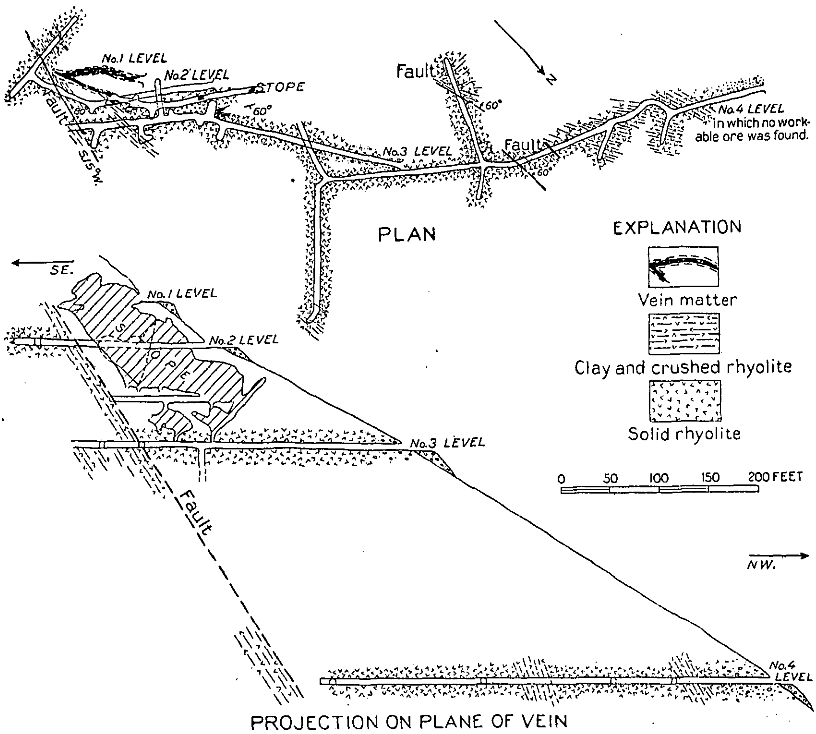


FIGURE 6.—Plan and section of North Star mine on Bourne vein.

NORTH STAR MINE.

The North Star mine is about 2,000 feet above the mouth of Bourne Gulch, in the steep south slope at about 350 feet above its floor. (See Pl. III and fig. 6.) It has produced $5,000 in gold ore. Its deposits were the first discovered in the district. They were found by D. A. Bourne and are described in the earlier report, at the time of which more than 1,000 feet of underground work had been done, chiefly by the owner, the North Star Mining & Milling Co. The company subsequently built a large Hardinge mill at the mine with a rock crusher and automatic gold separator and later added a 5-stamp mill and cyanidation plant but was able, it is said, to save only about 38 per cent of the metallic content of the ore. The principal period of operation was from August, 1911, to February, 1912, during which the company treated 4,000 tons of $12 ore.

The company is a stock company and since 1918 has been mostly owned and controlled by the Elkoro Mines Co. The Elkoro Co. recently drove the lower 450-foot tunnel on level No. 4, 240 feet vertically below the main workings, for exploratory purposes, but found only traces of ore in a few places. The mine has about 3,000 feet of workings, all in the oxidized zone (fig. 6), the maximum depth of development being about 250 feet. It is opened mainly by adit tunnels on levels 1, 2, and 3. It contains two veins, the Bourne vein and the North Star vein, both in the old rhyolite. The more productive one is the Bourne vein; it is the higher up and the more westerly of the two. It strikes N. 40° W. and dips 60° NE., into the mountain. It is 3 feet or more in width. The best ore has a gangue of reddish or light-brownish soft fine-grained pseudomorphic replacement quartz.

Considerable work was also done in the early days on the North Star vein, but it did not produce much ore. After sampling this vein, however, the Elkoro Co. has decided to do further work on it.

O. K. MINE.

The O. K. mine is in the upper south slope of Bourne Gulch, about three-quarters of a mile from its mouth (Pls. II and III), No. 1 level (fig. 7) being at an elevation of 7,540 feet. It was discovered in 1914 by Add Rickard, of Jarbidge. In 1915, through the agency of George S. Shoup, it was bonded to Louis Greenbaum, of San Francisco, and in 1916 it was purchased by the Elkoro Mines Co., the present owner. Greenbaum developed No. 1 tunnel as far as shaft A-B (fig. 7). The remainder of the development work was done by the Elkoro Mines Co., which in 1920 built an aerial tramway to the mine to take out the ore that it had blocked out a few years earlier. The production up to July, 1920, was small, but late in 1921 the company was said to be working the mine with excellent results. In January, 1922, the company reported that it had mined practically all the ore above the Zero level; that it found the ore to decrease in value from the surface down; and that it would probably finish the mine in the summer of that year. In March it was reported that a good ore body had recently been found beyond the main fault. The ore above the Zero level averaged about $30 to the ton, and that below it ranged from about $15 down to material of nonworkable grade.

The vein lies in the old rhyolite, which is mostly firm, coarse to medium grained, and in part pyritic. It dips steeply to the northwest. It does not crop out but was discovered by the posthole, trench, and pan method of prospecting under 8 feet of talus, where it was found to be well developed. About all the surficial material at and near the mine is said to pan well. The vein ranges from 6 inches to 4 feet in width and averages about 2½ feet. It is opened to a depth of 400 feet and horizontally for about 1,400 feet and is reported to extend for a considerable distance farther to the southeast. It is crossed by several faults, of which the most important are "fault A," at about 350 feet in from the mouth of tunnel No. 1,

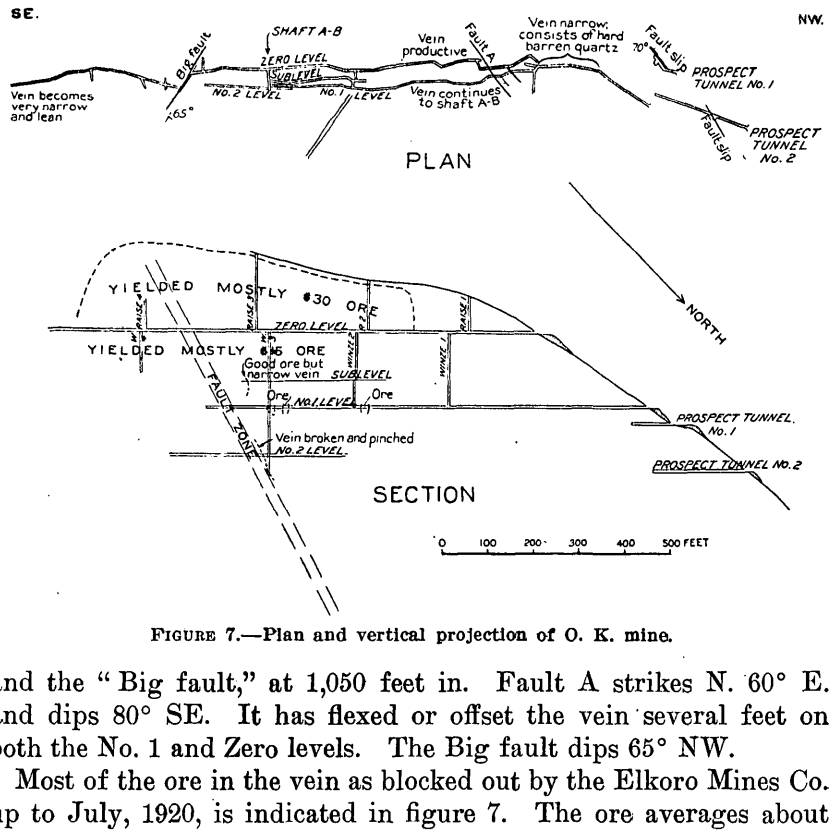


FIGURE 7.—Plan and vertical projection of O. K. mine.

and the "Big fault," at 1,050 feet in. Fault A strikes N. 60° E. and dips 80° SE. It has flexed or offset the vein several feet on both the No. 1 and Zero levels. The Big fault dips 65° NW.

Most of the ore in the vein as blocked out by the Elkoro Mines Co. up to July, 1920, is indicated in figure 7. The ore averages about $20 and ranges from $5 to $30 to the ton in gold and silver, with the silver content relatively high. The reddish phase of the ore is said to have the highest metal content.

From recent work it is inferred that the ore lies mostly near the surface and does not extend to any great depth. It occurs mostly against or in association with the fault on its northwest or hanging-wall side.

On the first 300 feet of level No. 1, from the portal to fault A, the vein is only about 1 foot in width and consists chiefly of hard, barren quartz. Beyond the fault it remains narrow but becomes of fair tenor and continues so for the distance of 500 feet to the shaft. It is in hard rhyolite and consists mostly of hard quartz, which is in part blocky, but in places the ore is soft, with the quartz showing the replacement pseudomorphic structure. Locally the vein consists of a few stringers and incloses a small horse. On level No. 2 it is broken and pinched and has little or no ore other than $5 to $6 ore occurring between the shaft and the Big fault. In prospect tunnel No. 2 no vein or mineralization was found.

ALPHA MINE.

The Alpha mine is in the upper south side of Bourne Gulch, adjoining the O. K. mine on the east (Pls. II and III). The property consists of five claims. The Alpha and neighboring mines are reached by a good wagon road ascending Bourne Gulch. The Alpha deposit was discovered in 1910 by Judge Hughes, of Jarbidge, and soon afterward workable ore was found by Add Rickard. The total production is $165,000.

In 1912 the mine was purchased, it is said, for $25,000 by the Elko Mines Co., of Chicago, which in 1913 put in a 50-ton 5-stamp and rod mill and operated it continuously for two years following, with the result that 6,400 tons of ore was mined and milled. A concentrator was also used during the last two months of this period. The extraction of gold obtained was 74 per cent. An aerial tram connects the mill with the mine at the 400-foot level.

After suspension of operations by the company in 1915 some work was done by lessees with fair results. At the time of the writer's visit the property had been bonded for a year to the Jarbidge Gold Mining Co. Commencing in September, 1920, the mine was being exploited and developed with a small crew of men by the Legitimate Mines of Jarbidge Co., which in February, 1921, claimed to have blocked out ore enough to keep the mill running for two years. Two good ore shoots, one of which is on No. 4 level (fig. 8), had been opened. By April the mine had been leased and bonded to the Jarbidge Nevada Mining Co., of Tacoma, Wash., the present owner. This company now owns 10½ adjoining patented claims, including the Guarantee, Legitimate, and Alpha groups.

Early in June, 1921, a third ore shoot, for which the company had been crosscutting for some time through 70 feet of very hard rock, was opened on the 362-foot level, which is that of the Snowbrush tunnel, a crosscut from the surface. It proved to be about 5 feet in width and was said to pan about $35 to the ton in gold and to assay $43 to the ton in gold and silver. Some of the gold is visibly free. The ore at this place is said to be similar to the ore on the 172-foot level, but the ore shoot seems to be a new one, as it rakes to the north, whereas the ore shoots in general rake to the south. The discovery was regarded as an important one, as it was made in hitherto unexplored ground and was thought to add to the resources of the mine 200 feet of stoping ground on the dip of the vein extending upward to the 172-foot level. But subsequent drifts and upraise at a point 50 feet southeast of the shaft failed to find the continuation of the ore body, which seems to be cut off by a fault, apparently the same fault that cuts off the ore in the O. K. mine. The fault dips 35° NW. and crosses the 362 level near the tunnel entrance. In December, however, the raise on the 362 level was said to be encouraging, and in March, 1922, it was reported that considerable good ore had been blocked out in connection with it, some averaging $35 to the ton, and that ore was being produced. In April a winze that was being sunk from the 362-foot level at a point 30 feet southeast of the shaft and had attained a depth of 18 feet was said to show the vein to be 3½ feet wide and to contain in the footwall side an 8-inch shoot of sulphide ore that averaged $176 to the ton, and it was reported that the rest of the vein averaged $12 to the ton, with the value in silver about four times that in gold. A sample taken from the bottom of the winze is said to have run $450 to the ton. The high-grade assays of sulphide ore are said to average about 4 ounces of gold and 300 ounces of silver to the ton. The company plans to extend the winze to a depth of 100 feet during the winter of 1922–23.

A specimen of the ore from this place received May 12, 1922, is considerably more oxidized than the sulphide ore at the shaft described on pages 32–34. However, from the wide dissemination of pyrite and silver sulphide in the specimen it is inferred that the workings are probably nearing the sulphide zone. The metallic contents are chiefly contained in or associated with specks and aggregates of blackish argentite and naumannite, the dominant silver-bearing minerals. Reddish-brown and pinkish material staining small spots of the ore seems to be proustite or pyrargyrite. In May the mine was said to have $30,000 in ore blocked out. In August it was reported that further work in the raise had disclosed a 7-inch streak of very rich ore at a point about 35 feet above the 362 level and 6 inches from the hanging wall, a sample of which, it is said, assayed 90 ounces in gold and 87 ounces in silver, or about $2,700 to the ton. Specimens of this ore kindly supplied by the superintendent of the mine and examined by the writer show the ore to be oxidized and stained pale to dark rusty brown by iron oxide on joint and fracture surfaces. It is closely banded or crustified, is medium grained, consists mainly of a laminated gangue of fine-grained quartz and adularia pseudomorphic after calcite and of remnantal calcite, and is highly calcareous. A little pale pyrite is present, mostly irregularly distributed along the contact of siliceous bands with the less siliceous bands. In places some pyrite is associated with argentite. The visible ore minerals so far as recognized are argentite, native gold, native silver, and electrum. The argentite is present in considerable quantity as dark or blackish irregular bodies. With it is associated most of the native gold. The native silver and electrum, which in places are abundant and are more or less associated, occur chiefly as specks, flakes, films, and wirelike forms, mostly along the darker bands of the ore. The native silver and the silver contained in the electrum were probably derived from argentite by oxidation.

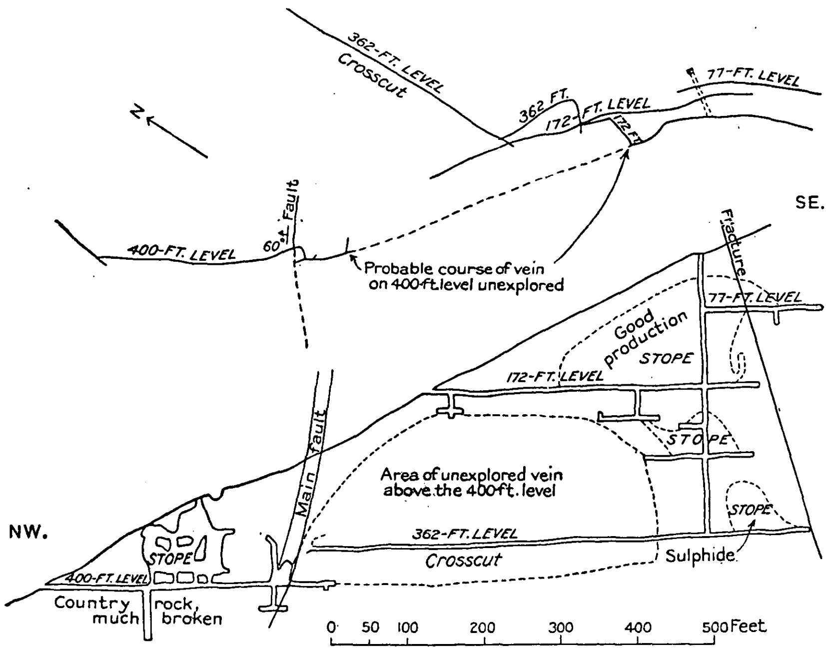


FIGURE 8.—Plan and projection of Alpha mine.

The deposits occur in the Alpha vein. The vein dips about 80° SW. in drab coarse country-rock rhyolite similar to that in the O. K. mine. It averages about 3 feet in width and looks well, but both vein and ore shoots occur in lenses or pinch and widen. The vein consists mostly of laminated replacement pseudomorphic quartz and adularia. As shown in branches or offshoots in the sulphide (?) zone, the vein is solidly frozen to the wall rock.

It is opened to a depth of about 300 feet by 2,000 feet of workings, chiefly by three adit tunnels or drifts and a shaft, as shown in figure 8. Each drift is about 500 feet in length. On the 400-foot level at about 300 feet in from the portal the vein is crossed by a fault known as the main fault, which has thrown its fore part 15 feet to the northeast. The fault dips about 60° NW. In this part of the mine the country rock is much broken. On the southeast or footwall side of the fault it has been crushed and altered to a soft medium-grained ash-gray mass and is pyritiferous. The vein is narrow but relatively rich, the small stope shown in figure 8 having produced $30,000 in ore said to have averaged $90 to the ton. In the winze about 30 feet beyond the fault the vein is said to contain 2 feet of $200 ore. Also the stope on the 172-foot level has produced well. In May, 1922, the showings on this level were said to be so encouraging that the company contemplated driving it well into the mountain.

The ore consists chiefly of thoroughly oxidized laminated pseudomorphic quartz and adularia. It is for the most part deeply stained reddish brown and blackish with iron and manganese oxides and apparently is an ideal milling ore. It is said to contain 1 ounce of gold and 2 ounces of silver to the ton. Some of it is very rich. Some contains considerable epidote, and some is coated with copper-colored blistery or microbotryoidal forms of iridescent hematite which might readily be mistaken for copper ore.

What is probably the beginning of the sulphide zone was reached in the vicinity of the shaft by the deepest workings on the 362-foot and 400-foot levels, in consequence of which the mill had recently been equipped with large tanks and facilities for an improved cyanide process for handling both oxide and sulphide ores. In August, 1922, however, it was said that arrangements had been made to have the ore treated in the Elkoro mill, to which it is taken by aerial tram by way of the Starlight head house, after being crushed in the Alpha mill. At that time 600 tons of broken ore was available.

The ore on the 400-foot level is chiefly sulphide ore with much black silver sulphide (argentite) and naumannite in a sparry quartz-adularia-calcite gangue. It is described on pages 32–34 and illustrated in Plates XI, *B;* XV, *A* and *B*. Two inches of the vein is said to average nearly $700 to the ton. Associated with the argentite are some native gold and a little cerargyrite and pyrargyrite.

STARLIGHT MINE.

The Starlight mine is one of a group that includes also the Legitimate, Flaxie, and Jarbidge Gold mines, located in Starlight Hill, in the upper north side of Bourne Gulch opposite the Alpha mine (figs. 9 and 10). The slope is steep but not rugged (Pl. II and fig. 11).

The veins in these mines are similar to the Long Hike vein and are characteristic of the leading productive veins north of Bourne Gulch. They all strike N. 50°–60° W. and, except the Starlight and Legitimate veins, dip 70°–80° SW. They consist chiefly of the lamellar replacement pseudomorphic quartz-adularia gangue. The gangue and ore are more or less sugary, but much of the gangue, though good looking, has either no metallic content or not nearly so much as the replacement deposits in the wall rock. The veins lie in the old rhyolite, which, however, is at a considerably higher horizon than that of the Long Hike mine, is not so typical of that rock, and contains more associated sedimentary rock.

The Starlight property includes the Starlight, Sunset, and Mahogany claims. It adjoins the Legitimate property on the southeast and the Flaxie on the northeast (fig. 9).

History.—The Starlight deposit was discovered in 1915 by William Holland and Charles and William Martin, all of Jarbidge. The dis-

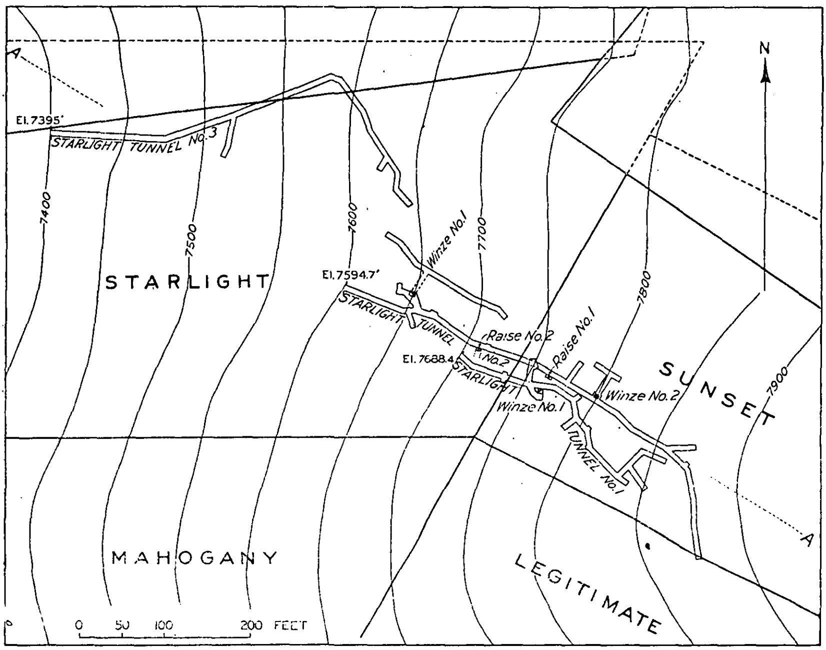


FIGURE 9.—Topographic, claim, and level map of Starlight mine. A–A, Line of section in figure 11.

covery was made by trenching and panning, as the vein does not crop out. The discoverers early developed it essentially as it is now developed in tunnel No. 1. Soon afterward Albert Hanford took a three months' option on the property and opened tunnel No. 2 in part. Then the Elkoro Mines Co., the present owner, took an option on and developed the property in general, except tunnels Nos. 4, 5, and 6. Later it purchased the property for $165,000 and brought the developments up nearly to the present stage, and recently it has continued development work by driving No. 2 tunnel eastward and stoping out ore. By September, 1922, this work was extended almost to the Guarantee ground, which it was expected to penetrate soon.

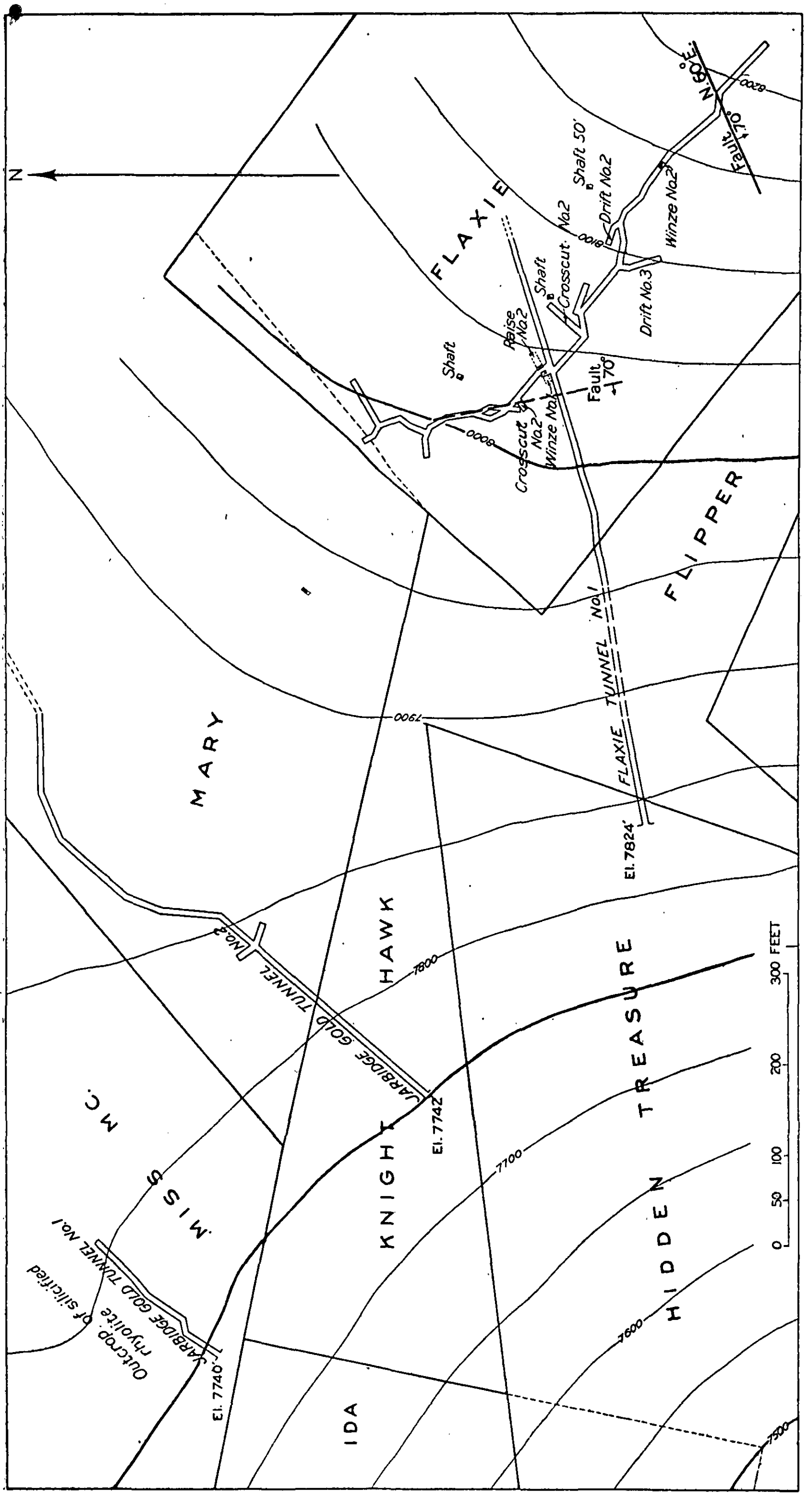


Figure 10.—Topographic, claim, and level map of Flaxie and Jarbidge Gold mines.

The production, figures of which are not available, has been considerable. The ore reserves seem to be moderate.

Development and equipment.—The mine is opened through a vertical range of 900 feet between the elevations of 6,900 and 7,800 feet. It is opened on seven levels, mainly by five adit tunnels, a shaft, drifts, winzes, and crosscuts, aggregating about 4,000 feet of workings. The levels are nearly all spaced about 100 feet apart vertically. They are numbered in descending order, No. 1 being the 100-foot level, No. 2 the 200-foot level, and so on, except that the one next below No. 2 is known as the sublevel. (See fig. 12.) The upper workings are mostly in very broken and soft ground beneath a ravine. The lowest workings are sufficiently high above Bourne Gulch to afford the mine good drainage.

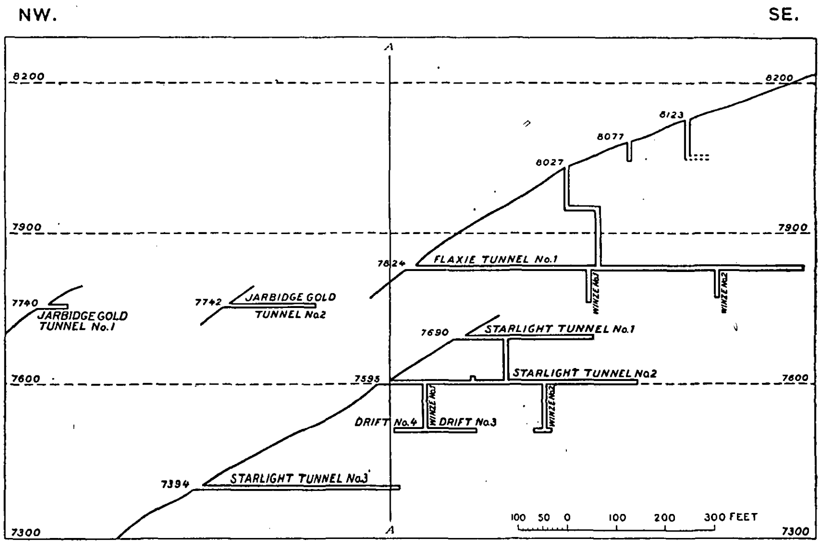


FIGURE 11.—Longitudinal section of Starlight Hill group of mines, on line A–A, figure 9, with Flaxie and Jarbidge Gold workings projected thereon.

The equipment consists chiefly of an electric-power line, electric compressors and drill sharpeners, tram tracks on about all levels, electric light, and buildings adequate for housing 50 men. The mine has more than 1,000 feet of tmbering. The lower 450 feet of the shaft is all timbered. The ore is treated in the Elkoro mill, where it is delivered by means of aerial tram, first by a 3,300-foot line to the Long Hike ore bin, then by a 1,250-foot line to the mill.

Ore deposits.—The deposits occur in or are associated with the Starlight vein. The vein has a known extent horizontally of about 1,400 feet and vertically of 700 feet. It is not regular but forks and branches. It strikes N. 60° W. and dips to the north. In the upper part of the mine the dip is 70°, but in depth it flattens to 50°.

The opposition in direction of the dip of the vein to that of the Flaxie vein and its parallelism in strike with that vein suggest that the Starlight vein may possibly be the northwestward continuation of the Flaxie vein tilted over to the south by a fault. Its position is more nearly diagonal than opposite to the Flaxie, and its apex is less than 1,000 feet from the Flaxie, measured across the strike. In case it is not the Flaxie vein, as the two veins converge in dip they should meet at no great depth, especially as the dip of the Starlight flattens with descent. It seems more probable, however, that the Legitimate vein, lying opposite to and parallel with the Flaxie vein, may prove to be the eastward continuation of the Starlight vein.

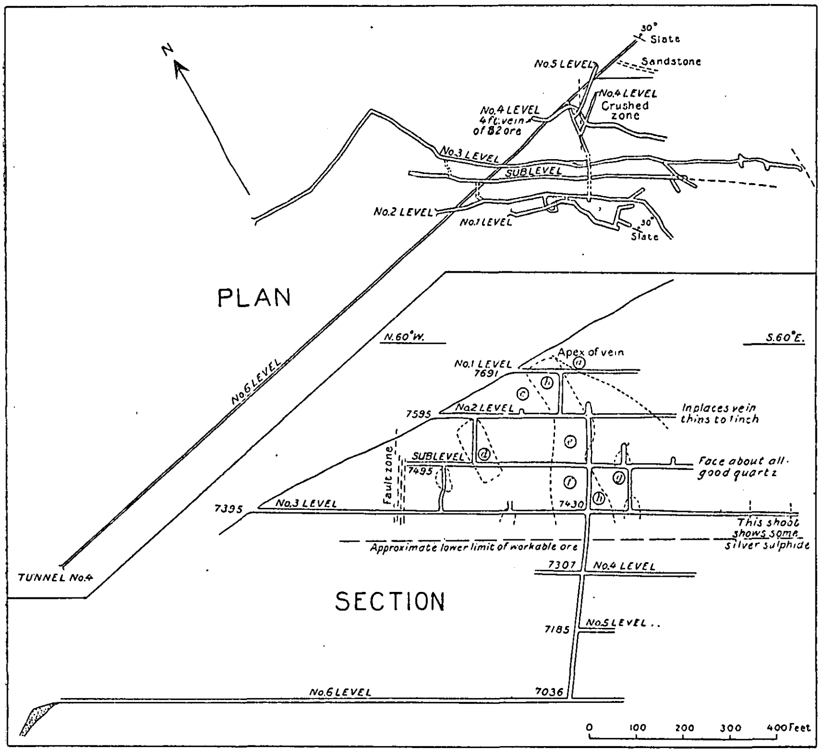


FIGURE 12.—Plan and projection of Starlight mine.

The Starlight vein is 7 feet or more in maximum width, and much of it is from 2 to 4 feet wide. A considerable part of it consists of good-looking soft sugary quartz or quartz-adularia-halloysite gangue but is of only small or no value. A little sulphide ore in which the ore mineral is chiefly argentite occurs in the deeper part of the mine west of the face of No. 3 level.

The mine is traversed by two faults, appearing notably on levels 1 and 3, both of which, as shown by recent work, delimit the vein and locally form its hanging wall. From these conditions the company concludes, apparently correctly, that the mineralization was effected by ascending solutions that came up under the faults, by which they were dammed back, presumably by impervious fault gouge.

The tunnel of No. 1 level, about 400 feet in length, owing to a cave-in was only in part enterable at the time of visit, but the large dump at the mouth shows that the vein material and ore are typical of the district. The dump consists of highly oxidized, mostly reddish and brownish gangue. It contains also considerable impure slate rock with black carbonaceous material. In its farther part the level exposes a 5-foot section of sedimentary rocks consisting in descending order of 4 feet of gray arenaceous slate or slaty sandstone and 1 foot of black impure slate dipping 30° NE. The rocks are carbonaceous and pyritic and are unconformable with the structure in the associated fault zone. The stope on this level is said to have contained 4½ feet of $25 ore. The fault exposed on this level appears also at a point 150 feet below the level, where the vein is in contact with it and extends along underneath it.

No. 2 level, about 100 feet vertically below No. 1, is about 550 feet in length. Its dump also consists mostly of oxidized material which is more or less fine and relatively soft. A crosscut to the northeast recently exposed a narrow branch vein containing good ore, which also is terminated by the faults above described.

The sublevel, 100 feet below No. 2, is southeast of the main fault zone. It is without an adit tunnel and is worked through No. 2 level. It is opened mainly by a drift about 600 feet long, which cuts three ore bodies about as indicated in figure 12. The face of the drift is nearly all in good-looking quartz.

No. 3 level, about 200 feet below No. 2 and 100 feet below the intervening sublevel, is opened by an adit tunnel 1,300 feet in length and has considerable ore in its middle part at and near the shaft. Near its face it is crossed by a fault that cuts off the vein. By drifting from a stope about 150 feet above this level the fault was again found forming the hanging wall of the vein, which, however, contained no ore at that place. The vein was followed to the southwest directly under the fault and apparently gradually pinches out in that direction.

On No. 4 level, which is 125 feet below No. 3, the vein, 4 feet in width, is crossed by stringers and shows only a small metallic content, $2 or less to the ton. Development work done in driving the drift toward its face and in raising to No. 3 level indicates that the ore extends but a short distance below No. 3 level.

No. 5 level is mostly in firm, tight, coarse rhyolite. The projected course of the vein is on what seems to be a fault in altered rhyolite only, though there is a good footwall, and the dip is flattened to 55°. No ore has been found here.

No. 6 level is the lowest adit crosscut. It is 1,650 feet in length and runs N. 80° E. It was driven to drain the mine, and incidentally it is said to drain also the Legitimate mine, through the Legitimate fault, which it cuts. A strong stream of water flows from its mouth. It is nearly all in rhyolite, but the face is in the interbedded slate-sandstone series, which here dips about 30° NE. The 100-foot crosscut, turned at about 100 feet back from the face, is in gray sandstone or graywacke, the more or less extensive occurrence of which suggests probable bottoming of the rhyolite in this locality.

In March, 1921, it was reported that the ore then being mined on No. 3 level, at a depth of 350 feet, and on the sublevel, above No. 3, contained more or less silver, especially on the footwall side of the vein. In some of the ore the silver was said to be worth more than the gold. Some of the ore was reported to assay 34 ounces in silver and to show considerable free gold, and some of it was said to average from $700 to $1,000 to the ton. The ore is thoroughly oxidized; some of it has a light lavender color, due to iron and manganese stain, and the gangue is in large part altered and mineralized rhyolite. Other ore is of light color, resembles kaolin or chalk in appearance, and seems to consist chiefly of halloysite and quartz. The ore is so "talcky" that in the process of panning the "talc" forms hindrance balls and lumps which retain the gold until they are reduced by trituration to solution or slime.

LEGITIMATE MINE.

Location.—The Legitimate mine is in the southwest base of Starlight Hill and the northeast side slope of Bourne Gulch (Pl. XVIII). It joins the Starlight mine on the southeast (fig. 9). The underground workings of the Starlight on the Sunset ground are said to be within 160 feet of the Legitimate main tunnel (No. 3), which is about 30 feet higher than the Starlight No. 2 level (Pl. XVII).

The property consists of eight patented claims, including three in the Legitimate group, four in the Guarantee group, and the Tacoma fraction (Pl. XVI).

History.—The Legitimate vein was discovered through trenching and panning by Add Rickard, who also prospected it. Subsequently Dave Marquardson, Steve Benan, and their associates became owners of the property and sold it to persons who organized the Jarbidge Nevada Mines Co., of Tacoma, Wash. This company did nearly all the development work, beginning in 1915, and worked the mine for nearly four years. It drove the adit tunnel (No. 3) into the vein and found an ore body 50 feet long by 150 feet high, on which it sank a short distance. It mined and milled 1,000 tons of $25 ore and ran a 5-stamp mill (the Alpha mill) for two months on its best ore but did not obtain a good extraction of the metals and is said to have recovered only $2,500 in bullion for an expenditure of $25,000. It tried the flotation process on the ore, but without success, and finally ceased work in October, 1919. In 1920 the mine was said to be about worked out, but in November, 1921, it was reported to have been taken over by the Elkoro Mines Co., which began to develop it through the No. 3 level of the Starlight mine and in March, 1922, was reported to be finding ore. The mine was not examined in the present work.

Development.—The mine is opened by about 2,000 feet of workings, including mainly three adit tunnels, of which one (No. 3) is 600 feet long, drifts, and a 300-foot raise (Pl. XVII). The work is about all on the Legitimate claim, but the vein is said to extend eastward through the Guarantee ground (Pl. XVI).

Ore deposits.—The vein strikes about N. 60° W. and dips 75° N. It is from 3 to 4 feet in width. The gangue is mostly halloysite and altered rhyolite, with a little associated quartz, which occurs mostly in cross slips. As the strike and dip are about the same as those of the Starlight vein and as the two veins are approximately in alinement the Legitimate vein is probably in general the continuation of the Starlight vein.

At a depth of 500 feet, or 160 feet below tunnel No. 3, the vein is cut off by a fault that approximately parallels it in strike but dips to the northeast. In 1920 what little ore was known to occur in the mine was said to lie against the fault.

FLAXIE MINE.

The Flaxie mine is just northeast of the Starlight and Legitimate mines, higher up the north slope of Bourne Gulch (fig. 10). It is owned by the Flaxie Mine Co., of which Hodge Brothers, of Bruneau, Idaho, are leading members. The property includes two patented claims. The production is $1,000, mostly in high-grade gold ore. The ore was milled on the ground in a small 3-stamp mill about 1916.

In 1921 it was reported that the Elkoro Mines Co. had taken a lease and bond on the property and was improving the equipment throughout for immediate mining. The mine is opened to a depth of 350 feet, mainly by a 500-foot crosscut tunnel and drifts (fig. 10).

The vein dips to the southwest in old rhyolite, which is said to be considerably broken, especially on the hanging-wall side. It is faulted at several places and in 1920 was known to contain a moderate amount of $9 to $10 ore, but it is of more than ordinary interest, as it is on the projected strike of the neighboring Long Hike vein, and more than 1,000 feet higher than the apex of that vein, which it resembles and of which it may be a continuation and therefore may attain considerable depth in the rhyolite. In March, 1922, it was reported that a new ore shoot 2 feet wide and averaging $20 to the ton had recently been found. In May, 1922, it was said that the mine had been equipped with an aerial tram and that the company was taking out ore. In August it was raising and sinking on ore of very good grade. The development work, it is said, shows the ground to be much faulted.[20a]

PAVLAK MINE.

The Pavlak mine is on Jarbidge River about a mile above Jarbidge and is easily accessible (Pl. II and fig. 13). It is owned chiefly by Henry McCormick, of Salt Lake City. It is described in the earlier report.[21] At that time the deposits had been opened mainly by the

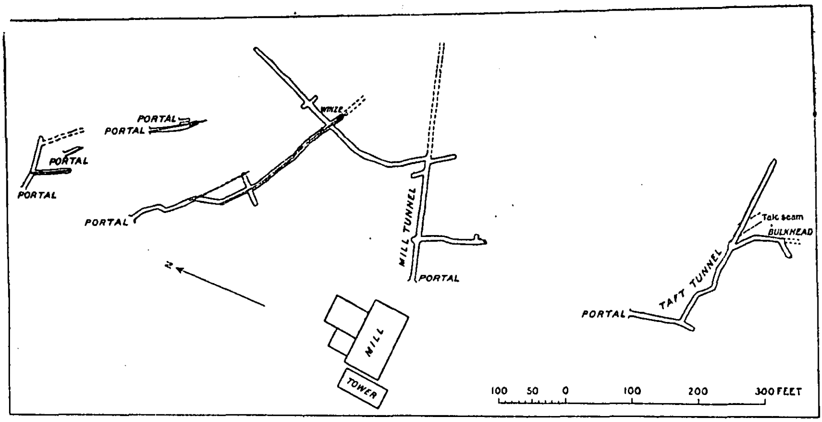


FIGURE 13.—Plan of Pavlak mine.

owner, the Jarbidge Pavlak Mining Co., by about 1,000 feet of workings. Several thousand dollars' worth of shipping gold ore, some of high grade, and considerable milling ore had been produced, and a mill was being built. The production to date is about $13,000.

The deposit was one of the first to be discovered, by Messrs. Pavlak and Truro, pioneers, in the fall of 1909. In 1910 or 1911 Messrs. Brown, of Salt Lake City, and Kinney, from the East, purchased the property from the Pavlak Co. for $125,000, according to reports, and worked it. The mill was started in August, 1911, and ran intermittently for four months or more, but owing to financial difficulties it was closed in February, 1912. During the period of operation it treated 3,000 tons of good-grade ore, but the extraction was so low that the total output was only about $10,000.

[20a] By November, 1922, the southeast drift had been extended to a point 100 feet inside the Guarantee ground, with encouraging results. The ore at that point, which is at a vertical depth of 700 feet, is said to be similar to the high-grade ore of the Legitimate mine, found in tunnel No. 2 at a depth of 60 feet, and the managers infer that it probably extends to a much greater depth and that the principal deposits of the mine may be found considerably below the 700-foot level.

[21] U. S. Geol. Survey Bull. 497, pp. 67–72, 1912.

The mill is a 50-ton cyanide plant with a Chilean crusher and high tower head Burke filters and uses a combination leaching and amalgamation process. Much of the failure to make suitable extraction of the metallic contents in the ore is said to be due to lack of adequate crushing and grinding facilities. The Chilean crusher was put in only toward the end of the operating period, and about the same time a Trent agitator was added but not used.

The mine has about 2,000 feet of development work consisting mainly of tunnels, drifts, and stopes, mostly on the mill-tunnel level (fig. 13). The long crosscut tunnel is more than 700 feet in length, of which the last 80 feet is in the Paleozoic quartzite. The quartzite, which is described more fully on page 13, is so shattered and brecciated as to suggest its being on a fault zone. A strong stream of water that flows from the mouth of the tunnel practically drains the mine and also a considerable portion of the surrounding ground, apparently through the fault zone.

The mine is said to contain a moderate quantity of ore, mostly in the Pavlak vein. Most of the output came from this vein, chiefly from the upper workings. At the face of the workings the vein is said to be cut off by a fault, but it can probably be recovered to the south. The vein is 3 feet or more in width and contains good ore where it is exposed for several hundred feet in the mine.

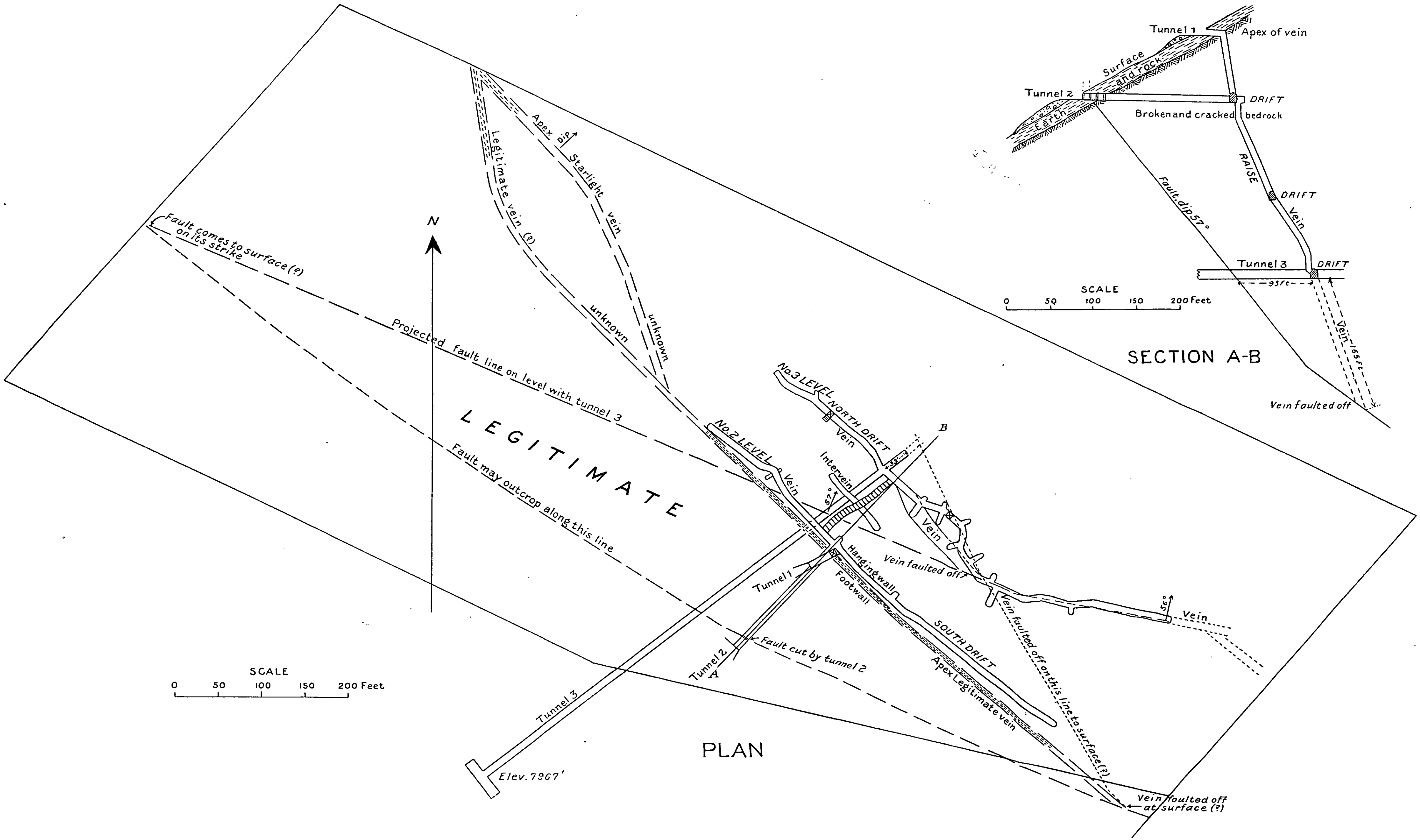
PICK AND SHOVEL MINE.

The Pick and Shovel mine is about 2¼ miles southeast of Jarbidge, 900 feet above Jarbidge River (Pls. II and XIX, *B*). With the neighboring Bluster and Success mines, it forms the Bonanza Hill group (fig. 14). These mines are described in the earlier report. The veins lie in the rhyolite and strike north-northwest with nearly vertical dips.

The Pick and Shovel property is owned and worked by John Escalon, the discoverer. In 1916 it produced $5,000 in gold ore. The ore was treated by the amalgamation process in a 3-stamp mill down near the river and the mouth of Bonanza Gulch. It came from a branch of the Pick and Shovel vein on the northwest, known as the Fleming or Arizona Fraction vein.

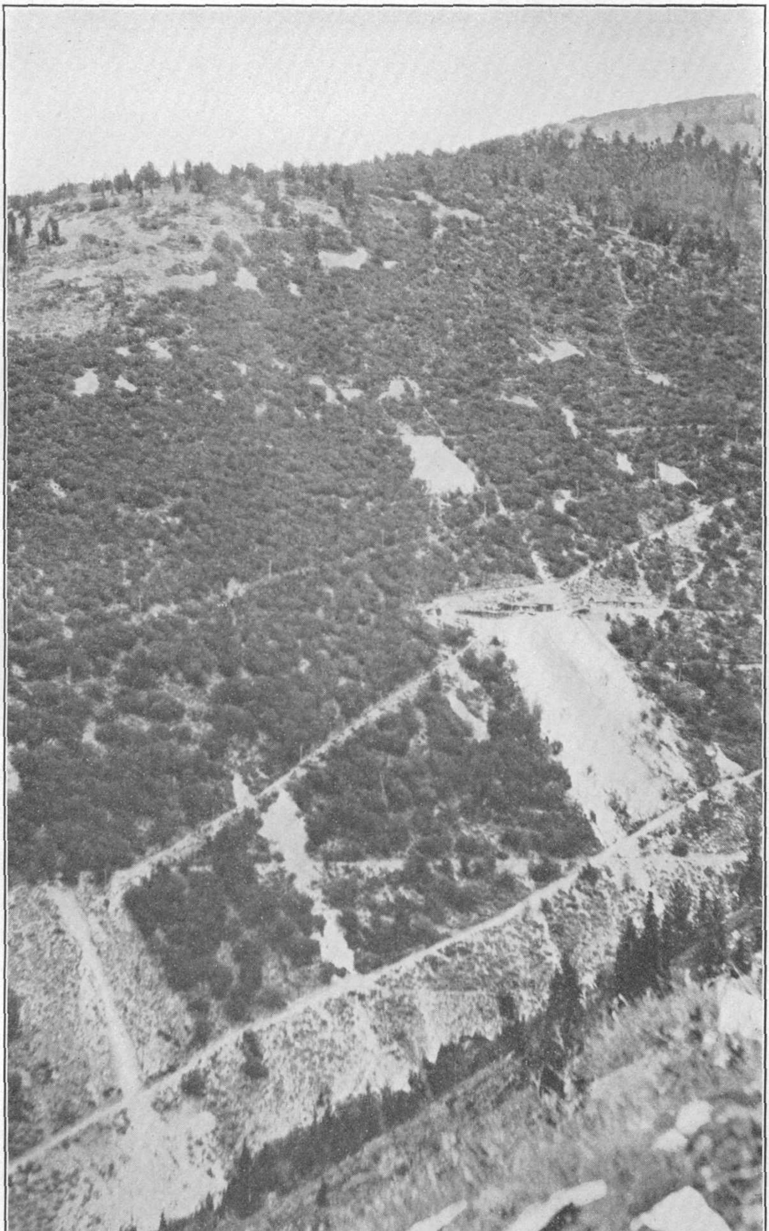
The mine is developed by 1,000 feet of workings, distributed interruptedly through the length of the claim and consisting mainly of several crosscut tunnels, one of which is 300 feet long, a 60-foot shaft, and several short drifts.

The vein is from 5 to 20 feet wide. It dips steeply eastward, into the mountain side, or is vertical. It is mostly quartz, much of it pseudomorphic after spar. It is relatively very sound and is firmer



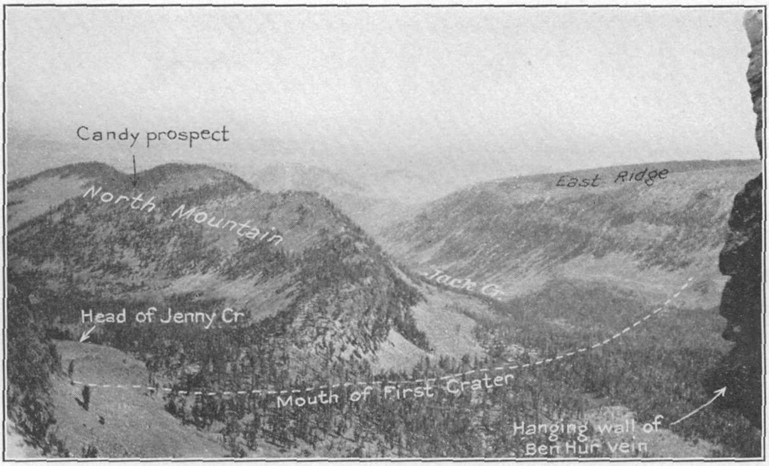
PLAN AND SECTION OF LEGITIMATE MINE.

By A. L. Rincarson.



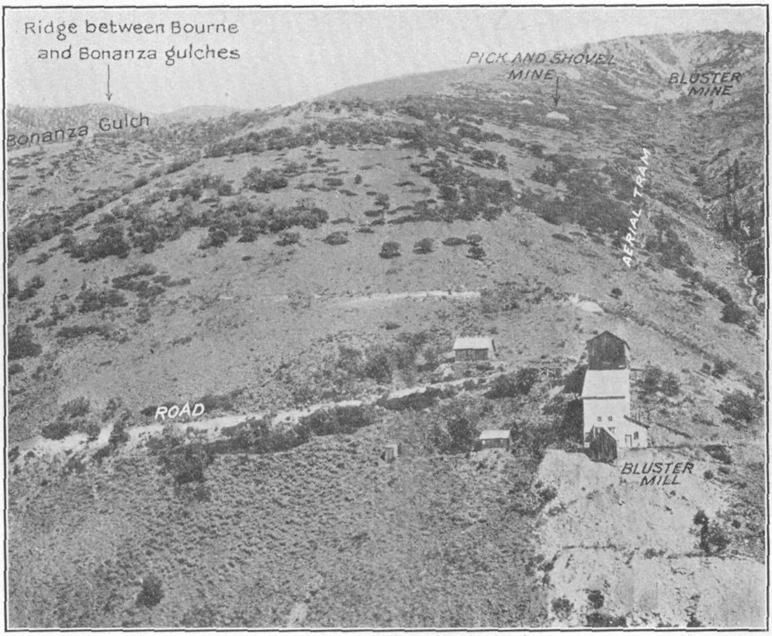
LEGITIMATE MINE.

Looking northwest across Bourne Gulch. Part of Starlight mine at left. The timber on the slope is mostly mountain mahogany.



A. NORTH MOUNTAIN AND CANDY PROSPECT.

On northerly extension of Altitude vein. Looking northeast from rim of First Crater and intersection of Ben Hur vein (shown in Pl. IV, *A*). Photograph by Claude C. Gillham, taken in August.



B. BLUSTER AND PICK AND SHOVEL MINES.

Looking east from west slope of Jarbidge Valley. Photograph by Claude C. Gillham.

and harder than the neighboring Bluster and Success veins. It carries good ore shoots, some of which are rich, and generally the ore shows much free gold associated with bluish-black argentite. Brownish areas several inches in diameter of surfaces of the ore are heavily frosted with fine spongy porous gold or electrum. A considerable portion of the ore averages about $3.50 to the pound. The gold runs about $12 to the ounce. In the fall of 1920 a southeast branch of the vein opened by a 95-foot crosscut was found to be 4 feet wide and to pan about $40 in gold to the ton.

BLUSTER MINE.

Location. — The Bluster and Success mines are 2½ miles southeast of Jarbidge, east of the Pick and Shovel mine (Pls. II and XIX, *B;* fig. 14). They are adjoining properties and are on the same vein, the Bluster or Bluster-Success vein. The vein approximately parallels

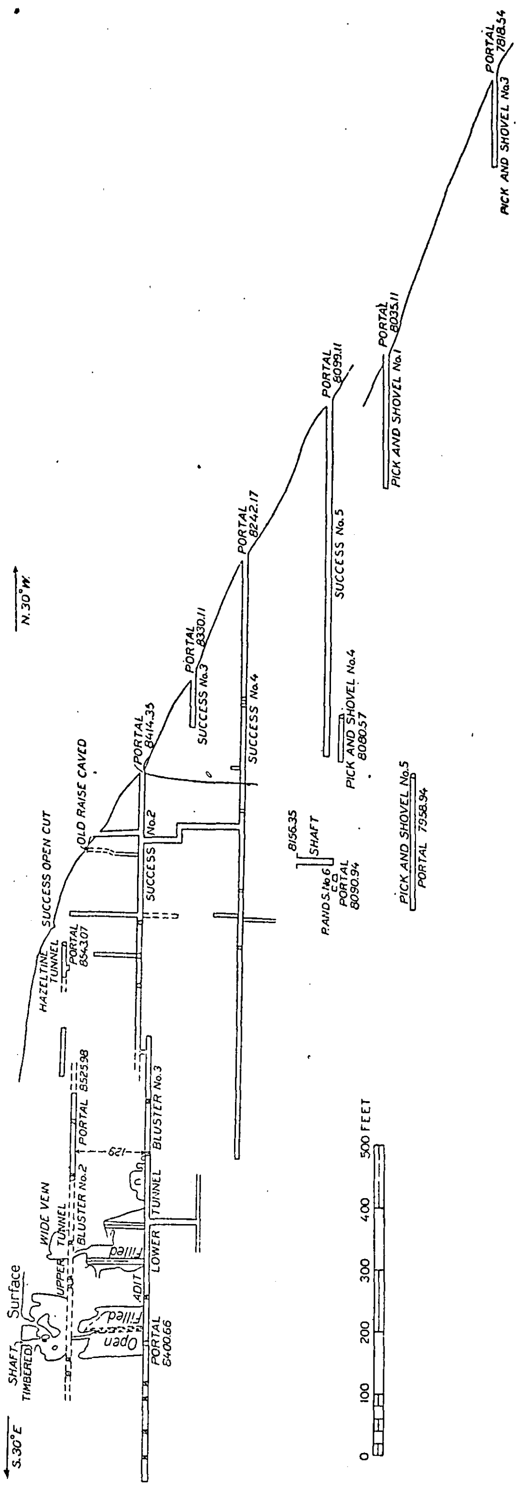


FIGURE 14.—Section of Bonanza Hill mines, with Pick and Shovel workings projected thereon.

the Pick and Shovel vein but is 800 feet distant from it horizontally to the east and 500 feet higher up the mountain slope, its apex having an elevation of about 8,600 feet. It strikes N. 30° W. and dips 60° E., into the mountain side. It is said to have a known extent of 1 mile, from Bonanza Gulch on the north to Gorge Gulch on the south. It ranges from a few feet to 45 feet in width, and though parts of it are barren the greater portion, so far as it has been exploited, is workable. The ore is mostly of the soft sugary quartz variety and is thoroughly oxidized. The best ore is found about 6 to 8 inches from the footwall side. The widest ore shoot is 26 feet in width and is best developed on No. 2 level of the Success mine. The ratio of gold to silver contained in the ore ranges from 15:1 in the Success to 3:1 in the Bluster. The Bluster mine is at an elevation of about 8,000 feet, or 1,300 feet above Jarbidge River.

History.—The Bluster vein was discovered early in the history of the district. Almost from the time of discovery the Bluster mine has been owned by the Bluster Consolidated Mines Co., of Jarbidge. About 1911 George Wingfield took a bond on the Bluster and Success mines jointly, but he soon discontinued the bond for want of an extension of time. Then the Bluster Co. opened up the veins, put in a 10-stamp straight amalgation mill below the mine near the river, and built a 3,400-foot aerial tramway with ⅓-ton buckets to connect the mine and mill. The company operated the mine and mill for six months in 1914 and produced $70,000 in gold bullion, but as the process of treatment was not suited to the ore the extraction was only about 35 per cent, with the result that nearly two-thirds of the metallic content of the ore treated, or about $140,000 in gold and silver, lies in the tailings pond. Since then only assessment work has been done on the property.

In September, 1921, it was reported that the property had been purchased by the Bonanza Gold Mining Co., of Los Angeles, and that operations would soon be resumed.[22] Later it was reported that the Bluster and Success mines had been examined by Chicago interests,[23] and in August, 1922, that negotiations were still pending. In November the company was said to be cutting much saw timber and excavating ground for a cyanide plant.

Development and equipment.—The mine is opened to a depth of about 300 feet by 3,000 feet of workings, chiefly drifts and adit crosscuts (fig. 14). There are two principal levels, the lower, or level No. 3, at an elevation of about 8,400 feet and the upper, or level No. 2, at an elevation of about 8,500 feet. On the lower level, which is the more extensive, the approach to the vein is a 400-foot crosscut tunnel leading from the head house of the aerial tramway.

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[22] Eng. and Min. Jour., Sept. 17, 1921, p. 473.
[23] Salt Lake Min. Rev., Nov. 30, 1921.

The equipment includes chiefly the 70-ton stamp mill and 3,400-foot aerial tramway above described and buildings sufficient to house 35 men. Good water and timber occur near by.

Ore deposits.—The deposits are contained chiefly in the Bluster vein, which is from 3 to 45 feet wide. The walls in general are well defined and are accompanied by a sheet of kaolin-like gouge. Together with several branches the vein has an extent of nearly 2,000 feet on the property. It is opened to a depth of about 300 feet and contains large and valuable ore bodies. A considerable tonnage of milling ore has been blocked out. The ore occurs mostly in the footwall side of the vein and as metasomastic replacement deposits in the adjacent rhyolite. It is soft and breaks easily, and holes for blasting are often bored with an auger. The ore shoots are nearly parallel with the vein. They range from thin tabular sheets to flattish lenticular bodies nearly 20 feet in width and 200 to 300 feet in length. The ratio of the value of the gold to that of the silver contained in the ore is 3:1. The gold occurs free and alloyed with silver, or as electrum.

On the lower level northward for 380 feet from the crosscut tunnel the vein is locally 45 feet in width and in places contained good ore shoots, of which one of the best had a width of 8 feet and averaged $21 to the ton.

For 380 feet southward from the crosscut tunnel the vein for the most part has good walls and shows ore in places. A considerable percentage of the ore is said to have averaged $40 to the ton. The ore shoot is said to have an extent of 250 feet. The drift at the time of visit was entering good-looking quartz ore. At an intervening point a short crosscut to the north shows 2 feet of black shale or slate underlying a similar thickness of gray sandstone.

BIG VEIN PROSPECT.

On the Bluster ground between the south ends of the Pick and Shovel and Bluster mines and approximately paralleling the veins of these mines in strike and dip is the north end of the so-called Big or 80-foot vein. From the Bluster ground this vein extends southward across the Single Jack claim and is said to continue at least to Gorge Gulch, three-fourths of a mile distant, where the Indian Camp and Oregon groups are staked on it and other veins thought to be related to the Bluster vein. Where it has been prospected near the Bluster mine it is said to carry from $5 to $10 in gold to the ton.

SUCCESS MINE.

Location.—The Success mine adjoins the Bluster mine and is on the northward continuation of the Bluster vein, in the upper south-side slope of Bonanza Gulch (Pl. II, fig. 14). It is owned by the Success Mining & Milling Co., of Jarbidge.

History.—The deposit was discovered by Charles Nelson and associates in 1910, but at that time they did little more than assessment work and did not know that the deposit was on the Bluster vein. Rich pannings were found in the outcrop at the portal of No. 2 tunnel. The mine has not yet been worked for production. In 1911 George Wingfield took a bond on the property and did most of the work which has been done to date, but he relinquished the property late in that year for want of an extension of time. The owner then began work and developed the ore. In 1917 Mr. Hanford, of the Elko Mines Co., of Chicago, took a bond on the mine and drove the last 400 feet of No. 4 tunnel, but seemingly he did not find much ore and relinquished it late in that year. Since then both the Success and the Bluster mines have been inactive, it is said for want of funds to build plants having a treatment process suited to the ore.

Development.—The mine is developed through a vertical range of 500 feet by about 3,500 feet of workings, consisting mainly of adit tunnels driven from the north (fig. 14). Of these the longest are tunnels Nos. 2 and 4, 160 feet apart vertically. Tunnel No. 2, which is but a few feet above level No. 3 of the Bluster mine, has a length of 450 feet. Tunnel No. 4 extends 1,000 feet from the portal. The lowest tunnel (No. 5), 300 feet long, with the portal near Bonanza Gulch at an elevation of approximately 8,100 feet, 140 feet lower than tunnel No. 4, has not yet reached the vein.

Ore deposits.—The mine is reported to have more than $300,000 worth of ore blocked out, and some good ore lies on the dump. The ore is mostly of the soft, sugary quartz-adularia kind and is said to average about $16 to the ton. The ratio of the metals contained in the ore is said to be about 1 ounce of gold to 1 ounce of silver. The proportion of silver increases toward the southerly part of the mine, where the vein is 30 to 40 feet wide.

On level No. 2, at 50 feet from the portal, the vein looks well and has an ore shoot 6 feet wide extending for a considerable distance. From the 150-foot point inward another ore shoot 9 feet wide looks well. It is banded, has well-defined walls, and is said to average $15 to the ton.

In the Discovery cut, 140 feet above the portal of level No. 2, is a 6-foot ore shoot said to average $35 to the ton.

On level No. 4 the face of the drift on the vein shows 3 feet of good quartz ore. The first 100 feet or more of drift on this level is on a smaller parallel vein that lies 40 feet east of the main vein.

JARBIDGE CENTRAL PROSPECT.

The Jarbidge Central prospect, just north of the Success mine, on the opposite side of Bonanza Gulch, is said to show good ore in its 50-foot shaft and several cuts.

BUCKEYE MINE.

The Buckeye mine is nearly 1½ miles southeast of Jarbidge, at an elevation of about 6,000 feet, or 1,800 feet above the river (Pls. II and III). The property comprises two claims—the Stray Dog and

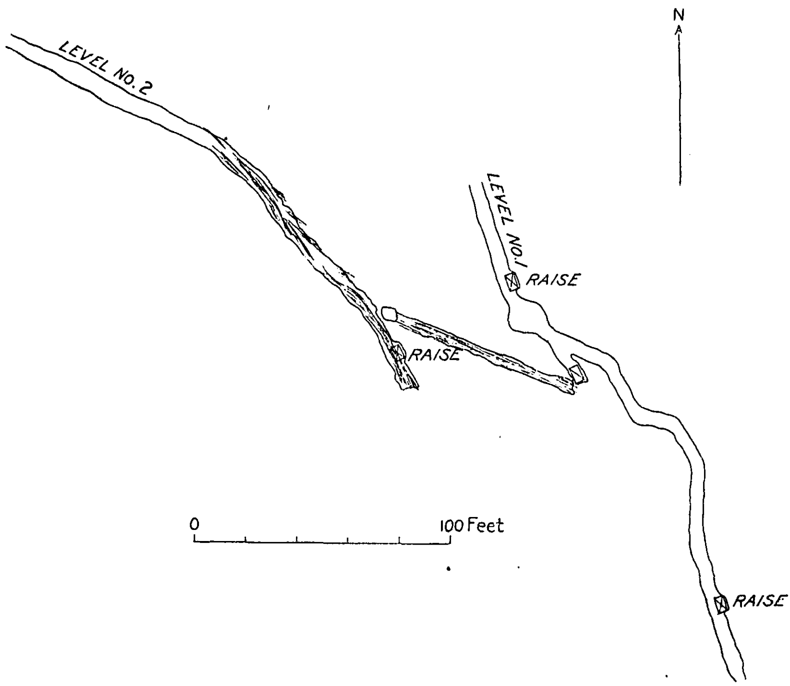

FIGURE 15.—Plan of Buckeye mine.

the Buckeye—and adjoins the patented ground of the Elkoro Mines Co. on the northeast. The deposit was discovered in 1910 by A. Dufrens and S. G. Hull, of Jarbidge, who with others later formed the Buckeye Mining Co., the present owner, which has been steadily developing the property and has opened about 1,000 feet of workings and blocked out about $75,000 worth of ore (fig. 15). It is estimated that about $3,000 in gold was recovered with an arrastre by early-day lessees. The ore is said to average $20 to the ton. Some of it is very rich.

COLD SPRING MINE.

The Cold Spring or Alice May mine, owned by the Cold Spring Mining Co., of Jarbidge, is north of Bonanza Gulch, between the Buckeye mine and the Jarbidge Central prospect, at an elevation of about 8,000 feet (Pls. II and III). The deposit was discovered in 1910 by Messrs. Dufrens and Hull. The property comprises five claims and is on three veins, all of which are said to have been opened to the north and to the south of the property with good results. The mine is developed by about 700 feet of workings similar to those of the Buckeye mine but not so extensive.

NORMAN MINE.

The Norman mine is about 8 miles south-southeast of Jarbidge, at the head of Jarbidge River, in the upper west slope of the Crater Range, about half a mile from the Marys River divide, at an elevation of about 9,100 feet (Pl. I). It is owned and worked by Olaf Norman, of Jarbidge, who discovered the deposit in July, 1910, by panning float on the mountain side. The property comprises a group of seven claims (Pl. XVI).

The country rock is old rhyolite, relatively coarse grained and in part porphyritic. It is profusely speckled by wine-colored quartz, much of which, owing to the abundance of iron oxide, resembles on casual observation reddish-brown garnet. The rock in general contains considerable iron oxide in grains and some in disseminated small cubes after pyrite. Much of it is stained yellowish brown with limonite and on joint faces and seams is more or less coated with pyrite.

The Norman vein strikes N. 25° W. and dips 80° W. In the present workings it has a maximum width of about 50 feet and apparently lies in a strong fissure. The mine is worked for gold but contains also silver and shows indications of copper. It is developed by about 1,600 feet of workings, consisting chiefly of three crosscut tunnels and drifts distributed through a vertical range of nearly 300 feet between elevations of 9,000 and 9,300 feet. Most of the workings are timbered and equipped with tram tracks. Water and timber are plentiful. A strong stream of excellent water flows from tunnel No. 2.

At the time of visit the vein was best exposed in tunnel No. 2. This tunnel, which is on the Lake claim at an elevation of 9,170 feet, cuts the vein at a depth of 60 feet at 100 feet from the portal (fig. 16). Here the vein walls are about vertical, are smooth, and look well. In the drifts on either side of the tunnel the first 2 feet of the hanging-wall side of the vein is ore averaging $23 in gold to the ton. The gangue is chiefly quartz, with more or less brecciated and mineralized rhyolite, all thoroughly oxidized. At about 25 feet from the tunnel, on each side, however, the ore and in part the vein cease, as if cut off by faulting, but in the muddy condition of the ground at the time of visit this point could not be satisfactorily determined. At the south end of the ore shoot the sheeting in the wall rock dips 50° NW. Another sheeting dips 50° NE., and in the roof of the drift slickensided surfaces in brown clay dip gently north-northwest.

Near the middle of the vein occurs another ore shoot about 4 feet wide that averages $8 to the ton. About 40 feet north of the tunnel the hanging-wall drift cuts an oblique 3-foot shoot of iron-gray copper-silver sulphide ore in which chalcopyrite is the dominant ore mineral (fig. 16). It is reported that later development shows that a width of 9 feet of the vein carries chalcopyrite and that the chalcopyrite tends to occur in boulder-like masses. The gangue consists of a microcrystalline mass of orthoclase and quartz, in which are numerous fragments of freshly broken feldspar crystals, giving the ore much the appearance of a breccia. Sericite is abundant, and much of it occurs in bodies of considerable size composed of small elongated foils and fiber-like bits. The chalcopyrite is widely disseminated in grains or crystals and in aggregates or bodies and masses as much as a quarter of an inch in diameter, but it does not seem to replace phenocrysts or other minerals. Some of the chalcopyrite on its surface is altered to secondary chalcocite and black copper oxide. Associated with the chalcopyrite is a little pyrite, and weathered joint planes are stained reddish brown by hematite derived from the pyrite. The oblique position of the copper-bearing ore shoot suggests that it is younger than the vein. Mr. Norman reports iron-stained or gossan-like croppings at several points along the course of the vein to the north of the mine, which he regards as fair indications of copper.

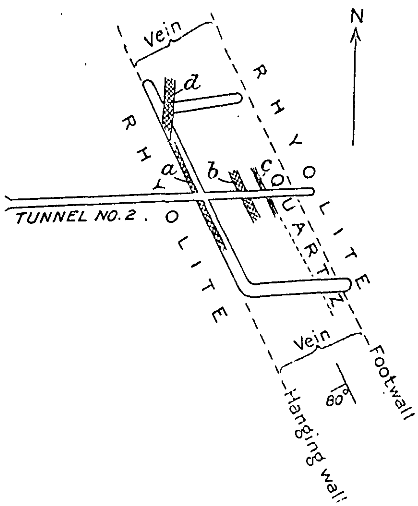

FIGURE 16.—Plan of No. 2 level of Norman mine. Scale, 1 inch equals 100 feet. *a*, 2 feet of $23 gold ore; *b*, 4 feet of $8 gold ore; *c*, kaolin-like gouge; *d*, dark quartz-gangue ore containing copper and silver sulphide minerals.

In tunnel No. 3, which is also on the Lake claim at an elevation of 9,180 feet and is 65 feet long, the vein shows 20 feet of sugary barren quartz. The dump of a 14-foot shaft sunk on the vein at an elevation of 9,300 feet contains considerable good-looking quartz.

Tunnel No. 1, on the Yellow Jacket claim, has a length of 364 feet. It reached the vein at a depth of 125 feet at a point 250 feet to the north of and 50 feet higher than tunnel No. 2. The cross section of the vein at this point, beginning on the hanging-wall side, is said to be as follows:

Section of Norman vein in tunnel No. 1.

	Feet.
Oxidized zone of quartz and ore	15
Sulphide zone of quartz and ore	12
Light-brown quartz (probably oxidized)	6
	33

The best ore is said to occur in the hanging-wall side of the sulphide zone, on which a 24-foot drift has been driven to the north.

That the vein is probably strong to the north of the Norman mine is indicated by the presence of large boulders of good-looking replacement quartz in the talus and float along the Jarbidge River trail in that vicinity. The vein is regarded by William Van Alder[24] as the southerly extension of the Altitude vein, and this view is probably correct, as it seems to be in the same fissure as that vein. But the vein itself is not known to have been carefully traced between the Altitude mine and the Norman mine. The intervening 4½ miles of country is mostly very rugged.

To the south of the Norman mine the vein is not so strong, but it continues through the low pass across the Marys River divide, on both sides of which it has been prospected by Al Knight and associates on the Summit and adjoining claims. The cut on the north side of the divide shows fairly good looking quartz, but being near the surface it is highly oxidized and leached.

MOORE PROSPECT.

The Moore prospect is two-thirds of a mile northeast of Jarbidge, in Moore Gulch half a mile above its mouth. It is on the south end of the Bluetop claim, which joins the Long Hike property (Pl. XVI). It is owned by Mr. Moore, of Buhl, Idaho. It consists principally of a fairly good looking 2½-foot vein, which at the cabin strikes N. 40° E. and dips 65° SE. The vein also shows in a near-by 20-foot shaft and 50-foot tunnel, where it is in part split up into several stringers. It lies in brownish-gray medium-grained rhyolite, which is hydrothermally altered, and contains considerable secondary quartz and other minerals.

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[24] Oral communication.

MINES AND PROSPECTS ON THE EAST VEINS.

The properties on veins of the east system are in the upper east slope of the Crater Range or near its crest on the west slope.

ALTITUDE MINE.

Location.—The Altitude mine is one of a group of six or more properties which might well be called the First Crater group, from their location in or near the First Crater (Pl. IV, *A;* fig. 17). They include the Altitude, Bullion, Ben Hur, Candy, New Star, New Hope, Red Dike, and others.

The Altitude mine, described as the Howard-McCoy mine in the earlier report, is 3¼ miles southeast of Jarbidge, in the upper east side of the Crater Range, at the head of Jack Creek, in the First Crater. It is in the steep south wall of the "crater," between elevations of 9,700 and 10,300 feet. It adjoins the Bullion property, described below, on the north.

The property comprises a group of six claims (fig. 18). It is owned and worked by the Jarbidge-Buhl Mining Co., of Buhl, Idaho, and Jarbidge. The camp is in the "crater" about one-third of a mile north of the mine. The production has been small, and it seemed doubtful whether the showings at the time of visit justified the large expense of building the electric-power line and wagon road to the mine. It was said, however, that the company planned to use the power line in developing the mine and finding ore before considering the project of building a mill, and later it was reported that considerable ore had been blocked out. During the open season of 1921 the mine and camp were fully equipped with a hoist and other apparatus for operating throughout the winter. Underground work with compressors supplied with electric power was started in November and continued till late in the spring of 1922, when operations were suspended, it is said for lack of funds.

Development and equipment.—The mine is opened to a depth of 500 feet by about 2,000 feet of workings, consisting mainly of an adit crosscut tunnel, drifts, and crosscuts (fig. 18). The tunnel starts on the Altitude claim.

The equipment consists chiefly of about 3 miles of electric-power line, which was built across the range from the Starlight mine in 1920; about 7 miles of good wagon road, built from Hot Springs up Jack Creek on the east; and buildings for housing a considerable force of men. Water and timber are plentiful on the ground or near by. The power line and a trail from Jarbidge enter the "crater" on the northwest (Pl. IV, *A*, and fig. 17).

Geology.—The country rock is the old rhyolite, which here, however, is near the upper part of the section of that rock and consists

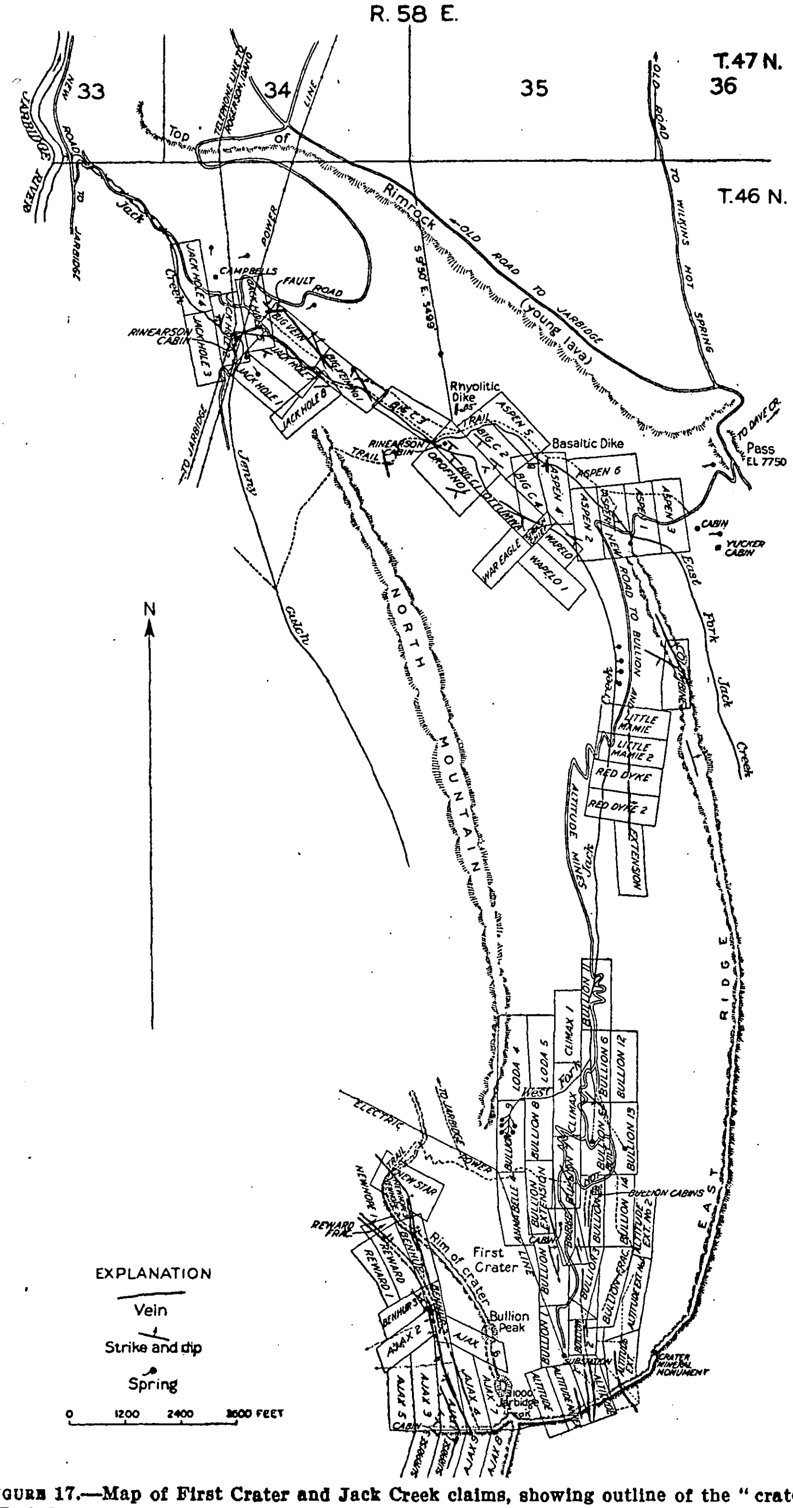


FIGURE 17.—Map of First Crater and Jack Creek claims, showing outline of the "crater," Jack Hole rim rock, and new road to Bullion and Altitude mines. By A. L. Rinearson.

of flows that are greatly varied in color and texture and are apparently considerably younger than the rocks occurring down near the river and the base of the section, as at the North Star and Pavlak mines. The color is mostly drab-gray or bluish gray of various

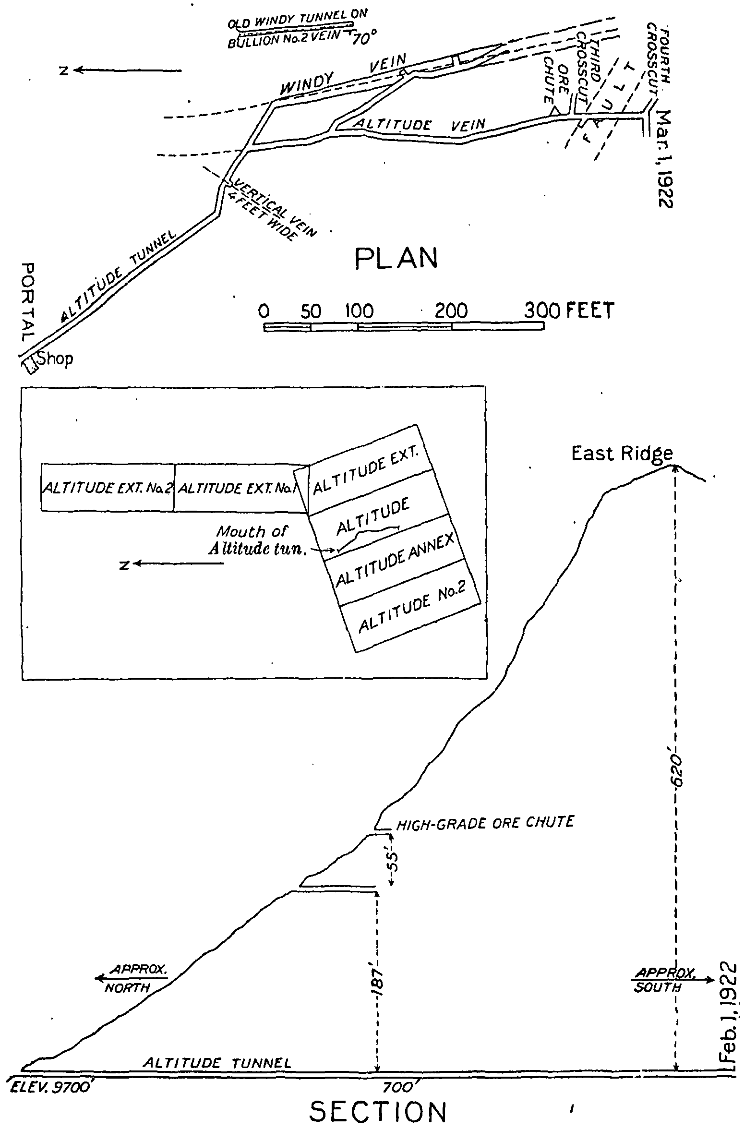


FIGURE 18.—Plan and section of Altitude mine. Scale of claim map, 1 inch=2,000 feet.

shades, and the texture is fine to medium grained. Flow structure and flow breccia are common. Associated with the rhyolite is considerable lignitic and other sedimentary material.

Ore deposits.—The mine is on two veins, the Altitude vein and the Windy vein (fig. 17), which in the first report were described respectively as the Howard-McCoy vein and the Van Alder or East vein. The present main opening is near the foot of the "crater" wall, 192 feet below the openings made on these veins in 1910. The veins strike about parallel and converge in dip. In the upper or old workings they are 140 feet apart, and in the present workings only 50 to 60 feet apart. The Altitude vein, which seems to be the richer, dips steeply to the east. It is opened to a point 800 feet from the portal of the tunnel and 620 feet vertically below the top of East Ridge. The Windy vein is opened to a point about 600 feet from the portal.

The veins are from 3 to 16 feet wide and are more or less banded. For a length of 140 feet the opened portion of the Windy vein is said to have carried $14 ore and locally ore that averaged more than $100 to the ton. There are barren places, however, in both veins.

The ore in both veins is gold ore, and the gangue is mainly replacement pseudomorphic quartz and adularia, as described in the earlier report.

At about 670 feet from the portal the Altitude vein is crossed by an east-west fault zone about 40 feet wide. It consists mostly of soft altered iron-stained rhyolite and contains numerous seams of talc-like material, most of which lie parallel with the fault. At 24 feet back of the fault the vein contains a 5-foot ore shoot with well-defined walls. A short distance back of the fault the company in February, 1922, began driving a crosscut eastward to intersect the Windy vein at a point about 100 feet beyond the face of its present workings.

To the south of the Altitude mine the veins are said to have been traced interruptedly for several miles through the "craters" and intervening ridges (Pl. XVI). Northward from the mine, down the Jack Creek valley, they have been traced for 1½ miles to a point where they seem to unite, as beyond that point only one vein, the Altitude, continues for a considerable distance.

BULLION PROSPECT.

The Bullion property lies in the floor of the First Crater at an elevation of about 9,500 feet and adjoins the Altitude mine on the north. It comprises a group of 17 claims known as the Bullion group (fig. 17). It is owned by the Crater Mining Co., of New York, which is said to be interested also in the neighboring New Star, New Hope, National, and Ajax groups, a total of 36 claims.

The Bullion claims are on what seems to be mostly the northward continuation of the Altitude and Windy veins, but they include other veins, which lie approximately parallel with these veins. The veins as a whole stand nearly vertical. Nearly all of them show replacement pseudomorphic quartz-adularia gangue and mineralized replaced rhyolite, and several of the openings show sulphide ore, or at least pyrite very finely disseminated through the veins. This is notably true of the Victoria No. 5 vein in the 65-foot tunnel on Bullion claim No. 3 and the 17-foot vein on the Bullion claim in the southwestern part of the property.

The general presence of sulphide at or near the surface is probably due to a locally high ground-water level being maintained in the "crater" by the abundant supply of water constantly issuing from springs and the melting of huge snowbanks that skirt the foot of its surrounding wall.

The veins are mostly narrow, being 2½ to 3 feet wide, though one recently opened is reported to be more than 20 feet in width. The Victoria No. 5 vein has a width of 4 feet. At the time of visit only shallow openings had been made on the veins, but in most of them the showings were good.

Since the writer's visit a 60-foot drift and crosscuts have been driven on the so-called 17-foot vein, which according to notes and specimens kindly furnished by Mr. A. L. Rinearson may be described essentially as follows: The vein lies in gray rhyolite about 700 feet west of the Altitude vein or its projected course, with which it is approximately parallel. It dips about 85° E. or is vertical and is 20½ feet wide. The footwall is regular and the hanging wall more or less irregular. The vein consists mostly of mineralized and replaced or bluish-gray rhyolite, which is similar to the country rock but which by the invading quartz-adularia (?) hydrothermal solutions has been largely changed to a gray sulphide ore, through which fine-grained pyrite and a little chalcopyrite are widely disseminated. Besides the minerals above mentioned, the vein also contains considerable secondary quartz-adularia gangue, sericite, and some chlorite.

The vein contains several parallel layers or zones composed essentially of relatively pure adularia or quartz-adularia gangue, of which the two thickest are a 2-foot layer at about 6 feet from the hanging-wall side and a 2½-inch layer at 11½ feet from the hanging wall or 9 feet from the footwall. The 60-foot drift is mostly driven on the 2-foot layer.

The adularia bands are stained brown or reddish brown with hematite and limonite and are sharply in contrast with the gray sulphide bands. They are fine grained and are free from pyrite and chalcopyrite, which have apparently been oxidized and in part leached out of them by descending percolating waters. Locally in open seams along the contact of the sulphide ore with the adularia ore the face of the sulphide wall is coated with adularia crystals 0.2 inch in maximum dimensions (Pl. IX, *A*). The crystals are mostly stained yellowish brown by limonite.

Near the foot of the west crosscut the vein is traversed by a small normal longitudinal fault which dips 60° W. The rhyolite above the fault is similar to the adularia layers in that it contains no pyrite, the pyrite seemingly having been oxidized and leached out. On claim No. 11 a 14-inch quartz vein which occurs on the footwall of a dike is opened by a 36-foot tunnel.

BEN HUR PROSPECT.

The Ben Hur prospect, formerly owned by the Vukovich Brothers, of Jarbidge, and now said to be owned by the Crater Mining Co., of New York, is in and near the west wall and adjoining rim of the First Crater (Pl. IV, *A*). It is about 2⅓ miles southeast of Jarbidge and half a mile west of the Bullion group. The property comprises three claims (fig. 17) and contains several veins, of which apparently the most valuable is the Ben Hur vein, which extends through the length of two claims on the property. The Ben Hur vein strikes about N. 20° W. and dips steeply to the east or is nearly vertical. It is best exposed on the north. Here on the north end of the Ben Hur No. 1 claim and adjoining New Star and New Hope ground the vein is gashed or broken through by erosion in the northwest corner of the "crater." The gash extends about 1,000 feet horizontally at the top or rim of the "crater" and 500 feet or more in depth to the floor. Through this nearly vertical distance the vein, especially its footwall, is more or less exposed in cross section on either side of the gash.

The vein is 2½ to 3 feet in average width, but on No. 2 claim it is 14 feet wide. It is composed mainly of the usual lamellar pseudomorphic quartz-adularia gangue and appears to be all oxidized. It is mostly banded and shows a fiber-like cross growth or structure, which becomes conspicuous by oxidation and weathering.

In general the vein is tight walled and relatively hard. In its exposed descent of 500 feet from the top to the bottom of the "crater" it shows no sign of pinching or weakening, and openings made in it on the New Star ground in the bottom of the "crater" are said to be encouraging.

Southward from the rim of the "crater" the vein or its branches have been opened at several points on Nos. 1 and 2 claims with moderately fair results, as have also other veins west of it on the No. 3 claim and on the Reward, Ajax, and other claims a little lower down the mountain slope to the west.

AJAX PROSPECT.

The Ajax prospect adjoins the Ben Hur on the south and the Altitude on the west (fig. 17). It is 3 miles southeast of Jarbidge, in the steep head slope of Bonanza Gulch, at an elevation of about 9,600 feet (Pl. VIII, *A*). The last mile of the approach is covered by a good trail. The property comprises 10 or more claims, known chiefly as the Ajax group. It is owned and worked by Pat Donahue, of Jarbidge. There are several veins in the vicinity, of which a total length of 3,600 feet is said to lie within the Ajax property. They probably include a southerly extension of the Ben Hur vein or a branch of it. They have been prospected at several points, chiefly by cuts and adit tunnels or drifts, some of which present fair showings. One of them, the Ajax vein, where opened by the Ajax tunnel at an elevation of about 9,800 feet, is 4 to 5 feet in width and dips 80° W. The face of the tunnel, which is 400 feet long, is 250 feet below the surface and contains 2½ feet of fairly good looking banded ore. The gangue includes, besides quartz and adularia, considerable altered rhyolite and clay.

CANDY PROSPECT.

The Candy prospect, which was not visited in this work, is about 2 miles east of Jarbidge and half a mile north of the First Crater, on the east slope of North Mountain between the heads of Jenny Creek and Jack Creek (Pl. XIX, *A;* fig. 17). It is owned and worked by Mark Leffler, of Jarbidge, who discovered the deposit in 1919.

It is said to be on the northward continuation of the Altitude vein, which is here from 5 to 15 feet wide, is banded, and contains a 10-inch shoot of high-grade ore that shows and pans much free gold. In a specimen of the ore received from the owner the gangue in which the gold is embedded is chiefly adularia. The specimen is highly oxidized. It is noncalcareous or contains no calcite and shows a very finely laminated and honeycombed pseudomorphic structure. A panning made of it shows the gold to consist of particles scarcely visible to the unaided eye. They are rough or sharply angular, even more so than those shown in Plate XIII, and nearly all are elongated or wiry. Some of the longer ones are longitudinally striated or filiform, the striations probably being due to twinning. Most of the gold is of a pale brass color, but some is a deep, rich yellow.

Associated with the gold concentrates in the pan is considerable fine-grained magnetite and a little zircon and apatite. Besides several small openings, a 270-foot crosscut, which now has a length of 110 feet, is being driven to tap the vein at a depth of 100 feet.

The property contains also several small yellowish gold-bearing veins lying in or near a rhyolite dike, with which they are parallel.

RED DIKE PROSPECT.

The Red Dike prospect, also called the Red Vein, concerning which the following data were kindly furnished by Mr. Pat Donahue, is on East Ridge, on the southeast side of Jack Creek and the First Crater (Pl. IV, *A;* fig. 17). The vein was discovered by Mr. Donahue in 1916 and is owned by Finch & Sons, of Alazon, Nev. It extends from an elevation of about 8,000 feet southward up the ridge for about 2,000 feet. It is from 2 to 12 feet wide and dips 35° E., into the ridge. It consists chiefly of a quartz-adularia gangue which is more or less greenish and similar to that of the Pick and Shovel mine. The value is chiefly in gold and ranges from $1 to $40 to the ton.

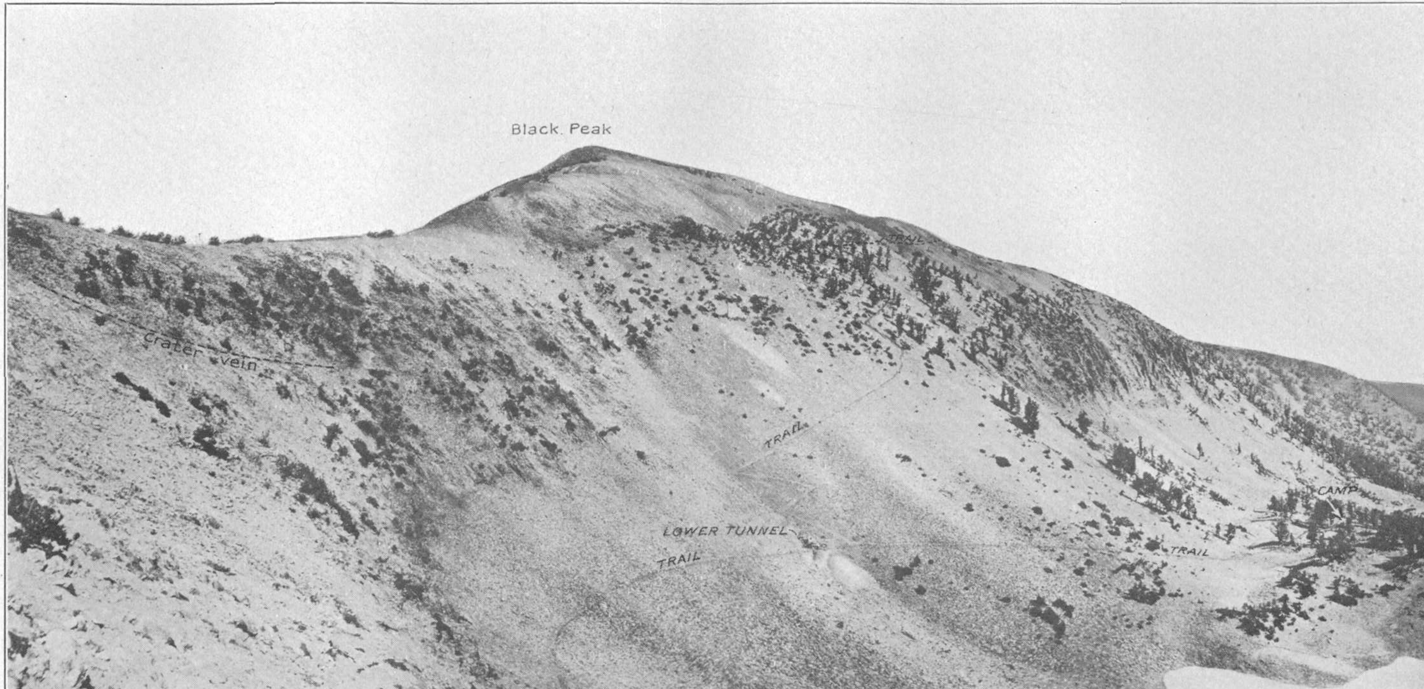
MORNING STAR MINE.

The Morning Star mine, formerly known as the Arkansas property and so described in the earlier report, is in the head of the Third Crater, 4 miles southeast of Jarbidge (Pl. XX). It is reached by way of the Bonanza-Bluster or Crater trail. The deposit was discovered in 1910 by Ralph F. Harder and Bishop Norman, of Jarbidge, who in the next five years did considerable development work on it. It is owned by Harder & Gillham. The property comprises 10 claims and contains 4,500 feet of the Morning Star vein, formerly called the Harder-Norman, supposed to be the southward continuation of the Windy vein. This vein is intersected by the Altitude vein, of which about 3,000 feet lies on the property (Pl. XVI).

The Morning Star vein, which is about 7 feet wide, strikes about N. 20° E. and dips 80° W., and the Altitude vein, which is 5 feet wide, strikes N. 20° W. and dips 80° E. The Morning Star vein is opened by an upper 103-foot drift, a lower 300-foot crosscut, from which 80 feet of drift extends northward to the junction of the two veins, and several open cuts, all of which are said to yield good returns. It contains 1 foot of $12 ore in the footwall side, and its remaining 6 feet averages about $3.50 to the ton.

BATY PROSPECT.

The Baty prospect is in the Fourth Crater, 4½ miles southeast of Jarbidge (Pl. V, *A*). It is owned by Mrs. Etta Baty, of Jarbidge. The vein, which strikes about north through the length of two claims, lies about one-third of a mile east of the Altitude vein (Pl. XVI). It seems to be a compound vein or lode. It is said to be 50 feet in width and to contain numerous parallel high-grade ore shoots from 3 to 6 feet in width, which appear to be exceptionally encouraging.



MORNING STAR MINE.

In head of Third Crater. Looking west. Photograph by Claude C. Gillham, taken September 1.

COUGAR MOUNTAIN PROSPECT.

The Cougar Mountain prospect is 7 miles southeast of Jarbidge, on Cougar Mountain, between the Fifth and Sixth craters (Pl. V, *B*). It contains several openings. It is owned by Knight & Blakely, who have done considerable development work on it in the last five years. The veins, of which there are several, are said to be promising.

PLACERS.

The only placer deposits in the district are the so-called Park placers, on Jarbidge River below Jarbidge, and a few similar deposits on the East Fork, none of which, however, seem to have any value.

The eroded portions of the Jarbidge veins doubtless yielded detrital gold enough to form workable placers of considerable extent, but owing to the character of the gold, the fineness and the porous or fluffy structure of its particles, it is so buoyant in water that it is easily carried out of the district by the streams. This is indicated by the string of fine gold particles often found floating on the surface of the water in panning, and by observations made by Mr. Donald Steel[25] on gold washed out of thawing Jarbidge dumps, the gold being concentrated only at the termini of the streams without a trace being deposited in the intervening riffle-like fractures, crevices, and rock cavities over which it passed.

Deposits of the Jarbidge class are probably an important source of the well-known placer gold which is so abundant in many places along Snake River but which, owing to its extreme fineness and buoyancy, has baffled repeated attempts to recover it.

FUTURE OF THE DISTRICT.

As practically no work has yet been done in the sulphide zone that would afford data for forming an opinion concerning the probable continuation and character of the deposits in depth, the following forecast is based largely on experience and results with similar deposits in other districts.

Nearly all the ore thus far mined in the district has come from the oxidized zone and owes its metallic content largely to enrichment. The enrichment was accomplished mainly through the agency of descending meteoric waters, which leached the metallic contents from the higher parts of the veins before they were eroded away and concentrated them in the lower parts, which are now being mined. Some of these oxidized deposits, as shown in a few of the mines, extend to maximum depths of about 700 feet. They apparently decrease in depth with nearness to the axis of the Crater Range, where the sur-

[25] Oral communication.

face slopes that shed the meteoric water steepen. In some of the veins there still remains a fair reserve of this class of ore.

As the veins with increase in depth extend into the sulphide zone they must be expected to become more regular in tenor, but narrower and leaner than they are in the oxidized zone. Many of them probably extend to considerable depths, and some of these are probably workable. Most of them, however, are likely to become too narrow or too lean to be workable in depth, their silver and gold minerals giving way to practically barren pyrite. The outlook for deep mining in the district is therefore not regarded as encouraging.

Although active mining in the Jarbidge district will continue for several years, the fate of certain valuable unworked deposits in other remote districts of the West, from which after a prosperous period of activity expensive power lines were removed and the districts abandoned, should suggest to the Jarbidge owner the advisability of working his mine while power and transportation are so readily available as now.

CHARLESTON DISTRICT.

LOCATION.

The Charleston district, also called the Copper Mountain district, adjoins the Jarbidge district on the southwest. It was not examined in this work other than by meager observations made from the auto-stage on the Elko-Jarbidge road. The present description is based largely on information gathered from prospectors and engineers who have visited different parts of the district and accordingly is general in character.

The district is a somewhat indefinite area contained mostly in a north-south belt about 5 miles wide by 20 miles long, extending from about the latitude of the north edge of the Jarbidge district southward to Charleston, where it includes the Charleston district of early days. The natural boundary between the two districts is the high mountain ridge southwest of Jarbidge separating the Jarbidge River drainage, represented by Bear Creek and Pine Creek, on the east from the Bruneau River drainage, represented by Coon Creek and Copper Creek, on the west (Pl. I). The country east of the ridge is more accessible from the northeast or Idaho side, and that west of it from the south or Elko side.

The discovery of mineral deposits in the district must have at least preceded the rise of Charleston as an early-day camp, which is said to have been in 1885 but may have been in 1876, the year from which 76 Creek is said to take its name. At any rate, Charleston came into existence through gold-placer mining at a site 4 miles to the north, on 76 Creek, near the southwest base of Copper Mountain. It soon became a lively camp, with three schools, several stores, a hotel, ice house, saloon, and other buildings, some of which still remain. The site is in the midst of a wide hilly sagebrush basin, largely surrounded by mountains, which are mostly low and in part bare and which on the northeast slope up into the main range.

TOPOGRAPHY.

The district is strongly mountainous. It lies in the westward continuation of the Jarbidge Mountains and their west foothills, which slope down nearly to Bruneau River at an elevation of about 6,000 feet northwest of Charleston. It is drained chiefly by Coon Creek on the north and Copper Creek and 76 Creek on the south, all of which flow into Bruneau River. The most prominent topographic feature is Copper Mountain, near the center of the area. It rises to an elevation of about 10,000 feet and is separated from the main mass of the Jarbidge Mountains by the deep valley of Coon Creek and the Charleston saddle or pass, which has an elevation of about 8,500 feet and is traversed by the Elko-Jarbidge road.

Copper Mountain is a relatively compact domical mass about 4 miles long by 2 miles broad and trends a little west of north. On the east and north it is largely encircled by Coon Creek; on the south its surface slopes off rapidly into Copper Basin, a deep depression several miles in diameter drained by Copper Creek and its tributaries. On the west the surface declines 4,000 feet nearly to Bruneau River. Copper Basin is separated from 76 Creek on the southeast by a long sloping ridge, which the Elko-Jarbidge road ascends.

Beyond Coon Creek the axial uplift of Copper Mountain seems to be continued northward by a lower range locally known as the Buck Creek Mountains. This range is said by Mr. A. L. Rinearson to lie mainly in Tps. 40 and 47 N., R. 57 E., and to extend nearly to the Idaho State line.

GEOLOGY.

The country rocks of the district are principally the Paleozoic sedimentary series already described in connection with the Jarbidge district. They consist, in ascending order, of schist, quartzite, limestone, and shale. These beds have been considerably faulted and folded. They mostly dip to the north and exhibit a general thickness of several thousand feet. They rest upon gray, coarsely crystalline hornblende granite, which seems to be intrusive, and are cut by dikes of slightly younger granodiorite. Locally they are overlain or capped by thin flows of the Jarbidge old rhyolite.

The accompanying sketch map (fig. 19), by Mr. Frank Erno, of Jarbidge, is introduced to show the relative position of the principal rock formations and places of metallization, in the belief that it will be helpful to the prospector visiting the district in the near future. On the map have been added a few notes from other sources.

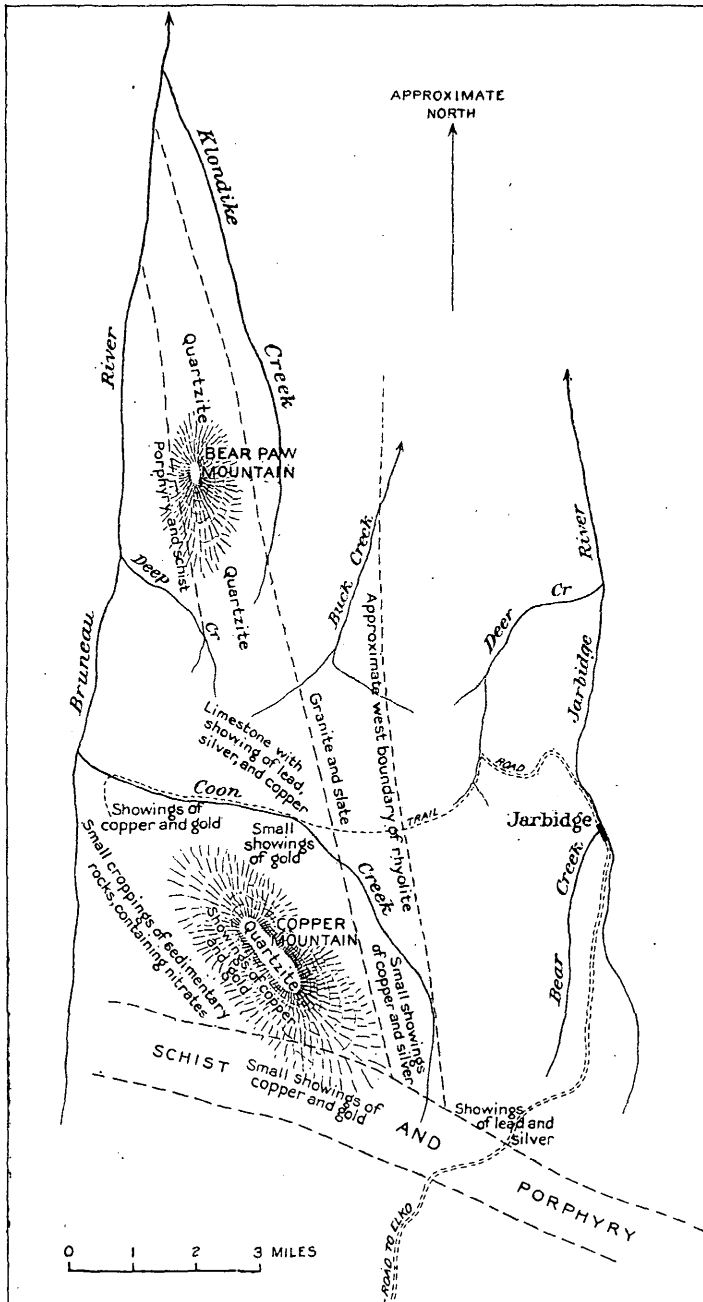


FIGURE 19.—Sketch map of part of Charleston district, showing relative position of principal rock formations and areas of mineralization. By Frank Erno.

In the Buck Creek Mountains the rocks are said to be block faulted on a large scale. Near the head of Buck Creek they dip to the southwest, and at the north end of the mountains they dip to the northwest.

Some of the quartzite, as seen in the gravels of 76 Creek, a few miles above Charleston, and in place at the head of Copper Basin, is a hard gray to brownish-gray rock and seems to be relatively very old. A specimen collected by Mr. Erno at Bear Paw Mountain, in the northern part of the district, is a black fine-grained rock that somewhat resembles slate but is hard, siliceous, heavy, and slightly laminated or cleaved.

As exposed on 76 Creek along the Elko-Jarbidge road, 3 to 6 miles above Charleston, where limestone and black or dark shale form the mountains that rise 600 to 1,000 feet on either side, the limestone is mostly bluish lead-gray to buff and is in part heavy bedded. It extends northwestward, seemingly into Copper Mountain.

The gravels of 76 Creek, which are mostly rhyolite, contain also several varieties of limestone—fine-grained noncrystalline, blue semicrystalline, blackish medium-grained crystalline, and white crystalline calcite or marble. The different degrees of crystallinity probably represent different phases of contact metamorphism due to the intrusion of the igneous rocks rather than large bodies of these several varieties of limestone.

The upper parts of Copper Basin and 76 Creek valley contain a considerable deposit of whitish volcanic ash, locally called "limestone." In the northeastern part of the basin the deposit is eroded into low rounded hills and mounds of fairly regular shape and uniform slope. It seems to have a thickness of several hundred feet and to rest mainly on the sedimentary rocks, but on the north above the road, at an elevation of 8,100 feet, it locally extends up onto the rhyolite.

The intrusion of the limestone and other sedimentary strata by granite and allied igneous rocks renders conditions in the district peculiarly favorable for the occurrence of mineral deposits. The useful minerals known or reported to occur there are gold, silver, copper, lead, antimony, manganese, nitrates, and oil shale. They are about all in or near Copper Mountain (fig. 19).

METALLIFEROUS DEPOSITS.

LODES.

The metalliferous lode deposits occur in the sedimentary Paleozoic rocks and their associated granitic intrusives. They occur chiefly as tabular fissure veins having a quartz gangue, but they may include also contact-metamorphic and replacement deposits in the limestone, such as occur in the Contact and other neighboring districts. From their association with the granitic intrusive rocks the deposits are regarded as probably of Cretaceous age. A few of them are credited with a small production.

GRAHAM MINE.

The Graham mine, owned by Charles and Edgar Graham, of Charleston, is on a quartz lode in limestone in the hillside a few hundred feet west of 76 Creek, in the same general vicinity as the gold placers above noted, 4 miles north of Charleston. It is said to contain 1,600 feet of underground workings, most of which have been opened in recent years. The tunnel drift, 900 feet long, is on a good vein, which in 1914, when examined by Mr. Erno, is said to have contained an 18-inch ore shoot of $16 ore. The ore when hand sorted ran 24 per cent in copper and $6 in gold to the ton.

PRUNTY MINE.

The Prunty mine, owned by the Messrs. Prunty, of Charleston, is on 76 Creek about one-third of a mile above the Graham mine. It has been worked intermittently since 1905, and the ore was treated in a hydraulic 5-stamp mill, water being brought to the mill in a ditch around the side of the mountain. The production has been small. The metals produced are silver, gold, copper, and antimony. Antimony seems to be present in the ore in considerable quantity, as it alone is said to be nearly sufficient to pay for operating the mine.

PROSPECTS.

Prospects of one or more of the metals above listed occur at various places in the district, most of which are indicated on figure 19.

A lead-silver prospect in the northeast rim of Copper Basin along the wagon road is in limestone and quartzite, which crops out through the Jarbidge old rhyolite at or near its western margin. A little work has been done on this prospect.

At several points 1 to 2 miles northwest of this prospect, in the east slope of Copper Mountain, there are showings of copper and silver, and in the northeast slope of the mountain showings of gold.

On the upper west slope of the mountain copper and gold have been found, and at about the middle of the west slope is an old tunnel, the Carlton tunnel, 700 feet long, driven on copper deposits which are said to average about 2 per cent in copper but which were of too low grade to be workable at the early-day time of exploitation.

At about the middle of the northwest slope of the mountain are traces of manganese. A specimen of the mineralized rock at this place received by the writer from Mr. Vukovich, of Jarbidge, was found to contain considerable rhodonite (manganous silicate).

In the limestone area to the north of Copper Mountain and north of Coon Creek are said to occur good showings of lead, silver, and copper.

In the Buck Creek Mountains small quartz veins containing free coarse gold are said to occur in the slate and dark quartzite.

PLACERS.

The placer diggings, the first mineral deposits found in the district, were chiefly on the west side of 76 Creek about 4 miles above Charleston. Of the two ditches visible from the Elko road that lead the water from the creek around the steep mountain side, the lower one was used for placer mining and the upper one supplies power to the Prunty quartz mill, above described. The placers were doubtless derived from lode deposits, probably from lodes that now occur near by, as above described. But they may have been derived from lodes that have since been eroded away. Their occurrence and origin are of more than passing interest, as the adjoining Jarbidge district, with its numerous gold veins, has not yielded any placers.

NONMETALLIFEROUS DEPOSITS.

Down the west slope of Copper Mountain from the Carlton tunnel occur small croppings of sedimentary rocks that are said to contain nitrates.

Oil shale in float or talus is reported to have been found a few miles southeast of Charleston. As the formations of that locality apparently continue northward into the mountains on 76 Creek, it is probable that oil shale is contained in the limestone-shale series on and near the creek, in which the quantity of dark shale is large.

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