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from which the oxidation minerals may have been formed has yet been found.

F. Cornu,[20] in reporting the results of a search for the parent mineral of ilsemannite, states that the black mineral from which ilsemannite is formed with water is a colloidal molybdenum sulphide (MoS_2), which he calls jordisite. His material was obtained from Himmelsfuerst, a little south of Freiberg, Saxony. Cornu's short notice is almost wholly lacking in necessary details and leaves much to be desired. It does not convince one that his material was really a sulphide of molybdenum. Such a mineral as that he supposed to exist might occur not only in complex sulphide veins, such as those of Himmelsfuerst and the Gilpin-Boulder County mineral belt, but here and there in deposits of molybdenite.

The evidence is not conclusive as to the composition of ilsemannite, though it seems to me, as it does to Schaller, more probably a molybdenum sulphate than a molybdyl molybdate.

Ilsemannite, like wulfenite, is probably formed from some unknown mineral, perhaps a sulphide.

[20] Natürliches Kolloides Molybdänsulfid (Jordisit): Zeitschr. Chem. Ind. Kolloide, vol. 4, p. 190, 1909.

ORIGIN OF CERTAIN RICH SILVER ORES NEAR CHLORIDE AND KINGMAN, ARIZONA.

By Edson S. Bastin.

INTRODUCTION.

The mineral deposits of the Cerbat Mountains between Kingman and Chloride, in northwestern Arizona, were described by Schrader[1] in 1909. The writer visited some of the silver mines and prospects of the Cerbat Mountains in 1913, in the course of a study of silver enrichment undertaken by the United States Geological Survey in many mining camps of the western United States. The work of preparing the results for publication has been delayed by the war and other causes.

The practical application of the results lies in the determination of the extent to which the several silver minerals of the ore are secondary or primary and hence to what extent they are likely to play out at moderate depths or to persist below the reach of surface processes of alteration. The results are summarized at the end of the report.

The mines described were reached from Kingman, on the main line of the Atchison, Topeka & Santa Fe Railway, and from Chloride, the terminus of a short railroad line from Kingman.

GENERAL FEATURES OF THE AREA.

The area here considered is arid, with hot summers and mild winters. The annual precipitation is about 5 inches, almost never in the form of snow. The area is for the most part treeless, and its vegetation is of desert types.

The Cerbat Mountains constitute one of the numerous desert ranges of nearly north-south trend that form a characteristic feature of the Great Basin topography. In the parts of the range under discussion the altitude ranges between 4,000 and 6,000 feet.

The Cerbat Mountains consist in the main of pre-Cambrian igneous and metamorphic rocks, and these form the wall rocks at all the mines

[1] Schrader, F. C., Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Ariz.: U. S. Geol. Survey Bull. 397, 1909.

visited. Near Kingman and along the western flank of the range occur rhyolite, andesite, and other volcanic rocks of Tertiary age. The familiar desert wash occupies the valleys that flank the mountains.

The ore deposits of the Cerbat Mountains are veins of prevailingly northerly or northwesterly strike and steep dip. All those studied have been worked mainly for their silver content, although minor amounts of gold were present in some. A few veins worked mainly for their base metals were not included in this investigation. The veins are believed by Schrader to have been formed in Tertiary time and to be connected in origin with the granite porphyry of the area.

The bulk of the silver produced in this area in the seventies and eighties came from oxidized ores extending from the surface to depths varying from 50 to 300 feet. Cerargyrite (horn silver) and native silver were the dominant silver minerals of these ores. In the lower part of the oxidized zone ruby silver (proustite) was commonly present, in places so abundantly as to constitute very rich ore. Most of the silver veins were worked to depths of only a few hundred feet and in 1913 had been idle for many years. Few workings could be entered, and samples of the ores were obtained mainly from the dumps or were generously donated by former operators from their personal collections. Specimens of the rich oxidized ores were not available, and these studies therefore relate almost wholly to the sulphide ores.

The reasons for the suspension of mining on most of the silver veins were probably complex. Foremost, perhaps, was the rapid decline in the price of silver between 1885 and 1895. To this was added the fact that the sulphide ores were in general not as rich as the oxidized ores and were more costly to mine. Resumption of mining during the recent period of high silver prices has perhaps been hindered by a fear that the best of the ruby silver ores also owed their richness to enrichment by waters of surface origin, but as indicated on pages 36–39 this belief appears to have no justification in fact.

CHLORINE IN SURFACE WATERS.

The abundant development of silver chloride in the oxidation of the ores of this desert area suggested the testing of the surface waters for chlorine by neutralization with silver nitrate tablets of known weight in the presence of an indicator. Because most of the streams are intermittent only one good opportunity presented itself for such a test. The water of a stream in Tennessee Wash, a quarter of a mile east of the Elkhorn shaft, was collected at a point where it emerged from a dry wash. This water carried about 80 parts per million of chlorine, a large content as contrasted, for example, with the average chlorine content of surface waters close to the New England coast, which is about 6 parts per million.[2] For comparison may be cited the chlorine content of 65 parts per million[3] in descending mine waters in the West End mine (500-foot level) at Tonopah, Nev., and of 127 parts per million[4] in similar waters of the Comstock lode, Nev. Both these Nevada waters occur in regions climatically much like the Chloride-Kingman area.

DETAILED DESCRIPTIONS.

DISTAFF MINE.

The Distaff mine is about three-quarters of a mile east of Chloride. The shaft is on the southwest slope of a small hill, and the shaft collar is about 250 feet above the level of the plain on which the town is situated.

The wall rock is somewhat gneissic granite, and the vein, 2 to 3 feet in width, is nearly vertical and strikes nearly north, about parallel to the foliation in the granite. The vein has been traced for about a mile. The principal surface indications of the presence of a vein are several bands of white quartz 1 to 3 inches in width. When this quartz from the surface is broken it is occasionally found to inclose pyrite, but commonly small limonite-stained cavities mark the original position of the pyrite grains; in addition there is staining with limonite along fractures traversing the vein and the granite. There is no heavily iron-stained gossan or "iron hat."

The Distaff shaft was reported to be 265 feet deep, with short levels at 100, 200, and 250 feet. At the time of visit the mine was idle and the water stood about 220 feet below the collar of the shaft—that is, close to the level of the flats bordering the hill on which the mine is situated.

All ore above the 250-foot level is reported to have shown oxidation. Horn silver (cerargyrite) was the principal silver mineral from the surface to depths of 100 to 150 feet. Native silver was most abundant somewhat deeper; some occurred on the 100-foot level, but most of it between the 200 and 250 foot levels. Schrader[5] mentions the occurrence of slabs of native silver many pounds in weight. A specimen in the collection of Jack Lane at Kingman showed a slablike mass of native silver one-eighth of an inch thick along a fracture in sulphide ore. Wire silver occurred in small vugs in this ore.

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[2] Jackson, D. D., The normal distribution of chlorine in the natural waters of New York and New England: U. S. Geol. Survey Water-Supply Paper 144, 1905.

[3] Bastin, E. S., and Laney, F. B., Genesis of the ores at Tonopah, Nev.: U. S. Geol. Survey Prof. Paper 104, p. 29, 1918.

[4] Bastin, E. S., Bonanza ores of the Comstock lode, Virginia City, Nev.: U. S. Geol. Survey Bull. 735, p. 60, 1922.

[5] Op. cit., p. 60.

In ore from the bins argentite was noted in two associations—(1) in scattered thin fungus-like patches along fractures in unoxidized ore, and (2) intimately associated with proustite and pearceite in quartz-lined vugs in unoxidized ore; some of this argentite is well crystallized. In one specimen from the 250-foot level small octahedral crystals of argentite show quartz crystals coating them or implanted on them. Minute amounts of chalcopyrite and sphalerite are intercrystallized in places with this argentite, and all three minerals should apparently be interpreted as primary (hypogene), whereas the argentite occurring in fungus-like patches along fractures is probably secondary (supergene).

Proustite was noted in ore from the 250-foot level in irregular masses as large as the end of a man's thumb, in places well crystallized. It is intimately intercrystallized with quartz, sphalerite, and pyrite and has every appearance of being contemporary with them and primary.

A small specimen from the ore bins shows a very fine intergrowth of proustite, pearceite, and chalcopyrite bordering an association of base-metal sulphides, mainly sphalerite and pyrite. The silver minerals and chalcopyrite were clearly the latest to crystallize; they interlock, however, with the base-metal sulphides and are believed to be late primary (hypogene). The primary origin of the proustite is confirmed by the microscopic study of a specimen from the ore bins. The main portion of a 3-inch veinlet shown by this specimen is a granular aggregate of galena, sphalerite, and pyrite, but next one wall is a quarter to half an inch of gray quartz carrying scattered grains or crystals of chalcopyrite, proustite, and pearceite. In the polished specimen some areas of galena lie within 1 millimeter of areas of pure proustite, but tarnishing of the galena with hydrogen peroxide shows that it has not been replaced even incipiently by proustite or other minerals. In places proustite is intercrystallized with chalcopyrite very intimately. The contacts between these two minerals are crystal faces and not the ragged contacts usually developed by the replacement of one metallic mineral by another. Furthermore, the chalcopyrite areas in one place show a radiating arrangement. Neither mineral forms veinlets in the other. The two minerals are interpreted as contemporary and primary (hypogene).

To summarize the evidence obtained at this mine bearing on the origin of the rich silver ores: The zone of oxidation is 200 to 250 feet deep. Within this zone oxidation of sulphides has been only partial, and no heavily iron-stained gossan has been developed. From the surface to depths of 100 to 150 feet the dominant silver mineral appears to have been horn silver (cerargyrite). This mineral, here as everywhere else, is a product of weathering. Lower down, from depths of 100 to 250 feet, native silver was abundant. It occurred as plates in fractures and as wires and teeth in vugs. Its disappearance in depth shows that it also was a product of near-surface oxidation. Some argentite occurring along fractures is also probably a result of alteration near the surface.

Primary (hypogene) minerals noted are quartz, pyrite, sphalerite, galena, chalcopyrite, proustite, pearceite, and probably argentite. Evidence of the primary origin of the silver minerals is found in the entire absence of replacement phenomena in ores in which these minerals are abundant. The silver minerals can not reasonably be regarded as having completely replaced older minerals, inasmuch as galena adjacent to them is wholly unreplaced. Galena is one of the minerals most readily replaced by silver minerals in the process of downward enrichment. Primary origin is also indicated by the intimate contemporaneous intergrowth of proustite with chalcopyrite, a mineral formed only rarely in processes of downward enrichment.

EMPIRE MINE.

The Empire mine, about 2 miles north-northeast of Chloride, was not visited by the writer, but a specimen of rich silver ore from a depth of 150 feet on the vein was presented by the owner, Mr. E. F. Thompson, and was studied in detail.

The specimen is unoxidized and carries pyrite, arsenopyrite, quartz, sphalerite, galena, tennantite, and proustite. It shows the entire width of a 1½-inch vein. In the median portion of this vein tennantite, proustite, and quartz are the dominant minerals, but there is complete gradation from the silver-rich central portions to the border portions carrying mainly the base-metal sulphides.

Microscopic study shows that the proustite and tennantite are commonly intergrown and that the proustite-tennantite contact shows the crystal outlines characteristic of tennantite, as is shown in Figure 2. The proustite can not therefore have replaced tennantite, nor is there any evidence of replacement of any sort in the polished specimens. The galena when tarnished with hydrogen peroxide shows absolutely no replacement by other minerals. Evidence of the primary (hypogene) character of the proustite in this specimen appears to be conclusive.

GEORGE WASHINGTON CLAIMS.

The George Washington group of claims, in Mineral Park, about 3 miles southeast of Chloride, was in 1913 being developed through a tunnel then 300 feet long. The vein exposed in this tunnel was nearly vertical and had a strike of N. 40° W. Widths up to 3½ feet were noted. The dominant vein minerals are quartz and pyrite, but silver minerals are present in fair abundance in about 1 foot of the vein thickness next the southwest wall. The vein walls, which are granite, show alteration of the feldspars and carry disseminated small crystals of pyrite.

The workings are all shallow, even the face of the tunnel attaining a vertical depth of only about 80 feet below the surface. Even at these slight depths, however, much of the ore, because of its dense, fine-grained texture, is unoxidized. Oxidation is limited to the immediate vicinity of fractures traversing the ore and commonly does not extend more than 1 or 2 centimeters from such fractures.

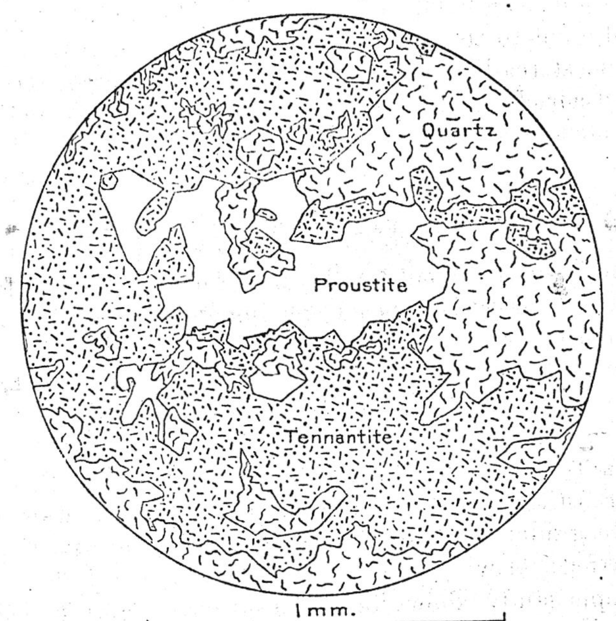

FIGURE 2.—Primary (hypogene) intergrowth of proustite with tennantite and quartz, Empire No. 2 mine, Chloride, Ariz.

Ore obtained near the face of the main tunnel is reported by the operators to have assayed $175 to the ton, mainly in silver. Assays of $240 a ton were reported from lesser depths on the vein.

Three specimens of the richest ore were collected for detailed study; one came from a depth of 56 feet and the others from depths of about 80 feet. In most respects these samples are similar. All are fine-grained grayish aggregates of quartz carrying scattered sulphides in grains that rarely exceed 1 millimeter in diameter. Oxidation is confined to fractures and to the 1 or 2 centimeters of ore adjacent to them. Vugs are rare in the unoxidized ore, but a few as much as 5 millimeters across were noted.

The primary ore minerals identified, in the approximate order of abundance, are quartz, pyrite, proustite, chalcopyrite, arsenopyrite,

polybasite, and sphalerite. The secondary minerals noted are native silver and covellite.

Evidence of the primary (hypogene) origin of the silver minerals, proustite and polybasite, though negative is convincing. It consists in the absence of any suggestion that these silver minerals have replaced older minerals. The relatively large unmixed areas of proustite or polybastite must either be primary or the results of complete replacement of older minerals. In places, however, they occur adjacent to chalcopyrite that has been peripherally replaced by covellite. Complete replacement of some older mineral by proustite and

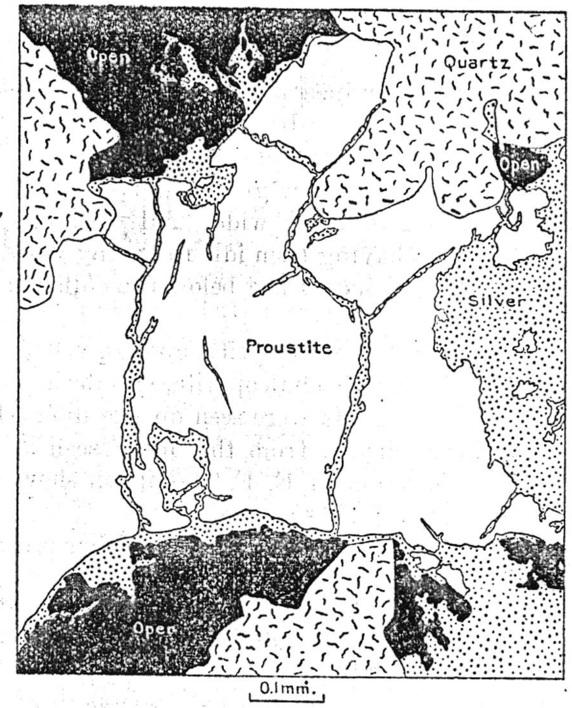

FIGURE 3.—Replacement of proustite by native silver, George Washington claim, Mineral Park, Ariz.

polybasite is hardly compatible with the incipient replacement of chalcopyrite by covellite close by; it is much more probable that the sulphosalts of silver are a primary deposit from the same solutions that deposited pyrite, chalcopyrite, quartz, and the other undoubtedly primary minerals.

Added indication that the proustite and polybasite are primary is found in their replacement near small open spaces in the ore by native silver, after the fashion shown in Figure 3. These replacement deposits are confined to porous and somewhat oxidized portions of the ore and are clearly the result of alteration by waters of surface origin. In degree the replacement of proustite by silver is com- patible with that of chalcopyrite by covellite in the same specimen, and both are attributed to descending oxidizing solutions.

The silver content in the specimens examined is therefore in part primary, in proustite and polybasite, and in part secondary, as native silver. The primary silver content is high—sufficient in itself to produce a rich silver ore. Such abundance of primary sulphosalts of silver in ores from depths of only 50 to 80 feet is unusual but is due to the dense, highly quartzose, fine-grained nature of the ore, which narrowly limits oxidation and enrichment to the immediate vicinity of fractures.

RURAL AND BUCKEYE MINES.

The Rural and Buckeye mines are about 1½ miles northeast of Mineral Park and are a few hundred feet apart on the same vein. The wall rocks are granite gneiss and schist of pre-Cambrian age, intruded by dikes of much younger granite porphyry. The vein is nearly vertical and from 2 to 8 feet wide. All workings were inac- cessible in 1913, the mines having been idle for many years. Ground water stood at a depth of about 50 feet below the collar in the Rural shaft.

Ores seen on the dumps showed pyrite, arsenopyrite, and quartz as the dominant minerals, with chalcopyrite, sphalerite, and galena subordinate. No silver minerals were seen on the dump, but native silver is abundant in specimens from this mine seen at Kingman. One specimen in the collection of E. F. Thompson shows a mass of nearly solid native silver 1½ inches across.

The following records show the tenor of the richer ores:

Tenor of smelting ores shipped from Rural and Buckeye mines in 1886–87.

Net weight (pounds).	Silver (ounces per ton).	Gold (ounces per ton).	Net weight (pounds).	Silver (ounces per ton).	Gold (ounces per ton).
9,033	722	6.13	29,862	266	5.85
8,024	440	2.66	21,106	249	4.00
13,089	200	2.55	72,680	480	8.25
28,376	479	9.46	10,212	442	8.16
23,575	119	4.90	27,142	172	4.70
30,999	196	6.05	87	4,467	4.80
9,898	109	5.12	167	4,024	5.35
20,314	73	7.29			

QUEEN BEE MINE.

The Queen Bee mine is in the northwestern part of the Mineral Park district, close to the cut-off trail to Chloride. The mine is owned by James B. Uncopher, of Mineral Park, to whom the writer is indebted for valuable information and specimens. The property when visited in 1913 had been idle for many years, and none of the workings could be entered. The main shaft, 225 feet deep, was filled with water within 60 feet of the surface.

The wall rock at the mine is mica schist of pre-Cambrian age. The ore is said to be somewhat oxidized to a depth of about 70 feet. The following minerals were noted in specimens from the mine dump and from Mr. Uncopher's collections:

Primary (hypogene): Quartz, pyrite, arsenopyrite, manganiferous siderite, calcite (white), sphalerite, galena, tennantite, chalcopyrite, proustite, pearceite (probably primary), argentite (probably in part primary).

Secondary (supergene): Argentite, native silver, cerargyrite (reported by Schrader[6]).

The proustite abundant in many of the ores from this mine appears clearly to be a primary (hypogene) mineral deposited from the same mineralizing solutions that deposited the common base-metal sulphides; the evidence for this conclusion is given below.

In one specimen studied a piece of proustite three-fourths by three-eighths by one-half inch in dimensions was intercrystallized with quartz and ferruginous calcite, all three minerals interlocking and having apparently been deposited contemporaneously. In one specimen in Mr. Uncopher's collection proustite in vugs is wholly inclosed by calcite. Other well-formed crystals of proustite are coated with calcite.

A particularly rich specimen of unoxidized ore donated by Mr. Uncopher shows the entire width of a 2½-inch veinlet carrying abundant proustite. Microscopic examination shows that in general the proustite has not replaced other ore minerals. The galena when tarnished brown with hydrogen peroxide (which does not tarnish the silver minerals) usually shows no evidences of replacement. Figure 4 shows a contact between galena and an intergrowth of proustite and sphalerite. The galena can not have been replaced by proustite alone, because there are no sphalerite areas in the galena corresponding to those so abundant in the proustite. Simultaneous replacement of galena by an intergrowth of proustite and sphalerite is highly improbable and if it occurred would probably be a part of the process of primary (hypogene) mineralization, for the deposition of sphalerite in the downward enrichment of ore deposits is extremely rare. The proustite is interpreted as hypogene and broadly contemporaneous with galena and sphalerite.

Additional evidence that most of the proustite is not the result of a replacement of galena is found in the fact that in many places minute inclusions of chalcopyrite are abundant in the proustite but are absent from the adjacent galena.

[6] Op. cit., p. 86.

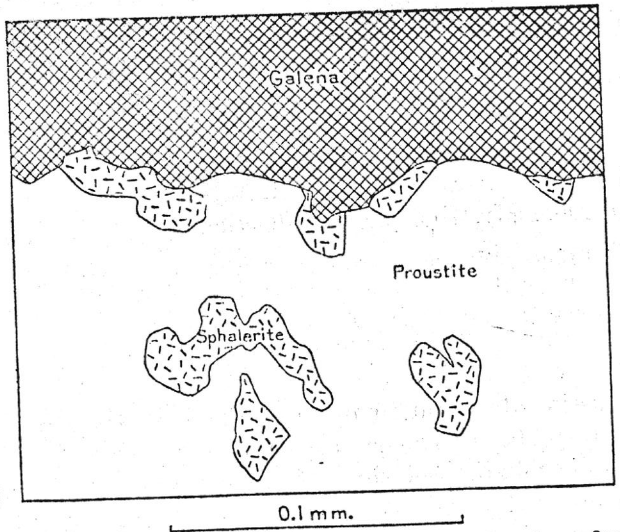

FIGURE 4.—Contact relations of proustite and sphalerite with galena, Queen Bee mine, Mineral Park, Ariz.

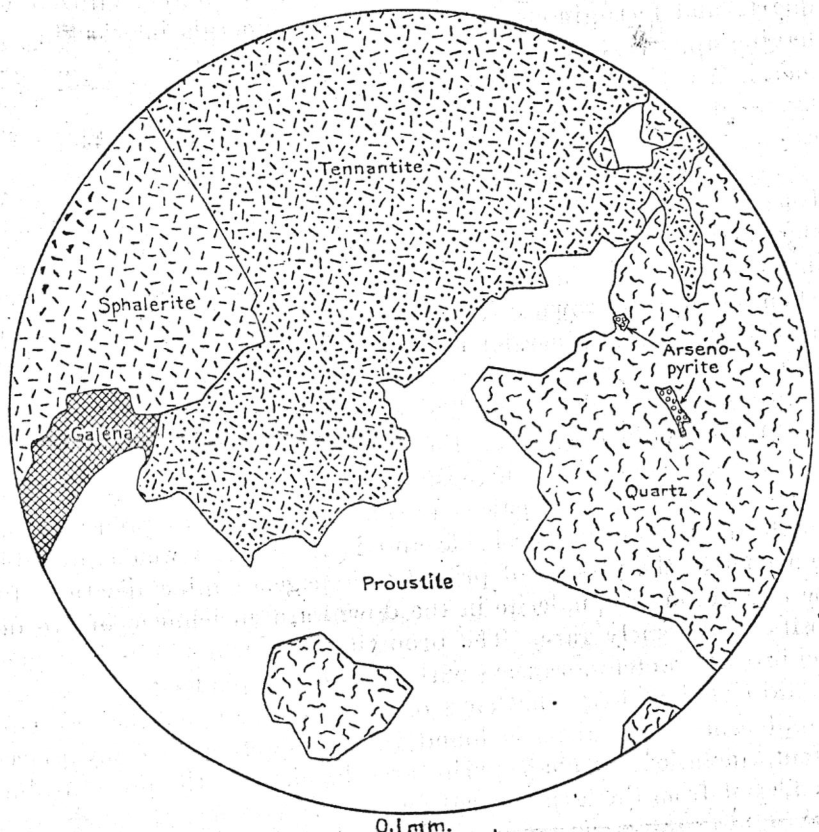

FIGURE 5.—Primary (hypogene) association of proustite and tennantite, Queen Bee mine, Mineral Park, Ariz.

Throughout the mine the proustite is intimately intergrown with tennantite and for this reason appears to the unaided eye somewhat darker than most proustite. It is clear that the two sulpharsenides—of silver and of copper, respectively—crystallized at essentially the same time. When their intergrowths are examined in detail it is found that the tennantite shows its own characteristic crystal faces against proustite, as illustrated in Figure 5. If the proustite had replaced tennantite, crystal faces of the tennantite should have been destroyed. The proustite is therefore interpreted as a primary (hypogene) deposit.

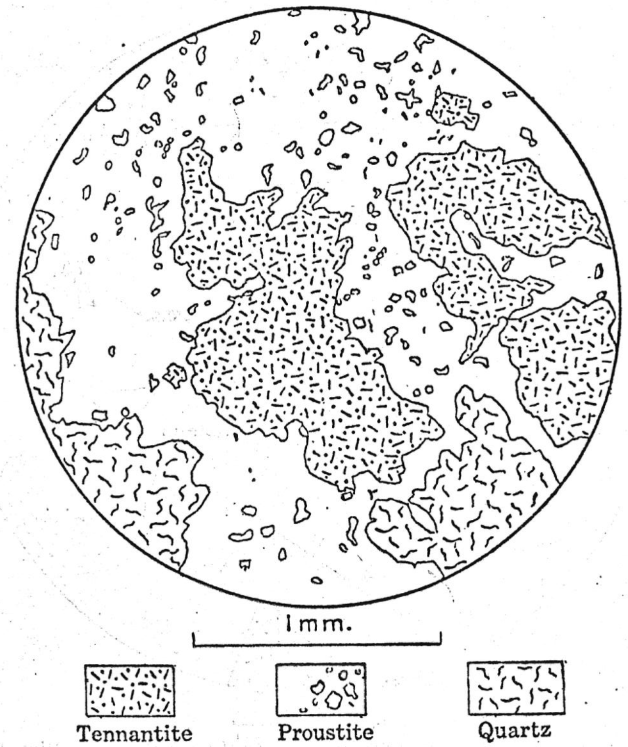

FIGURE 6.—Proustite crowded with inclusions of sphalerite and chalcopyrite and bordering tennantite essentially free from such inclusions, Queen Bee mine, Mineral Park, Ariz.

Additional evidence that proustite has not replaced tennantite is furnished by the fact that many areas of tennantite carry few and small inclusions of sphalerite, whereas immediately adjacent areas of proustite carry numerous and relatively large sphalerite inclusions, as is shown in Figure 6.

The presence of inclusions of sphalerite and chalcopyrite in both proustite and tennantite is itself an indication of the primary (hypogene) origin of the proustite, as chalcopyrite, sphalerite, and tennantite are rarely products of enrichment.

In a few places inclusions of proustite occur in galena in the manner illustrated in Figure 7. The inclusions have straight crystal outlines, but these bear no definite relation to the crystallographic directions of the inclosing galena. Replacement of galena by a silver mineral is usually controlled by the galena cleavages or by its contact planes with other minerals; absence of such control indicates that replacement has probably not been operative. The proustite inclusions are interpreted as primary (hypogene).

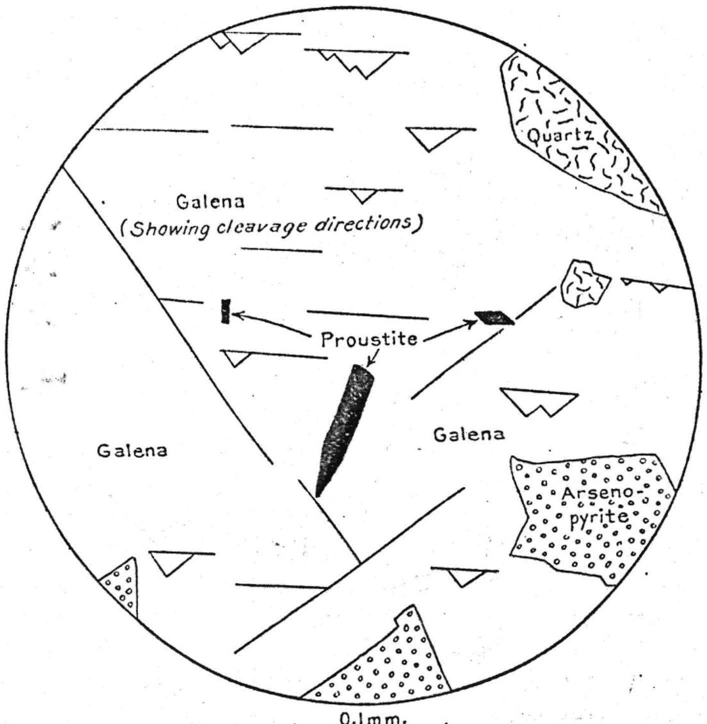

FIGURE 7.—Inclusions of primary proustite in galena, Queen Bee mine, Mineral Park, Ariz.

A possible partial exception to the rule that the proustite has not replaced other minerals is illustrated in Figure 8. The minute veinlets of proustite shown in this figure parallel cleavage directions in the galena and are interpreted as formed mainly by fracture filling, combined possibly with slight replacement. These veinlets of proustite are rare and are interpreted as of late primary (hypogene) origin rather than products of downward (supergene) enrichment.

Argentite occurs here and there. A specimen in Mr. Uncopher's collection shows calcite, argentite, and wires of silver in vugs. One

octahedron of argentite is a quarter of an inch in diameter, and in places argentite is so intimately intercrystallized with calcite as to leave little doubt that it is primary (hypogene). In other specimens argentite forms patches or fungus-like growths along fractures cutting primary sulphides. Such argentite is very probably secondary (supergene).

Pearceite is also of local occurrence. One specimen shows tabular hexagonal crystals of pearceite in vugs. On some of these small

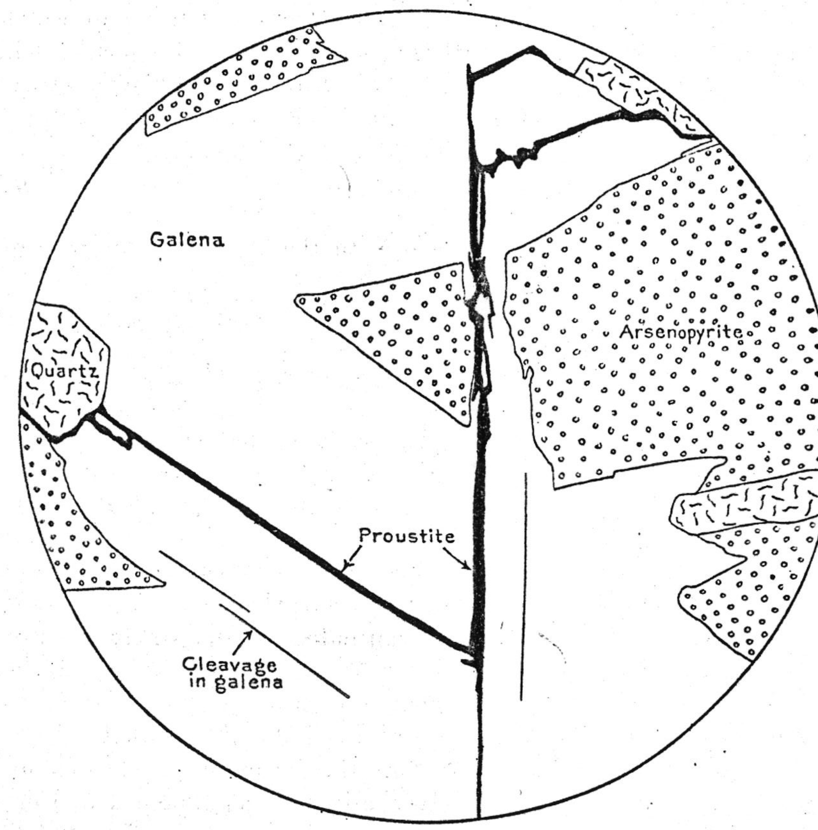

FIGURE 8.—Veinlets of proustite following cleavage planes in galena and contacts between galena and quartz, Queen Bee mine, Mineral Park, Ariz.

crystals of chalcopyrite have later been deposited. As chalcopyrite is rarely a product of downward enrichment, this pearceite is probably though not demonstrably primary.

Native silver is clearly secondary (supergene). It occurs as wires and teeth attached to argentite, proustite, and pearceite in vugs and is manifestly formed by their alteration. Native silver also occurs in matted masses of wires and teeth along fractures in sulphide ore.

Here it is associated with remnants of argentite, from which it was probably derived. In a number of places the silver is in contact with unetched crystals of calcite or of manganiferous siderite, an association which indicates that it was not deposited from solutions that were notably acid.

KAY CLAIM.

The Kay claim is about half a mile northwest of the settlement of Mineral Park. A steeply dipping vein striking nearly due east is developed by a shallow shaft and a short tunnel, neither of which was accessible in 1913. The shaft is near the bottom of a small gulch, and ground water stood only 25 feet below its collar. The vein traverses medium-grained granite. Proustite is reported to have occurred within a few feet of the surface in this vein. Specimens of ores were collected from the dump, and two were obtained from Mrs. Kay.

The minerals recognized in the ore, in the approximate order of abundance, are as follows:

Primary (hypogene): Quartz, pyrite, sphalerite, tennantite, pearceite, proustite, galena, chalcopyrite.

Secondary (supergene): Chalcocite, native silver, copper pitch ore, malachite.

Of the primary minerals quartz, pyrite, sphalerite, and galena were the oldest; after their deposition some brecciation occurred, and additional quartz and chalcopyrite, tennantite, pearceite, and proustite were deposited in the fractures so produced. The pearceite and proustite are most abundant and occur in the largest masses near small vugs. The later quartz is white; the earlier is dark gray.

In the granite of the wall disseminated grains of pyrite are abundant.

Evidence that the silver minerals pearceite and proustite are primary is found (1) in the absence of any indication that they have replaced earlier minerals and (2) in the intimate penetration of tennantite by crystals of these silver minerals, as sketched in Figure 9. In this figure proustite and pearceite are not differentiated by separate symbols, but both show similar relations, with characteristically sharp crystal outlines against tennantite. The narrow lathlike white areas in the tennantite of this figure are mostly pearceite; the larger white areas are mostly proustite. There is no evidence that the proustite of this specimen replaces either tennantite or pearceite.

In some vugs in the same specimen from which Figure 9 was sketched wires and teeth of native silver have been developed by the alteration of proustite and pearceite.

KING CLAIM.

The King claim, at Mineral Park, was located to develop a vein striking nearly east and dipping steeply south. Prior to 1913 two shafts, 35 and 50 feet deep, had been sunk on the vein, and two short tunnels had been run.

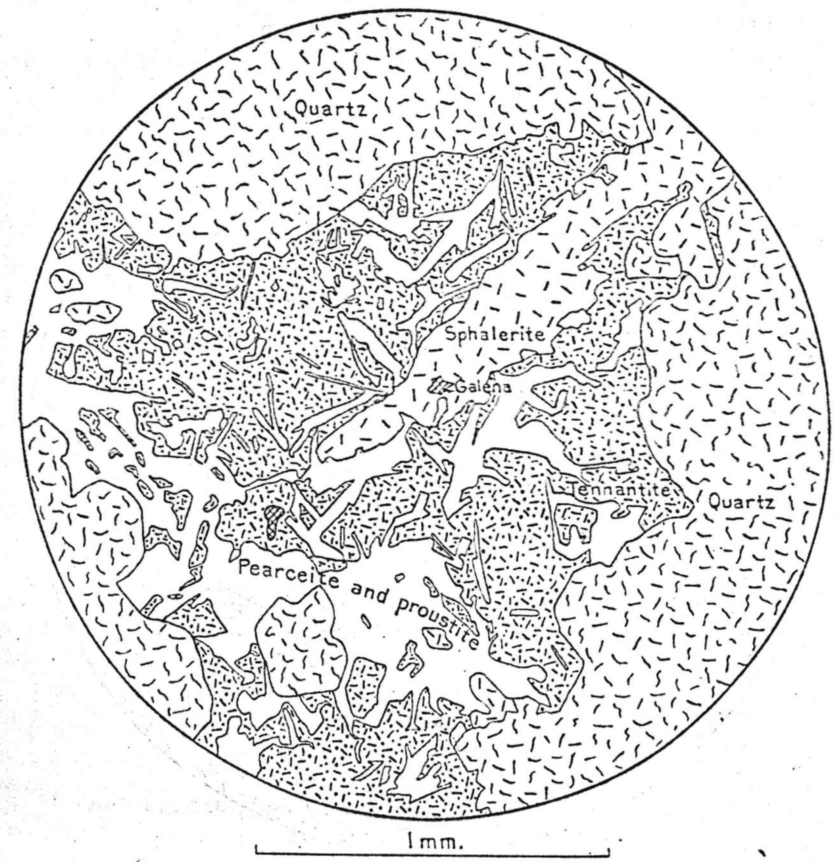

FIGURE 9.—Primary intergrowth of proustite and pearceite with tennantite, Kay mine, Mineral Park, Ariz.

The vein as exposed in the tunnels is 6 inches to 2 feet wide and shows gray quartz carrying scattered pyrite. Ore seen on the dump carried the following minerals:

Primary (hypogene): Quartz, pyrite, sphalerite, galena, chalcopyrite.

Secondary (supergene): Covellite, chalcocite, native copper.

A specimen from the mine dump when polished showed peripheral replacement of chalcopyrite and sphalerite by covellite. Ore from a depth of 12 feet shows dendritic growths of native copper along small fractures in flinty-looking quartz. Another specimen obtained within a few feet of the surface at this mine shows chalcocite developed along and close to small fractures in granite. The chalcocite appears to replace pyrite, remnants of which remain within some of the chalcocite. In places native copper in thin platelike masses is associated with the chalcocite and appears to be an alteration product from it.

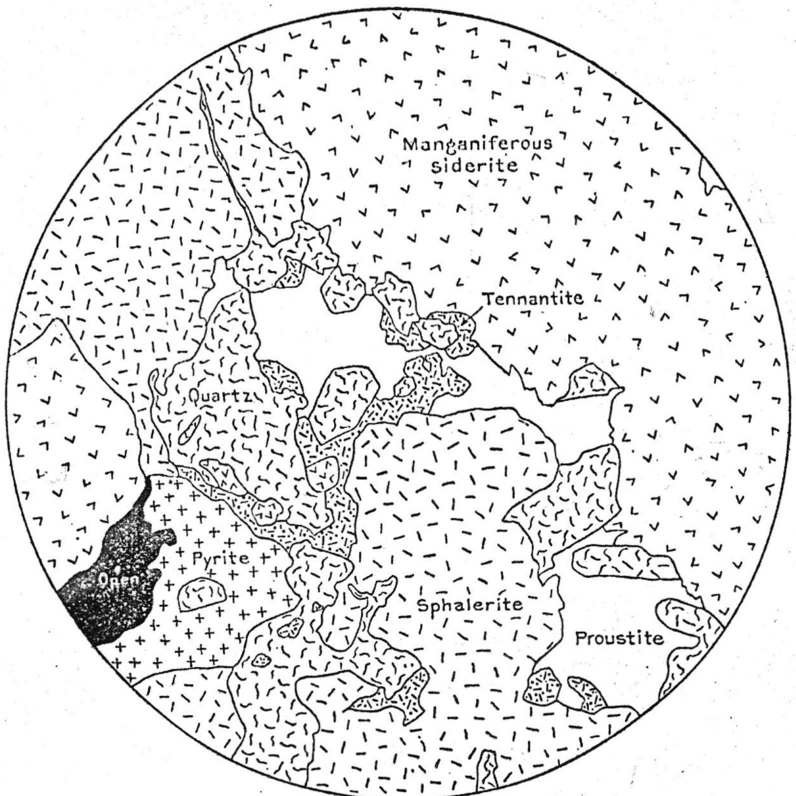

FIGURE 10.—Primary intergrowth of proustite with tennantite, sphalerite, etc., Mineral Park, Ariz.

UNSPECIFIED ORES FROM MINERAL PARK.

A very fine specimen of rich proustite ore from Mineral Park was presented by Mrs. Kay, of that place, but she was unable to specify more closely the exact source of the material. The minerals recognized in this ore, all primary (hypogene), are quartz, pyrite, galena, sphalerite, manganiferous siderite, tennantite, and proustite.

All these minerals appear to have been deposited during a single period of primary mineralization, but pyrite appears to have been

the first mineral deposited, and some fracturing of it occurred prior to the deposition of the other ore minerals. As in most of the ores of Mineral Park the proustite is clearly associated with tennantite, a relation which suggests that it may replace tennantite. Close examination, however, shows that the tennantite nearly everywhere has sharp crystal faces next to proustite, as shown in Figure 10 and on a larger scale in Figure 11. The proustite can not have replaced tennantite and is interpreted as primary (hypogene). The galena when tarnished brown with hydrogen peroxide, a reagent that does not tarnish silver minerals, shows no evidence of replacement by other minerals to more than the most incipient degree. The proustite is never found along galena contacts or cleavages.

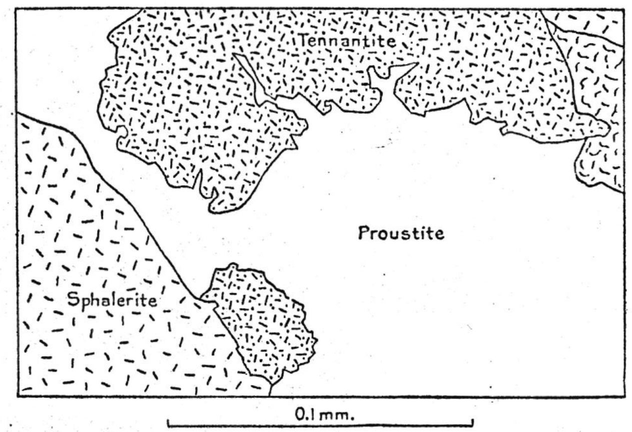

FIGURE 11.—Primary association of proustite and tennantite, Mineral Park, Ariz.

MINES NEAR STOCKTON HILL.

The mining camp of Stockton Hill is about 9 miles north-northwest of Kingman, near the south end of the Cerbat Range and on its east slope. It lies within the area of pre-Cambrian gneiss and schist. In 1913 all the mines had been idle for many years, but some old mine dumps were examined. According to Schrader[7] the district was noted for its rich minerals—cerargyrite, native silver, argentite, and proustite—found in the upper portions of its mines. The water level stood commonly at a depth of about 100 feet.

At the Cupel mine the dump is very old, and the workings are caved, operations having ceased in 1891. The output of the mine is variously estimated at $500,000 to $1,500,000, chiefly in silver. According to Schrader[8] some of the ruby silver ore averaged 3,000

[7] Op. cit., p. 108.

[8] Op. cit., p. 111.

ounces of silver to the ton. Cerargyrite and argentite were found in some of the ore.

Specimens collected by the writer from the old dumps and one especially rich specimen of unoxidized ore presented by Mr. H. H. Watkins, of Kingman, showed the following minerals:

Primary (hypogene): Quartz (usually gray and fine grained), pyrite, arsenopyrite, galena, sphalerite, siderite, chalcopyrite, tennantite, proustite, pearceite.

Secondary (supergene): Proustite and argentite, both very rare.

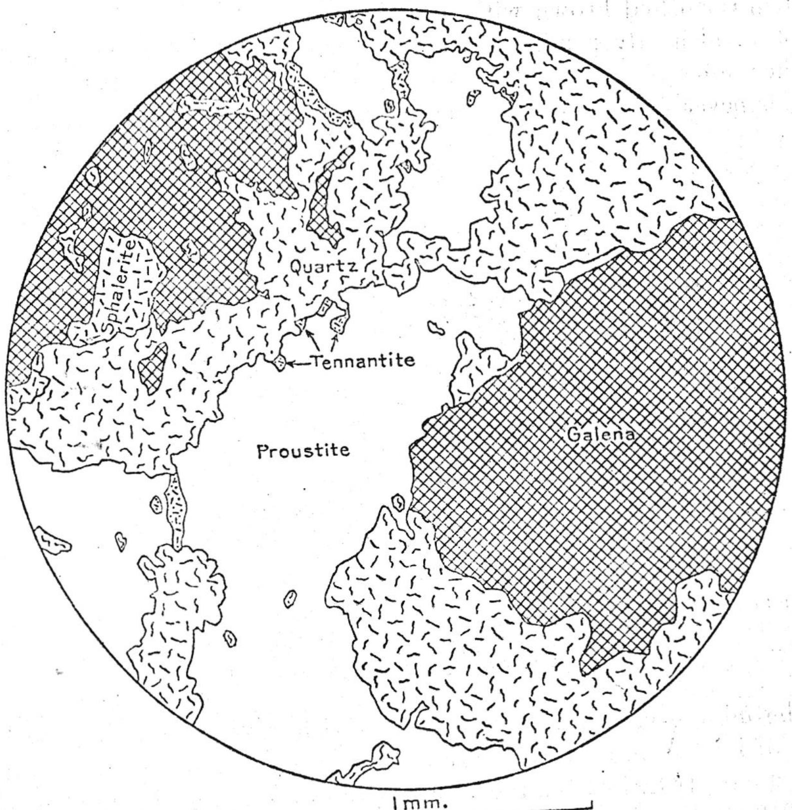

FIGURE 12.—Primary proustite in association with galena, tennantite, and quartz, Cupel mine, Stockton Hill, Ariz.

In the specimen presented by Mr. Watkins proustite constitutes fully half of the volume of the ore throughout an ill-defined band 1½ inches wide. Microscopic study of this specimen fails to disclose any evidence that the proustite either fills fractures in older minerals or has replaced them. The mineral commonly most susceptible to replacement by silver minerals in downward enrichment is galena. In this ore, however, there is no indication that galena has been replaced by proustite. On the contrary, the two minerals occur side by side in areas of comparable size, as shown in Figure 12.

Tennantite is present in small amounts and here, as in the ores of Mineral Park and Chloride, is particularly intimately associated with proustite, usually forming small patches within the proustite. These patches of tennantite are not, however, replacement remnants, because they are as likely to occur at the border of proustite areas as in their interior and because they commonly show crystal outlines characteristic of tennantite. If tennantite had been replaced by proustite the original crystal outlines would have been destroyed. Added evidence that proustite has not replaced tennantite is found in the localization of some tennantite crystals along the contact between two crystals of proustite; such a relation is not explainable on the assumption that proustite has replaced tennantite but is readily understood if the two minerals crystallized at about the same time. In places proustite carries abundant inclusions of quartz and of chalcopyrite, both of which show crystal outlines.

Though nearly all the proustite in the ores of the Cupel mine is interpreted as primary (hypogene), one specimen of partly oxidized ore from the dump showed very thin films of argentite and of proustite, with dendritic outlines, along a small fracture. These minerals are very probably secondary (supergene), but they are quantitatively of almost negligible importance. This mode of occurrence of proustite is in marked contrast to that of the proustite which is intercrystallized with the primary ore minerals.

SUMMARY AND CONCLUSIONS.

The minerals noted in the silver ores of the Cerbat Mountains, between Kingman and Chloride, Ariz., are listed below. Those marked with an asterisk (*) are rare under the conditions indicated.

Oxidation products: Cerargyrite (horn silver), native silver, *copper pitch ore, *malachite, *native copper.

Products of downward sulphide enrichment: Argentite, *proustite (very rare), *covellite, *chalcocite.

Primary (hypogene) minerals: Quartz (usually gray and finely crystalline), manganiferous siderite, *calcite (white), pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, tennantite, *argentite, proustite, pearceite, *polybasite.

It is noteworthy that the ores are prevailingly arsenical, with four arsenic minerals, arsenopyrite, tennantite, proustite, and pearceite. Only in one specimen were small amounts of an antimony mineral (polybasite) noted.

The unoxidized ores are in general fine grained and compact. Vugs are few and small. Because of this compactness oxidation above the ground-water level is very commonly incomplete, being confined to the vicinity of fractures that traverse the ore. Ore specimens several inches across essentially unoxidized may in places be found within a few feet of the outcrop. Heavily limonite-stained gossans or "iron caps" are not characteristic.

The ground-water level stood at depths of 25 to 250 feet in the mines studied. A test of stream water near Chloride showed the high chlorine content (80 parts per million) usual in desert regions.

According to Schrader the dominant silver mineral in the ores found close to the surface was usually cerargyrite. No specimens of these ores were obtainable for study. In this area, as elsewhere, cerargyrite is confined to the oxidized zone.

Native silver appears to have been most abundant at slightly greater depths than those at which cerargyrite was dominant—that is, close to the surface native silver is dissolved and partly reprecipitated as cerargyrite by chloride-bearing waters. Native silver appears to have been confined mainly to the oxidized zone in the vicinity of vugs and fractures. A little may have been deposited a short distance below the ground-water level. Some of the silver has replaced proustite, as shown in Figure 3. It was also noted replacing polybasite, pearceite, and argentite. In places the silver forms tapering and curling "teeth" attached to these minerals and obviously formed by their alteration. Some such silver "teeth" are in contact with older crystals of calcite that are unetched, indicating that the silver was not deposited from acid solutions. The manganiferous siderite and calcite present in most of the veins would insure the prompt neutralization of acidity developed in solutions descending through the oxidized zone. Schrader[9] mentions the occurrence in the Distaff mine of slabs of native silver many pounds in weight.

Chalcocite is not abundant, but it was noted along fractures in granite near the King vein, in Mineral Park. It contained remnants of pyrite and was evidently formed by the replacement of pyrite. In places a little native copper is associated with this chalcocite and probably represents a residuum after the oxidation of the sulphur of the chalcocite.

Argentite, though not abundant, occurs in two contrasting ways—in scattered, thin fungus-like scales or patches along fractures in unoxidized or only slightly oxidized ore and in small but well-formed octahedral crystals occurring side by side with crystals of proustite and pearceite in small vugs in unoxidized ore. Some of this argentite is intercrystallized with small amounts of chalcopyrite and sphalerite, and on some of the argentite small crystals of later quartz are implanted. It is probable that the argentite occurring in octahedral crystals is primary (hypogene); that occurring in scales or patches is very probably supergene, a product of downward enrichment.

Downward (supergene) sulphide enrichment, or the deposition of sulphides below the ground-water level by solutions descending from

[9] Op. cit., p. 60.

the oxidized zone, appears to have been of nearly negligible importance in these ores. The supposedly supergene argentite mentioned above is present in only small amounts. In one specimen of ore from the Cupel mine, at Stockton Hill, very thin films of argentite and of proustite, dendritic in form, occurring along small fractures cutting primary ore, are believed to be secondary (supergene). Quantitatively such occurrences are negligible, and most of the proustite, for reasons enumerated below, is believed to be primary (hypogene). Very slight downward enrichment in copper was shown in some specimens by peripheral replacement of pyrite by chalcocite and of chalcopyrite and sphalerite by covellite.

Proustite, or light ruby silver, is the only abundant silver mineral of the unoxidized ore, although pearceite, polybasite, and argentite also occur. In some specimens studied masses 1 or 2 inches across are mainly proustite, and masses of pure proustite as large as the end of a man's thumb were noted. Such proustite is believed to be primary (hypogene), and the evidence for this opinion will next be summarized.

1. Masses of proustite as large as the end of a thumb and with well-developed crystal faces were noted intercrystallized with the undoubtedly primary minerals quartz, sphalerite, pyrite, and ferruginous calcite—all having apparently been deposited at about the same time.

2. In one specimen studied small areas of proustite are wholly inclosed by calcite that forms the lining of vugs. Elsewhere well-formed crystals of proustite are coated with calcite. There is no evidence that this calcite has been deposited by descending (supergene) solutions.

3. Relatively large unmixed areas of proustite in a granular aggregate of ore minerals must either be primary (hypogene) or the product of complete replacement of older minerals. In places, however, such proustite areas are adjacent to chalcopyrite and sphalerite that show only incipient peripheral replacement by covellite. Such incipient replacement by covellite would hardly be expected to occur side by side with complete replacement of relatively large masses of some hypothetical mineral by proustite. It is more probable that the proustite was formed not by replacement but by primary crystallization.

4. In all the ores studied proustite is more intimately associated with tennantite than with any other mineral. Proustite is the sulpharsenide of silver; tennantite is the sulpharsenide of copper. The proustite has not, however, replaced tennantite, for the tennantite nearly everywhere has its own characteristic crystal outlines, as shown in Figures 2, 5, 9, and 10. Added evidence that proustite has not replaced tennantite is furnished by the fact that certain

areas of tennantite carry only scattered small inclusions of sphalerite, whereas bordering areas of proustite are crowded with relatively large sphalerite inclusions.

5. The presence of inclusions of sphalerite and chalcopyrite in both tennantite and proustite is itself suggestive of a primary origin for the proustite, because sphalerite, chalcopyrite, and tennantite are exceedingly rare as products of secondary (supergene) enrichment.

6. Galena, fairly abundant in these ores, is a mineral that is usually particularly susceptible to replacement by silver minerals in the processes of downward enrichment. Where galena and proustite are found together in these ores they commonly occur side by side without evidence of replacement. Figure 4 shows an association of sphalerite and proustite in contact with galena. The smooth galena contacts extending from proustite to sphalerite indicate either simultaneous replacement of galena by proustite and sphalerite or an absence of replacement, the three minerals all being essentially of the same age and primary. Simultaneous replacement of galena by an intergrowth of proustite and sphalerite is highly improbable and if it occurred would almost certainly be a part of the process of primary (hypogene) mineralization, for the deposition of sphalerite in the downward enrichment of ore deposits is exceedingly rare. In Figure 7 are shown small areas of proustite inclosed by galena. If these were formed by replacement of the galena, they should be related to the galena cleavages, but they show no such relation and are interpreted as inclusions of primary proustite in galena. A single possible exception to the general rule that proustite has not replaced galena is illustrated in Figure 8. This figure was drawn from a specimen which in most places shows the relations illustrated in Figures 4 and 7. The veinlets are interpreted as fillings of a fracture in galena by primary proustite, possibly combined with very slight primary replacement of the galena by the proustite. Such relations are very exceptional. Additional evidence that proustite has not replaced galena is found in the common presence of many small inclusions of sphalerite and chalcopyrite in proustite and the absence of such inclusions from adjacent galena. It can not be assumed that the proustite has replaced galena unless sphalerite and chalcopyrite have replaced it simultaneously.

7. In some ores proustite and pearceite intergrown with tennantite possess regular crystal outlines, as shown in Figure 9. The narrow white areas in this figure are pearceite showing its own characteristic tabular crystal forms (lath-shaped in cross section); the larger white areas are mostly pearceite. Sulphides occasionally develop their own crystal form in replacing other sulphides, but the relation seems to be rare. In ores from the Mowry mine, in the Patagonia district, Ariz., the writer has observed radiating groups of tabular crystals of covellite replacing galena. The development of the covellite was, however, clearly controlled by cleavage planes of the galena or by contacts of galena with other minerals. In the association of pearceite and tennantite under description there is no such relation of the pearceite to tennantite contacts or partings, but the pearceite appears to be fairly evenly distributed through the tennantite. The two are interpreted as in primary intergrowth. There is no evidence that the proustite of this specimen is the result of a replacement of pearceite; it appears rather to be contemporaneous. On theoretical grounds the supergene replacement of pearceite ($9Ag_2S.As_2S_3$), a rich silver mineral, by proustite ($3Ag_2S.As_2S_3$), a mineral poorer in silver, is unlikely, for it would involve a reversal of the progression to richer silver minerals characteristic of the process of downward silver enrichment.

Although some of the relations outlined above taken singly would not form conclusive evidence that the proustite was primary, taken collectively their significance is unescapable.

The possibility of profitable operation of any particular deposit in this area is dependent upon many considerations, among which may be mentioned the price of silver, costs of transportation and labor, milling and smelting facilities, the width and horizontal extent of the ore body, the primary distribution of silver minerals within the vein, and the nature and extent of downward enrichment in silver.

Some of the richest silver ores of the area, carrying cerargyrite and native silver, were unquestionably products of oxidation and downward enrichment, and the playing out of these ores in depth was certainly an important factor in the closing down of many of the mines. The decline in the price of silver from 1872 to 1916 was unquestionably an added discouraging factor.

The conclusion that the rich ruby silver ores of the region are in the main primary offers encouragement to further exploration of the ore bodies, although this work should be undertaken only with due regard to the many other and perhaps unfavorable factors involved. A general decrease in the primary silver content of veins of this type with increase in depth is probable, but such primary changes are likely to be much less abrupt than those due to downward enrichment and to be recognizable only through vertical intervals measured in many hundreds rather than a few hundreds of feet. The depth of most of the mines is too small to afford any valid test of this factor, even had the workings been accessible for study. Underground studies, had they been possible, would have aided in determining whether the rich primary proustite ores were of spotty or patchy distribution, or of fairly regular distribution within the veins, a question of fundamental practical importance.

composed mainly of barren or very low-grade material. According to available production records, only two mines, the Tennessee and the Golconda, exceeded a total production of $1,000,000. While a great many mines have made appreciable productions, the geological conditions favorable for ore bodies of the size of the Tennessee and Golconda are rare. These two ore shoots were explored for vertical distances of 1,600 and 1,400 feet, respectively.

Schrader[79] noted that some ore shoots coincide with intersections or forking of veins. Many vein intersections, however, do not show ore shoots.

Ore shoots appear to be localized where changes of strike or dip of the vein faults gave rise to open spaces due to the reopening movements that occurred just before and during mineralization. Open space filling seems to have been most important as far as valuable vein minerals are concerned. Areas of faults choked by either clay gouge or greatly crushed rock were too tight for big ore shoots. No striking control of ore shoots by wall rock is known. One small shoot was seen to pinch out where the vein passed from granitic rock to dense black schist.

Oxidation.—Weathering of the veins is incomplete where the filling is highly siliceous, except along open fractures or where the vein is brecciated. High-grade sphalerite ore shoots or heavy pyrite streaks were more or less completely oxidized and leached. Galena, however, is often seen on natural outcrops. Water level is ordinarily at depths of 25 to 250 feet, but oxidation does not tend to be prominent for more than 30 to 100 feet, except along open fissures. Ground water is rich in chlorine, according to Bastin,[80] who found 80 parts per million in a stream near the town of Chloride.

Secondary enrichment.—Bastin[81] does not believe that secondary sulphide enrichment of silver and copper is important in rich silver ores. His microscopic studies indicate argentite, occurring in funguslike patches, to be the main secondary silver mineral. He found pearceite and abundant proustite intimately associated with primary sulphides to be probably primary.

Several veins, however, may have undergone considerable secondary enrichment. An exploited vein in Mineral Park shows small base-metal shoots with good silver content that dropped out below the third level. The narrow Alpha vein in the Cerbat district has a strong gossan at the outcrop. Schrader[82] noted silver sulphide, pyrite, galena, zinc blende, and chalcopyrite in Alpha ore. Chalcocite can be seen in some specimens. Ores mined recently had high copper and silver content and appeared to be secondarily enriched.

Regardless of whether the veins have been enriched primarily or secondarily in silver, available evidence does not indicate that

[79] *Op. cit.*, p. 51.
[80] *Op. cit.*, p. 18.
[81] *Op. cit.*, pp. 36-37.
[82] *Op. cit.*, p. 103.

high-grade silver can be expected to extend downward more than a very few hundred feet.

Gold has been enriched residually by leaching of zinc and iron from heavy sulphide ore shoots carrying relatively low primary gold. A thin zone of very rich gold ore is reported near the bottom of the oxidized zone in several veins. This may be secondary gold. Nature of gangue, ground-water chloride ion, common presence of pyrite, and persistent though only locally abundant manganese oxides are all favorable for gold enrichment. Some gold enrichment has occurred, but how much residual and how much chemical is unknown. Such gold ore shoots have been small, but some were spectacular. Many sections of veins that are very low grade in the sulphide zone have yielded small bodies of gold ore of shipping grade from the oxidized zone.

Summary.—The Cerbat Range is an area of numerous veins with mostly small ore shoots. The excellent grade ores and fair-sized shoots of several mines indicate the area to be important and worthy of study. The great need of the present is for a good topographic map of adequate scale and for a sufficiently detailed geologic map to bring out essential features. Many problems of structure, petrology, ore occurrence, and mineralogy are unsolved. Microscopic study of ordinary sulphide ores is needed. The exact manner of occurrence of gold and silver in ores of ordinary grade should be determined.

Acknowledgments.—The writer is indebted to G. M. Fowler, of Joplin, Missouri, for direction and for the opportunity to study part of the Cerbat area. Many local people facilitated the field work and gave information.

TENNESSEE-SCHUYLKILL MINE[83]

BY S. K. GARRETT[84]

LOCATION

The Tennessee-Schuylkill Mine is at the western foot of the Cerbat Range, about 1 mile east of Chloride, in the Wallapai mining district, Mohave County, Arizona.

ROCKS

The rocks of the Wallapai mining district can be grouped as diorite gneiss, granite, quartz monzonite porphyry, rhyolite, and diabase. The oldest rock, diorite gneiss, has been intruded by granite, and both the diorite gneiss and the granite have been intruded by quartz monzonite porphyry. The rhyolite and diabase

[83] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.
[84] Geologist, Tennessee-Schuylkill Mine.

occur as dikes, some of which are in the same fissures as veins. In one place a diabase dike has been intruded along an earlier rhyolite dike.

Veins

The fissure veins near Chloride can be grouped according to strike. One set strikes nearly north and the other about N. 25 degrees W.; the dip ranges from 35 degrees E. at the western foot of the range to 85 degrees W. near the crest. The progressive steepening toward the crest of the range may indicate overthrusting stresses as the cause of the fissuring.

The Tennessee-Schuylkill fissure vein, which can be traced for nearly 2 miles, strikes N. 5 degrees W. and dips 85 degrees NE.

Strong gouge is present on both the hanging and footwalls of the vein. There was some movement on the fissure after the formation of the vein.

At abrupt changes in strike, there is some horse tailing of the fissure, but there are no cross fissures.

Ore Deposits

The Tennessee-Schuylkill deposits occur as a vein filling a fissure in the complex of diorite gneiss, granite, and quartz monzonite porphyry. The ore is in shoots which, above the 900-foot level, rake northward and between the 900- and 1,400-foot levels are nearly vertical (Pl. XXX).

Most of the ore shoots range from 35 to 300 feet in length and average about 5 feet in width.

Ore Controls

The different wall rocks have not influenced the deposits; the ore filling is as wide in diorite gneiss as in quartz monzonite porphyry. The only recognized control is that of strike and dip of the fissure.

The four ore shoots in the Tennesee-Schuylkill Mine (Pl. XXX) occur where the vein has changed to a more than average northwesterly strike. The ore filling is wider on steep dips than on flat dips.

The combination of strike and dip control the rake of the ore shoots. A change to a northwesterly strike on a flat dip gives a pronounced northward rake, and a change in strike on a steep dip gives a rake that varies from slightly southward to vertical.

Zoning

There is marked horizontal zoning of the ore minerals in two of the ore shoots above the 900-foot level. The north limits of these two shoots contain principally galena and gold-bearing pyrite with practically no sphalerite. As the south limits of the shoots are approached, the galena and gold-bearing pyrite decrease, and sphalerite increases until, at the southern limits of the shoots, sphalerite is the only ore mineral present (Pl. XXX).

Little is known of the zoning below the 900-foot level other than a general decrease of galena and increase in sphalerite and crystalline pyrite with increased depth. On the 1,600-foot level a small amount of development along one of the ore shoots shows no galena but considerable sphalerite and crystalline pyrite.

Mineralogy

The hypogene ore minerals are galena, fine-grained gold-bearing pyrite, and sphalerite. The gangue minerals are milky quartz, fine-grained chalcedonic quartz, crystalline pyrite, and arsenopyrite.

Supergene ore minerals, found to a depth of about 80 feet are: plumbojarosite, anglesite, cerussite, bromyrite, cerargyrite, native gold, and, rarely, native silver. The supergene ores are of little importance.

The paragenesis, determined megascopically, is milky quartz, sphalerite, galena, pyrite, and fine-grained chalcedonic quartz.

The sphalerite occurs as older "black-jack," and younger "rosin-jack." Some galena shows a flow structure suggesting movement of the walls of the fissure after deposition. Argentite may account for the small amount of silver that the ore contains.

The pyrite is of two varieties. One variety occurs as well-crystallized cubes and pyritehedrons with no gold; the other is somewhat massive and fine grained and contains 0.3 to 15.0 ounces of gold per ton in the pure specimens. The gold in the pyrite is so finely divided that colors cannot be panned from a high-grade pyrite concentrate.

The fine-grained chalcedonic quartz occurs as fracture fillings in the sulphide ore.

Montana Mine, Ruby[85]

By George M. Fowler[86]

Introduction

A brief description of the geology of a limited area around the Montana Mine is presented in this paper. During the past few years a much larger area was studied in an attempt to find new ore bodies that could be worked in conjunction with this operation. At a later date it is hoped to present the results of this investigation as well as to give further details about the Montana Mine (Pl. XXXII).

The Montana Mine is in the Oro Blanco mining district, Santa Cruz County, Arizona, 5 miles north of the Mexican boundary and about 30 miles west of Nogales, Arizona.

[85] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

[86] Consulting geologist, Joplin, Missouri.

8/26/82

- Juno Mine - vein is 3-12 feet wide, good Au-Ag values

- Liberty Mine - up to 30' wide fault zone, vein widths erratic, but stope widths aver. ~6', good Au-Ag values

R. I. 4101,
August 1947.

REPORT OF INVESTIGATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

EXAMINATION OF ZINC-LEAD MINES IN THE WALLAPAI MINING DISTRICT MOHAVE COUNTY, ARIZ.[1]

By P. S. Haury[2]

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1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Report of Investigations 4101."

2/ Mining engineer, Bureau of Mines.

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INTRODUCTION

Many ore deposits were discovered in the Wallapai Mining District, which covers the Cerbat Range in Mohave County, Ariz., during the early period of mining there from about 1865 to the 1890's. A considerable amount of production was obtained from shallow lead carbonate ores that carried considerable gold and silver.

Mining was revived in 1906 and again during the first World War, and some of the mines were deepened into the underlying sulfide zone. Substantial quantities of metal were recovered from two mines, the Golconda and the Tennessee-Schuylkill, that were developed to depths of 1,600 and 1,400 feet, respectively. The Golconda is credited with $6,500,000 gross productions.3/

3/ Elsing, Morris J., and Heineman, Robert E. S., Arizona Bureau of Mines Bul. 140.

This mine was not operated after 1917. The Tennessee-Schuylkill is still operating after a yield of about 300,000 tons of ore that averaged 4.33 percent lead and 7.74 percent zinc and contained an appreciable amount of gold and silver.

Many of the old mines were reopened in 1942 or 1943 under the stimulus of premium prices for lead and zinc. A large proportion of this work was finished with loans from the Reconstruction Finance Corporation. It was believed that a good deal of lead and zinc could be recovered from the mines if a custom mill for concentration of the ores was available locally.

All the accessible mines in the Cerbat Range were examined by engineers of the Bureau of Mines[4] during August and September 1943, and many others were visited to make an estimate of the tonnage of ore that could be supplied to a custom mill at a central site near Chloride.

The information obtained on each mine visited was incorporated in a confidential War Minerals Report and is now presented in this report. Most of the accessible exposures of ore were sampled. The sample data are recorded in the reports on the individual mines. Some maps and sample data obtained from other sources are included in the mine reports. These are credited to their respective sources where they appear in the report.

The Mineral Park Milling Co. (F. J. McEntee, Jr., and D. F. Zlatnik) remodeled the old Keystone mill and began treating custom ore in July 1945. Production since September 1943 from all the mines in the district except the Tennessee-Schuylkill and the Emerald Isle was verified by the author on May 27, 1946. Production figures from mines that have loans from the Reconstruction Finance Corporation were obtained from that agency. Production data on other mines were obtained from the Mineral Park Milling Co.

The mines shipped 9,678 tons of ore in the 19 months from October 1, 1943, to May 1, 1946. The average grade of these shipments was 4.68 percent zinc and 0.54 percent copper. The average precious-metal content per ton was 0.094 ounce gold and 5.54 ounces silver.

ACKNOWLEDGMENTS

In its program of investigation of mineral deposits, the Bureau of Mines has as its primary objective the more effective utilization of our mineral resources to the end that they make the greatest possible contribution to national security and economy. It is the policy of the Bureau to publish the facts developed by each project as soon as practicable after its conclusion. The Mining Branch, Lowell B. Moon, chief, conducts preliminary examinations, performs the investigative work, and prepares the final report. The Metallurgical Branch, O. C. Ralston, chief, analyses samples and performs beneficiation tests.

4/ Curtis G. Mohney and Robert M. Grantham.

Acknowledgment of general direction of the work here reported is due J. H. Hedges, district engineer, and S. R. Zimmerley, regional engineer for the Western Region.

Concentration tests were made in the testing laboratory at Salt Lake City on a bulk sample from the Summit mine under the direction of C. H. Schack and H. G. Poole.

LOCATION AND ACCESSIBILITY

The Wallapai Mining District includes the Cerbat Mountains, which trend north-northwest for about 30 miles from near Kingman, a station on the Santa Fe Railroad. Paved U. S Highway 93 runs northwestward from Kingman through the Detrital Valley on the west side of the Cerbat Range to Boulder Dam and Las Vegas, Nev. A good paved road 4 miles long connects Chloride, the only active camp in the district, with this highway at a point 19 miles north of Kingman. Most of the mines are situated near Chloride or near the abandoned camps of Mineral Park, Golconda, and Cerbat, which lie within the mountain range south of Chloride. The majority are on the west slope of the range at altitudes ranging from 4,000 feet at the foothills to 5,700 feet at the crest of the range. A few of the mines are on the east slope. All the mines are connected by roads with Chloride, with the paved highway, or with Kingman. Parts of a few of these roads are in such a state of disrepair as to be virtually impassable. The claim map (fig. 1) shows the location of the several mines covered in this report.

HISTORY

Many ore deposits were discovered in this district during the period from the late 1860's through the 1890's, and considerable production was obtained, chiefly from lead carbonate ores near the surface that were mined for their gold and silver content. Activity was revived during 1906 to 1912 and again during the first World War, when deeper development was done at some of the mines, and some galena ores, containing gold and silver, were produced.5/ Two mines were developed to considerable depth and yielded notable production. The Golconda mine, in the southern part of the range, was developed to a depth of 1,600 feet and yielded about $6,500,000 worth of ore to 1917. In that year the mill was destroyed by fire, and the property has not been operated since. The Tennessee-Schuylkill mine, near Chloride, has been developed to a depth of 1,400 feet. The mine is still in operation after a yield of about 300,000 tons of ore averaging 4.33 percent lead and 7.74 percent zinc and having an appreciable gold and silver content.

PHYSICAL FEATURES

The topography at the mines ranges from comparatively gentle slopes at the foot of the range to rugged mountain slopes in the heart of the range.

5/ Schrader, F. C., Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Ariz.: Geol. Survey Bull. 397, 1909, 226 pp.

Roads to the mines near the crest have sharp curves and steep grades. The climate is arid, and the vegetation is sparse and stunted. Owing to the altitude, the summers are not extremely hot. Winters are mild.

The most practical site for a custom mill would be on the desert floor near the entrance to the Mineral Park basin. This location is fairly central and is easily accessible from all directions. Enough water could be obtained from the surface flow in the canyon out of the Mineral Park basin and from old shafts within the basin, which has a considerable drainage area. Water from these sources need not be piped very far.

ORE DEPOSITS

The area is underlain by pre-Cambrian schist, amphibolite, and altered granite, which have been intruded by later granite porphyry. Much of the schist is amphibole. Many veins occur in nearly vertical fault fissures that strike northwestward and outcrop for considerable distances. The fault fissures are largely occupied by breccia and gouge with discontinuous lenses of lead and zinc ores. Most of the ore lenses now exposed contain quartz, sphalerite, galena, and pyrite, with minor amounts of chalcopyrite and usually a fair amount of gold and silver. Oxidation generally extends about 70 to 150 feet below the surface. Most of the oxidized ore was mined during earlier operation. The ore lenses generally are not extensive and do not seem to be distributed according to any regular pattern. Frequently they do not fill the entire fault fissure and have walls of breccia and gouge that need support while the ore is being mined. This is not universally true. There are some quartz veins with solid walls that stand well.

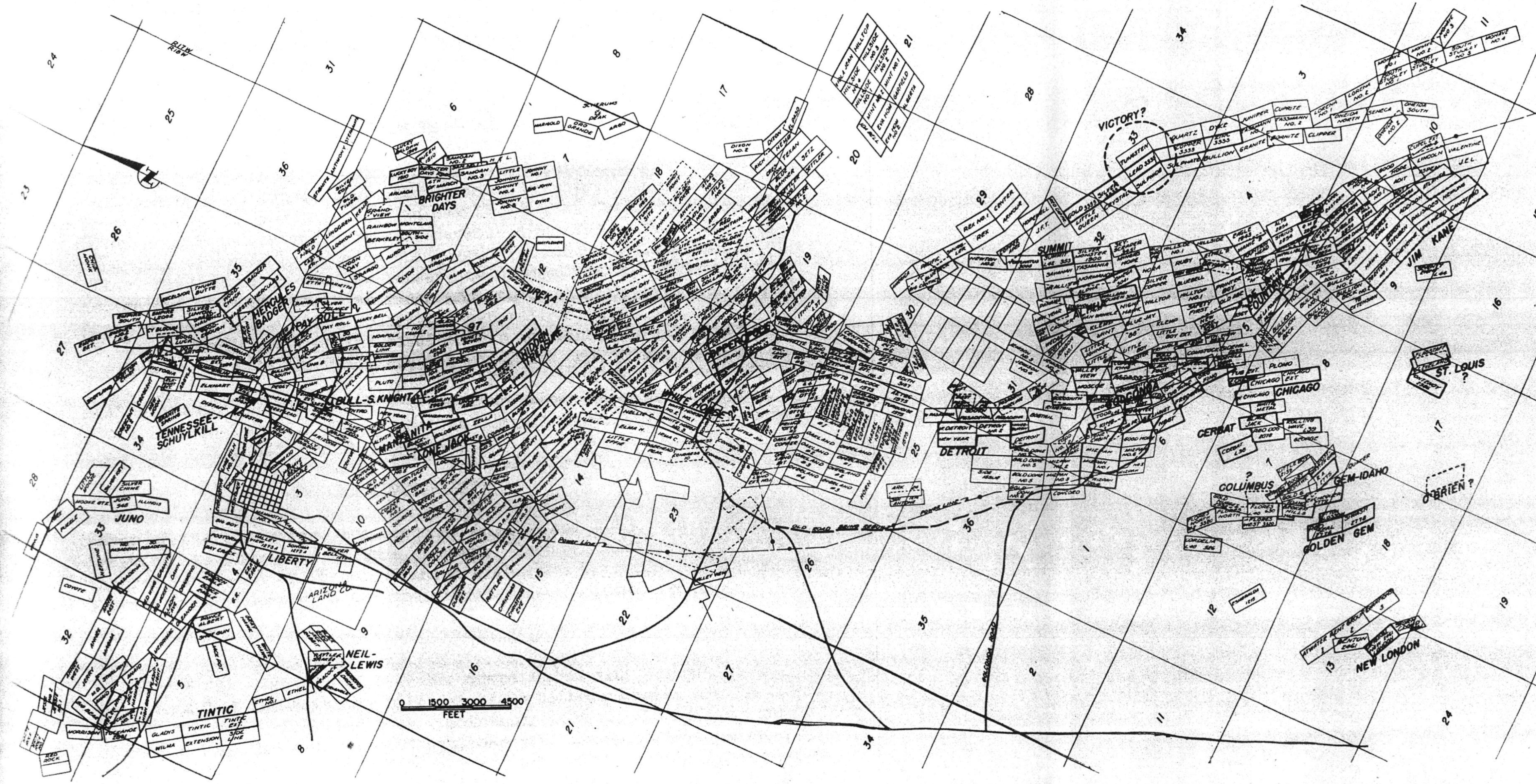
RECENT DEVELOPMENTS

A number of the old mines were reopened in 1942 and 1943, and some new development work has been done at some of them. Part of this work was privately financed, but more of it was financed with loans from the Reconstruction Finance Corporation. Reports on the individual mines examined follow.

CUSTOM MILL

F. J. McEntee, Jr., and D. F. Zlatnik, operating as the Mineral Park Milling Co., remodeled the Keystone mill and began milling custom ore in July 1945. The mill has four receiving bins. Shipments from the individual mines are accumulated and milled separately. Lead and zinc concentrates are made. Zlatnik reported, on May 28, 1946, that the ore treated had gradually increased to about 1,000 tons per month, and that shipments had been received from seven mines in May. He anticipated a considerably greater tonnage after the ceiling price and premium rates for the next fiscal year are fixed. The mill capacity is about 75 tons per day.

The ore-purchasing schedule, calculated on 50 percent lead concentrate and 50 percent zinc concentrate, follows:



Fi[illegible] Claim map of Wallapai mining district, Mohave County, Ariz.

Lead. - Deduct 0.5 percent and pay for 75 percent of the remainder at 4[illegible] percent of the E. & M. J. quotation for lead at St. Louis.

Zinc. - Deduct 0.5 percent and pay for 75 percent of the remainder at 2[illegible] percent of the E. & M. J. quotation for zinc at St. Louis.

Copper. - Deduct 0.15 percent from the wet assay and pay for the remainder as lead.

Gold. - Deduct 0.03 ounce per ton and pay for the remainder at $32 per ounce.

Silver. - Deduct 1.0 ounce per ton and pay for 75 percent of the remainder at $0.70 per ounce.

Treatment charge. - $4 per ton.

Zlatnik reported that occasional lots of ore are readily amenable to differential flotation, but that in the greater part of the tonnage milled many of the galena and sphalerite particles are slightly filmed by secondary copper sulfides. This makes clean separation of the lead and zinc minerals difficult.

He also reported that most of the sphalerite is marmatitic, so that the average zinc concentrate contains about 10 percent iron, of which about 1 percent is in pyrite.

BRIGHTER DAYS MINE

Location and Accessibility

This mine, consisting of the Brighter Days claims, the Lucky Boy claims, and the Samoa group, 7 claims in all, is situated near the crest of the Cerbat range, 4.5 miles east of Chloride. The mine is reached from Chloride by a good graded road, which has many sharp turns and steep grades.

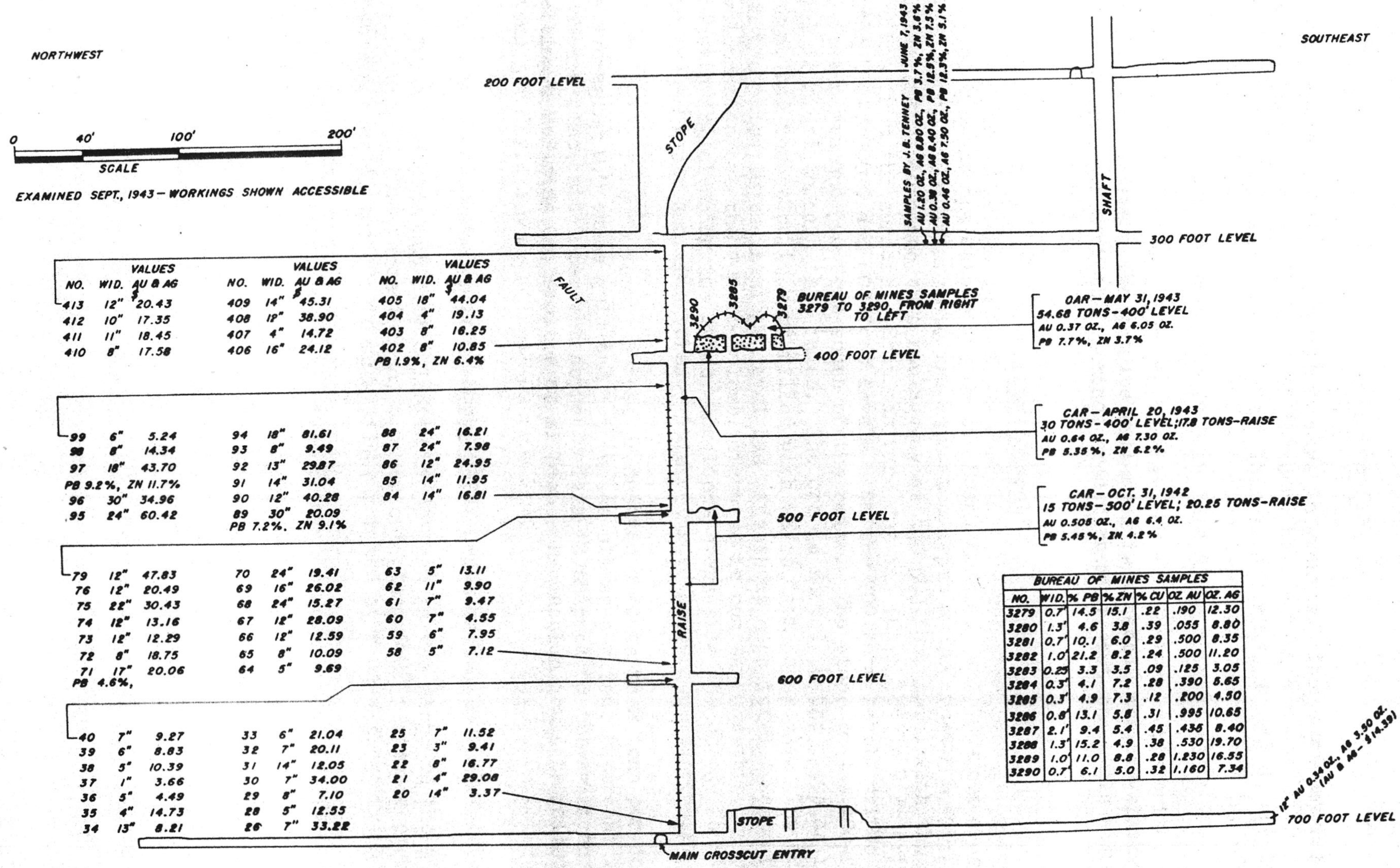
Ownership

The property is owned by the Brighter Days Mining Co., Peoples Bank Building, Passaic, N. J. Lewis A. Dunham, Box 4, Chloride, Ariz., is the engineer in charge.

History

The three mines that constitute this group were first opened in the 1870's or 1880's. It is reported that rich gold and silver ores were mined from workings near the surface during the early operation. According to a private engineer's report, 95 cars of ore, mined from above the 300-foot level, were shipped to smelters between 1900 and 1909 and four cars in 1936, amounting to 2,881 tons that averaged 8.1 percent lead, 1.217 ounces gold per ton, and 14.3 ounces silver per ton.[6]

6/ Report on examination made for the Tennessee-Schuylkill Corp. by S. K. Garrett, dated December 7, 1936.



BUREAU OF MINES SAMPLES						
NO.	WID.	% PB	% ZN	% CU	OZ. AU	OZ. AG
3279	0.7'	14.5	15.1	.22	.190	12.30
3280	1.3'	4.6	3.8	.39	.055	8.80
3281	0.7'	10.1	6.0	.29	.500	8.35
3282	1.0'	21.2	8.2	.24	.500	11.20
3283	0.25'	3.3	3.5	.09	.125	3.05
3284	0.3'	4.1	7.2	.28	.390	5.65
3285	0.3'	4.9	7.3	.12	.200	4.50
3286	0.8'	13.1	5.8	.31	.995	10.65
3287	2.1'	9.4	5.4	.45	.435	8.40
3288	1.3'	15.2	4.9	.38	.530	19.70
3289	1.0'	11.0	8.8	.28	1.230	16.55
3290	0.7'	6.1	5.0	.32	1.160	7.34

Figure 2. - Assay plat, Brighter Days mine, Mohave County, Ariz.
After map by Lewis A. Dunham, dated June 1943.

Ore Deposit

The ore is found in a fault fissure in granite. There are several small veins on the property, but most of the work has been done on one vein wider and more continuous than the others. This vein strikes N. 20° W. and dips steeply to the east. One stope 55 feet long is being mined from the 400-foot level. The average width of the vein in this stope is 0.87 foot.

The principal minerals in the ore are quartz, galena, sphalerite, chalcopyrite, and pyrite. The granite wall rock is altered, and air-slacks in places so that parts of the openings need timbering, but the walls stand well in most of the workings.

Development

The present operations are on the Samoa ground. A 1,700-foot crosscut, driven since 1936, intersects the vein at a depth of 700 feet. A 400-foot vertical raise connects this haulageway at the 300-foot level with the old workings from the surface. Stations were cut and short levels were driven on the 400-, 500-, and 600-foot levels. On the 700-foot level, drifts extend 330 feet north and 360 feet south of the raise. The stope on the 400-foot level is mined through this raise. The ore is sorted in the stope as it is broken, and the stope is kept filled with waste from the walls. The ore pass down the raise to the haulage level has offsets at each level. Waste from development above the 700-foot level likewise is run through this ore pass, necessitating cleaning the offset shoulders every time the change is made from ore to waste and vice versa. This retards the work considerably.

The mine foreman reported that production amounts to 2 tons per day of ore averaging 0.5 ounce gold and 3.5 ounces silver per ton, 6 percent lead, 7 percent zinc, and 1 percent copper. This is shipped to the American Smelting & Refining Co. smelter at El Paso. Production could be raised to 5 tons per day.

Sampling

Twelve samples cut over a length of 55 feet in the stope on the 400-foot level averaged 10.8 percent lead, 6.5 percent zinc, 0.28 percent copper, 0.546 ounce gold, and 10.9 ounces silver per ton over an average width of 0.87 foot. Table 1 is a record of these samples. Figure 2, an assay plat of the mine by the company engineer, also shows the location of the Bureau of Mines samples.

TABLE 1. - Record of samples from stope on 400-foot level, Brighter Days mine

No.	Location	Description	Length, feet	Percent Pb	Percent Zn	Percent Cu	Ounces/ton Au	Ounces/ton Ag
3279	South end of stope....	Heavy sulfide	0.7	14.5	15.1	0.22	0.190	12.30
3280	5 feet from south end of stope............	do.	1.3	4.6	3.8	.39	.055	8.80
3281	10 feet from south end of stope............	do.	.7	10.1	6.0	.29	.500	8.35
3282	15 feet from south end of stope............	do.	1.0	21.2	8.2	.24	.500	11.20
3283	20 feet from south end of stope............	do.	.25	3.3	3.5	.09	.125	3.05
3284	25 feet from south end of stope............	do.	.3	4.1	7.2	.28	.390	5.65
3285	30 feet from south end of stope............	do.	.3	4.9	7.3	.12	.200	4.50
3286	35 feet from south end of stope............	do.	.8	13.1	5.8	.31	.995	10.65
3287	40 feet from south end of stope............	do.	2.1	9.4	5.4	.45	.435	8.40
3288	45 feet from south end of stope............	do.	1.3	15.2	4.9	.38	.530	19.70
3289	50 feet from south end of stope............	do.	1.0	11.0	8.8	.28	1.230	16.55
3290	55 feet from south end of stope............	do.	.7	6.1	5.0	.32	1.160	7.34
		Average	0.87	10.8	6.5	.33	0.607	10.94

The sample plat shows good gold values over narrow widths throughout the mine, but lead and zinc values are low, and the vein is very narrow below the 600-foot level. Lead and zinc are almost entirely absent on the 700-foot level, but some gold ore was stoped south of the shaft on that level. Mining costs are very high, owing to the narrowness of the vein and the inefficient facilities for handling the ore.

No production is reported since the mine was examined in September 1943.

HERCULES-BADGER MINE

Location and Ownership

The mine is situated 2 miles by road northeast of Chloride.

The Hercules-Badger group, consisting of five patented claims, is owned by the Arizona & Western Mines Corp., A. T. Danbar, president, Berkeley, Calif. Albin Larsen and J. E. Layton of Chloride, Ariz., the present operators, have a 5-year lease on the property.

History

It is reported that the property has been worked intermittently since about 1900. Some production for 1911, 1912, and 1914 is recorded.[7]

Production

A considerable early production of gold-silver ore from the property is reported, but no reliable records are available. Smelter returns from one carload shipped in May 1941 were as follows: 3.10 percent lead, 5.30 percent zinc, 0.27 percent copper, 1.32 ounces gold per ton, and 6.10 ounces silver per ton.

Development

The Badger mine workings consist of an adit drift 1,025 feet long, a 100-foot winze from the drift, and about 250 feet of drifts on levels 50 and 100 feet below the main drift. The adit drift attains a depth of 175 to 200 feet below the outcrop. All the workings are in the Badger vein. Caved and flooded portions of the mine were reopened recently with the aid of an R.F.C. loan. This work revealed that all the originally developed ore had been mined. The vein area from the lowest level to some distance above the main drift has been stoped. Lead-zinc-gold-silver mineralization in a narrow vein is reported to continue downward from the 100-foot level, and a 2- to 5-inch vein of sulfides in the breast of the main drift is reported to assay 20 percent lead, 25 percent zinc, and about $36 per ton in gold and silver. However, no exploratory or development work is being done at either of these places.

The present work consists of clearing the drift of cavings on the 100-foot level.

Description of the Deposit

Gold-silver-lead-zinc ore occurred in lenticular shoots in a vein striking northwest and dipping about 80° northeast. Stope widths indicate the ore was locally as wide as 3 feet. Portions of the oxidized part of the vein near the surface carried considerable gold. High gold content has characterized the metal-bearing portions of the vein. Ore widths now exposed in the stope faces are too narrow to be minable.

PAY ROLL MINE

Location, Accessibility, and Ownership

The mine is 2 miles by road east of Chloride, Ariz. The last half mile of the road is in poor condition.

[7] Federal Geological Survey, Mineral Resources of the United States, 1911, 1912, and 1914.

The property, consisting of two patented claims, is owned by the estate of Thomas B. Scott and has been operated under several leases. The present lessee is M. F. Langley, Los Angeles, Calif.

History and Production

The first location work was done in 1887, and exploration and development work continued intermittently until 1929. Some gold-silver ore was reported mined from shallow workings before 1900. A "considerable quantity" of ore was reported produced and shipped in 1917, and in 1929 1,400 tons of ore was treated in a mill on the property, producing two cars of copper-lead concentrate and four cars of zinc concentrate.8/ Milling of a small tonnage is evidenced by a mill foundation, mill tailings, several tons of crushed ore, and a few tons of concentrates.

Description of the Deposit

Ore occurs in shoots within a vein that strikes N. 38° W. and dips steeply northeast. Zinc-lead ore shoots carrying some gold and silver have been found in workings that extend to a depth of 600 feet. A private mining engineer who sampled the mine in 1930 reported a shoot of marginal ore on the 400-foot level 150 feet long and 2 feet wide and one on the 600-foot level 360 feet long and with an average width of 5 feet, which was submarginal in grade but showed improved grade in a winze.9/ Entry to the mine workings was by a vertical shaft now partly caved and flooded. The condition of the shaft prevented examination and sampling of the underground workings by the Bureau engineers.

Development

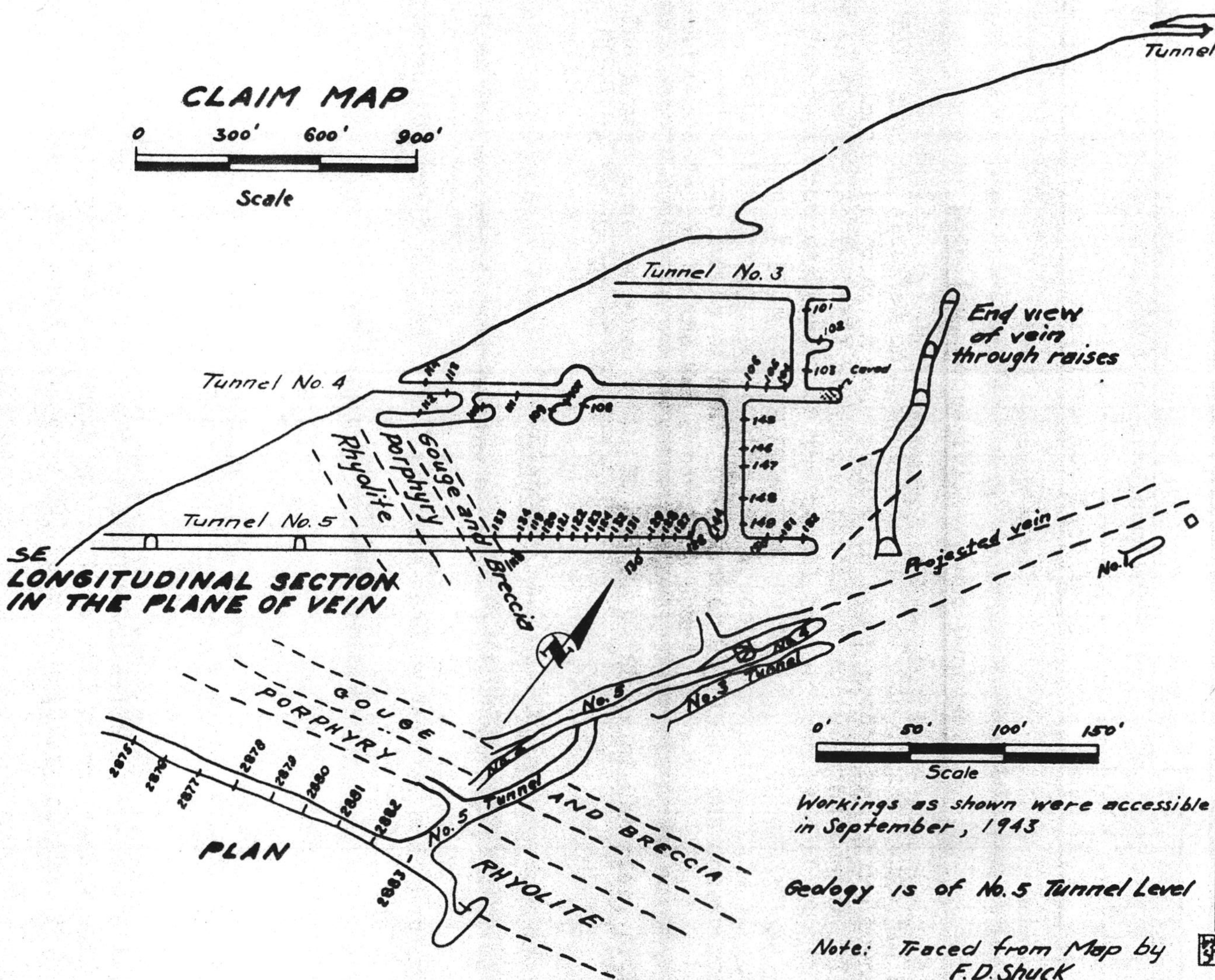
Old development work is reported to consist of a 600-foot vertical shaft with drift levels at 50-, 200-, 400-, and 600-foot depths. None of this is accessible.

Sampling

Grab samples were taken from the ore bin, from crushed ore, and from mill tailings. Values were found to be mainly in zinc with some silver. Sampling data follow:

8/ Federal Geological Survey, Mineral Resources of the United States, 1917. Federal Bureau of Mines, Mineral Resources of the United States, 1919.

9/ Report on the Payroll Mine by George M. Colvocoresses, mining and metallurgical engineer.



U.S. Bureau of Mines Samples						
No.	Ft. Wid.	% Pb	% Zn	% Cu	oz. Au	oz. Ag
2875	1.5	0.1	0.9	.15	.015	.40
2876	5.0	0.1	5.0	.05	Tr	.20
2877	3.7	0.1	1.0	.05	Tr	.40
2878	2.7	0.5	2.0	.06	.010	.50
2879	1.3	0.1	4.2	.11	.025	1.35
2880	1.0	0.1	1.7	.09	Tr	.15
2881	1.1	0.1	4.4	.10	.030	1.15
2882	2.4	0.1	5.0	.15	.015	.55
2883	0.2	0.2	3.2	.08	.015	.65

Samples taken by Others							
	No.	Ft. Wid.	% Pb	% Zn	% Cu	oz. Au	oz. Ag
Samples by F.D. Shuck - owner	101	4.2	3.0	6.5		.042	4.446
	102	4.0	9.3	7.0	4.0	.074	16.73
	103	4.0	0.5	6.4		.010	0.23
	104	3.5	0.5	9.7		.015	0.19
	105	4.0	0.5	3.3		.022	0.14
	106	3.5	0.5	5.4		.030	0.45
	107	4.0	2.6	11.0	4.0	.104	25.58
	108	4.0	2.8	27.2	4.0	.065	19.38
	109	3.5	3.2	24.3	4.0	.086	10.12
	110	4.0	0.5	22.2	4.0	.048	11.40
	111	3.0	4.0	0.5		.060	1.10
	112	2.0	13.5	Tr		.140	31.66
	113	4.0	3.9	0.5	2.5	.066	23.94
	114	2.0	12.6	1.4		.144	34.16
	118		Tr	3.8		.010	0.44
	119		0.20	3.3		.015	0.48
	120		Tr	1.6		Tr	0.12
	121		Tr	2.7		.020	0.52
	122		Tr	3.0		Tr	0.08
	123		Tr	0.6		.035	0.88
	124		Tr	Tr		Tr	0.08
By Lane, R.F.C. Engr.	126	2.3	0.81	8.60	0.19	Tr	0.8
	127	3.0	0.81	7.20	Tr	Tr	0.7
	128	0.8	0.60	9.0	Tr	Tr	0.5
	129	1.1	0.50	6.70	0.07	0.01	0.8
	130	2.1	0.33	3.50	Tr	Tr	0.4
	131	2.0	0.33	1.80	0.10	Tr	0.6
	132	1.7	0.33	2.20	Tr	Tr	0.3
	133	1.6	0.22	1.90	0.13	Tr	0.4
	134	1.7	0.22	1.60	0.13	Tr	0.1
	144	1.6	Tr	10.97	0.8	Tr	0.2
	145	1.8	0.53	4.58	Tr	Tr	0.1
	146	1.9	1.40	4.16	0.8	0.01	0.1
	147	1.7	4.44	6.38	1.05	0.01	6.3
	148	2.8	3.41	8.86	1.13	0.02	4.1
	149	5.0	Tr	7.60	0.17	Tr	Tr
	150	2.2	5.3	11.3	0.7	0.09	5.18
By Shuck	151	1.7	3.9	8.1	9.5	0.07	7.22
	152	3.3	4.2	13.1	2.5	0.09	4.79

Figure 3. - Longitudinal section in plane of vein, and plan, Eureka mine, Mohave County, Ariz.

Bureau of Mines samples

Sample No.	Location	Description	Percent			Ounces	
			Pb	Zn	Cu	Au	Ag
3312..	From pile of ore at crusher bin............	Quartz with galena and sphalerite	0.5	8.5	0.50	0.020	2.50
3313..	From crushed ore in bin.	do.	.1	4.1	.56	.010	3.20
3314..	From mill tailings dump.	Partly oxidized	.1	.1	.15	.035	.15

Samples reported by Colvocoresses in 1930

	Width, feet	Percent			Ounces	
		Pb	Zn	Cu	Au	Ag
Average of samples from 360 feet length on 400-foot level..	5	0.84	7.6	0.4	0.10	3.0
Samples from mine bin of ore from 400-foot level.		2.3	6.1	.7	.08	3.4

EUREKA MINE

Location, Accessibility, and Ownership

This mine is situated on a west side spur of the Cerbat range 3.7 miles east of Chloride by road. A fair road with steep grades and sharp turns was built to the top of the hill above the portal of the working tunnel. It is about 700 feet from the portal of the tunnel to the road by a rough, steep burro trail. About 1 mile of new road must be built, at an estimated cost of $3,000, to provide transportation for the present workings. This access road was approved by the Bureau of Mines on November 24, 1942, but construction of the road was deferred by the War Production Board.

The Eureka mine is owned by H. H. and F. D. Shuck of Chloride, Ariz. F. D. Shuck is in charge of operations.

History

Some ore was mined from shallow workings during the early activity in the district, but there are no records of that production. Shuck stated that he had packed two small shipments to the truck road by burros, and that smelter returns were $44 per ton of carbonate ore and $28 per ton on 11 tons of sulfide ore.

Development

Three adit levels, known as tunnels 3, 4, and 5, were driven on this vein. These are 100, 210, and 190 feet long, respectively. Tunnel 4 is 46 feet below tunnel 3, and tunnel 5 is 80 feet below tunnel 4. The three levels are connected by raises near their north ends, and a short sublevel was driven ahead between tunnels 3 and 4. A footwall branch drift on the No. 5 level crosses the fault zone at the south end of this vein to the quartz vein in the footwall of this fault, and there is 225 feet of drifting on that vein (fig. 3).

The present operator drifted about 290 feet on the lowest level and raised 70 feet from this level and has partly developed a shoot of sulfide ore (fig. 4).

Description of the Deposit

The vein strikes N. 30° W., and the dip varies from vertical to 60° west. This vein is interrupted toward the southeast by a brecciated fault zone that strikes northeast. A low-grade quartz vein parallels this fault zone in the footwall of the fault (fig. 3). The ore occurs in lenses in a fractured zone and is associated with considerable gouge. On the fifth level, the ore is all sulfide, but in the upper levels part of the ore is sulfide and part is oxidized. Near the surface the ore is all oxidized.

From the fifth level upward, the vein is vertical for 60 feet and then inclines to the east at an angle of 60° to the fourth level and above it. Thirty feet above the fourth level, the vein becomes nearly vertical again. The ore shoot on the fifth level is about 70 feet long, and there is still ore in the breast. On the fourth level the ore has pinched, and the vein is nearly all gouge at the north end of the drift.

Sampling

The vein on the fifth level was sampled at 5-foot intervals. In the raise from the fifth level to the fourth level the samples were taken at 5-foot intervals wherever possible, and at 10-foot intervals where the timber prevented closer sampling. The data on these samples are shown in table 2. The locations of the samples are shown on figures 3 and 4, traced from maps by F. D. Shuck. Samples by F. D. Shuck and by Lane, engineer of the Reconstruction Finance Corporation, also are shown on figure 3.

Later Production

Ore shipments were made to the U. S. Smelting, Refining & Mining Co. plant at Midvale, Utah, in the second half of 1944 and the first half of 1945. These amounted to 249 tons that averaged 4.55 percent lead, 11.44 percent zinc, and 0.89 percent copper, with 0.01 ounce gold and 7.36 ounces silver per ton. The mine was shut down in July 1945.

OLD 97 MINE

Location, Accessibility, and Ownership

The mine is situated about 2 miles east of Chloride. There is a graded road to the property that has several steep gradients and sharp turns.

The property, one claim, is owned by the Old 97 Mining Co. Lum and Abner, radio comedians, are the principal stockholders of the company. Paul Warner of Chloride is the secretary-treasurer of the company and the resident manager.

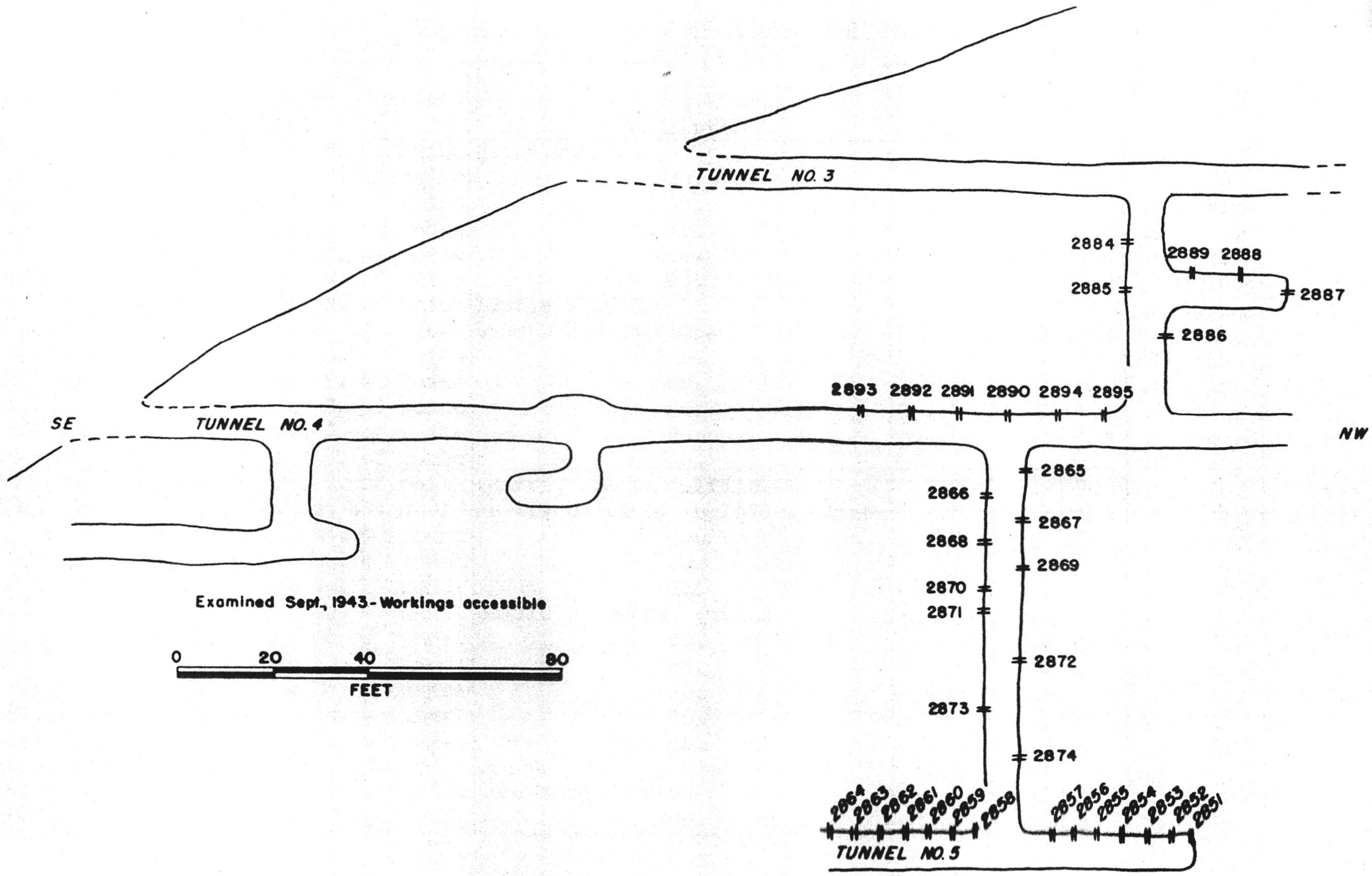


Figure 4. - Section of plane of vein, Eureka mine.

TABLE 2. - Detailed data on Bureau of Mines samples, Eureka mine

No.	Location	Description	Length, feet	Assays: Percent Pb	Percent Zn	Percent Cu	Ounces Au	Ounces Ag
2851	No. 5 tunnel, 40 ft. N. of raise	Heavy sulfides	2.5	5.2	11.0	0.44	0.005	11.05
2852	No. 5 tunnel, 35 ft. N. of raise	do.	2.0	5.3	25.1	.02	.005	9.25
2853	No. 5 tunnel, 30 ft. N. of raise	do.	2.5	.1	2.8	.02	Trace	1.20
2854	No. 5 tunnel, 25 ft. N. of raise	do.	1.5	2.1	7.1	.03	do.	2.30
2855	No. 5 tunnel, 20 ft. N. of raise	do.	1.3	0.1	7.4	.08	do.	1.20
2856	No. 5 tunnel, 15 ft. N. of raise	do.	1.0	11.0	10.0	.30	0.005	12.45
2857	No. 5 tunnel, 10 ft. N. of raise	Little sulfide	1.5	2.1	.5	.02	Trace	1.65
2858	No. 5 tunnel, 5 ft. S. of raise	Quartz and sulfides	1.2	.1	15.7	.05	do.	1.50
2859	No. 5 tunnel, 10 ft. S. of raise	do.	4.0	2.4	6.5	.04	do.	2.25
2860	No. 5 tunnel, 15 ft. S. of raise	do.	2.5	.1	3.5	.02	do.	.40
2861	No. 5 tunnel, 20 ft. S. of raise	do.	1.6	.1	6.5	.05	do.	.50
2862	No. 5 tunnel, 25 ft. S. of raise	do.	1.8	.5	5.4	.02	do.	.70
2863	No. 5 tunnel, 30 ft. S. of raise	do.	2.2	.1	3.2	.05	do.	.25
2864	No. 5 tunnel, 35 ft. S. of raise	Quartz, little sulfide	1.1	.2	1.6	.03	do.	.10
2865	Raise, 5 ft. below No. 4 tunnel	Partly oxidized, sulfide, quartz	1.8	.1	2.5	.03	do.	.20
2866	Raise, 10 ft. below No. 4 tunnel	do.	1.7	.2	2.2	.09	do.	.25
2867	Raise, 15 ft. below No. 4 tunnel	do.	1.9	1.1	2.6	.08	do.	.30
2868	Raise, 20 ft. below No. 4 tunnel	do.	2.3	.2	.1	.09	do.	.20
2869	Raise, 25 ft. below No. 4 tunnel	Sulfides, gouge, quartz	3.3	5.8	8.4	.71	do.	7.80
2870	Raise, 30 ft. below No. 4 tunnel	do.	2.3	8.6	5.4	.47	do.	13.30
2871	Raise, 35 ft. below No. 4 tunnel	do.	1.8	.1	15.6	.21	do.	1.40
2872	Raise, 45 ft. below No. 4 tunnel	do.	2.5	1.5	10.8	.61	do.	3.75
2873	Raise, 55 ft. below No. 4 tunnel	do.	2.0	.3	13.6	.14	do.	.40
2874	Raise, 65 ft. below No. 4 tunnel	do.	.3	1.3	19.0	.11	do.	4.25
2875	Portal of lower tunnel (No. 5)	Quartz	1.5	.1	.9	.15	0.015	.40
2876	Lower tunnel, 20 ft. from portal	Quartz and schist	5.0	.1	5.0	.05	Trace	.20
2877	Lower tunnel, 40 ft. from portal	do.	3.7	.1	1.0	.05	do.	.40

TABLE 2. - Detailed data on Bureau of Mines samples, Eureka mine (Continued)

No.	Location	Description	Length, feet	Assays: Percent Pb	Assays: Percent Zn	Assays: Percent Cu	Assays: Ounces Au	Assays: Ounces Ag
2878	Lower tunnel, 60 ft. from portal	Quartz and schist	2.7	0.5	2.0	0.06	0.010	0.50
2879	Lower tunnel, 80 ft. from portal	Quartz	1.3	.1	4.2	.11	.025	1.35
2880	Lower tunnel, 100 ft. from portal	do.	1.0	.1	1.7	.09	Trace	.15
2881	Lower tunnel, 120 ft. from portal	do.	1.1	.1	4.4	.10	0.030	1.15
2882	Lower tunnel, 140 ft. from portal	Quartz and schist	2.4	.1	5.0	.15	.015	.55
2883	Lower tunnel, 160 ft. from portal	Hard quartz	.2	.2	3.2	.08	.015	.65
2884	Raise, 10 ft. below 3d level, S. side	Partly oxidized, some sulfide	2.4	5.2	7.8	.55	.020	4.95
2885	Raise, 20 ft. below 3d level, S. side	do.	2.0	1.5	14.4	.04	Trace	1.85
2886	Raise, 30 ft. below 3d level, N. side	do.	1.8	.1	8.3	.02	do.	1.00
2887	3rd level, sublevel breast	Soft oxidized, some sulfide	1.0	6.3	8.6	.16	do.	3.30
2888	3rd level, sublevel, 10 ft. from breast	do.	.8	6.9	6.8	.28	0.005	7.40
2889	3rd level, sublevel, 20 ft. from breast	Quartz and sulfide	4.0	5.9	8.9	1.10	.005	11.35
2890	No. 4 tunnel, centerline of raise from No. 5 tunnel	Partly oxidized, little sulfide, quartz	2.0	.2	3.7	.02	Trace	.60
2891	No. 4 tunnel, 10 ft. S. of raise	do.	2.3	.1	5.6	.02	do.	.20
2892	No. 4 tunnel, 20 ft. S. of raise	do.	2.0	.1	4.3	.03	do.	.20
2893	No. 4 tunnel, 30 ft. S. of raise	Oxidized, gouge	1.1	.1	.6	.02	do.	.10
2894	No. 4 tunnel, 10 ft. N. of raise	Partly oxidized, some sulfides, quartz	3.0	.1	5.6	.06	do.	.25
2895	No. 4 tunnel, 20 ft. N. of raise	do.	2.0	.1	12.0	.02	do.	.95
2896	No. 1 tunnel, breast	Oxidized	3.0	.1	.6	.04	do.	2.00

Of the 46 samples taken 22 were from the sulphide oreshoot and averaged 3.56 percent lead, 9.28 percent zinc, 0.26 percent copper, and 4.37 ounces silver per ton, with an average thickness of 2 feet.

History and Production

Some gold ore has been produced from this mine at various times since the 1880's. Warner stated that 500 tons of ore shipped to the Producers' Mines, Inc., assayed $18 to $28 gold per ton.

Description of the Deposit

The ore occurs in lenses in a fault fissure in amphibolite and granite. This vein strikes N. 36° W., dips 81° northeast, and ranges in thickness from a few inches to 4 feet. Most of the earlier work was confined to one lens that has furnished virtually all of the ore. This was opened and nearly all stoped out for a length of 100 feet and a depth of 125 feet. This stope is in the oxidized zone, and only a small amount of sulfide ore was found. The values were all in gold and silver.

Development

A shaft was sunk on an ore shoot to a depth of 125 feet, and the ore was stoped from both sides of the shaft. In addition, several open-cuts and a 40-foot shaft were made on the outcrop of the vein. A crosscut has been driven from the hillside for a distance of 517 feet that intersects the vein at a depth of about 300 feet below the collar of the shaft and 350 feet north of it. A drift was then driven north on the vein for 400 feet, but no ore was developed. A ventilation raise is being driven from the crosscut 175 feet to the surface. Some galena was found in this raise 100 feet above the drift. Small scattered bunches of galena were noted along 75 feet in the raise. These are 2 to 10 inches thick. It is planned to drift north on the vein at this point to see whether a body of lead ore can be developed. It is also planned to drive south on the vein from the crosscut. This will open up the ore shoot on which the shaft was sunk, if the ore continues to this depth. Three men are working at the property.

Sampling

No samples were taken on the property. Warner reported that samples taken in the raise assayed 39 percent lead and 35 ounces per ton silver, but these were assays of specimens and not average samples of the vein.

HIDDEN TREASURE MINE

Location, Accessibility, and Ownership

The mine is situated about 2 miles by road from Chloride. A portion of the road is little used and has sharp turns and steep grades.

The property comprises a patented claim owned by W. C. and Helen W. Babcock and George R. Neil, and is leased to Frank Grannis of Chloride.

History

The mine was operated in 1927 by the Chloride Mining Co. F. C. Smith was the manager. The company built a mill near Chloride and an aerial tram from the mine to the mill. After milling a few thousand tons, the company ceased operations, and apparently no more ore has since been produced from the mine. Recently, the mine was partly cleared of cavings and drained.

Production

The only recorded production from this mine was 9,300 tons in 1927. This ore was transported by aerial tram to the company's mill at Chloride.

The total metal recovered in concentrates and 18 tons of mill cleanings was 137,012 pounds of lead, 252,174 pounds of zinc, 6,450 pounds of copper, 70 ounces of gold, and 7,093 ounces of silver. This is equivalent to a recovery per ton of ore of 14.73 pounds of lead, 27.11 pounds of zinc, 0.69 pound of copper, 0.0075 ounce of gold, and 0.76 ounce of silver. Obviously the ore was too low-grade to support a profitable operation.

Description of the Deposit

Several fissure veins are crosscut and explored laterally by the underground workings. Occurrences of lead and zinc minerals in accessible workings are small and scattered. The veins in general strike northwest and are nearly vertical. Exploratory drifting has been extended about 1,000 feet on the strongest vein. In the northwest portion of the mine, this vein has been opened on two levels. The only minable ore body now exposed in the accessible workings is on the lower level in this area.

Of five stopes shown on old mine maps, three were inaccessible. These stopes were in lead- and zinc-bearing vein material, but faces along the margins of the stopes do not appear to contain an appreciable quantity of lead and zinc minerals. These five stopes evidently furnished the 9,300 tons of ore milled.

Sampling

Four samples were taken at 15-foot intervals from the ore body on the lower level (3303 to 3306).

The length of the ore was 30 feet, the average width 1.1 feet, and the average grade 5.4 percent lead, 4.9 percent zinc, 0.13 percent copper, 0.171 ounce gold, and 1.64 ounces silver per ton.

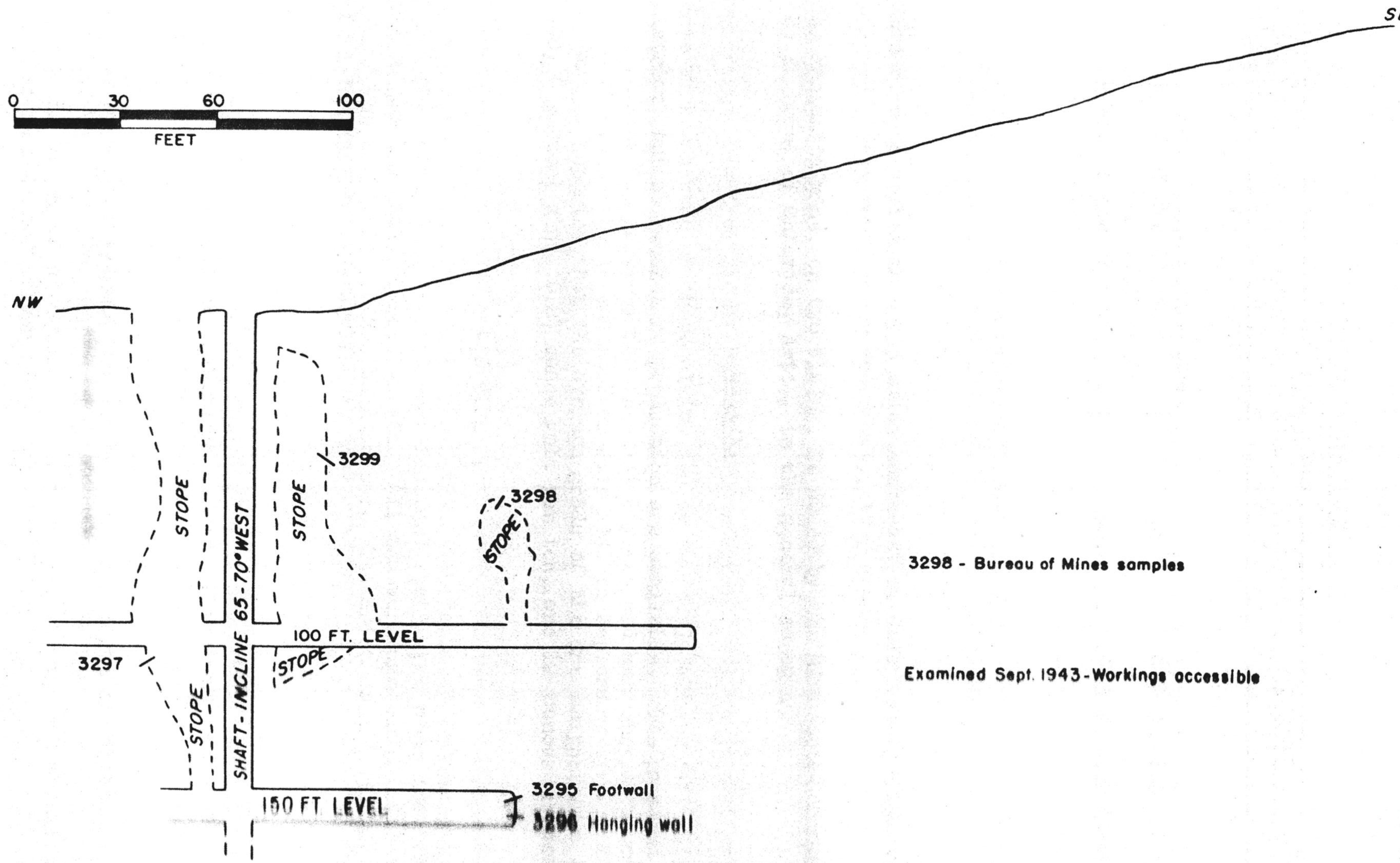


Figure 5. - Section in plane of vein, Manzanita mine.

Bureau of Mines Samples

No.	Length	Location	Description	Percent			Ounces	
				Pb	Zn	Cu	Au	Ag
3303	1.3	Lower tunnel, N. end of ore shoot.	Quartz, sulfide	4.6	4.2	0.12	0.360	1.40
3304	.8	Lower tunnel, 15' S of N. end of ore shoot.	do.	6.6	5.3	.16	.060	1.70
3305	1.3	Lower tunnel, 30' S of N. end of ore shoot.	do.	5.0	5.0	.10	.025	1.20
3306	1.0	Lower tunnel, 45' S of N. end of ore shoot.	do.	.1	.6	.05	.075	.30

MANZANITA MINE (MINNESOTA-CONNER)

Location, Accessibility, and Ownership

This mine is approximately 3 miles southeast of Chloride by a fair road having two or three sharp turns and short, steep grades.

The Manzanita mine, on two claims, is owned by the Minnesota-Conner Mines, Inc. R. E. Lord, of Chloride, Ariz., is the general manager.

History

Some work was done on these claims during the early mining activity in this district, but no records of production are available. The present company has operated the property for the last 2 years and has shipped about 1,200 tons of ore in the 14 months from July 1942 to September 1943. The general manager reported that the average grade of the ore shipped was 4 percent lead, 4 percent zinc, 0.27 ounce gold per ton, and 12 ounces silver per ton.

Development

Development consists of a 150-foot inclined shaft with about 300 feet of drifting on the 100- and 150-foot levels. All the workings are in the vein, and most of the developed ore has been stoped. The drift on the 150-foot level is being advanced southeastward.

Description of the Ore Deposit

A locally mineralized vein striking northwest-southeast and dipping 65° to 70° southwest has an almost continuous outcrop of stained quartz for several hundred feet. This vein is opened on two levels (fig. 5).

The bulk of the ore from the stopes above the 100-foot level, which was oxidized, contained mainly gold and silver. Below a depth of 60 feet, sulfide minerals occur at some points in the stopes and in the breast of the 150-foot level. As shown by sampling, the principal values in the sulfide zone are also in gold and silver.

Sampling

Five samples were taken - three from stopes and two from the breast of the drift on the 150-foot level (fig. 5). Three other samples, Nos. 3300 to 3302, were taken from shallow workings on adjoining claims. Detailed sampling data follow:

Bureau of Mines Samples

No.	Location	Description	Length, feet	Assays				
				Percent			Ounces/ton	
				Pb	Zn	Cu	Au	Ag
3295	150-foot level, breast, footwall side.	Heavy pyrite	1.9	3.8	5.0	0.39	3.400	9.75
3296	150-foot level, breast, hanging-wall side.	Soft, talcy, some pyrite	2.7	.4	1.4	.13	Trace	1.30
3297	North side of stope, 5 ft. below 100-foot level.	Hard quartz, some sulfide	3.0	8.0	4.0	.43	0.060	7.75
3298	100-foot level, south stope, back of stope.	Pyrite in altered granite	.5	9.9	3.5	.46	1.200	15.80
3299	50-foot level, south end of stope.	Quartz and pyrite, partly oxidized	1.2	.3	1.3	.15	.190	3.05
3300	Uncle Abe claim, footwall of winze.	Oxidized, soft	2.3	.4	.5	.20	.020	1.20
3301	Uncle Abe claim, hanging wall of winze	do.	2.0	7.8	.4	.38	.020	3.65
3302	Shaft at north end of property, 50-ft. level, S. end.	Oxidized, manganese iron, stained	.9	.1	1.2	1.10	Trace	17.60

LONE JACK AND BLACKFOOT MINES

Location, Accessibility, and Ownership

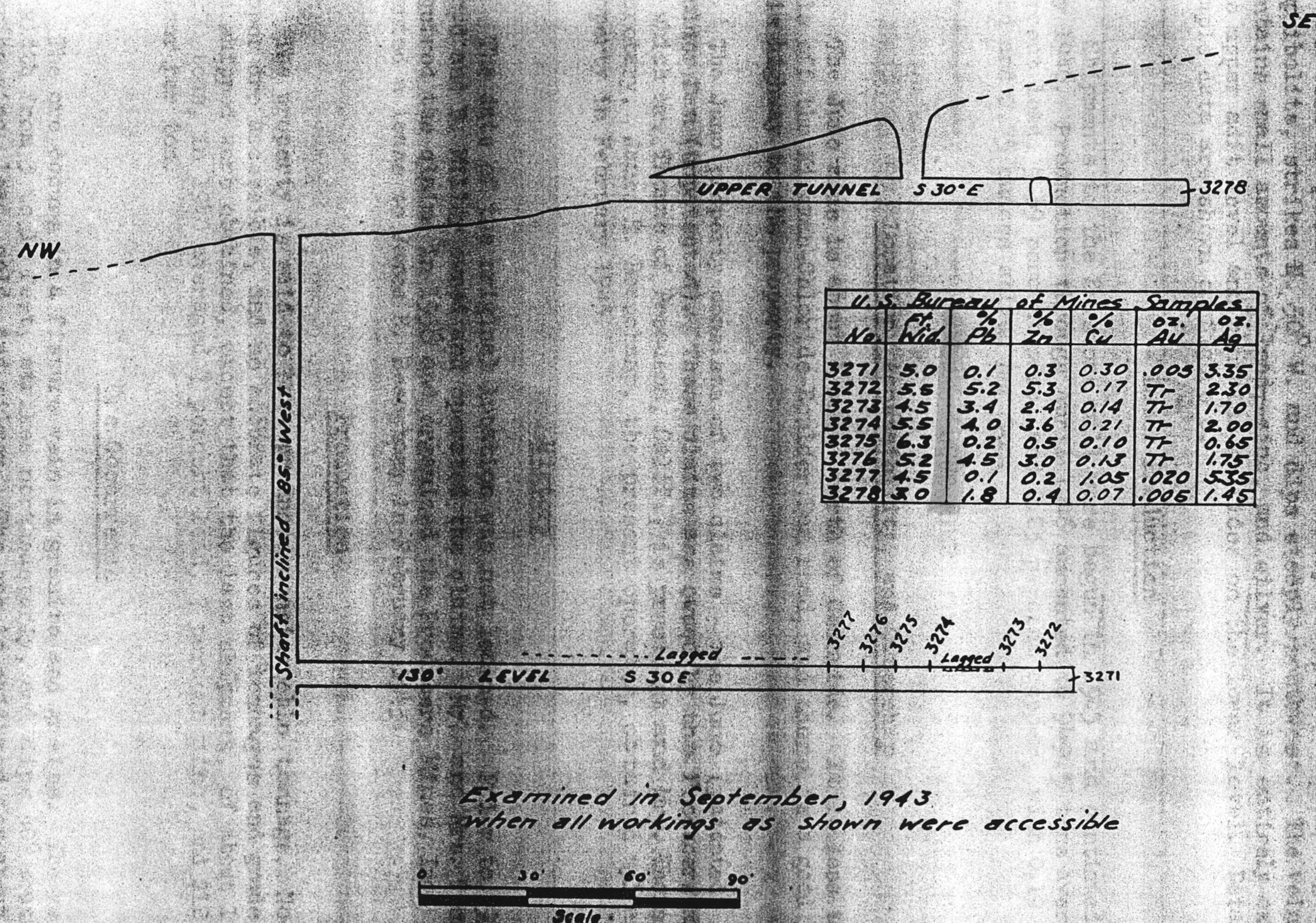
This property is situated about 3 miles by road southeast of Chloride.

The Lone Jack and Blackfoot claims are owned by H. C. J. Lennox and Mrs. Louise E. Hughes, both residing in Chloride. Lennox is in charge of operations.

Development

Mine workings on the Lone Jack consist of a steeply inclined shaft 130 feet deep and 218 feet of drifting southeast from the bottom of the shaft. An adit drift extends 200 feet southeast at the shaft-collar level (fig. 6).

An R.F.C. loan was used for re-opening the properties. The Blackfoot shaft was standing full of water when it was visited by the Bureau of Mines engineers, but repair work on the timbering indicated that the shaft had been pumped out and made accessible for sampling.



U. S. Bureau of Mines Samples						
No.	Ft. Wid.	% Pb	% Zn	% Cu	oz. Au	oz. Ag
3271	5.0	0.1	0.3	0.30	.005	3.35
3272	5.5	5.2	5.3	0.17	Tr	2.30
3273	4.5	3.4	2.4	0.14	Tr	1.70
3274	5.5	4.0	3.6	0.21	Tr	2.00
3275	6.3	0.2	0.5	0.10	Tr	0.65
3276	5.2	4.5	3.0	0.13	Tr	1.75
3277	4.5	0.1	0.2	1.05	.020	535
3278	3.0	1.8	0.4	0.07	.005	1.45

Figure 6. - Lone Jack mine, section in plane of the vein.