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

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

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

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

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

BLANKET VEIN PROPERTY.

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

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

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

STOCKTON HILL DISTRICT.

GENERAL OUTLINE.

LOCATION AND HISTORY.

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

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

TOPOGRAPHY AND GEOLOGY.

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

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

ORE DEPOSITS AND MINES.

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

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

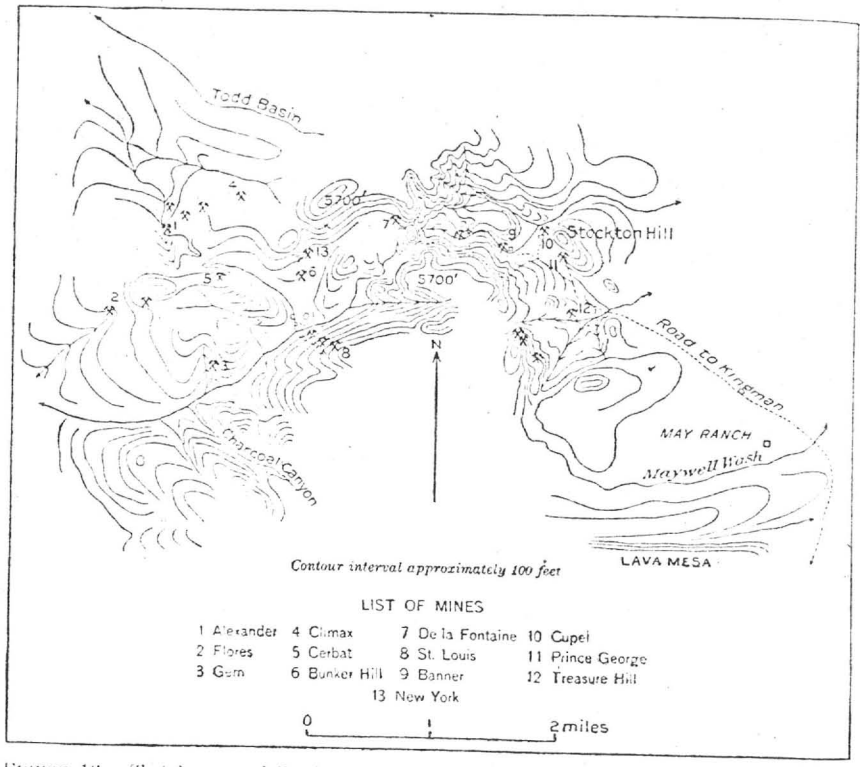
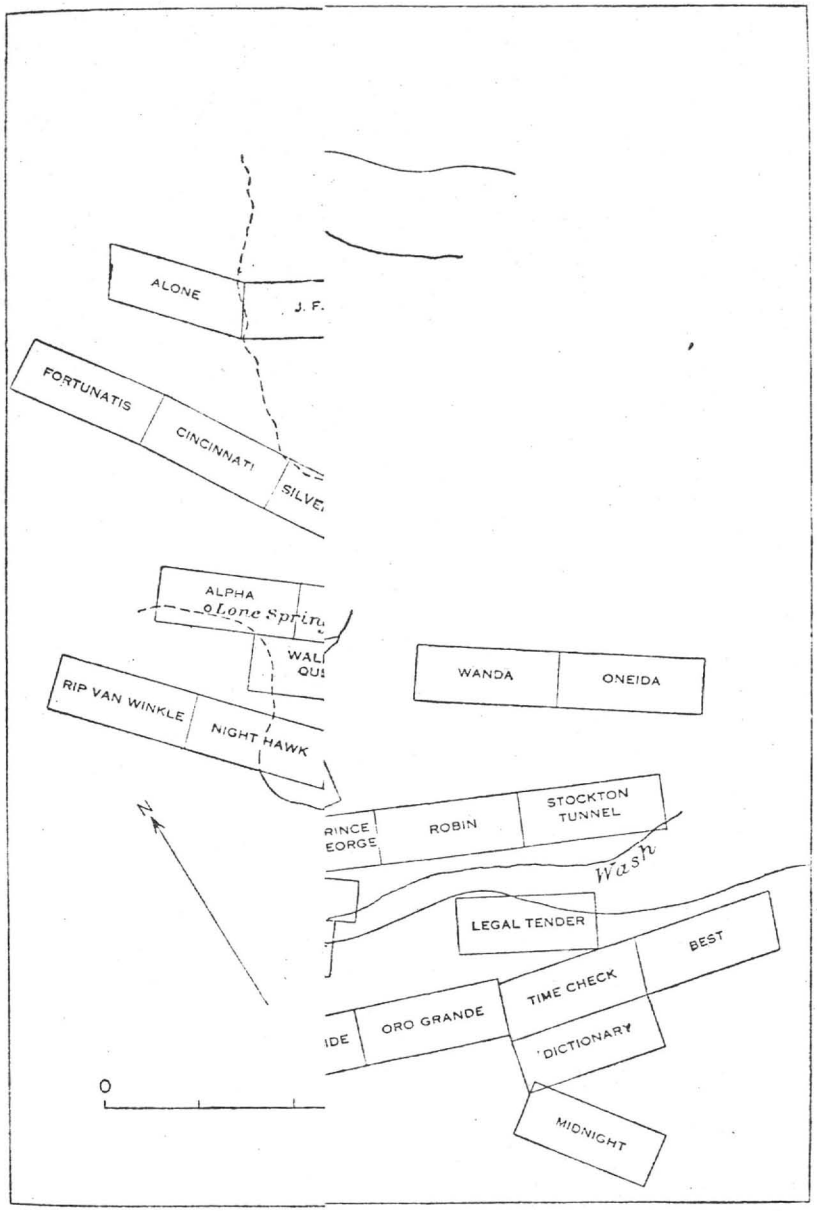


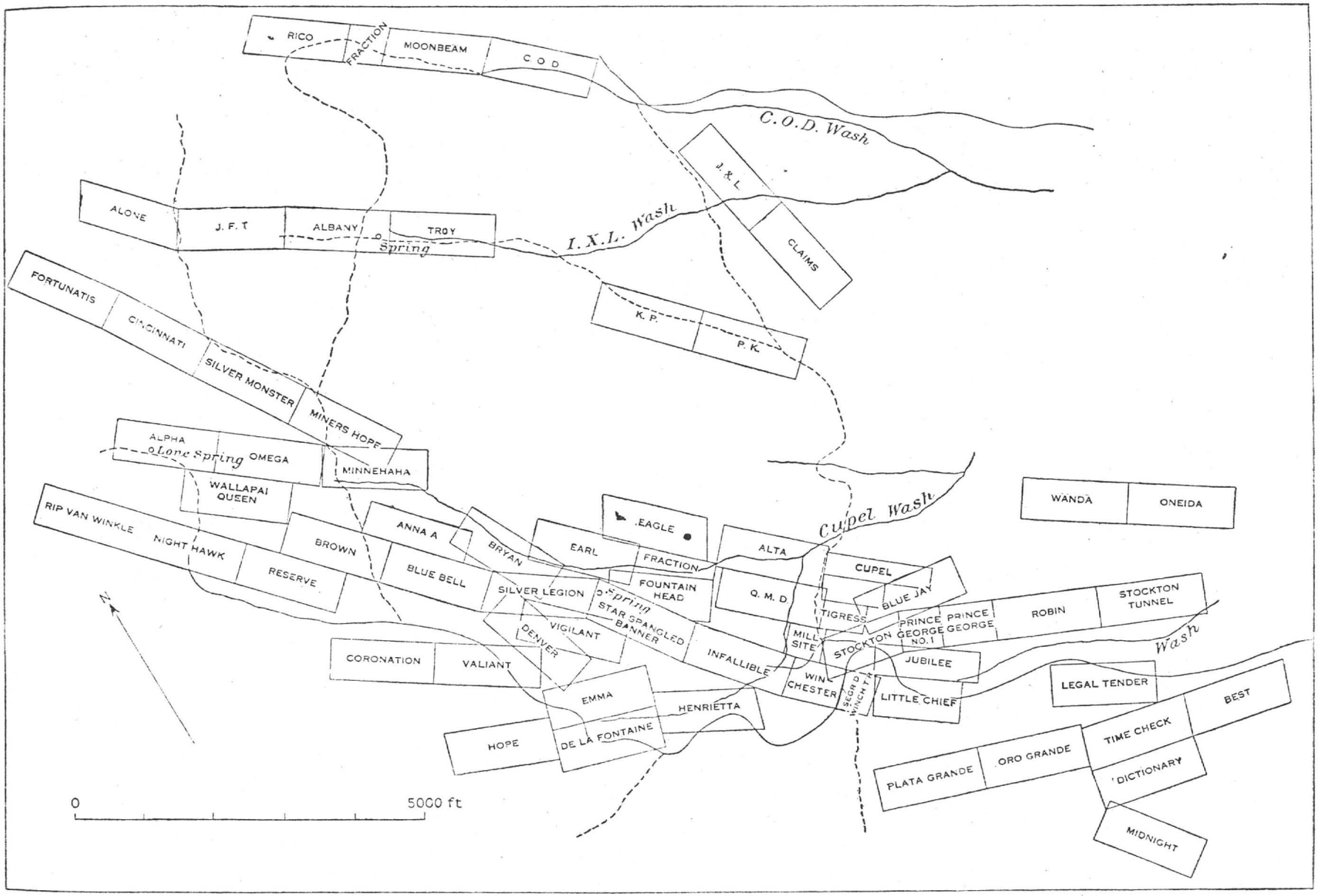
FIGURE 16.—Sketch map of Stockton Hill district and adjoining part of Cerbat district.

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

MINES ON STOCKTON HILL WASH.

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





CLAIMS IN STOCKTON HILL DISTRICT.

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

BANNER GROUP MINE.

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

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

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

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

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

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

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

CUPEL MINE.

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

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

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

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

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

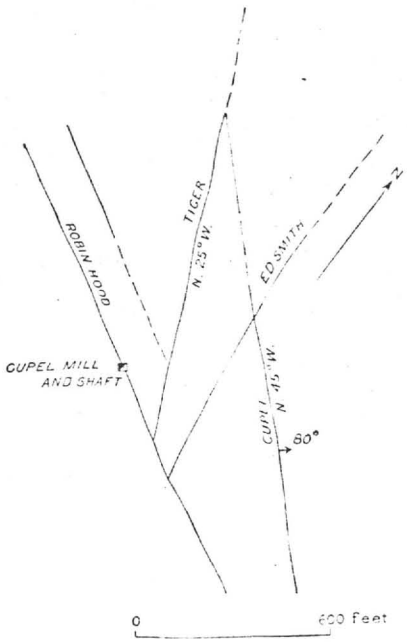


FIGURE 17.—Sketch showing relations of veins on Cupel claim.

PRINCE GEORGE MINE.

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

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

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

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

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

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

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

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

LITTLE CHIEF MINE.

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

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

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

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

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

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DE LA FONTAINE MINE.

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

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

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

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

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

MINES ON TREASURE HILL WASH.

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

TREASURE HILL MINE.

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

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

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

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

The gangue is principally quartz, in which the ore occurs in streaks or shoots from 100 to 200 feet long. The shoots usually favor the hanging wall and are associated with clay gouge. The ore contains galena, with some pyrite and a little chalcopyrite. No zinc has yet been found on the property. The ore, so far as the experience of the present management goes, is said to average about 100 ounces of silver and $5 to $16 in gold to the ton, and from 7 to 10 per cent of lead, in both the oxidized and unoxidized zones.

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

SIXTY-THREE MINE.

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

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

MINES IN I. X. L. BASIN.

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

K. P. MINE.

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

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

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

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

J. F. T. MINE.

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

MINES IN C. O. D. WASH.

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

C. O. D. MINE.

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

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

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

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

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

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

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

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

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

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

MINES OF CANYON STATION WASH.

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

MINES IN "TOP OF STOCKTON HILL" AREA.

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

GOLD BASIN DISTRICT.

GENERAL FEATURES.

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

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

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

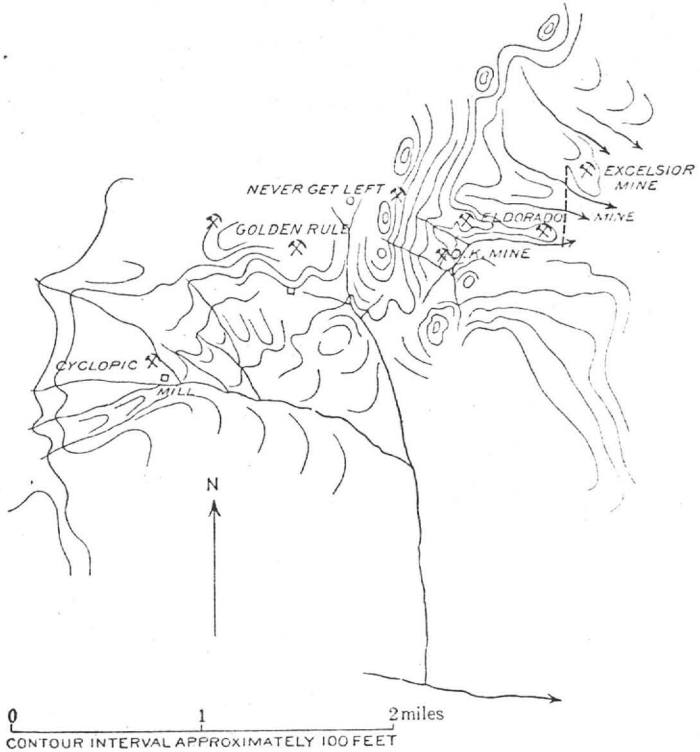

FIGURE 18.—Sketch map of Gold Basin district.

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

Stockton Hills Mohave (file)
date: 1950

SUMMARY

After a careful preliminary examination of the 3 lode mining claims, comprising the CHIEF ENGINEER mine group, located in the Stockton Hill section of the Wallapai Mining District, Mohave County, Arizona, it would seem that the indications on the property, its past production record, and the quality of the ore now exposed, warrants the carrying out of the proposed development and further exploration to open up the ore bodies and veins on the group, that has been outlined in this report. Upon the completion of this exploration program the management could decide intelligently upon any future development program, such as the mining and extraction of any ore bodies thereby opened up, in the primary zone.

The other promising veins having excellent ore exposures can be explored after this main development program is underway. At some future time it might be advisable to continue the drifting from your present Little Chief tunnel of the CHIEF ENGINEER mine, that is now 500 feet northwesterly from its portal, along the main vein of the mine toward the Winchester claim of the Comstock Silver, which will give you a depth of about 200 feet below the surface, and will explore the ore bodies above, from which earlier shipments have been made.

It is possible, by granting the continuance of the ores and assuming it to be of a value similar to like ore bodies in the district under similar conditions, that this work will prove remunerative to the owners. For economical operation in prosecuting this work, suitable mechanical equipment would here be necessary also.

There exists at this mine property every apparent geological similarity with the other productive mines of the section, such as the fissure veins, the same ore characteristics, the same strike and dip of veins as those of the neighboring producing mines, which occur in the geological formations recognized as the most favorable in which to expect commercial ore deposits of importance in the district.

The veins on your property are strong and well defined, and there is no question as regards their permanency and continuity to a very great depth, the future explorations of which will likely result in the uncovering of important ore bodies of remunerative content that will prove profitable to the operators.

Another thing to be considered is the past record of the many neighboring mines in the immediate vicinity, and the present producers, such as the Comstock Silver, "78", Cupel, Prince George, Arizona Premier, De La Fountain, C. O. D., I. X. L., Wrigley, etc. In other words, your property is in a proven production area. Your CHIEF ENGINEER mine has had important production.

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The ores subsequently found in the CHIEF ENGINEER mines will readily respond to treatment such as is now in practice in this same district with similar ores. There is always a ready and available market for either ores of shipping grade direct from the mine or concentrates from the mill, such as those that have already been produced from these mines.

HISTORY

The exact date of discovery and original location of the Little Chief, now the CHIEF ENGINEER, cannot be definitely determined, but evidently the first substantial ore shipments were made between 50 and 60 years ago, when the operators at that time packed their high grade ores out on animals. In an article published in the Mohave County Miner, the mining editor who was personally familiar with this property, having been a successful operator of the neighboring Cupel mine, stated, "In the early days the Little Chief (now the CHIEF ENGINEER) was a shipper of high grade silver ore, many car-loads of ore averaging 1100 ounces going out to the smelters. At that time it was owned by John Kennedy, known to the Indians as 'Little Scalway' (meaning man with tooth out in front). With the money from the ore sales Kennedy purchased a good-sized cattle ranch". After the mines had passed into other hands lessors shipped largely from the property, the ore being from the oxidized zone."

Since the earlier operation of these mines, now included in the CHIEF ENGINEER group, this area has been owned and operated on a small scale intermittently to the present time, as was the case with the other mines of the Stockton Hill section of the Wallapai Mining District.

In the earlier operations only the oxidized ores were extracted because it has only been comparatively recent that sulphide ores could be mined at a profit. The rate of progress in the last fifteen years in the development of differential flotation, and the construction of suitable mills at the smelters, has been rapid beyond the realization of most people. So today sulphide ores such as are shipped from the Stockton Hill section can be mined at a profit, stimulating mining here, with the result that such mines as the CHIEF ENGINEER can find a ready market for their ores.

FURTHER HISTORY OF CHIEF ENGINEER MINE

Although I have been familiar with the Little Chief, now known as the CHIEF ENGINEER mines, for over 20 years, having been an operator in the immediate area; in order to complete the record at my request the following remarks were furnished me by E. Ross Housholder, E. M., of Kingman, Arizona, a widely known mining engineer, who is the present owner of the property. His remarks as to the early day operations give a good account of those conditions consistent with the obtainable facts as I believe them to be:

HOUSHOLDER'S REMARKS

"Andy Goodwell, an old timer, and owner of the property between the CHIEF ENGINEER and the Cupel, including the Pr. George, as well as the property on which is located the Stockton Hill development tunnel, was familiar with the early operation on the CHIEF ENGINEER mine, in those days known as the Little Chief. He said, several years before he died, that the original locator of the Vigilanty lode claim, between this mine and his Pr. George shaft, had also acquired the Little Chief. The ruins of the old rock cabins can yet be seen from the surface workings of the Little Chief in the wash below.

"Although he made considerable money from the ore shipments from his Vigilanty claim, he later turned the Little Chief (now the CHIEF ENGINEER) property over to the Taggert Mercantile Company, of Kingman, Arizona, to settle his account with them. As often was the case in those early days the mercantile company was also in the mining business. It was their policy to grant 90 to 120 day leases to miners for a portion of the vein, having a length of between 50 and 100 feet. The miners would be furnished a grub stake of tools and supplies and they would go to work on the ore. As long as they were in the ore they would keep sinking, with the idea in mind that after they had reached a depth of 75 to 80 feet they could easier mine the ore by stooping.

"But when they attempted to get an extension on their leases the mercantile company owners would not grant such a time extension. So the lessor-miners would stop sinking and endeavor to stoop out all the ores they could in the time that was left. No more timber was used than absolutely necessary. Much of the timber that was used was local cedar or juniper. The owners would be willing to grant other leases on their property, but never in a place that had been opened up.

"This accounts for the seven or eight surface holes that had a depth of from 30 to 60 feet with the ore stooped out on each side of the original shaft.

"Greeley Clack still living in Kingman was the youngest of several brothers who were early day mine operators. He told me that he visited, for several days, his brother William Clack who was extracting ore from one of these Little Chief leases, when he was a young man. He said his brother was mining ore that contained over 60 ounces of silver per ton and some went well over 100 ounces per ton.

"When I first visited these workings about 1925 or 1926, several of these old shaft holes were still open, and some of the reject from the ore sorting operations was still in little piles on the surface.

DJG

"Since then the holes have caved in or been filled with the surface soil and debris. It is my knowledge of the ore, that I actually saw there, supplemented by the geological conditions existing on the property, together with the substantiating information from the well informed old timers who personally related their information and knowledge to me that has caused me to hold on to these three lode claims comprising the CHIEF ENGINEER mine group.

"In 1941 and late 1942 I had established a camp at the mine and had several men doing work there. But shortly after the attack on Pearl Harbor I was called back into Military Service and could not return until after the war ended. I had served in World War I also. This I relate here, so you will understand that as an individual I found conditions changed when I returned and could not on my own continue a development program. I have had a road built from the new county road across the CHIEF ENGINEER claim to the mine campsite above the development tunnel and accessible to some of the surface workings, besides other valuable improvements to the mine, within my means to do so.

"It is the one property that I have held, because I have faith in it based on my study and understanding of the situation, made clear to me by my experience as a mining engineer familiar with production mines of this area. That, too, is the reason why I am more interested to take my royalty off the mine production, instead of selling outright. This also helps the operator. In the long run it will be best for me, too."

"E. Ross Housholder."

DEVELOPMENT TUNNEL

The Little Chief development tunnel on the CHIEF ENGINEER lode mining claim, just off the old county road was first run in the mountain as a cross-cut to a place from which a stoop and manway made a connection with a known ore shoot in the intermediate workings above.

Then the tunnel was driven in further with a view to getting on the main Little Chief vein and it was expected that drifting would be done to the westward to get under the known productive surface openings, and thus penetrate the ore shoots.

However, about two thirds of its present (1950) length, the mineralization lead the operators, at that time, to veer to the right where a mineralized vein was encountered. The showing of sulphides over a width varying from three to four feet was such that a winz was started and sunk about 22 feet. So much water was encountered that the operators could not handle it with the equipment available to them. Then, too, altho the sulphides persisted, the commercial values were not present. Some of the last ore taken from this winz is still on the tunnel dump. Assay returns show very low silver and gold values.

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Now, this work was all done apparently without a proper survey to tie in the surface workings and correlate them with the underground work. It became apparent to the workmen, however, that they had been drifting on a vein parallel to the productive Little Chief vein. This drifting had proceeded about 60 feet beyond the winz, then cross-cutting started to the left, for about 40 feet more, where the work was stopped due to lack of funds.

PROPOSED DEVELOPMENT & EXPLORATION

Although a more precise survey should be completed, enough work was done in late 1942 to show that this last crosscut would not enter the Little Chief vein at right angles. It is proposed to direct this crosscut, after the suggested mapping has been completed, directly to the Little Chief vein, estimated now to be about 35 to 40 feet. Then, when the Little Chief vein has been entered, to drift, possibly easterly and westerly to get under the known productive ore shoots to tap the ore reserves at a depth of about 1 60 to 200 feet below the surface. Extraction of the ores can then begin, but the drifting should also be continued westerly to the end-line of the CHIEF ENGINEER claim where it adjoins the Manchester claim of the Banner mine owned by the U. S. States Smelting & Refining Co. The production from this same vein which is known as the Banner vein on the Banner mine group has been over a quarter of a million dollars. The ores have similar mineralogic and geologic characteristics as well as a like width in this Banner vein as its easterly extension on the CHIEF ENGINEER mine property where it has been designated as the Little Chief-Banner vein.

Once having topped the Little Chief-Banner vein ore shoots from this tunnel level, the ores can be transported through the tunnel to the surface portal where it can be placed in suitable bins for loading. Besides mining ores by stooping is much less expensive. Haulage of the ores to the rail head for shipment to a smelter or to a treatment mill presents no problems.

TOPOGRAPHY

The district ranges in elevation from 3,000 feet in the foothills on the northeast to 5200 feet at the crest of the Cerbat mountains on the west. The western end of the CHIEF ENGINEER group is almost 800 feet higher than the eastern end of the property. The average elevation of this g roup is about 4,600 feet.

The topography of this portion of the district is typica of eroded igneous formations in this region belong to the pre-cambrian, essentially gra nitic. The accompanying photographs wil give one a splendid idea of the topography of the CHIEF ENGINEER mine estate and the surrounding territory.

LOCATION AND TRANSPORTATION

The CHIEF ENGINEER mine group is located on the easter slope of the Stockton Hill section, of the Kallapai Mining Distr in the Cerbat mountains, Mohave County, Arizona, and comprises t lode mining claims, at a maximum elevation of 5000 feet. The m westerly portion of the group is endlined and sidelined by the

Banner-Prince George mining property of the Comstock Silver Mining Company and includes what has been known for years as the Little Chief mines. The famous Cupel mine is about 2000 feet north of the Little Chief workings.

The Western Union mine property adjoins this estate on the southwest. A good grade of lead silver ore is now being extracted from this adjoining mine. South of the Windsor group is the Mountain Queen, and the "78" mine that has been a heavy producer of high grade ores and is today producing 42 ounce silver ore for shipment to the smelters. The De La Fountain mine lies to the west about a quarter of a mile.

The CHIEF ENGINEER mine group is in section 9, Township 22 North, Range 17 West, Gila and Salt River Base Meridian, Arizona.

There is a good county truck road traversing the entire length of the estate, which with connecting mine roads on the property affords easy access to the more important workings of the property. This same road connects with another county road at the northwest corner of the group, a few hundred feet from the Little Chief main tunnel, and again with this same road near the east end of the property in the lower foothills. This latter road section is of easier grade and is being used daily for transportation of supplies to the different mines and ranches and the hauling of the shipping ore to the reduction plants or to the railroad at Kingman, Arizona, on the main line of the Atchison Topeka & Santa Fe R. R., a distance of about 12 miles from the CHIEF ENGINEER mine property. This road is kept up by the county and is in excellent shape.

CLIMATE & WATER SUPPLY

The district has a healthful climate with mild winters which permits good working conditions the year round. The rainfall is a bout 10 inches a year. The deeper shafts on the property produce enough water to insure an ample supply for mining as outlined in the present development program.

GEOLOGY OF STOCKTON HILL SECTION OF THE WALLAPAI MINING DISTRICT

The country rock is the pre-Cambrian granite, gneiss and schist complex, belonging to the laminated metamorphic series of that age, with a tendency to grade into mica chlorite schists in places. It is intruded by dykes of minette, granite, granite porphyry, diabase basalt, and other rocks, that are products of differentiation in the pre-Cambrian series.

The veins for the most part are regular and persistent with well defined walls. They occur chiefly in the pre-Cambrian granitic rocks. Many of the pay chutes coincide with the intersection of fissures. Oxidation has altered the upper part to a depth ranging from 50 to 300 feet, and this oxidized zone changes to the primary ore within a vertical range of 10 to 40 feet. The old time operators were unable to market the sulphide ores at a profit such as can be mined in the district today. Only the oxidised and secondarily enriched ores were they able to treat and ship. Therefore, today there

are mines being developed here which may be capable of great production. The veins have suffered great erosion, and their mode of occurence leads to the belief that they were deposited at comparatively great depth by hot circulating waters.

LOCATION OF THE STOCKTON HILL SECTION

The Stockton Hill district joins the Cerbat district on the east, and is about parallel and coextensive with it north and south, being situated on the opposite slope of the Cerbat Mountains, in the Wallapai Mining District. It is about four miles in width and but little more in length. It ranges in elevation from 3000 feet at the edge of the Wallapai Valley on the east to 5,800 at the crest of the range.

The principal and oldest camp for many years was Stockton Hill, situated in the foothills in the eastern part of the district, just north of the present CHIEF ENGINEER group ~~of the Stockton Hill Mining Company's estate~~, 10 miles north of Kingman, at an elevation of about 4,800 feet. It dates from early in the sixties, when the principal veins were first discovered and began to produce. In former days much ore was shipped to Swansea, Wales, but later it was treated in the Mineral Park and Cerbat mills and shipped to the smelters in San Francisco and to New Mexico. Then followed a period when the ores were hauled by wagon to the station of Berry on the then new railroad, or to Kingman, whence it was shipped to the mill and smelter at Needles, California, on the Colorado River.

During the past years the shipping ores and concentrates from the milling plants have been trucked over excellent highways to a sampler at Kingman or to the reduction works in the district, where the ores of the district have found a ready market.

ORE DEPOSITS OF THE STOCKTON HILL SECTION

In writing about this section in United States Geological Bulletin #397, F.C.Schrader, the government geologist, stated, "The deposits occur in the pre-Cambrian gneiss or schist, intruded in places by a later aplitic granite or by basic dikes. They are fissure veins, which in general strike northwesterly and are vertical or dip at steep angles to the northeast. The gangue is quartz and the ores contain chiefly silver, with some gold, lead, zinc, and copper. Primary sulphide minerals are galena, zinc, blende, chalcopyrite, and pyrite, but the district owes its reputation to the rich silver ores, such as native silver, ceragyrite, argentite, and ruby silver, which were found in large quantities in the upper levels. The water level is about 100 feet below the surface. Galena is often found above it, while rich silver minerals descend to a considerable distance below it. The greatest depth so far attained is 400 feet."

CHIEF ENGINEER GEOLOGY

Commenting upon the Little Chief, now the CHIEF ENGINEER, mine in the same government report, the author, F.C.Schrader, wrote, "The country rock is pre-Cambrian complex. To judge from talus debris on the surface at the mine, it seems to be intruded by diabase near by, and portions of a light-colored altered rock, which seems to be the intrusive porphyry, are associated with the vein.

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

Since the above government report was written the entrances to the works referred to, have been caved and are now with few exceptions impassible. Samples that have been taken from rather narrow streaks in the vein as now exposed and left by the early miners gave assay returns between 20 ounces and 80 ounces in silver, besides about $1 in gold per ton. Samples from the old shaft sorting dumps also carried up to 27% lead. The ore shows a low percentage of copper, but zinc is now present in any appreciable quantity.

Other openings on the CHIEF ENGINEER mine group have exposed veins of varying width and metallic content, which were not extensively investigated, as the two mines of this estate more fully described will warrant the immediate attention of the owners as to the present and near future exploration program.

DEVELOPMENT

The development work on the CHIEF ENGINEER consists for the most part in six or seven shafts, connecting drifts, stopes, raises, crosscuts, etc., between the northwest endline along the vein toward the portal of the present development tunnel a distance of about 1200 feet. This development tunnel has been driven northwest a distance of 500 feet. As this tunnel is pushed ahead it will open up this same vein about 200 feet below the surface and between 100 and 160 feet below the older workings and enter the ore chutes exposed above at the depth indicated.

Taking into consideration all the shallow shafts, tunnels, crosscutting, and drifting, that has been completed in all the workings of the three claims of this CHIEF ENGINEER group, there is in excess of 400 feet of shaft work, with a maximum depth of 120 feet on the Little Chief, now the CHIEF ENGINEER. This has been supplemented by several tunnels having a maximum length of 500 feet on the CHIEF ENGINEER, formerly the Little Chief, together with other tunnels on the remaining parts of the group, where one tunnel has several thousand feet of underground work. The tunnel work crosscutting, drifting, etc., will exceed 1000 feet of work. Considerable ore has been shipped from some of these openings during the history of the property, that is reported to be better than a hundred thousand dollars.

FUTURE EXPLORATION OF THE CHIEF ENGINEER

An accompanying topographical and claim map, on which the general geology of the property has been superimposed will give one an idea about the trend of the more important veins and dykes, together with the general character of the country rock, and the relative position of neighboring mines.

RECOMMENDATIONS

It would be advisable to continue the drifting from your present main tunnel, that is now 500 feet northwestwardly from the portal to and along the main vein of the CHIEF ENGINEER mine toward the northwest endline that joins the Winchester claim of the Comstock Silver, which will give you a depth of about 200 feet below the surface, and will explore the ore bodies above from which earlier shipments have been made. It is possible, by granting the continuance of the highgrade ore and assuming that it will maintain its present value per ton, this work of drifting could be made to almost pay for itself from ore shipments after the chute was entered.

In carrying on this development program I would further suggest that you open up the known ore bodies and thereby give you an opportunity to begin production on such a scale that will, I believe, prove profitable to you and your associates, for the conditions here prove the existence of ore bodies of magnitude and remunerative content and I expect the result of such development on this property will prove it ~~to be one of the richest ever opened up~~ in the Stockton Hill section.

be one of profitable

HERBERT HOOVER ENGINEER
CERTIFICATE COPIES
S. S.
HOWES
DEC 31, 1960
PALO ALTO, U.S.A.

A28

The Wallapai Mining District Cerbat Mountains Mohave County Arizona

By McCLELLAND G. DINGS

CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1951

GEOLOGICAL SURVEY BULLETIN 978-E

A study of the geology and ore deposits

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THE WALLAPAI MINING DISTRICT, CERBAT MOUNTAINS, MOHAVE COUNTY, ARIZ.

By McClelland G. Dings

ABSTRACT

The Wallapai mining district is in Mohave County, northwestern Arizona, near the center of the Cerbat Mountains. The district is approximately 10 miles long and 4 miles wide. In the early days (1863–1900) miners sought silver, and to a less extent gold, in the oxidized parts of the fissure veins. Later, lead with a low silver content was mined, and still later the zinc and lead production became the most valuable, owing very largely to the combined output of the Golconda and Tennessee mines. From 1904 to 1948 the district had a recorded recovery of 54,760 tons of zinc and 35,736 tons of lead.

The rocks include granites, gneisses, schists, and amphibolite of pre-Cambrian age intruded by two younger masses of granite. The older of these two granite intrusions is in the northern part of the district and is named the "Chloride granite" in this report. It is probably of pre-Cambrian age. The other intrusion, the Ithaca Peak granite, is near the center of the district. In this report it is assigned a Mesozoic (?) age, although it had previously been designated as Tertiary (?). Gneissic granites predominate throughout the district. Dikes of pegmatite, rhyolite, and lamprophyre are abundant and widespread. Remnants of volcanic rocks of probable Tertiary and Quaternary age flank the Cerbat Mountains but are not present in the district.

The structural history has been complex. Most of the rocks, except the large Mesozoic (?) granite intrusion, are gneissoid or schistose. The prevailing schistosity strikes northeast, with steep dips either to the northwest or to the southeast. A large northeastward-trending fold occurs near Chloride; other, less prominent ones are indicated on the map. The veins occupy fissures in a very prominent and persistent northwestward-trending zone. Postmineral faulting offsetting the veins is rare and where present has resulted in only minor displacements.

The typical ore occurs in pyritic quartz veins and lodes formed at intermediate depths. Veins range considerably in thickness but average 3 to 4 feet. Only a few exceed a length of 1 mile. The oxidized zone, averaging 150 feet in depth, commonly contains cerargyrite, native gold, galena, and cerussite. The primary ore consists chiefly of sphalerite, galena, pyrite, and some chalcopyrite. The sulfides occur in irregular masses and in crudely banded forms in quartz gangue. Ore shoots vary greatly in size, but the smaller ones, averaging about a foot in thickness and 20 feet in length and breadth, predominate. Primary enriched zones are commonly, though not always, found at abrupt changes in the strike of the veins and also at the junctions of branch veins. Mineralization took place probably in the Mesozoic, and the solutions probably are genetically related to a granite intrusion exposed near the central part of the district.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Wallapai (Hualpai) mining district is in Mohave County in the northwestern part of Arizona (fig. 45). It occupies the central part of the Cerbat Mountains, which extend north-northwestward from Kingman for about 30 miles. The Wallapai district is about 10 miles long and 4 miles wide, trending northwestward obliquely across the mountains. The district includes the mining camps of Chloride, Mineral Park, Cerbat, and Stockton as well as outlying and intermediate areas such as Union Basin, Todd Basin, C. O. D. Wash, and I. X. L. Wash. All the camps are practically deserted except Chloride, which has a population of about 620 (1943 estimate by local

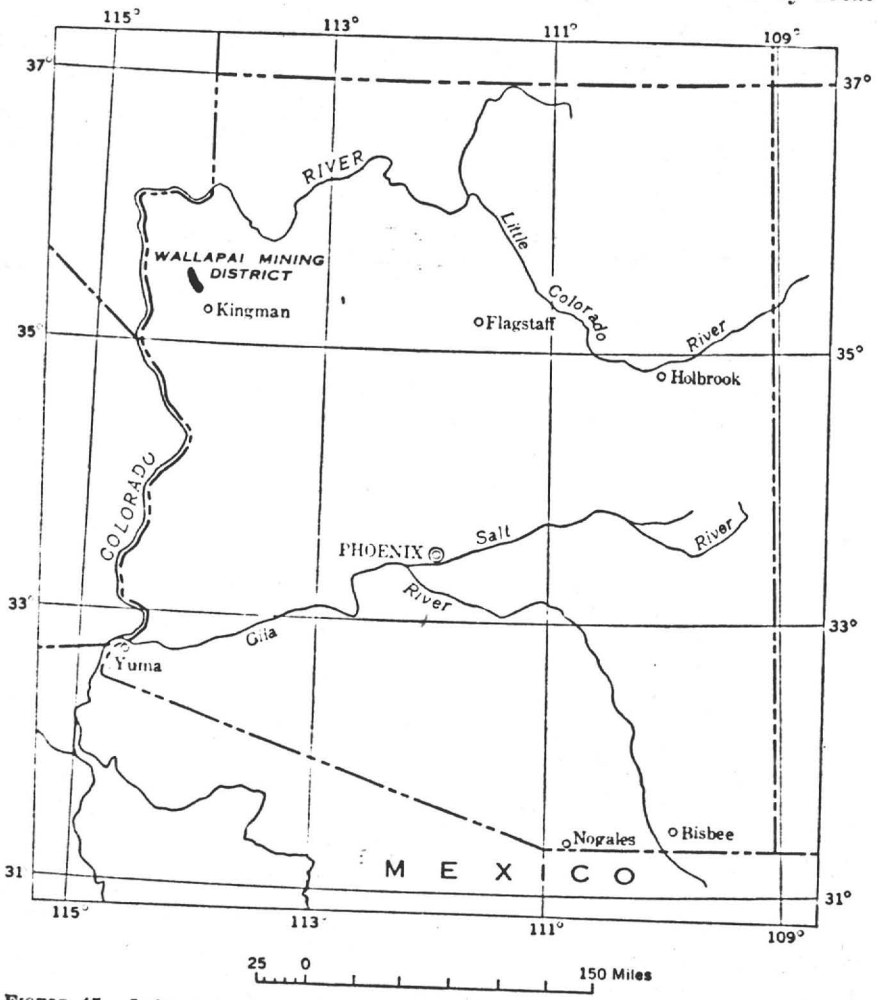

FIGURE 45.—Index map showing the location of the Wallapai mining district, Arizona.

postmaster). With the exception of those in the Stockton area, most of the mines are on the western slope of the mountains.

The nearest railroad station is at Kingman, reached from Chloride by a good paved road 24 miles long. Numerous dirt roads, generally in fair condition, extend to, or near, many of the mines.

TOPOGRAPHY

The topography is typical of eroded granite and gneiss masses in the more arid parts of the Southwest. The Cerbat Mountains rise sharply from the detritus-filled valleys bordering them on the east and west. The relief in the district amounts to about 3,500 feet: the lowest point is in Sacramento Valley in the southwestern part of the area, and the highest point is Cherums Peak (altitude 6,973 feet).

CLIMATE AND VEGETATION

The climate is arid, with mild winters and hot summers. The average temperature of the summer months is high, but the heat is allayed by cool nights, low humidity, and a more or less constant breeze. The annual precipitation is low. It is chiefly rain except in the higher mountains where snow falls in winter, but usually most of the snow melts within a short time. In summer the precipitation is largely concentrated in cloudbursts. Mining operations can be carried on throughout the year.

Vegetation is sparse and of the desert type, being confined largely to the valleys and lower slopes of the mountains. It consists chiefly of cacti, sage, yuccas, greasewood, soapweed, and a scanty growth of grasses. Scrub piñon or juniper is found in open groves and is particularly abundant in Mineral Park.

HISTORY AND PRODUCTION

Many of the mines were discovered between 1863 and 1900 by prospectors in quest of the silver and gold which occurred in the oxidized parts of the fissure veins, the silver commonly in very rich concentrations. Cerargyrite, argentite, galena, and some gold were the principal ore minerals recovered in the early days. Improvement in transportation facilities and milling methods led to the subsequent production of base-metal ores. At first, lead with a low silver content was mined, but later the production of zinc and lead exceeded in value that of all other metals in the district.

The value of the metals produced during the years 1904–48 (table 1) totals about $22,500,000. The value prior to 1904 is not known, but it probably amounted to at least five million dollars, for much high-grade silver ore, and to a less extent gold ore, is reported to have been mined in the early days.

TABLE 1.—*Production of gold, silver, copper, lead, and zinc in the Wallapai district, Mohave County, Ariz., 1904–48, in terms of recovered metals*

[Compiled by Metal Economics Branch, U. S. Bureau of Mines, Salt Lake City, Utah]

Year	Crude ore produced (dry tons)	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)	Value (dollars)
1904	1,531	1,592.42	64,335	1,480	6,036	----------	----------
1905	5,868	1,137.00	58,751	173	112,266	----------	64,294
1906	9,946	2,772.00	125,331	114,502	904,390	----------	----------
1907	13,013	5,358.62	58,895	62,917	1,229,654	30,666	229,206
1908	2,179	1,193.13	29,931	11,920	249,328	505,133	76,313
1909	11,658	2,350.77	69,966	1,774	113,112	5,264,121	374,335
1910	1,109	424.33	48,509	20,341	235,368	----------	47,908
1911	12,692	2,735.75	71,233	27,428	2,394,629	960,097	260,220
1912	4,472	1,461.87	43,761	7,828	1,350,920	799,219	174,362
1913	32,933	2,588.27	177,853	30,782	5,171,988	4,233,642	630,350
1914	22,492	1,205.41	88,951	18,297	3,708,102	4,932,108	472,695
1915	85,635	5,202.75	243,819	46,171	6,452,406	17,382,849	2,697,982
1916	104,658	6,106.90	229,237	190,807	5,825,791	17,024,626	3,007,298
1917	104,362	7,012.38	294,197	84,394	6,087,742	17,127,596	2,680,978
1918	4,739	987.82	42,098	91,596	533,462	82,853	130,558
1919	3,352	872.91	44,531	90,990	504,095	----------	111,561
1920	2,399	682.81	37,500	11,160	338,623	----------	84,133
1921	10,206	1,009.88	82,947	15,855	278,321	----------	118,393
1922	3,453	553.94	42,099	22,638	84,142	----------	61,234
1923	1,150	235.81	25,843	21,570	11,620	----------	30,047
1924	388	165.30	5,027	6,460	172,088	----------	21,398
1925	3,169	758.29	38,744	26,646	341,646	174,703	89,346
1926	10,076	2,034.39	75,470	80,728	697,805	1,669,266	281,469
1927	19,289	837.17	49,499	37,220	696,086	1,184,454	169,906
1928	995	198.45	10,770	10,450	43,791	150,319	23,617
1929	1,849	298.54	10,224	19,393	64,296	133,414	27,889
1930	342	103.06	4,181	2,411	37,640	35,104	7,620
1931	103	15.88	253	581	----------	----------	454
1932	236	193.55	3,553	2,333	17,500	----------	5,675
1933	333	236.11	3,517	1,422	56,916	11,024	9,927
1934	1,057	223.69	4,718	2,737	11,514	10,698	11,973
1935	14,775	1,965.20	76,519	26,506	140,725	133,205	126,970
1936	36,185	5,782.00	193,763	107,859	1,681,478	1,047,960	491,334
1937	119,246	15,348.00	528,640	400,182	4,978,220	3,428,354	1,511,063
1938	109,810	15,027.00	560,518	311,163	4,007,239	3,319,812	1,262,478
1939	68,716	9,301.00	451,325	146,077	1,406,553	1,539,692	793,253
1940	76,317	8,135.00	284,760	224,221	4,607,480	8,589,000	1,284,039
1941	70,398	7,500.00	213,577	132,700	4,816,200	4,692,000	1,056,459
1942	70,533	5,406.00	157,112	136,800	3,312,600	4,487,700	956,787
1943	43,724	1,922.00	88,695	236,500	2,784,800	3,084,000	703,019
1944	33,579	895.00	57,856	1,005,200	1,567,000	2,091,000	571,903
1945	24,462	1,063.00	49,708	454,800	1,503,000	1,367,000	420,414
1946	34,899	730.00	38,229	390,500	737,000	971,000	318,495
1947	46,224	474.00	45,253	456,100	1,308,500	1,713,200	549,046
1948	51,734	694.00	32,059	621,400	891,100	1,344,700	526,501
Total	1,276,266	124,491.40	4,863,757	5,712,992	71,473,202	109,520,515	22,472,902

Zinc-lead production reached its peak in the years 1915–17, which coincided with large-scale production from the Tennessee and Golconda mines under the stimulus of high metal prices.

At the time the present investigation was being carried on in the district (early 1943), the Tennessee mine was producing and milling about 150 tons of crude ore per day averaging 7 percent zinc, 3.5 percent lead, and 17 to 25 ounces of silver per ton. A disastrous fire destroyed the Golconda mill in October 1917. Since then the Golconda has produced only intermittently and on a small scale, and the mine is now largely inaccessible on account of caving and the encroachment of water.

FIELD WORK AND ACKNOWLEDGMENTS

Field work for the present investigation was carried on from February to June 1943. Aerial photographs on a scale of about 1 inch

equals 1,100 feet were used as base maps. The contour map on which plate 18 is based was made from the aerial photographs, after the field work was completed, by the Topographic Division of the United States Geological Survey.

It is a pleasure to acknowledge the wholehearted and able assistance rendered by Paul K. Sims, of the Geological Survey, during the field investigation. He performed a large share of the surface mapping and assisted in many other ways. Thanks are due G. E. Woodward and C. E. Needham, of the Salt Lake City office of the United States Bureau of Mines, who generously compiled much valuable statistical data on the district. Local assistance was freely given by people too numerous for specific acknowledgment. Those who were especially helpful include F. C. Cassidy, W. C. Wimer, W. J. Gardner, Frank Shuck, J. G. Blackwell, and Andrew Brown.

GEOLOGY

ROCK TYPES

The rocks exposed at the surface comprise pre-Cambrian crystalline rocks, chiefly of granitic composition, cut by large intrusions of Mesozoic (?) granite (the Ithaca Peak granite), especially one mass near the center of the area (pl. 18), and pre-Cambrian granite (Chloride granite) in the northern part of the area. Dikes of many rock types, probably related genetically to the Mesozoic (?) granite, are scattered throughout the area. Some are alined parallel to the prominent northwestward-trending system of fractures and veins, but others trend in different directions. Remnants of volcanic rocks of probable Tertiary and Quaternary age are found around the margins of the Cerbat Mountains but are not present in the mapped area.

Work in the area was done under the stress of war conditions; therefore it seemed inadvisable to devote much time to detailed petrographic studies of the various rock types. Also, little attempt was made to map the various types of pre-Cambrian crystalline rocks that form an intricate complex with each other and with the amphibolite and related schists and gneisses. The rock types delineated on the geologic map (pl. 18) are fairly well defined units that were selected to aid in structural interpretations or that appeared to be of sufficient size or possible genetic significance to warrant separate mapping. The units, with the exception of the dike rocks, shown on the geologic map are (1) amphibolite and related gneiss and schists; (2) undifferentiated granite, gneisses, and schists; (3) Chloride granite (new name); (4) Ithaca Peak granite (restricted name); and (5) gabbro. The first two units are considered to be of pre-Cambrian age. The Chloride granite is assigned tentatively to the pre-Cambrian, and the Ithaca Peak granite and gabbro are assigned tentatively to the Meso-

zoic. Three categories of dike rock are shown on the geologic map: intermediate to basic types, diabase, and rhyolite. All the dike rocks are younger than the Mesozoic (?) intrusions.

PRE-CAMBRIAN CRYSTALLINE ROCKS

AMPHIBOLITE AND RELATED GNEISS AND SCHISTS

One of the oldest rocks is a fine- to medium-grained dark-green to black amphibolite composed essentially of hornblende and plagioclase. In some places it appears to grade into hornblende schist, biotite schist, chlorite schist, or diorite gneiss. Locally it is epidotized, and it is very commonly cut along its schistosity by granite and granite pegmatite intrusions. The rock is particularly conspicuous in the area near Chloride; here it forms the bulk of the low hills near town and also occurs as conspicuous blocks in the granite slopes to the east. In the low hills southwest of Long Wash it is also present over a large area. It is widely distributed throughout the district, although in many places it is found in masses too small to be shown on the geologic map.

UNDIFFERENTIATED GRANITE, GNEISSES, AND SCHISTS

The rocks in this group are represented by many types which are not separated on the geologic map. However, this group has certain outstanding characteristics, the most important of which is that most of the exposed rocks are granite. Gneissic structure is widespread, and a large percentage of the rock is granite gneiss. Some of the rocks are distinct and separate intrusions, but others are probably differentiation facies of these intrusions. Still others may represent metamorphosed sedimentary beds.

The granite in this group of rocks varies considerably in color, texture, and mineral composition, although there are certain characteristics that are common to most outcrops. The variations, some of which are extreme, are widespread but generally of small areal extent. The rock is most commonly light-gray, medium-grained, gneissoid granite, containing a small amount of mafic minerals, chiefly biotite. It commonly weathers light buff, although in a few places weathered surfaces are reddish brown.

The extreme variation in color of the fresh granite is from white to almost black. The lighter shades are characteristic of the many irregular bodies of pegmatitic granite and alaskite, generally small, which contain little or no mafic minerals. Alaskite is particularly abundant in the hills about 1 mile northwest of Cerbat Wash. Dark, biotite-rich granites are most abundant in an irregular zone on the northeast side of the main mineralized belt.

Grain size is likewise variable. Fine-grained rocks, although less common than the medium-grained ones, are nevertheless much more abundant than coarse-grained types. Coarse-grained texture is generally confined to pegmatitic granite, alaskite, or biotite-rich granite, although the latter two may also show fine- to medium-grained textures. Porphyritic texture is not common, but a few facies show enough feldspar phenocrysts to class the rock as porphyritic granite. These bodies are generally of small areal extent and are more commonly found in the biotite-rich granite than in the other types.

Variations from the usual gneissoid structure in the granite are widespread. Some facies show little or no banding or mineral orientation, whereas others show pronounced banding and are more properly classed as granite gneiss. The gneissoid structure in most of the granite is indicated by streaks or thin bands of biotite 0.1 inch or less thick.

Several distinct types of gneisses and schists are irregularly distributed throughout the pre-Cambrian complex. The most common type of metamorphic rock is granite gneiss, which varies from place to place but most commonly consists of biotite-rich lenticles and bands 0.5 to 1 inch thick alternating with lighter, irregular lenticles and bands of mixed quartz and feldspar. Some of the gneiss is highly garnetiferous, particularly in the southwestern part of the mapped area, roughly centering around the junction of Charcoal and Cerbat Canyons. Typical injection gneiss, formed usually by injection of granite or granite pegmatite into biotite schist or hornblende schist, is commonly and widely distributed.

Diorite gneiss, hornblende schist, biotite schist, and chlorite schist are sparsely distributed throughout the area, usually in small bodies associated with, and grading into, amphibolite. For this reason most of these rocks were mapped with the amphibolite, but locally they are included with the undifferentiated granite and gneisses of pre-Cambrian age. Probably most, if not all, of these rocks are genetically related to the amphibolite.

PRE-CAMBRIAN(?) IGNEOUS ROCKS: CHLORIDE GRANITE

Schrader (1909, p. 53) has stated that the main part of the large mass of granite exposed north and northwest of Chloride much resembles the granite porphyry of the Mineral Park batholith, the Ithaca Peak granite of this report. Thomas (1949, p. 667), who likewise considered the granite near Chloride similar to the granite stock of Mineral Park, proposed the term "Ithaca Peak porphyry" for these two intrusives and tentatively assigned them to the Tertiary. The two granites, however, are quite different in their general appearance, alteration, and composition. The granite near Chloride is not nearly so altered as the granite in the Mineral Park district, and its prominent gneissic structure suggests that it may be older.

Because of this difference the name "Ithaca Peak" is here restricted to the granitic intrusive in the Mineral Park district, and the granite near Chloride, which is tentatively assigned to the pre-Cambrian, is here named the "Chloride granite."

The Chloride granite, which is well exposed north and northwest of Chloride (pl. 18), has intruded the amphibolite and older granite gneisses, forming a central band at the northeast end of a large fold in the pre-Cambrian crystalline rocks. Except near its borders, the intrusive body is fairly uniform, although it contains numerous inclusions of the older rocks. Some small, irregular masses and dikelike bodies extend beyond the limits shown on the geologic map. No attempt was made to map these smaller units. The Chloride granite weathers yellowish brown. Locally the rock breaks down easily and forms rounded hills, but most of it stands out as large blocky masses that are prominently jointed.

The rock is typically a light-gray, medium-grained, gneissoid granite. The gneissic structure, which in general conforms to the schistosity of the older folded rocks, in many places grades into a schist as the borders of the older rocks are approached. Microscopic examination discloses microcline, quartz, and biotite as the dominant minerals. The quartz is largely recrystallized. Biotite is the green variety, greatly frayed, fragmentary, and drawn out into bands. Accessory minerals are magnetite, apatite, and zircon. Locally the granite shows considerable variation in texture, ranging from fine to moderately coarse, and some facies are lacking in the typical gneissic structure. Near the border of the intrusion is a garnetiferous, light-gray or dull-white granite.

MESOZOIC (?) IGNEOUS ROCKS

ITHACA PEAK GRANITE

The name "Ithaca Peak" as used by Thomas is restricted by this writer to the granite of the Mineral Park district. The granite stock, near the center of the Mineral Park district, has intruded the pre-Cambrian granite, gneisses, and schists (pl. 18). Pegmatite, aplite, rhyolite, and many, if not all, of the diabase and intermediate- to basic-type dikes, as well as the veins in the district, are believed to be genetically related to this intrusion.

The main mass of the granite stock near Mineral Park weathers buff to reddish brown and generally forms a distinctive color contrast to most of the older rocks in this area, which weather to much lighter shades of buff and brown. Both Ithaca Peak and Turquoise Mountain are composed of the Ithaca Peak granite.

Unaltered specimens of the Ithaca Peak granite are rare. Those found show that the fresh rock is typically a light-gray, fine- to medium-grained, porphyritic granite. Microscopic examination of thin sections of the fresh rock shows that the phenocrysts are chiefly subhedrons of pink orthoclase commonly ranging from 2 to 5 millimeters in length. Phenocrystic quartz is much less abundant than the orthoclase and occurs as irregular grains commonly ranging from 0.15 to 0.25 millimeter in length. The groundmass consists chiefly of quartz and orthoclase. Biotite and rarely hornblende are the principal mafic minerals, and together they seldom constitute more than 7 percent of the rock. Other minerals found in small quantities include microcline, microperthite, oligoclase, sphene, magnetite, apatite, zircon, sericite, chlorite, and a clay mineral, probably kaolin.

Most of the rock of the stock contains only a few percent of phenocrysts and for that reason is classed as porphyritic granite. Locally, however, fine-grained facies contain abundant phenocrysts, and the rock is typical granite porphyry. Other differentiation facies are coarse-grained granite and granite pegmatite.

In many places it was difficult or impossible to locate the contact of this intrusive with the pre-Cambrian granites because of the alteration of the intrusive and the surrounding rocks, combined with the similarity of some of the differentiation facies of both the older and the younger granites.

Outlying bodies of the Ithaca Peak granite are particularly abundant from Mineral Park south into Stockton and Cerbat camps (pl. 18). Some extend beyond the southern border of the area mapped. They occur as dikes or, more commonly, as irregular elongated intrusive masses of diverse sizes, many too small to be shown on the geologic map. A few of the intrusives occur irregularly alined along northwestward-trending fissures. Some appear, in part at least, to have been intruded along the older schistosity planes. Dips of the outlying bodies are generally steep, the lowest recorded being 57° on the wide northeastward-trending dike a few miles southeast of Mineral Park. The direction of dip varies, but dips to the northeast, north, and northwest are the most numerous.

These outlying granite bodies are somewhat different from the main intrusive body exposed near Mineral Park. The rock is of finer grain size, and porphyritic texture is more common. Some of the rock grades into granite porphyry, although most of it is porphyritic granite. Badly altered feldspar phenocrysts are characteristic, and only rarely are parts of the rock found that are not intensely altered. The outlying granite bodies stand out in bold relief, particularly in the area near the Golconda mine and in the vicinity of Stockton. The bodies very commonly are intensely sheared, fractured, and silicified. The rock has weathered to brownish red, dark brown, or black, probably from alteration of finely disseminated pyrite.

In the northern part of the district a few narrow dikes and elongated bodies of granite, generally too small to be shown on the geologic map, are poorly exposed for short distances. Some may be genetically related to the Ithaca Peak granite, but no certainty exists as to this correlation.

The age of the intrusion is not known except that it is younger than the pre-Cambrian complex and older than the volcanic rocks of Tertiary (?) age. Schrader (1909, p. 30) states that it is very likely of late Jurassic or early Cretaceous age and of the same period of intrusion as the batholiths of California and western Nevada. Thomas (1949, p. 667) believes that his Ithaca Peak porphyry is of Tertiary (?) age on the "basis of close areal and structural relationships between the Mineral Park stock and the mineralization." However, on a later page (1949, p. 695) he makes the statement that "a direct genetic connection between the Ithaca Peak porphyry and these ore deposits does not seem reasonable. * * * owing to the time interval that elapsed between intrusion and mineralization." It is quite possible that the intrusion may be Tertiary in age, but the only direct evidence Thomas obtained is that the intrusion cuts rocks of pre-Cambrian age. Since no positive evidence is available in the Wallapai district to aid in dating the intrusion, it is still considered tentatively in this report as Mesozoic in age.

GABBRO

In the southern part of the mapped area, centering around Cerbat, are numerous small stocks and irregular bodies of gabbro (pl. 18). The largest of these, located 0.6 mile northeast of Cerbat, is about 1,500 feet in its longest dimension. Gently dipping gabbro or diabase sills are scattered throughout the district from the locality north of Chloride to the southern part of the mapped area. Many of these are too thin or discontinuous to be shown on the geologic map. The thickest and best-exposed sill is on the steep west slope of the Cerbat Mountains about 2 miles east of Chloride near the Redemption mine. The sill reaches a maximum thickness of about 60 feet north of the mine.

The gabbro is typically a greenish-black, medium-grained rock commonly having a pronounced diabasic texture. Chilled border facies and small dikes stemming from the larger gabbroic masses are typical diabase. Weathered surfaces are usually reddish to dark brown. Microscopic examination of thin sections shows that the dominant minerals are labradorite, olivine, augite, and hypersthene. The olivine has been slightly serpentinized. Other minerals present include biotite, a very small amount of green hornblende, apatite in long needles, magnetite, and calcite.

The diabase sills, as well as the diabase dikes to be described later, are all believed to be related to the smaller gabbro intrusives. Hernon (1938, p. 113) states that the diabase of the Cerbat Mountains closely resembles the diabase sills in the Grand Canyon series and in the Apache group of southeastern Arizona, which are regarded as pre-Cambrian in age. The exact age of the diabase in the Wallapai district is not known. The gabbro cuts the pre-Cambrian granites, gneisses, and schists but in turn is cut by mineralized quartz veins and rhyolite dikes.

DIKE ROCKS

Dikes of many lithologic types cut the rocks of the Wallapai district. They range in thickness from a few inches to 300 feet. Some extend only a few hundred feet or less, whereas others, notably the rhyolite dikes, extend for long distances. The most abundant dike rocks are granite pegmatites. Others, some of which are abundant locally, include porphyritic granite, aplite, and rhyolite. Also, there is a group of dikes of intermediate to basic composition, including such rock types as vogesite, minette, kersantite, camptonite, andesite, and diabase.

Only dikes that are 1 foot or more thick and appear to be fairly continuous are shown on the geologic map. Granite pegmatite dikes, although abundant, were not mapped because an excessive amount of time would have been required to outline these generally narrow and discontinuous bodies. Aplite dikes are not common and generally occur as short, very narrow bodies; hence they also are not delineated.

The age relationships between the various types of dike rocks are rarely indicated in the field. Many of the dikes, particularly some of the intermediate to basic types, are found only in the pre-Cambrian rocks far removed from outcrops of the Ithaca Peak granite. It is possible that some of these are older than that granite. Nevertheless, all the dikes shown on the geologic map are assigned an age younger than the Mesozoic (?) intrusives because of their lithologic similarities to other dikes definitely younger than these intrusives. All the dikes shown on the geologic map are likewise believed to be genetically related to the Ithaca Peak granite, even though some, particularly the rhyolites, may represent considerably younger intrusions.

Granite, porphyritic granite, and granite porphyry.—Dikes and somewhat irregularly shaped, elongated bodies of fine- to medium-grained, rarely aphanitic or coarse-grained granite occur at many places in the southern part of the mapped area. They are most commonly alined parallel to, or fill, the northwestward-trending fractures. These bodies are related to, and in places are definitely part of, the intrusive at Mineral Park, the Ithaca Peak granite, and are shown as part of this mass on the geologic map. Many of them change along

their trends from typical tabular dikes to irregularly shaped, elongated intrusions or to irregular bodies. The typical dikes commonly range in thickness from 50 to 250 feet.

The rocks show many gradations in texture, commonly within short distances. Most of the rock is porphyritic granite, although some is granite, and only rarely is the grain size so small that the rock should be classed as granite porphyry. Orthoclase phenocrysts are much more common than quartz.

Granite pegmatite and aplite.—Most of the granite pegmatite dikes are less than 2 feet thick and seldom can be traced for more than a few hundred feet. Many appear to stem from highly irregular bodies of pegmatite a few hundred feet or less in longest dimension. The pegmatites are composed almost entirely of quartz and feldspar, though rarely other minerals, chiefly muscovite, may be present. They probably are genetically related to the Ithaca Peak granite.

Granite aplites, though widely distributed, are not abundant. They generally occur as narrow dikes ranging from a few inches to a foot in thickness. They are fine-grained, equigranular rocks consisting largely of quartz and feldspar.

Andesite, minette, vogesite, diabase, kersantite, and camptonite.—Andesite, minette, vogesite, and diabase are the most common rock types in the dikes of intermediate-to basic composition, although some more nearly approach kersantite or camptonite. On the geologic map (pl. 18) the diabase dikes are shown distinct from the other dikes of intermediate to basic composition.

Alteration of these dikes commonly results in a greenish or brownish earthy appearance, but when fresh they are grayish to dark green. Porphyritic textures predominate. Partly because of their basic character these dikes weather easily and are poorly exposed, but they also seem to occur as less continuous bodies than the other dikes, particularly those consisting of rhyolite. On the geologic map (pl. 18), only the more continuous dikes of intermediate to basic composition are shown; there are many more that are too short to map.

Many of these dikes cut the pre-Cambrian rocks. They range from a few inches to 10 or more feet in thickness, but they average about 2 feet. In a few places they fill the vein fractures, but they seldom extend continuously along the veins for more than a few hundred feet. In every case where definite age relations could be obtained, the dikes are older than the veins.

Rhyolite.—Extending irregularly northward across much of the district is a network of rhyolite dikes (pl. 18), all believed to be of the same general age. The dikes are most abundant in a fairly obvious belt about 4 miles long that extends from a short distance south of Cerbat north to the southern edge of the main body of the stock at

Mineral Park. Rhyolite dikes are extremely rare, however, in the area northwest of the northern part of the Great White dike.

Many of these dikes trend northwest roughly parallel to the prominent vein system. The dips are generally steep, but some are as low as 50°; strike and dip commonly change within comparatively short distances. In places the rhyolite dikes cut, border, or trend parallel to the elongated bodies and dikes of the Ithaca Peak granite, a characteristic that is particularly conspicuous in the area north and northwest of the Oro Plata mine. Many of the dikes have numerous branches, some of which are too small to be indicated on the geologic map. The rock is characteristically white to light buff, aphanitic with occasional quartz phenocrysts, and in general greatly fractured.

The largest rhyolite dike, the one known locally as the "Great White dike," cuts the western part of the main mass of Ithaca Peak granite. It can be traced with little difficulty throughout most of the district, for a distance of about 6 miles, and it continues for an unknown distance to the northeast beyond the limits of the mapped area. This dike ranges in thickness from a few feet to as much as 100 feet but generally averages about 30 feet. In places it forms sharp ridges as much as 35 feet high, but more commonly it shows as a band of chalky white debris cutting irregularly across the other rocks. Schrader (1909, p. 92) states that this dike is an altered basic rock. However, microscopic examination of thin sections of the rock indicates a rhyolitic composition.

About 2 miles north of Cerbat, near the Oro Plata mine, is a prominent branch of the Great White dike that trends N. 10° E. and is locally known as the "Broncho dike." It can be readily traced to the northeast for a distance of 2 miles. It dips about 60° NW. and traverses or borders a wide dike of porphyritic granite related to the main Ithaca Peak granite. Hernon (1938, p. 113) states that the Broncho dike may be genetically related to the volcanic rocks of Tertiary (?) age in adjacent areas which are composed principally of rhyolite flows, tuffs, and agglomerates. Reconnaissance by the author in the volcanic area near Kingman failed to disclose any of the rhyolite dikes cutting or stemming from the volcanic beds.

All the rhyolite dikes in the Wallapai district, including the Great White dike and the Broncho dike, are believed by the author to be genetically related to the intrusion of the Ithaca Peak granite of Mesozoic (?) age. They cut this granite and its associated dikes but in turn are cut in a few places by mineralized veins that are believed to represent the last stage of the intrusion at Mineral Park. Thomas (1949, p. 668), however, assumes that the rhyolite dikes in the Wallapai district "were intruded in Tertiary times as part of the Tertiary volcanic system of the Basin and Range Province." His

assignment of a probable Tertiary age to the Ithaca Peak granite, as opposed to a Mesozoic (?) age for this granite in the present report, would account for Thomas' assumption, as the dikes cut the stock at Mineral Park.

STRUCTURE

The Cerbat Mountains are in the Basin and Range geomorphic province only 20 miles west of the edge of the Colorado Plateau. The major geologic setting is shown on the geologic map by Schrader (1909, pl. 1), which is not duplicated in this report.

The structure of the rocks in the Wallapai district is complex. Gneissic and schistose structures are common, the prevailing schistosity striking northeast. Large and small folds in the schistosity generally have axes that strike northeast. In contrast faults, sheeting, and joints most commonly show a northwesterly strike.

SCHISTOSITY

The gneissic and schistose structure of the pre-Cambrian rocks in the Wallapai district strikes in general from N. 40° E. to N. 65° E. and dips steeply either to the northwest or to the southeast. Local variations are numerous, but the structure is unusually persistent throughout most of the district, and reconnaissance visits to a few other parts of the Cerbat Mountains disclosed essentially the same general structure.

FOLDS

Folds in the pre-Cambrian rocks occur on both a large and a small scale. The most prominent of these folds is near the town of Chloride (pl. 18), where the type of fold is reflected in the outcrop of pattern of the amphibolite. It is a large anticlinal fold, plunging northeast, only the northeast end of which is shown on the geologic map. To the southwest, beyond the limits of the mapped area, the fold is exposed for about a mile before it is concealed under the debris in Sacramento Valley. Much more of this fold is clearly shown on Thomas' geologic map (1949, p. 669, fig. 2), which covers an area extending about 3 miles west of the area mapped for this report. His map shows that the fold is several miles wide where it disappears under the alluvium of Sacramento Valley. North and northwest of Chloride a granite intrusive (Chloride granite) occupies a sill-like belt in the folded amphibolite.

FAULTS

The most outstanding structural feature of the district is the northwestward-trending fault fissures along which veins have formed (pl. 18). A few faults, generally of small displacement, crosscut and offset these mineralized faults. A large normal fault (Sacramento fault), which strikes northwest, is probably concealed under the alluvium of Sacramento Valley near, or west of, the border of the mapped area.

NORTHWEST FAULT FISSURES

From the southern end of the district northwest to the folded area near Chloride the fault fissures are very generally parallel in strike, the direction of strike being approximately at right angles to the regional schistosity. In the folded area near Chloride, however, the fissures conform to the general direction of schistosity. Here they change first to a more northerly strike, then follow the curvature in the strike of the rocks to the north and west around the axis of the fold so that in the extreme northwestern part of the mapped area the fissures strike nearly due west.

The dips of the faults are generally steep and may be either to the northeast or to the southwest, although northeasterly dips predominate. In places the faults are in conjugate systems. The fissures likewise show much branching and, in a few places, considerable "horsetailing." Gouge, breccia, and slickensided surfaces, as well as numerous tear faults in the walls, are present along some of the faults. The direction of the striations along the walls of the faults may be nearly horizontal, but a far greater number show dips down or diagonally down the dip of the fault surface. Most of these features suggest that shearing stress was important.

The age of the faulting that produced the northwest fault fissures is not known. The initial, and probably most intense, movement occurred after the gneissic and schistose foliation was developed in the pre-Cambrian complex and prior to the Mesozoic (?) intrusions. This is indicated by the fact that the faults cut the old (probably pre-Cambrian) gneissic and schistose structures and in turn are filled, or partly filled, in many places by the Mesozoic (?) dikes and veins. Brecciation of the veins and dikes in places indicates that some movement occurred at intervals throughout, and following, ore deposition. These later periods of movement, however, are believed by the author to have been very minor compared to the tectonic forces that formed the main northwestward-trending faults. It is likely that the major tectonic forces were active early in the Nevadian orogeny and that the minor period of movement occurred near the close of this orogeny.

TRANSVERSE FAULTS

Some faulting, believed to be still later than the brecciation of the veins and dikes that occupy the northwest fault fissures, occurred in a few places throughout the district. There is no evidence to indicate that this faulting was of major structural importance, for it most commonly is expressed by small crosscutting faults offsetting

the dikes and veins a few feet or less. Several crosscutting faults, however, have greater displacements. One mile north of Mineral Park, about 1,400 feet northeast of the Eureka mine, a northwestward-trending fault has offset the Great White dike about 140 feet. About a mile east of Chloride is a northeastward-trending fault that is shown on the geologic map. The Payroll vein has apparently been offset about 600 feet by this fault, the South Georgia mine supposedly being on the offset part of the Payroll vein. This fault, however, may predate mineralization, according to data obtained on the inaccessible workings in the Payroll mine. Dr. J. G. Blackwell, of Chloride, stated in April 1943 that the Payroll vein turns abruptly to the southwest and follows the fault. He added that the vein is thick and shows no evidence of brecciation of the ore minerals along the fault.

SACRAMENTO FAULT

The large normal fault previously referred to as lying concealed beneath the alluvium in Sacramento Valley is based upon Thomas' mapping (1949, fig. 2) several miles west of Chloride and beyond the area mapped for this report. This fault has been aptly termed the "Sacramento fault." It strikes northwest and brings volcanic rocks of assumed Tertiary age on the southwest side in fault contact with rocks of pre-Cambrian age on the northeast side. The fault was traced by Thomas southeast to a point about 2½ miles west of Chloride; beyond this point he projects it southeastward under the alluvium for almost 4 miles to a point near the border of his mapped area. This fault is not shown on the geologic map (pl. 18) accompanying the present report, because its location under the alluvium is entirely too uncertain.

In discussing the Sacramento fault Thomas (1949, p. 671) states that it seems to be a boundary fault between Sacramento Valley and the Cerbat Range and that "vertical displacement on this fault and perhaps on allied faults that might be buried under an alluvial cover is believed to be responsible for the formation of the Cerbat Range, which is essentially an eastward-tilted block."

JOINTS

Jointing is pronounced throughout most of the district. In places it grades into sheeted and sheared zones, both generally of small areal extent. Commonly one of the joint systems is far better developed than the others, and on the geologic map accompanying this report only the attitudes of the most prominent joint systems are shown. The strike commonly ranges from N. 30° W. to N. 60° W., approximately parallel to the mineralized fissures. Dips are generally moderate to steep and may be either to the northeast or to the southwest. In a few places low-dipping fractures are fairly well developed, but they are not common. In general they have the same northwesterly strike as the other fractures and dip either to the northeast or to the southwest.

ORE DEPOSITS

TYPES OF DEPOSIT

The ore deposits are conveniently separated into three types. The first is represented by the vein deposits of the district, the second by a quartz-sulfide stockwork deposit, and the third by the Emerald Isle copper deposit. The vein deposits are overwhelmingly the most important in the district. The quartz-sulfide stockwork deposit contains some low-grade copper and molybdenum. The Emerald Isle copper deposit is quite different from all other deposits in the district and consists of a fissure vein and mineralized area of chrysocolla chiefly confined to alluvium.

VEIN DEPOSITS

GENERAL FEATURES AND DISTRIBUTION

The chief ore deposits of the Wallapai district occur in veins along fissures in all the rock types previously described. In some places the veins are along dikes of intermediate to basic composition, but they seldom extend continuously along these dikes for more than a few hundred feet. Other veins border or cut the rhyolite dikes, but generally such veins are poorly mineralized and of erratic extent and width. The most notable exception is the Eureka vein north of Mineral Park, where the mineralization was fairly rich. Wherever definite age relations could be observed, the veins are younger than the dikes. The source of the vein-forming solutions is believed to have been the magmatic reservoir of the granite stock (Ithaca Peak granite) centrally exposed about 1 mile south of Mineral Park (pl. 18). The veins in the district are classed as mesothermal deposits.

The veins range from a few inches to 33 feet in thickness but average 3 to 4 feet. In a few places the deposits are in lodes or vein zones, which rarely exceed a width of 50 feet. Most of the Silver Hill vein is of this type. Schrader (1909, p. 62) states that in the older workings of the Payroll mine a lode 100 feet wide was encountered. Vein widths reported in many of the mines are often exaggerated, as they frequently include considerable unmineralized wall rock between vein branches.

The veins show a strike length that varies from a hundred feet or less to almost 2 miles, but only the Victory, Tennessee, Clyde, Payroll, Emerson, Dutch Joe, South Washington, Rico, White Eagle, Banner, Summit, and Manzanita veins exceed a length of 1 mile. The aggregate length of the veins in the district as measured from plate 18 is about 85 miles. The veins commonly pinch and swell along both

strike and dip. Numerous irregular branches, short spur veins, narrow parallel veins, and hydrothermally altered fissures are characteristic. About 2 miles southeast of Chloride, in the vicinity of the Twentieth Century and Midnight mines, the veins are unusually irregular and branching. This is the area in which the northwestward-trending veins deviate to a more northerly course.

VEIN DIPS AND TRENDS

Dips are commonly steep, only occasionally being less than 60°. Some veins show a moderate amount of reversal in dip as they are traced along strike or down dip. The dips shown on the geologic map (pl. 18) are, almost all of them, those obtained near the surface in shafts or prospect pits. In places the vein systems are conjugate, as noted by Schrader (1909, p. 50), but the conjugate arrangement is not nearly as common as suggested by its mention in brief descriptions of the district. Garrett (1938, p. 118) states that the progressive steepening of the dip of the veins to the northwest may indicate overthrusting stresses as the cause of the fissuring. However, detailed mapping does not support this conjecture.

Reference to plate 18 will show the prevailing northwesterly trend of the veins. Throughout the greater part of the district strikes range from N. 30° W. to N. 60° W. Near Chloride the average strike changes to a few degrees west of north, and still farther north and west a few veins trend nearly west. Throughout the main mineralized area southeast of Chloride the sparsity of eastward- or northeastward-trending veins is notable.

Plate 18 shows clearly that the veins occur in two main groups, one north and the other south of the main body of the stock of the Ithaca Peak granite. The total length of the mapped veins in each group is about equal. Veins of the northern group have more branches than those in the southern group. Likewise a statistical study of the direction of dip of the veins in the two groups shows differences. In both groups the total mapped lengths were measured separately for veins dipping to the northeast, to the southwest, and vertically, and the percentages of each were calculated. The results are as follows: northern group, 57 percent northeasterly dip, 25 percent southwesterly dip, and 18 percent vertical dip; southern group, 88 percent northeasterly dip, 11 percent southwesterly dip, and 1 percent vertical dip. In the northern group it is further notable that southwestward-dipping veins are almost entirely absent in the folded area north of Chloride.

RELATION OF VEINS TO COUNTRY ROCK

Some veins are separated from the wall rock by soft gouge bands a fraction of an inch to several feet in thickness. Gouge may be present on the hanging wall, on the footwall, on both walls, or irregularly traversing the veins. Many veins, however, are frozen to the walls. The type of wall rock has had little effect upon the character of the veins. In a few places, particularly near Chloride, some veins tend to split into branches as they pass laterally into large amphibolite blocks, but a short distance inside the block the veins generally assume their usual characteristics.

APPEARANCE AT OUTCROP

A few veins, notably the Payroll, Cerbat, and Manzanita, crop out over part of their lengths as prominent iron-stained quartz "ridges," but moderate to very careful observation is generally required to follow them. In tracing the veins on the surface by far the greatest aid is the many man-made excavations such as shafts, trenches, pits, and short adits. These are so numerous and in many areas so closely spaced that not all of them are shown on the geologic map (pl. 18). Probably there are at least a thousand prospects in the district. It is largely upon the data obtained from these workings that most of the veins are shown on the geologic map as solid, instead of broken, lines.

Vein outcrops commonly appear as brown, porous gossan or as pink to dark reddish-brown bodies composed chiefly of iron-stained quartz. Variations in depth of oxidation are so numerous that generalizations are difficult. The upper parts of the veins have been moderately oxidized to depths commonly ranging from about 75 to 200 feet. In some places unaltered pyrite is found within a few feet of the surface, yet Dr. J. G. Blackwell, of Chloride, stated in May 1943 that partially oxidized ore was found as deep as the 600-foot level of the Payroll mine. Complete oxidation seldom extends lower than 75 feet below the surface.

The depth to water level, although commonly 35 to 200 feet, ranges from 20 to 400 feet. In general this range coincides fairly well with the depth of the oxidized zone.

MINERALS

The vein minerals of the district fall into three general groups: oxidation products, products of downward sulfide enrichment, and primary (hypogene) minerals. In recent years, the primary ores have been the most worked for their base metals, but in the early years of mining in the district most attention was paid to the oxidized ores because of their precious-metal content.

The principal minerals of economic importance in the oxidized zone are cerargyrite, native silver, cerussite, and to a less extent native gold. Locally anglesite, azurite, malachite, mimetite, and vanadinite are common. Other minerals which are rare or occur as coatings

include native copper, chalcanthite, covellite, cuprite, smithsonite, and manganese oxides. The most common gangue minerals are limonite and limonitic quartz. Calcite and particularly gypsum are rare.

The secondary sulfide enrichment products as determined by Bastin (1924, p. 35) are argentite, chalcocite, covellite, and proustite. He states that all except argentite are rare. Secondary enrichment in the vein deposits of the Wallapai district has not been important.

Excluding gangue minerals, the most abundant of the primary minerals are pyrite, sphalerite, galena, and chalcopyrite. Other minerals include arsenopyrite, proustite, molybdenite, and argentite. In addition to those listed Bastin has recognized tennantite, pearceite, and polybasite. Gangue minerals are quartz, calcite, manganiferous siderite, and rarely rhodochrosite.

Quartz, usually accompanied by varying amounts of pyrite, is by far the most abundant gangue mineral. Most of the quartz is fine-grained and milky to gray in color. Some is of the chalcedonic variety. In many places along the veins small vugs are lined with quartz crystals. In a few places the veins show a poorly defined comb structure, but the quartz is generally massive and commonly fractured and recemented by later quartz.

Sphalerite ranges in color from brown through reddish brown to black. It occurs most commonly in irregular masses or grains intimately associated with quartz and the other sulfides. The grain size varies greatly, but generally sizes of less than 0.3 inch predominate. The sphalerite also occurs as narrow bands or streaks. J. W. Sharpe, metallurgist for the Tennessee-Schuylkill Corp., stated in June 1943 that careful analyses of specimens of sphalerite collected in the Tennessee mine indicated the presence of a considerable amount of gold as well as minor amounts of silver. Sphalerite has been leached from the completely oxidized parts of the veins.

Galena occurs in fine to coarse grains; some is the very fine grained steel type, and some, commonly in the same ore shoot, is in cleavable masses as much as 3 inches in length. Practically all the galena, regardless of type, is silver bearing, and much of it is high in grade. J. W. Sharpe stated in June 1943 that the galena from the Tennessee mine contained most of the gold values produced in the mine. He believes that the pyrite in the Tennessee mine is practically, if not entirely, barren of gold. This is in contrast to Garrett's statement (1938, p. 119) that gold in this mine is obtained from pyrite. Additional analyses from the mine, and also for the district, would be needed to clarify these contradictory statements.

In many places unaltered galena is found at or near the surface; elsewhere it has altered to cerussite.

PARAGENESIS

The paragenesis of the principal hypogene minerals, as determined megascopically, is quartz, pyrite, arsenopyrite, sphalerite, galena, and chalcopyrite. Much of the ore shows a second generation of pyrite following galena. Quartz was introduced intermittently throughout the period of mineralization. A few veins show late calcite, manganiferous siderite, and—rarely—rhodochrosite.

Observations during this investigation coincide in general with Hernon's statements (1938, p. 115) regarding the main stages of mineralization. Fissures, some of them locally occupied by earlier dikes, were reopened; in the openings solutions deposited quartz, usually accompanied by pyrite. Many of the vein fissures were closed by this early stage of mineral deposition. Subsequent reopening permitted solutions to bring in the valuable constituents of the veins. A still later but minor reopening followed; in the voids thus formed quartz was deposited as narrow veinlets commonly cutting the earlier sulfides. A final movement produced gouge and quartz breccias, but the mineralization is believed to have ceased largely thoughn not entirely before this stage. The structure of the veins is irregularly massive or crudely banded by the arrangement of the sulfides.

ORE SHOOTS

The typical ore shoots in the unoxidized zone are complex assemblages of galena, sphalerite, and pyrite in quartz gangue. Chalcopyrite and arsenopyrite are not nearly as abundant, but a few of the mines, such as the Pinkham, Midnight, and Keystone, recovered a moderate amount of copper along with the other metals. Much of the vein matter is very low in grade. Narrow stringers and small irregular masses of the valuable minerals may persist throughout almost the entire length of the vein, but they are too small to be commercially valuable unless the gold or silver content is exceptionally high. However, few completely barren quartz veins occur in the district, and those which exist are short. Likewise, most of the veins have not been explored to sufficient depths to warrant condemnation based on the low base-metal content near the surface.

Ore shoots are generally small and as a rule range from 8 or 10 inches to 3 or 4 feet in thickness. The thickest shoot found measured 20 feet (Tennessee mine). Both the pitch lengths and the breadths of the shoots commonly measure about 10 to 50 feet. In the Tennessee mine (pl. 19) one ore shoot extends 400 feet horizontally and 700 feet vertically. An ore shoot in the Golconda mine is reported to have greatly exceeded in size any in the Tennessee, but the Golconda was not accessible for examination. The Tennessee and Golconda mines probably represent extreme cases, although the com-

paratively shallow depth reached in most of the other mines does not permit too broad a generalization. Commercial ore has been reported from the Tennessee and Golconda mines to depths of about 1,600 feet.

The character of the wall rock has had no apparent effect upon the localization of the ore bodies. Garrett (1938, p. 118) states that in the Tennessee mine ore shoots tend to occur where the vein has changed to a more westerly strike than normal. Later work in the mine supports this generalization. Schrader (1909, p. 51) states that many of the ore shoots coincide with intersections or forkings of the veins. Distinct vein intersections, however, are rare. Many of the forks are enriched, but many of them have lower-grade ore than average.

QUARTZ-SULFIDE STOCKWORK DEPOSIT

Centering around the main stock at Mineral Park is an area embracing several square miles of altered and fractured rock that contains many short and irregular sulfide-bearing quartz seams and veinlets that are distinct from the fissure veins found elsewhere. Mineralization of this type is chiefly confined within the Ithaca Peak granite but locally extends about 2,000 feet beyond into the older granites, gneisses, and schists. It is a poorly defined area with gradational and irregular borders and likewise much irregularity of mineralization within the main granite mass. Mineralization also extends into part of the large tongue of Ithaca Peak granite extending southeastward from the main stock to the Oro Plata mine. Most of the rhyolite dikes that cut the main stock are fractured and mineralized.

The veinlets occur most abundantly in highly fractured rock and form an intricate network generally with no persistent strike or dip. They are closely spaced and are rarely more than 6 inches apart. Thicknesses most commonly range from one-twentieth to one-half inch, although some veinlets are very thin seams and others reach a thickness of several inches.

The primary minerals are quartz, pyrite, chalcopyrite, bornite, molybdenite, galena, and sphalerite. Quartz and pyrite are by far the most abundant, and the amount of quartz greatly exceeds that of pyrite. Most of the quartz and sulfide minerals fill fractures, and only rarely are the sulfides disseminated in unbroken rock. For this reason the deposits are classed as a stockwork rather than as a disseminated deposit.

Locally chalcopyrite and molybdenite are associated with the quartz-pyrite veinlets as low-grade deposits. Rarely chalcopyrite occurs disseminated in small grains in the granite. Many veinlets of quartz and pyrite cut veinlets of quartz, pyrite, and molybdenite, although this relation was reversed in one specimen examined from

the Gross molybdenite prospects. In general, however, most of the molybdenite formed at an early stage.

Small veinlets of galena, sphalerite, and pyrite in quartz gangue occur in a few places, notably on the northwest side of Ithaca Peak. No definite paragenetic relations could be established between these and the more common quartz-pyrite-chalcopyrite (or molybdenite) veinlets. The mode of occurrence and the intimate association of the two types suggest a close relationship, and both are probably of the same general period of mineralization as the prominent fissure veins of the district.

Much of the mineralized area, particularly around Ithaca Peak, has been so thoroughly silicified that the rocks have eroded into very rough forms. Hydrothermal alteration has produced abundant sericite, and much of the rock in the highly altered areas seems, in hand specimens, to consist almost entirely of sericite and quartz.

Oxidation and secondary enrichment have been widespread. Hydrous iron oxides are abundant on the higher peaks and also form the principal cementing material for some alluvial conglomerates. In Bismark Canyon, about half a mile east of the Gross ranch, is an alluvial conglomerate consisting of pebbles and cobbles cemented by hydrous iron oxides, cuprite, and malachite. Chalcanthite, azurite, malachite, covellite, native copper, and chalcocite are fairly widespread although generally not abundant. The Gross copper prospects are reported to have encountered considerable chalcocite and native copper.

EMERALD ISLE COPPER DEPOSIT

The Emerald Isle mine, located about a mile west of Mineral Park Wash, is the only known deposit of its type in the district. The ore mineral is chiefly chrysocolla contained in a fissure vein and filling spaces in alluvium of Quaternary age. It is described in detail under the heading "Emerald Isle mine."

GENESIS AND AGE

The vein and stockwork deposits are believed by the author to be genetically related to the Ithaca Peak granite. The granite, dikes, and mineralizing solutions are believed to have had a common source and were merely drawn off at different times. The time interval between the dikes and the mineralizing solutions in this area may have been fairly long, for the dikes and granite were locally brecciated prior to the introduction of the mineralizing solutions. The central position of the Ithaca Peak granite and the close association of the granite, dikes, and ore deposits strongly favor a genetic relation. The major structural control for their localization was established prior to the period of granite intrusion.

The vein and stockwork deposits are assigned a Mesozoic (?) age, for they are believed to be genetically related to the Ithaca Peak granite of that age. Schrader (1909, p. 48) likewise assumes a similar age and a genetic relationship of these ore deposits to the stock at Mineral Park; furthermore, he points out that they are quite different from the veins of the nearby Black Mountains that are of Tertiary age.

The Emerald Isle copper deposit is of Quaternary age. (See pp. 149–153.)

ZONING

The scanty information in the mine records and the exposed mine workings suggest that chalcopyrite and sphalerite increase relative to galena with depth in the mines of the district. However, exceptions are so numerous that this generalization should be very tentatively accepted. The best indication of increase in sphalerite with depth is found in the Tennessee vein (pl. 19). Here Garrett (1938, p. 118) has demonstrated an increase in sphalerite and a decrease in galena with depth from those parts of the mine for which reliable records have been kept. It should be remarked, however, that no records exist for a large part of the mine.

Indications of pronounced lateral zoning in the district are generally lacking. There is evidence, however, that copper and molybdenum are found in larger amounts in and nearer to the intrusive granite of the Mineral Park area than in the outlying parts of the district. Also, the chief values of the veins in the extreme southeastern and northwestern parts of the district were in silver, suggesting that silver was more characteristically formed at a considerable distance from the intrusive body. Garrett (1938, p. 118) notes horizontal zoning in the Tennessee vein (pl. 19), with a general increase in sphalerite and a decrease in galena and gold-bearing pyrite to the south.

PRODUCTION OF SELECTED MINES

Table 2 gives the production of gold, silver, copper, lead, and zinc from 1901 through 1948 of the more important mines in the district, as well as that of some of the smaller operations. Mines that have been small producers during this period may, however, have had a substantial production prior to the years for which accurate records were kept, particularly the old mines in which rich silver and gold ore was obtained from the oxidized parts of the veins.

It is notable that the combined output of the Tennessee-Schuylkill and Golconda mines has accounted for more than 90 percent of the total lead and zinc produced in the district from 1904 to 1948.

TABLE 2.—*Production of gold, silver, copper, lead, and zinc of selected mines in the Wallapai district, Mohave County, Ariz., cumulative from 1901 through 1948, in terms of recovered metals*

[Compiled by Metal Economics Branch, U. S. Bureau of Mines, Salt Lake City, Utah]

Mine	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)
Alpha (*m*)	292	35,499	22,265	16,476	----------
Altata and Altata Extension (*c*)	382	36,024	136,616	7,691	----------
Badger, Hercules, and Hercules group (*c*)	561	12,287	1,418	331,365	52,524
Banner group (*s*)	1,697	79,382	21,603	2,195,988	39,948
Blackfoot (*cer*)	158	11,886	19,617	104,565	144,369
Blue Bell (*s*)	469	50,954	44,274	182,001	----------
Cerbat (*cer*)	12	2,055	1,153	4,120	----------
Champion (*cer*)	982	23,689	14,931	825,993	335,391
C. O. D. (*s*)	1,550	151,263	23,924	348,872	23,188
Columbus-Monroe Doctrine (*cer*)	646	5,083	4,370	17,322	154,535
Copper Age (*c*)	3	1,062	266	24,575	----------
Distaff (*c*)	93	55,883	1,392	149,600	----------
Elkhart (*c*)	662	10,385	7,482	245,199	----------
Empire and Silver Union (*c*)	1	2,475	122	----------	----------
Eureka (*c*)	7	2,311	3,371	23,861	42,714
Flores (*cer*)	422	366	172	3[illegible]2	----------
George Washington (*m*)	114	11,059	15,777	84	----------
Golconda (*m*)	20,752	510,180	354,703	2,031,719	56,226,020
Golden Eagle and Bobtail (*m*)	1,777	25,845	890	40,076	----------
Golden Gem (*cer*)	2,478	8,243	3,365	14,980	----------
Hidden Treasure (*c*)	251	9,074	7,897	159,861	231,345
Idaho (*cer*)	280	5,285	4,742	9,348	51,900
Juno (*c*)	1,239	43,128	4,517	235,498	154,138
Keystone (*m*)	2,703	452,049	340,778	348,845	114,063
Little Chief (*s*)	391	68,351	2,070	111,825	----------
Lucky Boy (*c*)	1,923	40,438	230	8,140	----------
Mary Bell (*c*)	26	955	557	19,155	28,733
Midnight (*c*)	44	8,533	10,746	4,122	----------
Minnesota-Connor (*c*)	2,890	228,129	50,702	169,722	71,053
Mint (*m*)	222	15,265	----------	----------	----------
New London (*cer*)	13	3,268	1,558	136,699	31,243
Nighthawk group (*m*)	324	16,297	5,410	1,589	----------
Old Colony (*s*)	21	2,969	654	4,370	----------
Paymaster (*cer*)	99	25,090	----------	----------	----------
Payroll (*c*)	128	4,104	11,694	39,928	192,137
Pinkham (*c*)	56	14,695	55,136	3,133	----------
Rainbow (*c*)	2,400	34,982	4,748	313,271	22,426
Redemption (*c*)	21	4,042	11,449	----------	----------
Rico (*s*)	1,149	15,309	1,449	2,620	----------
Samoa and Samoan (*c*)	4,480	57,891	4,454	656,377	67,886
St. Louis (*cer*)	24	11,142	1,050	855,841	1,496
Silver Age (*c*)	24	3,550	----------	----------	----------
Silver Hill (*c*)	708	8,842	10,722	229,949	143,594
Tennessee and Schuylkill (*c*)	42,383	1,514,187	839,837	59,897,096	66,805,907
Towne (*c*)	144	6,286	2,108	5,516	----------
Vanderbilt (*cer*)	1,012	2,119	327	2,568	----------
Washington and Washington Extension (*m*)	58	2,205	1,610	1,700	----------

c, Chloride camp; *m*, Mineral Park camp; *cer*, Cerbat camp; *s*, Stockton camp.

FUTURE ECONOMIC IMPORTANCE OF THE DISTRICT

It is believed that the future economic importance of the district will lie chiefly in the base-metal content of the fissure veins. Most of the veins have not been explored sufficiently at depth to test the base-metal content and particularly the zinc content. On the basis of a geologic study of the veins in the district there is no reason for assuming that any of several other veins will not be as productive of lead and zinc as the Tennessee or Golconda veins. Future development work, particularly at greater depths, on the many miles of veins in the district may disclose several that will prove to be their equal or better.

DESCRIPTIONS OF MINES AND PROSPECTS

Several inherent difficulties were encountered in attempting to obtain data on the many mines in the district. Most of the mines were worked for the high-grade silver or gold in the shallow oxidized parts of the veins. Operations generally ceased when the lower-grade primary sulfides were reached. The principal work in most of the mines was done many years ago, and most of them are now largely or entirely inaccessible owing to caving or flooding. A few mines are partly accessible, but generally such a small part of the mine workings is disclosed, commonly in the oxidized zone or unproductive parts of the drifts and crosscuts, that it is not possible to obtain much tangible information concerning ore bodies or reserves. Mine maps and records are generally lacking, and many of those available are of such character as to make their reliability very dubious. Even past records of such large-scale operations as the Tennessee-Schuylkill and Golconda mines leave very much to be desired.

During Schrader's (1909, pp. 54–118) visit to the district in 1907, most of the workings were accessible and information was relatively fresh in the minds of people consulted, so that his data on most of the mines still remain by far the most reliable source of published information even though considerable additional work has probably been done in many of them. Bastin (1924) describes a few mines in some detail, whereas the only mine Thomas (1949, pp. 700–703) describes in any detail is the Emerald Isle mine. Garrett (1938, pp. 117–119) has described the Tennessee-Schuylkill mine, and during August and September 1943 engineers of the United States Bureau of Mines obtained assay data (Haury, 1947) on about 30 mines in the district from records and from a sampling of mine dumps and parts of all the accessible mines.

A few of the mines for which worthwhile new data have been assembled, in addition to material previously published, are described on the following pages. Most of these are mines that have been the leading producers of lead and zinc (table 2), although some, such as the Aurora and Emerald Isle mines and the Gross prospects, are briefly described because they contain minerals not commonly found in the district.

AURORA MINE

The Aurora mine is about a mile east-southeast of Chloride. The property consists of one unpatented claim (Aurora) leased by E. E. Vondriska from J. G. Blackwell, of Chloride. The mine was formerly worked on a small scale primarily for lead and silver in the oxidized zone, but it was being worked in 1943 for vanadium and lead. No ore had been shipped by Vondriska, but about 5 tons of vanadinite and

5 tons of lead ore were piled near the portal. The main workings consisted of a drift about 300 feet long bearing south along the vein. About 30 feet from the south end of the drift a winze 40 feet deep had been sunk on the vein.

The Aurora vein strikes north, is nearly vertical, and averages 4 feet in width. It can be traced southward from the mine for about 1,400 feet (pl. 18). About 275 feet south of the north end of the vein vanadinite crystals occur in open spaces in the wall rock of pre-Cambrian gneissoid granite along the west side of the vein. The crystal aggregates are erratically and sparingly exposed over an area about 15 feet long and 10 feet high. The vanadinite is associated with an iron-stained earthy material. This is the only occurrence of vanadinite observed or reported in the district.

CHAMPION MINE

The Champion mine is about a mile southwest of Cerbat camp on the western front of the range at an altitude of about 4,000 feet (pl. 18). This mine is reported to be one of the first discoveries in the district, worked in its early history chiefly for gold, silver, and lead. Table 2 shows that the mine has produced a substantial amount of zinc during its later operations. No reliable information could be obtained concerning the extent of the mine workings or the more recent operations. The mine was idle when visited, and all the workings were inaccessible.

The vein on which the mine is situated strikes about N. 50° W. and dips about 75° NE. It can be traced on the surface for a little more than 1,000 feet. A minette dike averaging about 6 feet in width lies alongside the southeastern part of the vein (pl. 18). Schrader (1909, p. 104, fig. 15) shows a section of the vein and dike sketched at the mine near the surface. Metallic sulfides observed on the mine dump include pyrite, galena, sphalerite, and a very minor amount of chalcopyrite; all are contained in quartz gangue.

EMERALD ISLE MINE

An unusual type of copper deposit is found at the Emerald Isle mine, located about a mile west of Mineral Park, Wash. The mine was idle when visited early in 1943 and again in 1950. It was worked at various times from 1917 to 1943, and late in 1943 the Emerald Isle Copper Co. resumed mining and began the erection of a 300-ton leaching plant, which was completed in 1944. Mining continued until June 1946. In 1947 the Lewin-Mathes Co. started operations on the property and continued work until June 1948. About 55,000 tons of copper was recovered from the ores during the period 1943–48.

From the above considerations it is concluded that the mineralization has resulted from deposition of chrysocolla by ascending hypogene solutions that rose along one large and many small fissures and spread out into the adjacent alluvium. The conclusion is supported by the fact that the deposit was formed under essentially surface conditions. The main fissure and some of the associated minor fractures undoubtedly reached the original surface. In such an environment ascending hypogene solutions would be under the same pressures and could very easily have the same temperatures as the supergene solutions that deposit chrysocolla. And there is no reason why copper and silica could not be present in the proper amounts to form chrysocolla from such hypogene solutions.

Thomas' theory of a primary origin for the chrysocolla of the Emerald Isle deposit is disputed by Searls (1950), who states in part:

Rather than to have unchallenged in the record the rather startling suggestion that this chrysocolla "resulted from deposition by ascending hypogene solutions that rose along one large and many small fissures and spread out into the adjacent alluvium," the writer begs leave to contribute the following:

Churn drilling by the Calumet and Arizona Company and development by many individuals and groups (some listed by Schrader), have demonstrated these many years that important, although probably non-commercial, amounts of disseminated copper are contained in "The Broncho" or mineralized belt associated with the granite-porphyry intrusions of Mineral Park, and covered by Mr. Thomas as the "Ithaca Peak disseminated sulphide deposit."

The higher elevation of this belt and the present occurrence of soluble copper in the run-off from it, through Mineral Park wash (to the extent that copper has been and is still recovered from it, by precipitation on scrap in certain seasons), has convinced many geologists that Emerald Isle chrysocolla originally derived from the sulphides connected with this mineralization a mile or more distant.

This writer shared the skepticism of Mr. Thomas as to likelihood of the transfer, and still more of the localization, of the (circa) ten thousand tons of copper now known to exist in the secondary ore of Emerald Isle, from the Mineral Park disseminations; the more so as on the basis of present topography, higher bedrock separates the discharge of Mineral Park wash and the Emerald Isle deposit, a mile to the north of it. No chrysocolla deposits are known to exist in the bottom of the Gila conglomerate in the area currently receiving the waters of Mineral Park wash.

Equally unacceptable is the theory that the "vein" at Emerald Isle was the source of primary ore. The "vein" is one of a series of post-Gila faults that step down the pediment of the Cerbat Range and develop the graben of the Sacramento Valley, where the Gila and other agglomerate is very deep. Several of these faults are nearly parallel; and while only two are indicated by the topography, seismic work discloses others, successively stepping the bedrock down to the west and deepening the overburden on the basal layer.

As has been pointed out by several engineers, the "vein" ceases to be a vein below the depth at which it ceases to have the Gila conglomerate on one wall. Below its dip shift, the fault is unmineralized. Whatever the source of the copper, the emplacement of the chrysocolla (and copper pitch) in its present position has been brought about by a process equivalent to that, under which the African and Australian laterites accumulate. Acid copper-bearing solutions have at certain seasons over a long period of years trickled along the bedrock of this area and, as the rainy season yielded moisture to the pull of the sun, have been raised by capillary action into the lower layers of the gravel. Banding in the distribution suggests that certain of the layers contained a little calcium carbonate—as caliche—but not enough to exhaust the acid supply. Not only at the intersection of the "vein," but also at other small slips and irregularities in the conglomerate, the capillary action and perhaps osmosis has sucked the green water higher along these avenues of better circulation and, as Thomas says, the "veinlets pinch out upward" and "the chrysocolla filling apparently was deposited by ascending solutions." They ascend, however, only from the top of bedrock.

As this conclusion, amply supported—in the writer's judgment—by observation in the present workings, leaves unanswered the ultimate source of the copper, Mr. Arthur Storke and the writer, last year, in behalf of Climax Molybdenum Company and Newmont Mining Corporation, conducted geophysical surveys over the area, using a method that detects disseminated sulphides—whether of iron or copper. Briefly, the work resulted in the discovery of a large mass of "protore," lying adjacent to and east of the chrysocolla deposit. This rock carries from 1% to 2½% sulphide, and is too low in copper content to warrant drilling. At one small area, this remnant of a "porphyry copper" actually emerges east of the cover, and presents the gossan of a disseminated body of pyrite carrying perhaps 0.2% Cu.

There is little doubt that this dissemination (extending over several hundred acres) constitutes the roots or protore of a more important—and possibly at one time commercial—"porphyry," of which the secondary enrichment occurred, as elsewhere in Arizona, in pre-Gila time. Despite its destruction, the verdure deriving from its wasting chalcocite still adorns the residues of its former cap, and enclosing host rocks.

GOLCONDA MINE

The Golconda mine, which has been the second-largest producer of zinc in the district (table 2), is located in Todd Basin about 1.5 miles north of Cerbat. The mine was worked at various times and by numerous operators between the years 1910 and 1942, and Schrader (1909, p. 100) reports mining prior to his visit to the district in 1906–7. In May 1943 Bulwark Mines, Inc., of Kingman, Ariz., obtained a 10-year lease from Pontiac Mines, Inc., of Los Angeles, Calif., on 20 claims distributed around and including the Golconda mine. E. E. Bollinger, of Kingman, is president of Bulwark Mines, Inc.

The mine was idle when visited. Almost the entire production dates from 1908 to 1917, but by far the greatest amount of zinc was produced between 1914 and 1917. In October 1917 a fire destroyed the mill and most of the other surface equipment. Only a few intermittent and very small scale attempts to resume operations have been made since the fire. The main shaft has caved, and most of the other workings are inaccessible owing to caving or flooding.

Reliable information on the underground workings is scant. The main shaft is on the Golconda, or Prosperity, vein at an altitude of about 4,375 feet. It is inclined to the northeast and is reported to have reached a depth below the surface of 1,400 feet, following down, or approximately down, the dip of the vein. The mine has 12 levels, and drifts along the vein are commonly about 600 to 1,400 feet long.

roughly the same distance northwest and southeast of the shaft. The 600-foot level, however, extends northwestward from the main shaft along the vein, intersecting the surface at a point about 2,400 feet beyond the shaft. Southeast of the shaft this level is reported to extend for 400 feet. No drifts are reported between the 1,200-foot level and the bottom of the shaft (1,400-foot level).

The Golconda vein strikes northwest and dips to the northeast (pl. 18). The angle of dip varies, but it is reported to average about 65° in the underground workings. The vein pinches and swells, ranging in thickness from 2 to 7 feet. On the surface the vein can be traced, chiefly by small prospect pits, for about 4,000 feet. Near its northwest end it splits into several branches, two of which form approximately parallel prongs and have opposing dips. The Oro Plata mine is located on the southwest prong. A branch, about 1,700 feet long, trending in a more northerly direction, is known as the Primrose vein.

The country rock is chiefly the pre-Cambrian complex, mostly granite. Numerous small, irregular bodies of the Ithaca Peak granite, too small to be shown on the geologic map, are exposed on the surface in the area along and adjacent to the trend of the vein.

The principal metallic minerals, as determined chiefly from material on the mine dumps, are sphalerite, galena, pyrite, and chalcopyrite, contained in a milky quartz gangue. Much of the sphalerite is dark brown to almost black. Sphalerite is greatly in excess of galena. This is in marked contrast to the Tennessee-Schuylkill mine, which has produced about the same amount of zinc as the Golconda mine (table 2) yet has produced almost as much lead as zinc.

Information of a general nature indicates that the best ore shoots on the Golconda vein were found northward from the main shaft for about 1,000 feet. Most of the ore has been removed from the surface to the 600-foot level. Reports vary greatly regarding the grade and quantity of ore left in the workings below the 1,000-foot level.

About 500 feet southeast of the shaft on the 700-foot level a crosscut to the southwest connects with the mine workings along the Tubb, or Middle Golconda, vein. One of the higher levels in the Golconda mine also is reported to be connected by a crosscut to the Tubb vein. The Tubb vein roughly parallels the Golconda vein and, like it, dips to the northeast. On the surface the Tubb vein is 350 to 600 feet distant from the Golconda vein. Four levels, with a total of about 3,500 feet of drifts, are reported on the Tubb vein.

GROSS COPPER PROSPECTS

A low-grade deposit of chalcocite occurs on the Gross ranch near the western border of the main exposure of the Ithaca Peak granite

south of Mineral Park. The inaccessible mine workings are reported to consist of a 200-foot shaft and two drifts, each about 600 feet long. One drift is to the east, and the other is to the northeast. The workings were driven in 1926 by the C. and A. Mining Co. No ore has been shipped. Material on the mine dump shows malachite, azurite, and specks of chalcocite disseminated in minor quantities in pyritized and silicified granite. Several veinlets of chalcocite 0.05 to 0.2 inch thick were observed, and one such veinlet is reported to have been 2 inches thick. A few specks or paper-thin stringers of molybdenite also were seen. Native copper, occurring as small leaf forms, is reported to be present in minor quantities but was not observed during the visit to the prospect.

GROSS MOLYBDENITE PROSPECTS

In Bismark Canyon, 1,400 feet east of the Gross ranch house, two adits have been driven to explore a low-grade molybdenite deposit (pl. 18). The work was done about 1926 by the C. and A. Mining Co., but no ore has been shipped. The adit on the north side of the canyon bears almost due north for about 800 feet. Molybdenite occurs most commonly in specks and small stringers in quartz veinlets that cut the Ithaca Peak granite. The veinlets are 0.02 to 1.5 inches thick, but thicknesses of 0.5 inch or less predominate. Some molybdenite occurs in small disseminated specks in the granite or as paper-thin stringers with little or no quartz.

The adit on the south side of the wash is inaccessible but is reported to bear a little east of south. Near its south end a crosscut to the east encounters a rhyolite dike about 20 feet wide in nearby exposures. The material on the dump shows numerous narrow molybdenite-bearing quartz veinlets and stringers of pyrite cutting the rhyolite. The minerals extend into the granite in the same manner that was noted where they are exposed in the adit on the north side of the wash.

HIDDEN TREASURE MINE

The Hidden Treasure mine is nearly 2 miles southeast of Chloride on the lower western slope of the mountains (pl. 18). The property consists of five claims along and bordering the Hidden Treasure vein held by Frank H. Grannis, of Chloride. The mine has been worked intermittently for many years by numerous operators. Schrader (1909, p. 72) reports mining operations prior to his visit to the district in 1907. The mine has produced, in addition to gold, silver, and copper (table 2), a little more than 115 tons of metallic zinc and nearly 80 tons of metallic lead during the period of recorded production from 1901 to 1948.

The mine workings, which were partly accessible when the mine was visited, include several shafts, three crosscutting adits bearing northeast, and three levels vertically spaced about 50 feet apart. Drifts total about 3,000 feet.

The Hidden Treasure vein, on which the mine is located, has an average strike of about N. 50° W. and dips steeply to the northeast. It is correlated with the vein on which the Emerson mine is located (pl. 18). The vein pinches and swells to thicknesses ranging from 0.5 to 15 feet. Many branches and spur veins are disclosed in the underground workings of the Hidden Treasure mine. Crosscuts indicate several thin veins, some of which are probably branches of the main vein, trending about parallel to it. These smaller veins or branches, with few exceptions, could not be traced on the surface.

The country rock is the pre-Cambrian complex of granite, gneiss, schist, and amphibolite. In numerous places the country rock adjoining the vein is greatly altered to sericite or impregnated with pyrite for distances ranging from a fraction of an inch to several feet. Locally seams or thin zones of gouge an inch or two thick border the quartz veins.

The metallic sulfides, which are in a quartz gangue, include pyrite, sphalerite, galena, and minor quantities of chalcopyrite. Ore shoots that were observed in the underground workings are generally small bodies only a few feet long and a foot or less thick consisting of an intimate mixture of the various metallic sulfides and little or no quartz.

KEYSTONE MINE

The Keystone mine is in Mineral Park at an altitude of about 4,375 feet. Schrader (1909, p. 82) states that it was located in 1870 and that its surface ores were very rich in gold and silver, by reason of which it became the first important producer in the district. The mine, consisting of three patented claims, has changed ownership many times and, when visited, was reported to be owned by the Beach Estate. It was then idle, and water filled the underground workings and the shaft to a depth of about 50 feet below the surface. Table 2 indicates that the greatest values have been in silver and gold, although the mine has also produced substantial amounts of copper, lead, and zinc.

The mine was developed by a shaft, reported to be about 400 feet deep, and four levels at 150, 200, 300, and 400 feet. Drifting on the 150-foot level is reported to have reached a distance of 850 feet northwest of the main shaft and 450 feet southeast of it. On the 300-foot level drifts extend about 275 feet both northwest and southeast of the shaft. On the 400-foot level is about 125 feet of drifting, mostly to the northwest. The greater part of the ore above the 300-foot level is reported to have been worked out.

The vein on which the mine is located strikes northwest and dips to the northeast at angles ranging from about 65° to 80°. About 800 feet northwest of the shaft the vein splits into two main branches; the southern branch dips prevailingly to the southwest at a steep angle and near its west end cuts a wide rhyolite dike. Another vein about parallel to the main vein is reported to lie approximately 100 feet northeast of the Keystone shaft, although no evidence could be found of this vein in surface outcroppings northwest of the shaft.

Vein matter on the mine dump is milky quartz with abundant pyrite and lesser amounts of sphalerite, chalcopyrite, and galena. Argentite, although reported to be present in the ore, was not found.

PAYROLL MINE

The Payroll mine is about 1.5 miles east of Chloride, near the head of Payroll Gulch, at an altitude of about 4,500 feet. The property, which includes the patented Payroll and Black Prince claims, is held by the Thomas B. Scott Estate. The property is an old one, having been located in 1887, and much of the early work consisted of shallow diggings along the Payroll vein chiefly for high-grade gold ore. Considerable mining had been done prior to Schrader's (1909, p. 62) visit to the district in 1907, as he reports three shafts, about 400 feet of drifts, over 600 feet of tunnels, and some crosscuts and stopes. The main shaft was 225 feet deep. The mine was idle and the workings were inaccessible when visited by the writer in 1943. The main shaft is now reported to be a little more than 600 feet deep. The mine was developed by four main levels, the 50-, 200-, 400-, and 600-foot levels. Drifting and stoping from these levels has extended chiefly southeastward along the vein, the maximum distance from the shaft being 500 feet on the 600-foot level. The total length of all drifts is reported to be about 2,000 feet.

Production from the mine during the period 1901–48, as given in table 2, shows that during these years the mine was essentially a producer of zinc, although the early, unrecorded production may have been mostly in gold and silver.

The country rock consists of many types of the pre-Cambrian complex, although light-gray, fine-grained granite, dark, medium-grained biotite granite, hornblende schist, and amphibolite predominate. A diabase dike, not shown on the geologic map, is poorly exposed for a short distance along the northeast side of the vein near the main shaft. It could not be found in its projected position on the northwest side of the gulch, and it apparently has been cut off by the northeastward-trending fault shown on plate 18.

OTHER MINES AND PROSPECTS ON THE TENNESSEE VEIN

The Elkhart mine, at the extreme north end of the Tennessee vein, is an old mine that has been idle for many years. The total production from this mine from 1901 through 1948, as shown in table 2, has been small. The mine workings, now inaccessible, are reported to consist of three shafts, six levels (the lowest 500 feet deep), drifts totaling about 2,600 feet, numerous stopes, and several crosscuts.

The Silver Age mine, near the extreme south end of the vein, was primarily a silver mine (table 2). The silver was probably derived in large part from silver chloride (cerargyrite) found in the oxidized zone. Accurate data concerning the inaccessible mine workings could not be obtained. It is reported that the shaft is about 150 to 200 feet deep and that drifts and stopes extend northward from the shaft for some 200 or 300 feet. The vein material on the mine dump is partly oxidized, chiefly to iron hydroxides. Pyrite is the most abundant primary sulfide. Minor amounts of galena and sphalerite, together with sparse chalcopyrite, are associated with the pyrite in quartz gangue.

Several shafts have been driven and numerous pits and trenches have been dug along the Tennessee vein from the Silver Age shaft to the Tennessee shaft. The deepest of these is the Johnny Bull shaft (pl. 18), which is reported to be 88 feet deep. No drifting or stoping from this shaft is known.

Diamond drilling on the southern part of the Tennessee vein was carried out by the United States Bureau of Mines (Tainter, 1947) during the period from September 16 to December 8, 1943. The exploratory work consisted of eight drill holes on the Johnny Bull and Silver Knight claims, between 750 and 2,450 feet south of the Tennessee shaft. The holes were distributed along the vein at intervals ranging from 200 to about 375 feet. All holes were drilled from the surface and inclined toward the vein. Four were drilled from the west side of the vein outcroppings and the other four from the east side. Depths below the surface at which the vein was intersected ranged from about 100 to 350 feet, the deepest corresponding approximately in altitude to the 400-foot level in the Tennessee mine.

All holes intersected the vein, but the vein filling in seven of the eight cores was barren of ore minerals or was so low in grade as to be of little or no economic interest. The only hole that showed a substantial amount of the ore minerals was hole 8, located about 1,900 feet south of the Tennessee shaft. This hole intersected the vein about 100 feet below the surface, at an approximate altitude of 4,100 feet. A 3.5-foot interval of sphalerite, galena, and pyrite in quartz gangue assayed 7.6 percent zinc, 0.1 percent lead, and 0.03 percent copper.

This intersection might suggest that the top of an ore body was penetrated, but the Bureau of Mines engineers believed that the extensive drilling necessary to determine the existence of an ore shoot in the vicinity of hole 8 was not warranted.

TURQUOISE MINES

Deposits of turquoise are restricted to the Ithaca Peak granite and occur most abundantly in the southern half of the main intrusive body south of Mineral Park, particularly on Ithaca and Turquoise Peaks. Many small and shallow workings have explored these deposits, and only the larger ones are shown on plate 18. Some of the diggings are very old, having been started by the Aztec Indians. Very little work has been done on the deposits for many years.

Turquoise occurs typically in veinlets and small lenses in silicified, sericitized, and kaolinized porphyritic granite. Turquoise most commonly fills cavities in quartz veinlets, although some is in altered granite. Other minerals sparsely associated with turquoise in a few places are malachite, chrysocolla, and hydrous iron oxides. Sterrett (1908, pp. 847–852) describes some of the individual deposits in this area.

The features of the deposits suggest a secondary origin by supergene processes similar to those given by Paige (1912) for the origin of turquoise in the Burro Mountains of New Mexico.

LIST OF REFERENCES

The literature pertaining to the district is not extensive. The list given below includes the chief publications. Of these, Schrader's report on districts in Mohave County furnishes the most extensive description of the Wallapai district, and it is of particular value in furnishing descriptions of many of the mines. Thomas' manuscript contributes much information, particularly his detailed descriptions of the minerals and their paragenetic relationships. He includes a small-scale geologic map that covers an area extending from Mineral Park northwestward for several miles beyond Chloride. Most of the references are brief summaries of the geology and ore deposits, probably taken in part from Schrader's previous work.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
THOS. H. MILLER, ACTING DIRECTOR

REPORT OF INVESTIGATIONS

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

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BY

P. S. HAURY

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.[2]

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.

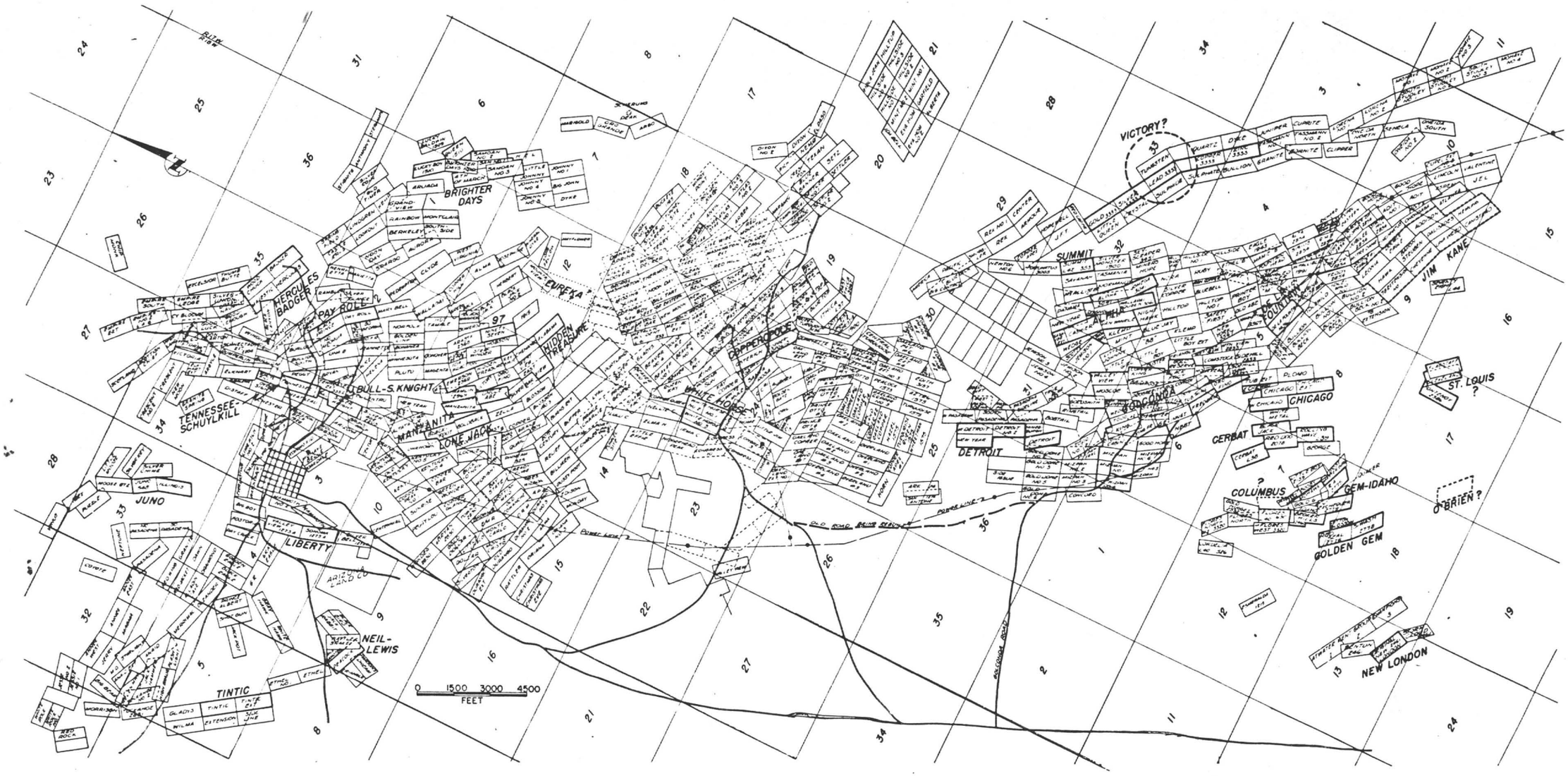

Figure 1. - Claim map of Wallapai mining district, Mohave County, Ariz.

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:

A small stope was mined from the oxidized footwall ore just south of the crosscut on the adit level. Two shallow shafts, 40 and 50 feet deep, were sunk on the outcrop. The 50-foot shaft is over the south drift on the adit level. An old adit was driven about 1,000 feet northwest of the portal of the working tunnel, and some drifting was done on a vein. That work is inaccessible.

Sampling

A grab sample of the muck from the winze assayed 3.7 percent zinc, 0.1 percent lead, 0.35 percent copper, and 1.55 ounces per ton silver. The winze could not be sampled without interrupting the work in progress.

Seven samples were cut in the south drift. The samples show that there is a width of about 5 feet of mill-grade ore in the last 55 feet of the drift. The samples from this part of the drift averaged 0.3 percent lead, 5.3 percent zinc, 2.50 percent copper, and 7.2 ounces silver per ton. The sample locations and detailed sample data are shown on figure 8.

An old shaft above the south drift shows evidence that the vein is completely oxidized down to 50 feet above the drift. The face of the drift is very near the end line of the claim.

This ore shoot extends across the south end-line of the Detroit claims into the Golden Eagle ground. Open cuts on the oxidized outcrop of the vein show low metal values for some distance south of the common end line. If later development should prove that this ore shoot extends downward to the lower level, then the extension of the ore shoot in the Golden Eagle ground could be extracted through the Detroit workings. The Golden Eagle has lain idle for a long time. It was worked during an earlier period through a shaft 1/2 mile farther south. The old workings are all caved but the dumps bear evidence that the workings were extensive.

No production was made after the mine was examined in September 1943.

VICTORY MINE

The Victory mine, formerly known as the Wrigley, is situated on the east slope of the Cerbat Range, about 15 miles by road north of Kingman and 38 miles by road from Chloride.

F. Nelson attempted to rehabilitate caved and flooded workings with the aid of an R.F.C. loan. Entry to the mine was through a shaft reported to be several hundred feet deep and to have several levels driven on the vein. The work of reopening this shaft had been abandoned when it was visited by engineers of the Bureau of Mines. Subsequent flooding and some fresh caving has made the mine entirely inaccessible.

SUMMIT MINE

Location and Accessibility

The Summit mine is situated near the crest of the Cerbat range about 12 miles southeast of Chloride. It is reached from the west by a road that serves the Alpha, Detroit, and Golden Eagle properties also. A road from Kingman goes up the east side of the range to the mine. The higher sections of both these roads were in such a state of disrepair as to be almost impassable. An access-road proposal for the improvement of the road from the west to the Summit and Alpha mines was approved by the Bureau of Mines and was completed before July 1, 1945.

Ownership

The Summit group of 40 claims is owned by L. L. Robinson of Los Angeles, Calif. It was leased to the El Dorado Rover Mining Co., but the lease was relinquished in August 1943.

History

The U. S. Smelting, Refining & Mining Co., operating the mine on a lease, sank a vertical shaft in 1924. The Keystone Mining Co. shipped 12,000 tons of ore, which was stoped above the first level in 1936. The mine was thoroughly sampled in April 1942 by Miles P. Romney, engineer for the U. S. Smelting, Refining & Mining Co. The El Dorado Rover Mining Co. leased it in December 1942. This company did some new development on the lower levels with the aid of an R.F.C. loan and shipped 23 cars of ore, much of which was stoped above the first level. The company decided that not enough ore could be developed to supply a mill from this mine alone. It shut down in August 1943 and returned a second R.F.C. loan.

Ore Deposit

The ore-bearing vein, which is 3 to 8 feet thick, occupies a fissure in granite and amphibolite that stand well with little timbering. It strikes northwesterly and dips steeply northeast. The principal gangue is quartz with a considerable amount of gouge. The ore minerals are galena, sphalerite, pyrite, and chalcopyrite, with some gold and silver. The sulfides are largely oxidized above the first level. The metal content is below ore grade in much of the vein. The material with sufficient concentration of the metallic minerals to constitute ore occurs in lenses that seldom occupy the full width of the vein. Some of these are too small to mine. Three ore shoots with sufficient volume to repay the cost of mining are exposed on the first level. One of these is developed on the second level also. Two of these shoots are lead-zinc ore and one is copper ore.

Development

The mine was opened by a 1-1/2-compartment vertical shaft with levels at depths of 160, 200, and 300 feet. The 160-foot level has about 750 feet of

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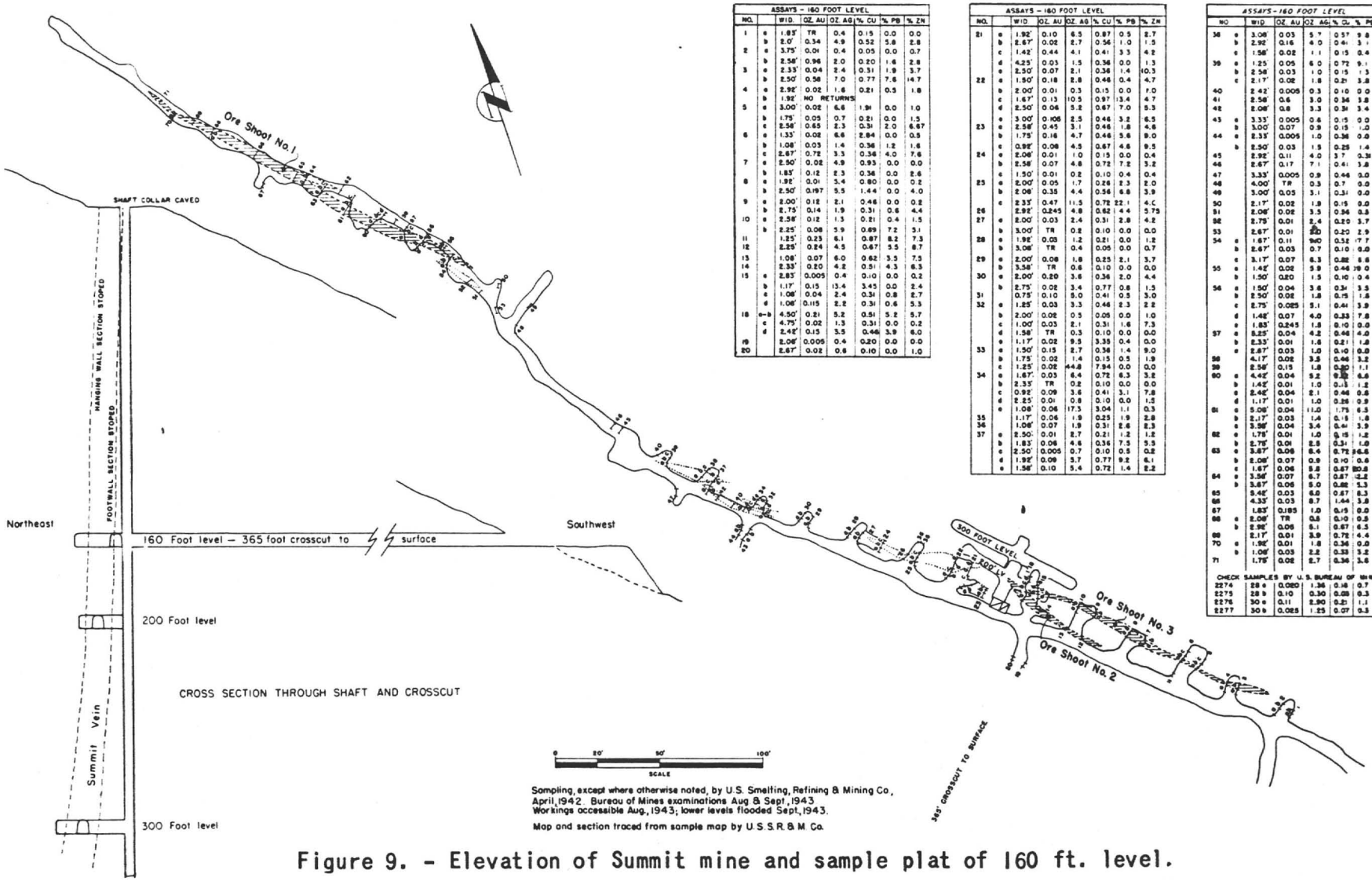


ASSAYS - 160 FOOT LEVEL							
NO.		WID.	OZ. AU	OZ. AG.	% CU	% PB	% ZN
1	a	1.83'	TR	0.4	0.15	0.0	0.0
	b	2.0'	0.34	4.9	0.52	5.8	2.8
2	a	3.75'	0.01	0.4	0.05	0.0	0.7
	b	2.58'	0.96	2.0	0.20	1.6	2.8
3	a	2.33'	0.04	2.4	0.31	1.9	3.7
	b	2.50'	0.58	7.0	0.77	7.6	14.7
4	a	2.92'	0.02	1.6	0.21	0.5	1.8
	b	1.92'	NO RETURNS				
5	a	3.00'	0.02	6.6	1.91	0.0	1.0
	b	1.75'	0.05	0.7	0.21	0.0	1.5
	c	2.58'	0.65	2.3	0.31	2.0	6.67
6	a	1.33'	0.02	6.6	2.84	0.0	0.5
	b	1.08'	0.03	1.4	0.36	1.2	1.6
	c	2.67'	0.72	3.3	0.36	4.0	7.6
7	a	2.50'	0.02	4.9	0.93	0.0	0.0
	b	1.83'	0.12	2.3	0.36	0.0	2.6
8	a	1.92'	0.01	3.4	0.80	0.0	0.2
	b	2.50'	0.197	5.5	1.44	0.0	4.0
9	a	2.00'	0.12	2.1	0.46	0.0	0.2
	b	2.75'	0.14	1.9	0.31	0.6	4.4
10	a	2.58'	0.12	1.3	0.21	0.4	1.5
	b	2.25'	0.08	5.9	0.69	7.2	5.1
11		1.25'	0.23	6.1	0.87	8.2	7.3
12		2.25'	0.24	4.5	0.67	5.5	8.7
13		1.08'	0.07	6.0	0.62	3.3	7.3
14		2.33'	0.20	4.2	0.51	4.3	6.3
15	a	2.83'	0.005	0.4	0.10	0.0	0.2
	b	1.17'	0.15	13.4	3.45	0.0	2.4
	c	1.08'	0.04	2.4	0.31	0.8	2.7
	d	1.08'	0.115	2.2	0.31	0.6	5.3
18	a-b	4.50'	0.21	5.2	0.51	5.2	5.7
	c	4.75'	0.02	1.3	0.31	0.0	0.2
	d	2.42'	0.15	3.5	0.46	3.9	6.0
19		2.08'	0.005	0.4	0.20	0.0	0.0
20		2.67'	0.02	0.8	0.10	0.0	1.0

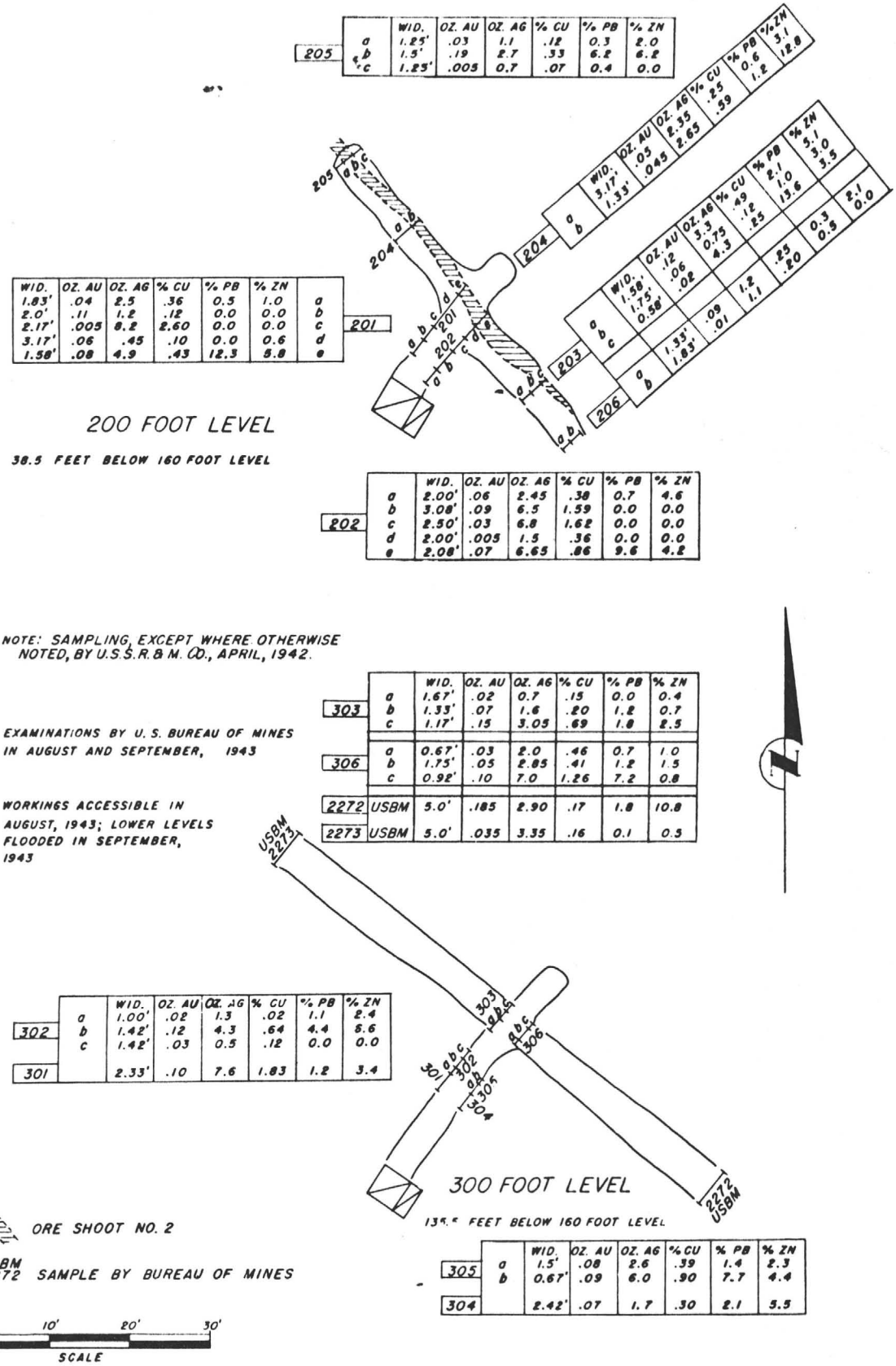
ASSAYS - 160 FOOT LEVEL							
NO.		WID	OZ. AU	OZ. AG	% CU	% PB	% ZN
21	a	1.92'	0.10	6.5	0.87	0.5	2.7
	b	2.67'	0.02	2.7	0.56	1.0	1.5
	c	1.42'	0.44	4.1	0.41	3.3	4.2
	d	4.25'	0.03	1.5	0.36	0.0	1.3
	e	2.50'	0.07	2.1	0.36	1.4	10.3
22	a	1.50'	0.18	2.8	0.46	0.4	4.7
	b	2.00'	0.01	0.3	0.15	0.0	1.0
	c	1.67'	0.13	10.5	0.97	13.4	4.7
	d	2.50'	0.06	5.2	0.67	7.0	5.3
	e	3.00'	0.108	2.5	0.46	3.2	6.5
23	a	2.58'	0.45	3.1	0.46	1.8	4.8
	b	1.75'	0.16	4.7	0.46	5.6	9.0
	c	0.92'	0.08	4.5	0.67	4.6	9.5
24	a	2.08'	0.01	1.0	0.15	0.0	0.4
	b	2.58'	0.07	4.8	0.72	7.2	3.2
	c	1.50'	0.01	0.2	0.10	0.4	0.4
25	a	2.00'	0.05	1.7	0.26	2.3	2.0
	b	2.08'	0.35	4.4	0.56	6.8	3.9
	c	2.33'	0.47	11.5	0.72	22.1	4.0
26		2.92'	0.245	4.8	0.62	4.4	5.75
27	a	2.00'	0.03	2.4	0.31	2.8	4.2
	b	3.00'	TR	0.2	0.10	0.0	0.0
28	a	1.92'	0.03	1.2	0.21	0.0	1.2
	b	3.08'	TR	0.4	0.05	0.0	0.7
29	a	2.00'	0.08	1.8	0.25	2.1	3.7
	b	3.58'	TR	0.6	0.10	0.0	0.0
30	a	2.00'	0.20	3.6	0.36	2.0	4.4
	b	2.75'	0.02	3.4	0.77	0.8	1.5
31		0.75'	0.10	5.0	0.41	0.5	3.0
32	a	1.25'	0.03	3.3	0.46	2.3	2.2
	b	2.00'	0.02	0.5	0.05	0.0	1.0
	c	1.00'	0.03	2.1	0.31	1.6	7.3
	d	1.58'	TR	0.3	0.10	0.0	0.0
	e	1.17'	0.02	9.5	3.35	0.4	0.0
33	a	1.50'	0.15	2.7	0.36	1.4	9.0
	b	1.75'	0.02	1.4	0.15	0.5	1.9
	c	1.25'	0.02	44.8	7.94	0.0	0.0
34	a	1.67'	0.03	6.4	0.72	6.3	3.2
	b	2.33'	TR	0.2	0.10	0.0	0.0
	c	0.92'	0.09	3.6	0.41	3.1	7.8
	d	2.25'	0.01	0.8	0.10	0.0	1.5
	e	1.08'	0.06	17.3	3.04	1.1	0.3
35		1.17'	0.06	1.9	0.25	1.9	2.8
36		1.08'	0.07	1.9	0.31	2.6	2.3
37	a	2.50'	0.01	2.7	0.21	1.2	1.2
	b	1.83'	0.06	4.6	0.36	7.3	5.5
	c	2.50'	0.005	0.7	0.10	0.5	0.2
	d	1.92'	0.09	3.7	0.77	9.2	6.1
	e	1.58'	0.10	5.4	0.72	1.4	2.2

ASSAYS - 160 FOOT LEVEL							
NO		WID	OZ. AU	OZ. AG	% CU	% PB	% ZN
38	a	3.08'	0.03	5.7	0.57	2.8	3.5
	b	2.92'	0.16	4.0	0.41	3.1	4.3
	c	1.58'	0.02	1.1	0.15	0.4	0.2
39	a	1.25'	0.05	6.0	0.72	9.1	6.7
	b	2.58'	0.03	1.0	0.15	1.3	0.8
	c	2.17'	0.02	1.8	0.21	3.8	2.0
40		2.42'	0.005	0.3	0.10	0.0	0.5
41		2.58'	0.6	3.0	0.36	3.8	3.0
42		2.08'	0.8	3.3	0.31	3.4	4.8
43	a	3.33'	0.005	0.6	0.15	0.0	0.3
	b	3.00'	0.07	0.9	0.15	1.0	2.7
44	a	2.33'	0.005	1.0	0.36	0.0	0.8
	b	2.50'	0.03	1.5	0.25	1.4	3.2
45		2.92'	0.11	4.0	3.7	0.31	2.7
46		2.67'	0.17	7.1	0.41	3.8	5.3
47		3.33'	0.005	0.9	0.46	3.0	0.5
48		4.00'	TR	0.3	0.7	0.0	0.3
49		3.00'	0.03	3.1	0.31	0.0	3.4
50		2.17'	0.02	1.8	0.15	0.0	1.4
51		2.08'	0.02	3.5	0.36	0.8	1.0
52		2.75'	0.01	2.4	0.20	3.7	3.0
53		2.67'	0.01	[illegible]	0.20	2.9	1.9
54	a	1.67'	0.11	940	0.52	17.7	3.8
	b	2.67'	0.03	0.7	0.10	0.0	0.7
	c	3.17'	0.07	6.3	0.82	8.8	7.5
55	a	1.42'	0.02	5.9	0.46	39.0	7.4
	b	1.50'	0.20	1.5	0.10	0.4	1.0
56	a	1.50'	0.04	3.6	0.31	3.5	1.9
	b	2.50'	0.02	1.8	0.15	1.6	3.0
	c	2.75'	0.025	5.1	0.41	3.9	8.9
	d	1.42'	0.07	4.0	0.33	7.8	11.6
	e	1.83'	0.245	1.8	0.10	0.0	0.0
57	a	2.25'	0.04	4.2	0.46	4.0	5.2
	b	2.33'	0.01	1.6	0.21	1.8	4.3
	c	2.67'	0.03	1.0	0.10	0.0	0.0
58		4.17'	0.02	3.5	0.46	3.2	8.0
59		2.58'	0.15	1.8	0.20	1.1	3.3
60	a	4.42'	0.04	5.2	0.[illegible]	6.6	9.4
	b	1.42'	0.01	1.0	0.1[illegible]	1.2	2.3
	c	2.42'	0.04	2.1	0.46	0.8	1.2
	d	1.17'	0.01	1.0	0.26	0.9	0.8
61	a	5.08'	0.04	11.0	1.75	6.3	16.3
	b	2.17'	0.03	1.6	0.15	1.0	1.4
	c	3.58'	0.04	3.4	0.41	3.9	8.8
62	a	1.75'	0.01	1.0	0.15	1.2	1.5
	b	2.75'	0.01	2.5	0.31	1.0	5.0
63	a	3.67'	0.08	8.4	0.72	26.6	6.2
	b	2.08'	0.07	0.9	0.10	0.6	0.4
	c	1.67'	0.08	9.8	0.67	20.0	8.0
64	a	3.58'	0.07	6.7	0.67	12.2	8.2
	b	3.67'	0.06	5.0	0.82	5.3	13.5
65		3.42'	0.03	6.0	0.67	5.3	7.0
66		4.33'	0.03	8.7	1.44	3.8	11.3
67		1.83'	0.185	1.0	0.15	0.0	1.0
68	a	2.08'	TR	0.8	0.10	0.8	0.3
	b	2.92'	0.06	5.1	0.67	6.5	12.5
69		2.17'	0.01	3.9	0.72	4.4	4.8
70	a	1.92'	0.01	1.8	0.36	0.0	0.8
	b	1.08'	0.03	2.2	0.33	3.2	5.6
71		1.75'	0.02	2.7	0.36	3.6	7.8
CHECK SAMPLES BY U.S. BUREAU OF MINES							
2274	28 a	0.020	1.36	0.18	0.7		1.0
2275	28 b	0.10	0.30	0.05	0.3		0.8
2276	30 a	0.11	2.90	0.21	1.1		3.5
2277	30 b	0.025	1.25	0.07	0.3		0.7

Sampling, except where otherwise noted, by U.S. Smelting, Refining & Mining Co., April, 1942. Bureau of Mines examinations Aug & Sept, 1943. Workings accessible Aug., 1943; lower levels flooded Sept., 1943.

Map and section traced from sample map by U.S.S.R. & M. Co.

Figure 9. - Elevation of Summit mine and sample plat of 160 ft. level.



		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
205	a	1.25'	.03	1.1	.12	0.3	2.0
	b	1.5'	.19	2.7	.33	6.2	6.2
	c	1.25'	.005	0.7	.07	0.4	0.0

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
204	a	3.17'	.03	2.35	.25	0.6	3.1
	b	1.33'	.045	2.65	.59	1.2	12.8

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
203	a	1.58'	.12	3.3	.49	2.1	5.1
	b	1.75'	.06	0.75	.12	1.0	3.0
	c	0.58'	.02	4.3	.25	13.6	3.5
206	a	1.33'	.09	1.2	.25	0.3	2.1
	b	1.83'	.01	1.1	.20	0.5	0.0

	WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN	
1.83'	.04	2.5	.36	0.5	1.0		a
2.0'	.11	1.2	.12	0.0	0.0		b
2.17'	.005	8.2	2.60	0.0	0.0		c
3.17'	.06	.45	.10	0.0	0.6		d
1.58'	.08	4.9	.43	12.3	5.8		e

201

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
202	a	2.00'	.06	2.45	.38	0.7	4.6
	b	3.08'	.09	6.5	1.59	0.0	0.0
	c	2.50'	.03	6.8	1.62	0.0	0.0
	d	2.00'	.005	1.5	.36	0.0	0.0
	e	2.08'	.07	6.65	.86	9.6	4.2

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
303	a	1.67'	.02	0.7	.15	0.0	0.4
	b	1.33'	.07	1.6	.20	1.2	0.7
	c	1.17'	.15	3.05	.69	1.8	2.5
306	a	0.67'	.03	2.0	.46	0.7	1.0
	b	1.75'	.05	2.85	.41	1.2	1.5
	c	0.92'	.10	7.0	1.26	7.2	0.8
2272	USBM	5.0'	.185	2.90	.17	1.8	10.8
2273	USBM	5.0'	.035	3.35	.16	0.1	0.5

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
302	a	1.00'	.02	1.3	.02	1.1	2.4
	b	1.42'	.12	4.3	.64	4.4	5.6
	c	1.42'	.03	0.5	.12	0.0	0.0
301		2.33'	.10	7.6	1.83	1.2	3.4

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
305	a	1.5'	.08	2.6	.39	1.4	2.3
	b	0.67'	.09	6.0	.90	7.7	4.4
304		2.42'	.07	1.7	.30	2.1	5.5

Figure 10. - Sample plats of 200 ft. and 300 ft. levels, Summit mine.

drift and has a second connection to the surface through a 365-foot adit. Drifts on the 200- and 300-foot levels are 50 and 65 feet long, respectively.

Sampling

Detailed sample plats of the 160-foot, the 200-foot, and the 300-foot levels were furnished by the U. S. Smelting, Refining & Mining Co. (figs. 9 and 10). A few check samples were cut by the Bureau of Mines' engineers.

Later Operation

The mine was leased by Ralph R. Langley of Kingman after it was released by the El Dorado Rover Mining Co. Langley assumed the unpaid balance due on the first R.F.C. loan to the former lessee. When the mine was visited by a Bureau of Mines' engineer[14] in December 1944, Langley had sunk a 50-foot winze on the 160-foot level, about 400 feet northwest of the main shaft, and drifted in both directions from the bottom of the winze. The winze is at the middle of the No. 1 ore shoot shown on figure 9. The sublevel is about 180 feet long. Ore was stoped continuously from this sublevel to the arch below the 160-foot level. This ore shoot was found undisturbed above the 160-foot level and was stoped to 20 feet from the surface. Langley reported that 3,800 tons of ore was mined from above the level. A total of 6,049 tons of ore was mined in the period from October 1943 through April 1946. This averaged 4.42 percent lead, 7.18 percent zinc, and 0.76 percent copper. The precious-metal content per ton was 0.0738 ounce gold and 5.82 ounces silver. The ore was shipped to the Keystone mill after that started operating. The truck haul is 8 miles with the grade against the load in the last 2.5 miles.

When the mine was visited on May 27, 1946, Langley had started drifting on the 300-foot level to continue the level about 500 feet northwest under the No. 1 ore shoot. The level had been advanced 65 feet northwest and also a little to the southeast.

Langley reported that they were entering good lead-zinc ore to the northwest and some copper ore to the southeast. He was beginning to stope this ore while the drift was being advanced.

Concentration Tests

Concentration tests of a bulk sample taken from stope chutes were made in the Bureau of Mines testing laboratory at Salt Lake City. Selective flotation, after grinding to minus 65-mesh, recovered 86.8 percent of the lead in a concentrate that assayed 61.1 percent lead, 7.4 percent zinc, 2.1 percent copper, 1.87 ounces per ton gold, and 34.46 ounces per ton silver; 68.7 percent of the zinc in a concentrate that assayed 3.0 percent lead, 50.0 percent zinc, 1.5 percent copper, 0.30 ounce per ton gold, and 7.2 ounces per ton silver.

14/ Chas. A. Kumke.

A third copper-iron concentrate assayed 24.0 percent copper, 0.27 ounce per ton gold, and 2.15 ounces per ton silver. The copper recovery in this concentrate was 65.4 percent.

ALPHA MINE

Location, Accessibility, and Ownership

The Alpha mine is situated about 1 mile from the Summit mine on the western slope and near the crest of the Cerbat Mountains in sec. 32, T. 23 N., R. 17 W. It is about 7 miles southeast of Chloride and 4 miles east of the old Kingman-Chloride highway. It is 4.5 miles by road from the highway to the Alpha mine. The road to the two mines was improved under the access road program prior to July 1, 1945.

The Alpha group of four claims is owned by Caroline Daniels Moore of Kingman. The mine has been leased to Ralph R. Langley, Box 455, Kingman, Ariz.

History

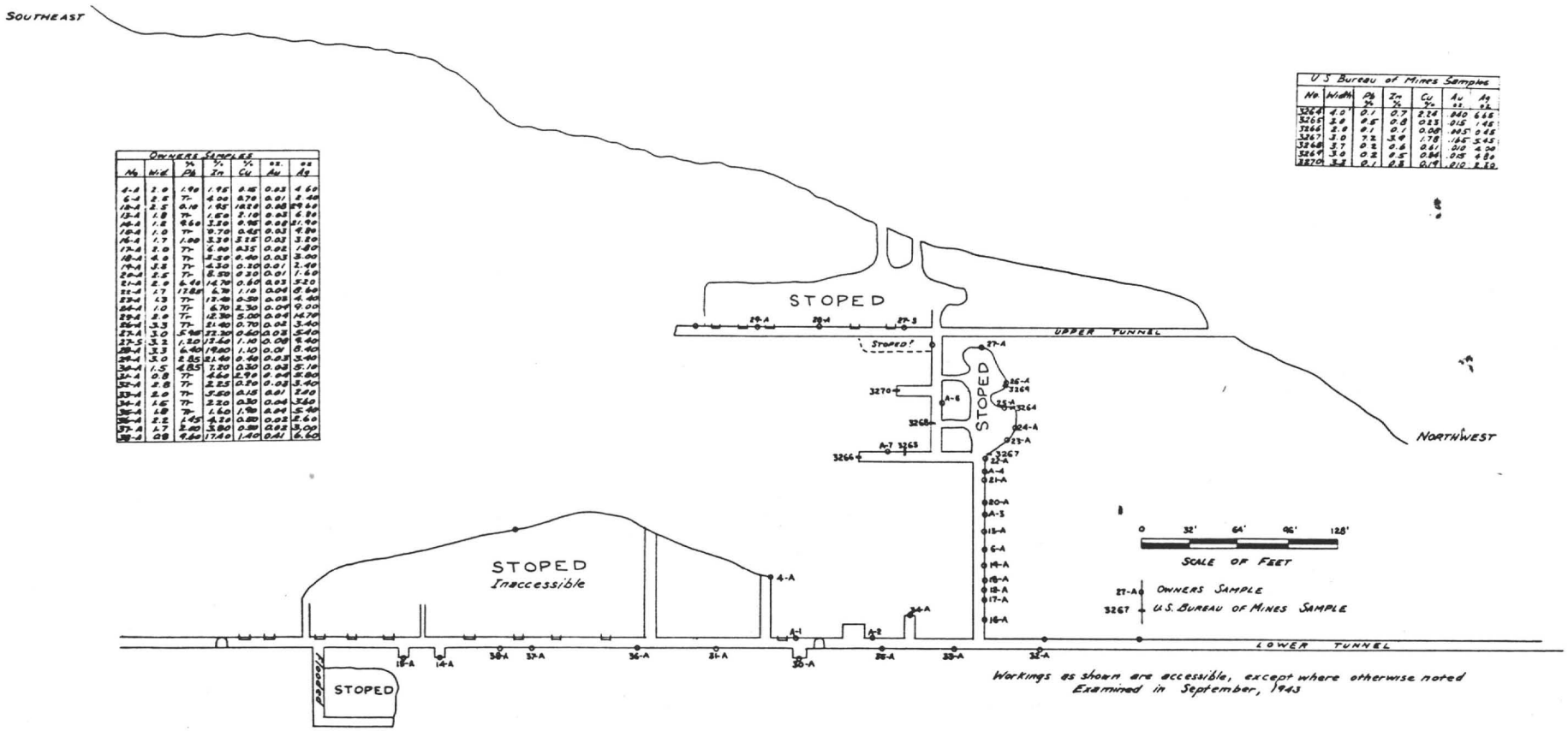
The mine was located in the late 1860's or early 1870's. It is reported that $200,000 worth of ore was taken from the mine and shipped. Part of this was from the oxidized zone and part from the sulfide zone. No records are available as to the grade or tonnage of the ore mined. The lower tunnel was partly cleaned out and retimbered with the aid of an R.F.C. loan. The greater part of the mine was accessible when the loan was exhausted and the work was suspended.

Description of the Deposit

The ore occurs as lenses in a fissure vein in granite. This vein strikes N. 60° W. and dips 50° to 65° northeast. It is continuous and has a considerable amount of gouge for the greater part of its length. There is very little metallization except in the sulfide lenses. The principal minerals are quartz, galena, sphalerite, chalcopyrite, and pyrite. From the work done so far, it appears that the lenses have no connection with each other and that they do not occur in any regular pattern.

Development and Mining

An adit was driven from the hillside a distance of 1,200 feet southeast on the Alpha vein (fig. 11). At a point 600 feet from the portal, a raise was driven 240 feet on the vein to connect with the upper adit or 200-foot level. This upper tunnel was driven from the surface a distance of 400 feet on the vein. From the lower level a stope over 300 feet long was carried to a height of 80 feet, according to mine maps. This stope has caved, and the back is inaccessible. A winze was sunk below the tunnel level, and it is reported that high-grade ore was taken from the winze and an adjoining stope. The winze is now flooded. A small stope has been mined from a sublevel off the raise to within a few feet of the upper tunnel. From the upper tunnel a



OWNERS SAMPLES						
No	Wid	% Pb	% Zn	% Cu	oz Au	oz Ag
4-A	2.0	1.90	1.95	0.12	0.03	4.60
6-A	2.5	Tr	4.00	0.70	0.01	2.40
10-A	2.5	0.10	1.85	12.10	0.08	29.60
12-A	1.8	Tr	1.60	2.10	0.03	6.80
14-A	1.8	4.60	3.30	0.90	0.08	21.90
15-A	1.0	Tr	9.70	0.45	0.03	4.80
16-A	1.7	1.00	3.30	3.15	0.03	3.80
17-A	2.0	Tr	6.00	0.35	0.02	1.80
18-A	4.0	Tr	4.50	0.40	0.03	3.00
19-A	3.2	Tr	4.30	0.30	0.01	2.40
20-A	2.5	Tr	8.50	0.30	0.01	1.60
21-A	2.0	6.40	14.70	0.60	0.03	5.20
22-A	1.7	12.80	6.70	1.10	0.04	8.60
23-A	1.3	Tr	12.40	0.50	0.03	4.40
24-A	1.0	Tr	6.70	2.30	0.04	9.00
25-A	2.0	Tr	12.30	5.00	0.04	14.70
26-A	3.3	Tr	21.40	0.70	0.02	3.40
27-A	3.0	5.90	22.30	0.60	0.03	5.40
27-S	3.2	1.20	12.60	1.10	0.04	9.40
28-A	3.3	6.40	19.00	1.10	0.01	8.40
29-A	3.0	2.85	21.40	0.40	0.03	3.40
30-A	1.5	4.85	7.20	0.30	0.03	5.10
31-A	0.8	Tr	4.60	2.90	0.04	5.80
32-A	2.8	Tr	2.25	0.20	0.03	3.40
33-A	2.0	Tr	3.50	0.15	0.01	2.00
34-A	1.5	Tr	2.20	0.30	0.04	3.60
35-A	1.8	Tr	1.60	1.90	0.04	5.40
36-A	2.2	1.45	4.30	0.80	0.02	2.60
37-A	1.7	2.40	3.80	0.30	0.02	3.00
38-A	0.8	4.60	17.40	1.40	0.01	6.60

U S Bureau of Mines Samples						
No	Width	% Pb	% Zn	% Cu	oz Au	oz Ag
3264	4.0	0.1	0.7	2.24	.040	6.65
3265	2.0	0.5	0.8	0.23	.015	1.45
3266	2.0	0.1	0.1	0.08	.045	0.45
3267	3.0	7.2	3.9	1.78	.165	5.45
3268	3.7	0.2	0.6	0.41	.010	4.20
3269	3.0	0.2	0.5	0.84	.015	4.80
3270	3.2	0.1	0.8	0.19	.010	2.10

Figure 11. - Section in plane of vein - Alpha mine, Mohave County, Ariz.
Traced from map by Ralph Langley.

stope 150 feet long was mined to a height of 30 to 60 feet. This stope breaks through to the surface. Some ore was stoped from below the upper tunnel, and the stope was filled with waste. No work is being done at the present time, and most of the machinery has been removed from the property.

Sampling

A copy of Langley's assay map of the Alpha mine was furnished to the Bureau of Mines and is included in this report. Most of these samples were taken at irregular intervals, and some of them were taken so as to include small bunches of high-grade ore. Seven samples were cut by the Bureau engineer to check the other sampling. The samples from the north side of the small stope off the main raise are mill-ore grade. The Bureau samples were cut across the entire exposed width of the vein. The two sets of samples are shown on the assay plat (fig. 11).

Detailed data on the sampling follow:

Bureau of Mines Samples

No.	Location	Description	Length, feet	Assays				
				Percent			Ounces	
				Pb	Zn	Cu	Au	Ag
3264	N. side of stope below 200-ft. level, N. side	Heavy sulfides on foot and hanging wall	4.0	0.1	0.7	2.24	0.040	6.65
3265	Sublevel, 17 ft. south of raise.	Oxidized, little sulfide	3.0	.5	.8	.23	.015	1.45
3266	Sublevel breast.	Oxidized, altered granite	2.0	.1	.1	.08	.005	.45
3267	Sublevel, N. end at top of ladder.	1 foot with heavy sulfide	3.0	7.2	3.9	1.78	.165	5.45
3268	Raise, 25 ft. above sub-level, S. side	Oxidized, some sulfides on footwall	3.7	.2	.6	.61	.010	4.00
3269	Stope below 200-foot level, N. side above platform.	Little sulfide	3.0	.2	.5	.84	.015	4.80
3270	Sublevel, 38 feet below 200-foot level.	Little sulfide, partly oxidized	3.3	.1	.3	.19	.010	2.30

Later Operation

One shipment of 64.8 tons of ore was made to the Keystone mill in 1945. This averaged 3.94 percent lead, 5.05 percent zinc, and 0.50 percent copper, with 0.07 ounce gold and 7.30 ounces silver per ton. Mr. Zlatnik, of the Keystone mill, reported that the ore responded exceptionally well to selective flotation. No work has been done at this mine in 1946.

GOLCONDA MINE

The Golconda mine was one of the two deep mines of the district. The shaft was sunk to a depth of 1,600 feet, and extensive stoping was done above the 1,400-foot level. Production ceased when the mill burned in 1917. Total production to that time is reported at $6,500,000 in lead, zinc, gold, and silver.15/ The mine has been idle since 1917, although good ore was reported on the 1,400-foot level. The workings are badly caved, and the mine stands full of water to the adit on the 600-foot level.

DE LA FOUNTAIN MINE

The De La Fountain claim is situated near the summit of the Cerbat Range, about 15 miles by road north of Kingman. It is owned by Messrs. Farley, Thomas, and Stevens of Flagstaff, Ariz., and is leased to L. M. Dickens of Kingman. The mine was operated recently and yielded two carloads of sorted ore in the last few months. The reported metal content of these shipments was 14 percent lead, 28 percent zinc, 0.02 ounce gold per ton, and 2.0 ounces silver per ton.

It is reported that four levels were opened in the course of the early mining. Only one is accessible. There are three stopes on this level, testifying to more substantial production during the earlier operation. The remaining ore on this level is in small pillars and along some of the stopes margins. The two carloads of sorted ore shipped by the present operator were gleaned from these stopes. Four samples, taken from such remnants of ore in the stopes averaged 3.6 percent lead and 14.2 percent zinc, with negligible gold and silver over widths of 1 to 4 feet.

JIM KANE MINE

Location, Accessibility, and Ownership

The Jim Kane mine is in Cerbat Canyon near the summit of the Cerbat range, 5.1 miles east of paved highway U. S. 93. The road to the property is in fair condition, but the grades are steep and the curves are sharp in the last 2 miles.

The group of 11 claims is owned by Jim Kane, of Kingman, who lives on the property.

History

A small shaft was sunk to a depth of 30 feet during the early mining in this district. Jim Kane relocated the claims in 1915 and has held them to the present time. The California Chemical Spray Co. leased the property in 1939 and drove some drifts from the lower tunnel. After 6 months work they gave up the lease. No work is being done at present. It is reported that a

15/ Arizona Bureau of Mines, Arizona Metal Production: Bull. 140.

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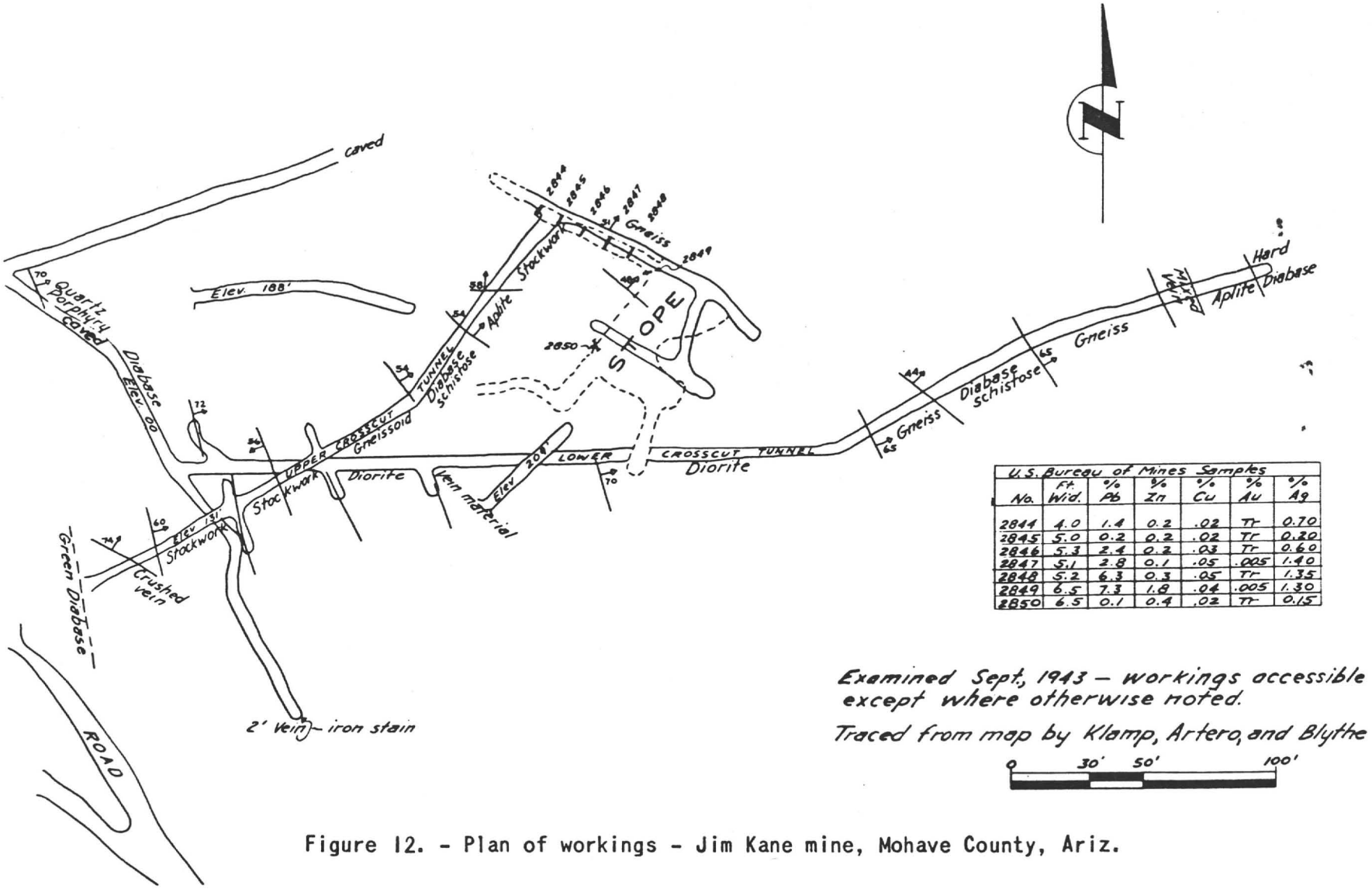


U.S. Bureau of Mines Samples

No.	Ft. Wid.	% Pb	% Zn	% Cu	% Au	% Ag
2844	4.0	1.4	0.2	.02	Tr	0.70
2845	5.0	0.2	0.2	.02	Tr	0.20
2846	5.3	2.4	0.2	.03	Tr	0.60
2847	5.1	2.8	0.1	.05	.005	1.40
2848	5.2	6.3	0.3	.05	Tr	1.35
2849	6.5	7.3	1.8	.04	.005	1.30
2850	6.5	0.1	0.4	.02	Tr	0.15

Examined Sept., 1943 — workings accessible except where otherwise noted.

Traced from map by Klamp, Artero, and Blythe

Figure 12. - Plan of workings - Jim Kane mine, Mohave County, Ariz.

few cars of ore were milled at a local mill, and some ore was shipped direct to the smelter, but no figures were available as to the amount or grade of this production. Kane stated that a carload of ore had been shipped from the claim south of his house, which assayed 47 percent lead and 42 ounces per ton silver. This ore was packed out by burros. He also reported that during the first World War several hundred pounds of steel galena was sold for radio crystals at $0.25 to $1 per pound.

Description of the Deposit

The ore occurs in brecciated and altered gouge material in a fault zone striking N. 60° W. and dips 60° northeast. This zone varies in width from 1 foot to 20 feet. The country rocks are amphibolite and gneiss intruded by dikes and irregular masses of younger granite porphyry. In the one accessible stope the galena occurs in small bunches and in small streaks in altered granite. Several tons of high-grade galena ore have been sorted and stored in the stope. The ore is very spotty, and hand sorting would be necessary to obtain a milling grade of ore. There are several minor fault zones of similar character that have been partly exposed in the workings (fig. 12). Small showings of lead and zinc minerals occur in these, but in general the small bunches of ore are more scattered than in the major fault zone described above. A little beryl has been found in two small outcrops of pegmatite on the claim at the south end of the group. Mr. Kane stated that he had picked up 20 or 25 pounds of crystals. Two small pieces were found on the outcrops by the Bureau engineers. The pegmatite does not seem to be a continuous dike, but rather two separate bunches. Both of the detached outcrops are small.

Development

The underground workings are shown on figure 12, traced from an undated map by Klamp, Artero, and Blythe of the Producers Mining Co.

Sampling

The prospect was thoroughly sampled by the Producers Mining Co. A copy of their assays, supplied by Mr. Kane, is attached.

Table 4. - Producers Mining Co., samples from Jim Kane mine

No.	Description	Width, feet	Ounces Au	Ounces Ag	Percent Pb	Percent Zn
2801	Dump at incline shaft.....	-	0.01	1.70	3.07	5.80
2802	Dump at 30 foot crosscut tunnel.....	-	.02	1.40	5.40	6.60
2803	Dump at 70 foot crosscut tunnel.....	-	.01	1.00	4.60	2.70
2804	Mill dump at middle tunnel.....	-	.01	0.60	3.20	1.10
2805	Grab of high-grade from dump.....	-	.04	7.50	59.30	3.60
2806	Face of north drift from stope.....	3.0	.02	2.70	1.56	1.20
2807	Cut north drift from stope, middle tunnel	4.0	.005	Trace	Trace	.60
2808	do.....	4.0	.01	.90	0.25	1.15
2809	do.....	5.0	.01	.90	3.54	.80
2810	do.....	5.0	.01	3.90	2.25	1.30
2811	do.....	8.0	.03	1.30	6.00	1.40
2812	Cut sample stope, north end hanging wall.	5.0	.04	29.40	3.65	1.30
2813	Cut sample stope.....	6.0	.01	.70	2.10	.80
2814	Cut sample stope, footwall.....	3.0	.01	1.30	5.80	3.80
2815	do.....	4.5	.005	.50	1.30	1.00
2816	do.....	3.0	.01	2.40	10.30	1.80
2817	do.....	4.0	.02	1.00	3.55	2.60
2818	do.....	4.5	.01	1.50	8.10	3.10
2819	do.....	5.5	.01	1.30	7.65	.70
2820	do.....		.005	.40	0.55	.50
2821	do.....	4.5	.02	.30	Trace	1.00
2822	Cut sample stope, hanging wall.....	4.0	.08	6.10	5.50	4.25
2823	Cut corner south drift from stope.....	3.5	.02	2.30	11.35	2.90
2824	Cut at corner E. side S. drift 4 ft. S. of manway.....	5.5	.03	3.80	7.80	1.90
2825	Cut in raise in hanging wall.....	2.0	.01	.20	3.00	.90
2826	Below 2825.....	2.0	.01	.50	2.50	1.20
2827	Below 2826.....	3.0	.04	4.30	13.60	3.80
2828	Cut 10 feet south of 2824.....	5.0	.02	1.10	1.80	2.50
2829	Cut 10 feet south of 2828.....	3.0	.02	2.30	0.25	.40
2830	Cut at face south drift.....	2.0	.02	2.00	5.75	1.00
2831	Grab from muck pile at face.....		.01	.90	Trace	.50
2832	Grab from pile in stope.....		.04	8.80	17.90	3.90
2833	No. 1 underhand middle tunnel 30 ft. from portal.....	3.5	.01	.80	5.50	1.80
2834	No. 1 underhand middle tunnel 30 ft. from portal.....	4.0	.01	.40	3.60	1.30
2835	No. 2 underhand, 60 feet from portal.....	1.3	.02	1.70	1.65	1.90
2836	do.....	3.0	.02	1.60	4.60	1.00
2837	Cut in bottom No. 1 drift south middle tunnel.....	5.0	.01	.20	1.40	2.50
2838	Cut at No. 1 chute, middle tunnel.....	9.5	.01	2.00	Trace	.70
2839	Cut face of 30 foot crosscut tunnel.....	2.3	.02	3.90	15.65	7.80
2840	Cut incline shaft on pillar.....	3.0	.01	1.00	4.80	11.20
2841	Cut from north incline shaft.....	2.5	.01	2.00	14.60	6.70
2842	Chip from outcrop south of middle tunnel.	2.5	.01	Trace	Trace	1.70

Table 4. - Producers Mining Co. samples from Jim Kane mine (continued)

No.	Description	Width, feet	Ounces Au	Ounces Ag	Percent Pb	Percent Zn
2843	Cut from incline raise.....	4.3	0.02	2.60	4.75	4.00
2844	do.....	3.0	.01	.80	4.30	5.40
2845	Cut from incline raise, north side.....	4.5	.01	1.10	11.70	5.30
2846	Cut from incline raise F. W.	2.0	.02	2.50	10.10	8.60
2847	Cut from tunnel 5.....	7.0	.01	.20	Trace	2.50
2848	do.....	5.0	.01	.30	do.	1.40
2849	Grab from dump tunnel 5.....		.01	.20	do.	1.10
2850	Cut incline raise above 2846.....	4.0	.01	.30	2.30	1.20
2851	Cut incline raise above 2850.....	2.0	.005	.10	.50	2.30
2852	Cut hanging wall 5 feet south 2851.....	2.0	.01	2.40	16.60	5.10
2853	Cut incline raise 10 feet 2843.....	3.2	.01	1.00	4.20	4.40
2854	Cut middle tunnel St. 15, north corner...	4.0	.01	.70	3.80	Trace
2855	Cut middle tunnel St. 15, south corner...	3.5	.01	.70	2.10	0.70
2856	Cut south drift 12 feet south of st. 15..	3.0	.01	.90	5.80	Trace
2857	Cut south drift 35 feet south of st. 15..	4.5	.02	3.30	Trace	do.
2858	Cut south drift 40 feet south of st. 15..	4.2	.02	4.50	2.00	0.60
2859	Cut middle tunnel st. 16, corner crosscut	2.5	.02	3.80	4.80	3.80
2860	Chip from boulders tunnel #5.....		.005	Trace	Trace	Trace
2861	Cut, face of open cut below tunnel #5....	2.3	.02	20.30	3.60	3.70
2862	Cut, outcrop below Kanes house.....	2.5	.005	.10	Trace	2.90
2863	Car sample from #1 chute.....	-	.01	1.60	10.70	.50
2864	Car sample from #2 chute.....	-	.01	3.10	17.10	4.20
2865	Cut, upper north tunnel.....	3.0	.01	1.80	7.20	2.40
2866	do.....	3.0	.01	1.60	9.60	5.50
2867	do.....	4.3	.01	3.60	6.80	4.20
2868	do.....	3.5	.01	1.50	4.00	7.20
2869	Cut, pit 300 feet north upper tunnel.....	3.0	.005	Trace	Trace	1.40
2870	Grab dump on Silver Queen claim.....	-	.01	3.90	0.10	1.00

These assays were copied from a sheet furnished by Jim Kane, who stated that they were copies of the samples taken and assayed by the Producers Mining Co.

Seven check samples were cut in the main stope. These agreed fairly closely with the Producers Mining Co. samples.

No.	Location	Description	Length feet	Assays Percent Pb	Zn	Cu	Ounces Au	Ag
2844	Stope drift, north breast	Altered granite and schist, some sulfide	4.0	1.4	0.2	0.02	Trace	0.70
2845	Stope drift, 10 ft. from N. breast	do.	5.0	.2	.2	.02	do.	.20
2846	Stope drift, 20 ft. from N. breast	do.	5.3	2.4	.2	.02	do.	.60
2847	Stope drift, 30 ft. from N. breast	do.	5.1	2.8	.1	.05	0.005	1.40
2848	Stope drift, 40 ft. from N. breast	do.	5.2	6.3	.3	.05	Trace	1.35
2849	Stope drift, 50 ft. from N. breast	do.	6.5	7.3	1.8	.04	0.005	1.30
2850	Stope, northwest side	do.	6.5	.1	.4	.02	Trace	.15

CHICAGO GROUP

The Chicago group of four claims is situated on the north side of Cerbat Canyon, about 12 miles by road south of Chloride. The group is owned by J. A. Bell of Summerton, Ariz., and B. Ableman of Chloride.

There are a number of short tunnels, shallow shafts, and pits, all on oxidized outcrops of veins. One sample of oxidized vein material was cut at the bottom of a 30-foot shaft. The sample, taken over 2.5 feet, assayed 0.4 percent lead, 0.2 percent zinc, 0.06 percent copper, 1.9 ounces per ton silver, and a trace of gold.

CERBAT MINE

Location, Accessibility, and Ownership

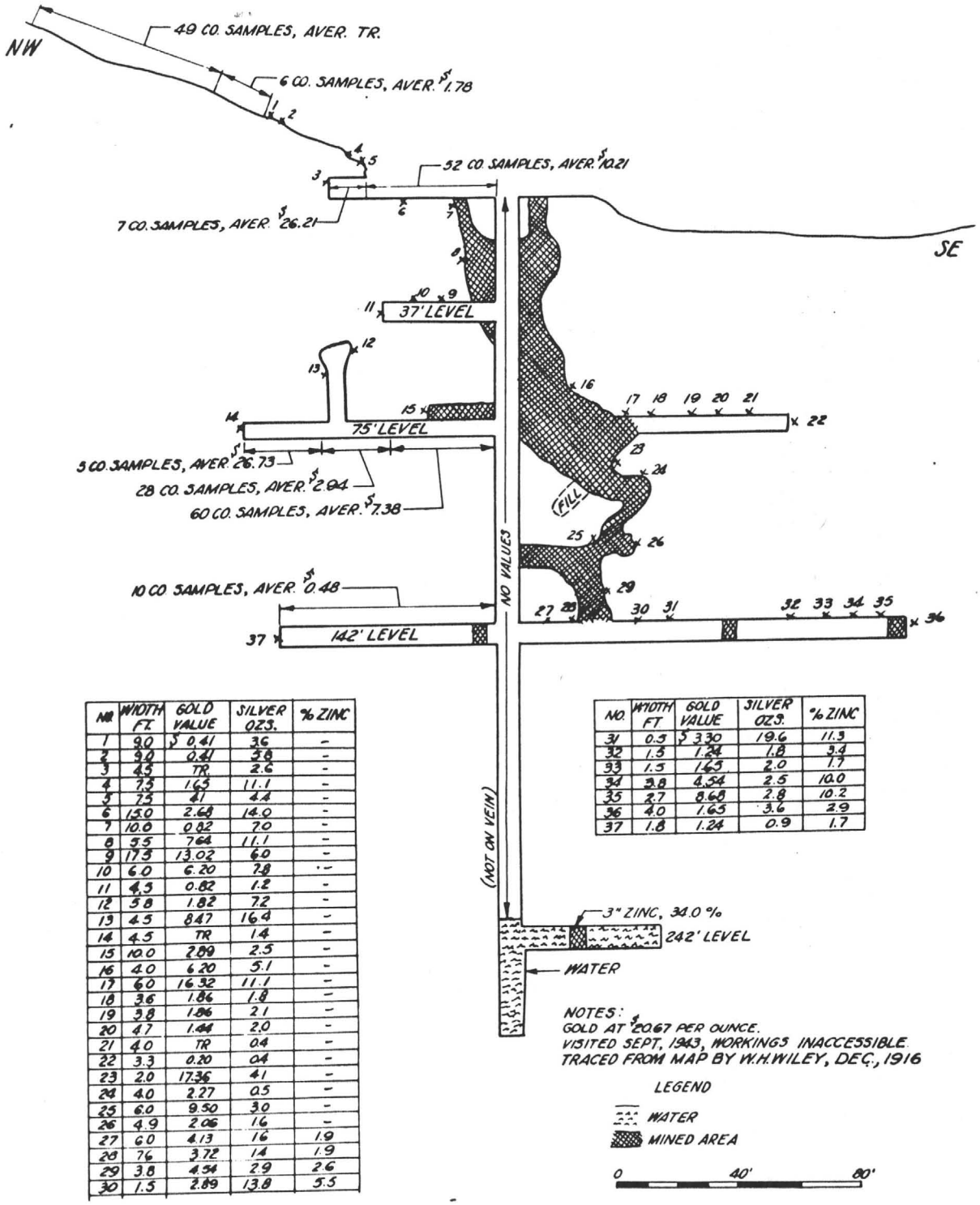
This property is on a western spur of the Cerbat Range north of Kingman and south of Chloride. The mine is reached by turning to the east off paved U. S. Highway 93, 7.7 miles south of Chloride and following a dirt road 3.7 miles, and then turning left on a branch road that leads to the Cerbat mine about 1 mile north. The last mile of the road is impassable.

There are five claims in the group, owned jointly by F. A. Morrison, of Kingman, who is in charge of the property, and the Pelton brothers. Three of the claims are patented and two are unpatented.

History

The property was worked intermittently during the period 1869 to 1906 for gold and silver. It was credited with a production of $200,000 in gold and $50,000 in silver.16/ The mine was acquired by the present owners in

16/ Arizona Bureau of Mines, Arizona Metal Production: Bull. 140. ser. 19.



NO	WIDTH FT.	GOLD VALUE	SILVER OZS.	% ZINC
1	9.0	$ 0.41	3.6	-
2	9.0	0.41	5.8	-
3	4.5	TR.	2.6	-
4	7.3	1.65	11.1	-
5	7.5	.41	4.4	-
6	15.0	2.68	14.0	-
7	10.0	0.82	7.0	-
8	3.5	7.64	11.1	-
9	17.5	13.02	6.0	-
10	6.0	6.20	7.8	-
11	4.5	0.82	1.2	-
12	5.8	1.82	7.2	-
13	4.5	8.47	16.4	-
14	4.5	TR	1.4	-
15	10.0	2.89	2.5	-
16	4.0	6.20	5.1	-
17	6.0	16.32	11.1	-
18	3.6	1.86	1.8	-
19	3.8	1.86	2.1	-
20	4.7	1.44	2.0	-
21	4.0	TR	0.4	-
22	3.3	0.20	0.4	-
23	2.0	17.36	4.1	-
24	4.0	2.27	0.5	-
25	6.0	9.50	3.0	-
26	4.9	2.06	1.6	-
27	6.0	4.13	1.6	1.9
28	7.6	3.72	1.4	1.9
29	3.8	4.54	2.9	2.6
30	1.5	2.89	13.8	5.5

NO.	WIDTH FT.	GOLD VALUE	SILVER OZS.	% ZINC
31	0.5	$ 3.30	19.6	11.3
32	1.5	1.24	1.8	3.4
33	1.5	1.65	2.0	1.7
34	3.8	4.54	2.5	10.0
35	2.7	8.68	2.8	10.2
36	4.0	1.65	3.6	2.9
37	1.8	1.24	0.9	1.7

Figure 13. - Longitudinal elevation - Cerbat mine.

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AUGUST 1947

NON-CIRCULATING

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
THOS. H. MILLER, ACTING DIRECTOR

REPORT OF INVESTIGATIONS

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

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BY

P. S. HAURY

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.[2]

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.

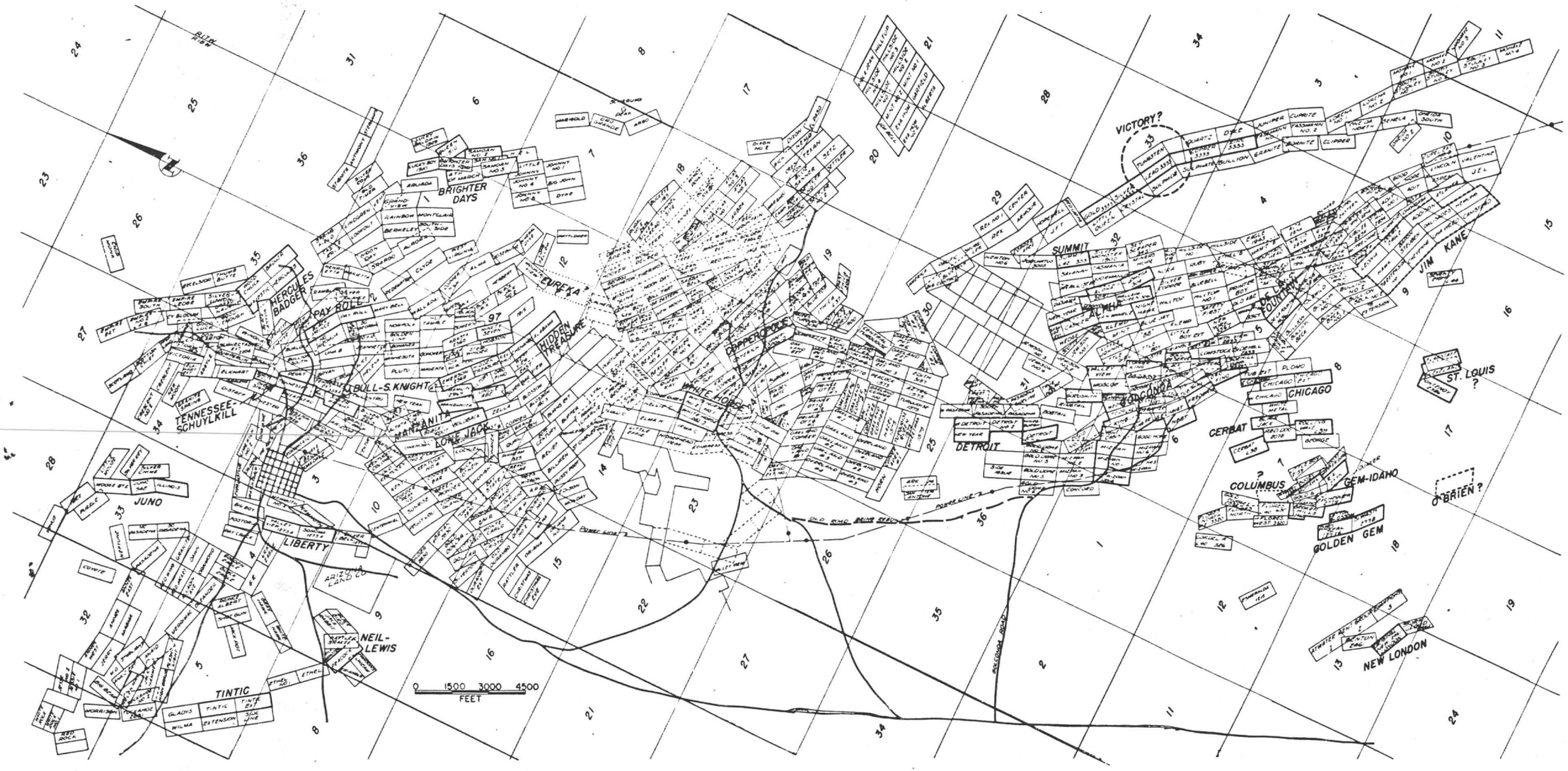


Figure 1. - Claim map of Wallapai mining district, Mohave County, Ariz.

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:

A small stope was mined from the oxidized footwall ore just south of the crosscut on the adit level. Two shallow shafts, 40 and 50 feet deep, were sunk on the outcrop. The 50-foot shaft is over the south drift on the adit level. An old adit was driven about 1,000 feet northwest of the portal of the working tunnel, and some drifting was done on a vein. That work is inaccessible.

Sampling

A grab sample of the muck from the winze assayed 3.7 percent zinc, 0.1 percent lead, 0.35 percent copper, and 1.55 ounces per ton silver. The winze could not be sampled without interrupting the work in progress.

Seven samples were cut in the south drift. The samples show that there is a width of about 5 feet of mill-grade ore in the last 55 feet of the drift. The samples from this part of the drift averaged 0.3 percent lead, 5.3 percent zinc, 2.50 percent copper, and 7.2 ounces silver per ton. The sample locations and detailed sample data are shown on figure 8.

An old shaft above the south drift shows evidence that the vein is completely oxidized down to 50 feet above the drift. The face of the drift is very near the end line of the claim.

This ore shoot extends across the south end-line of the Detroit claims into the Golden Eagle ground. Open cuts on the oxidized outcrop of the vein show low metal values for some distance south of the common end line. If later development should prove that this ore shoot extends downward to the lower level, then the extension of the ore shoot in the Golden Eagle ground could be extracted through the Detroit workings. The Golden Eagle has lain idle for a long time. It was worked during an earlier period through a shaft 1/2 mile farther south. The old workings are all caved but the dumps bear evidence that the workings were extensive.

No production was made after the mine was examined in September 1943.

VICTORY MINE

The Victory mine, formerly known as the Wrigley, is situated on the east slope of the Cerbat Range, about 15 miles by road north of Kingman and 38 miles by road from Chloride.

F. Nelson attempted to rehabilitate caved and flooded workings with the aid of an R.F.C. loan. Entry to the mine was through a shaft reported to be several hundred feet deep and to have several levels driven on the vein. The work of reopening this shaft had been abandoned when it was visited by engineers of the Bureau of Mines. Subsequent flooding and some fresh caving has made the mine entirely inaccessible.

SUMMIT MINE

Location and Accessibility

The Summit mine is situated near the crest of the Cerbat range about 12 miles southeast of Chloride. It is reached from the west by a road that serves the Alpha, Detroit, and Golden Eagle properties also. A road from Kingman goes up the east side of the range to the mine. The higher sections of both these roads were in such a state of disrepair as to be almost impassable. An access-road proposal for the improvement of the road from the west to the Summit and Alpha mines was approved by the Bureau of Mines and was completed before July 1, 1945.

Ownership

The Summit group of 40 claims is owned by L. L. Robinson of Los Angeles, Calif. It was leased to the El Dorado Rover Mining Co., but the lease was relinquished in August 1943.

History

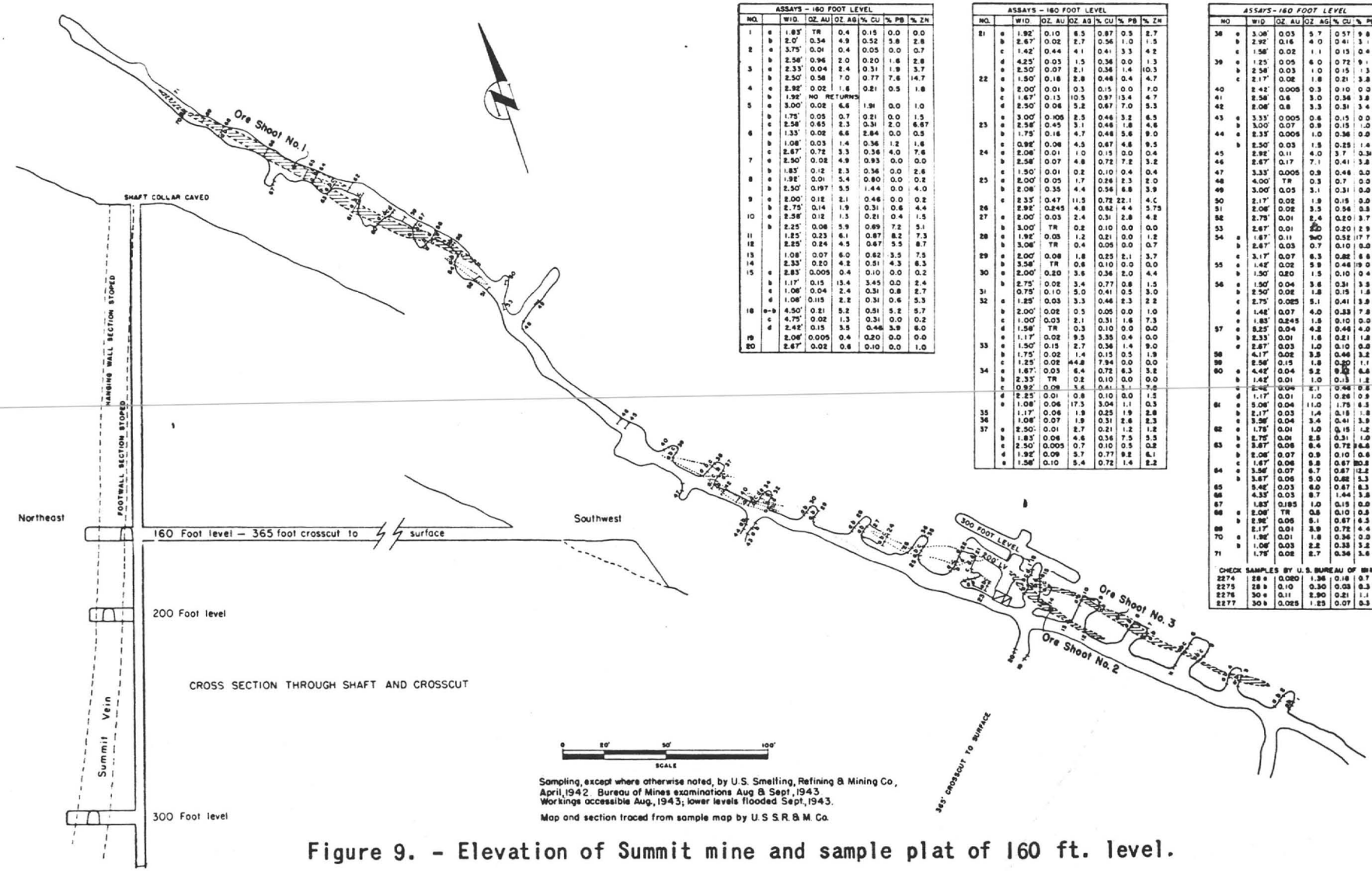
The U. S. Smelting, Refining & Mining Co., operating the mine on a lease, sank a vertical shaft in 1924. The Keystone Mining Co. shipped 12,000 tons of ore, which was stoped above the first level in 1936. The mine was thoroughly sampled in April 1942 by Miles P. Romney, engineer for the U. S. Smelting, Refining & Mining Co. The El Dorado Rover Mining Co. leased it in December 1942. This company did some new development on the lower levels with the aid of an R.F.C. loan and shipped 23 cars of ore, much of which was stoped above the first level. The company decided that not enough ore could be developed to supply a mill from this mine alone. It shut down in August 1943 and returned a second R.F.C. loan.

Ore Deposit

The ore-bearing vein, which is 3 to 8 feet thick, occupies a fissure in granite and amphibolite that stand well with little timbering. It strikes northwesterly and dips steeply northeast. The principal gangue is quartz with a considerable amount of gouge. The ore minerals are galena, sphalerite, pyrite, and chalcopyrite, with some gold and silver. The sulfides are largely oxidized above the first level. The metal content is below ore grade in much of the vein. The material with sufficient concentration of the metallic minerals to constitute ore occurs in lenses that seldom occupy the full width of the vein. Some of these are too small to mine. Three ore shoots with sufficient volume to repay the cost of mining are exposed on the first level. One of these is developed on the second level also. Two of these shoots are lead-zinc ore and one is copper ore.

Development

The mine was opened by a 1-1/2-compartment vertical shaft with levels at depths of 160, 200, and 300 feet. The 160-foot level has about 750 feet of



Sampling, except where otherwise noted, by U.S. Smelting, Refining & Mining Co., April, 1942. Bureau of Mines examinations Aug. & Sept., 1943. Workings accessible Aug., 1943; lower levels flooded Sept., 1943.

Map and section traced from sample map by U.S.S.R. & M. Co.

ASSAYS – 160 FOOT LEVEL

NO.		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
1	a	1.83'	TR	0.4	0.15	0.0	0.0
	b	2.0'	0.34	4.9	0.52	5.8	2.8
2	a	3.75'	0.01	0.4	0.05	0.0	0.7
	b	2.58'	0.96	2.0	0.20	1.6	2.8
3	a	2.33'	0.04	2.4	0.31	1.9	3.7
	b	2.50'	0.58	7.0	0.77	7.6	14.7
4	a	2.92'	0.02	1.6	0.21	0.5	1.8
	b	1.92'	NO RETURNS				
5	a	3.00'	0.02	6.6	1.91	0.0	1.0
	b	1.75'	0.05	0.7	0.21	0.0	1.5
	c	2.58'	0.65	2.3	0.31	2.0	6.67
6	a	1.33'	0.02	6.6	2.84	0.0	0.5
	b	1.08'	0.03	1.4	0.36	1.2	1.6
	c	2.67'	0.72	3.3	0.36	4.0	7.6
7	a	2.50'	0.02	4.9	0.93	0.0	0.0
	b	1.83'	0.12	2.3	0.36	0.0	2.6
8	a	1.92'	0.01	5.4	0.80	0.0	0.2
	b	2.50'	0.197	5.5	1.44	0.0	4.0
9	a	2.00'	0.12	2.1	0.46	0.0	0.2
	b	2.75'	0.14	1.9	0.31	0.6	4.4
10	a	2.58'	0.12	1.5	0.21	0.4	1.5
	b	2.25'	0.08	5.9	0.69	7.2	5.1
11		1.25'	0.23	6.1	0.87	8.2	7.3
12		2.25'	0.24	4.5	0.67	5.5	8.7
13		1.08'	0.07	6.0	0.82	3.5	7.5
14		2.33'	0.20	4.2	0.51	4.3	6.3
15	a	2.83'	0.005	0.4	0.10	0.0	0.2
	b	1.17'	0.15	13.4	3.45	0.0	2.4
	c	1.08'	0.04	2.4	0.31	0.8	2.7
	d	1.08'	0.115	2.2	0.31	0.6	3.3
18	a-b	4.50'	0.21	5.2	0.51	5.2	5.7
	c	4.75'	0.02	1.3	0.31	0.0	0.2
	d	2.42'	0.15	3.5	0.46	3.9	6.0
19		2.08'	0.005	0.4	0.20	0.0	0.0
20		2.67'	0.02	0.6	0.10	0.0	1.0

ASSAYS – 160 FOOT LEVEL

NO.		WID	OZ. AU	OZ. AG	% CU	% PB	% ZN
21	a	1.92'	0.10	6.5	0.87	0.5	2.7
	b	2.67'	0.02	2.7	0.56	1.0	1.5
	c	1.42'	0.44	4.1	0.41	3.3	4.2
	d	4.25'	0.03	1.5	0.36	0.0	1.3
	e	2.50'	0.07	2.1	0.36	1.4	10.3
22	a	1.50'	0.18	2.8	0.46	0.4	4.7
	b	2.00'	0.01	0.3	0.15	0.0	1.0
	c	1.67'	0.13	10.5	0.97	13.4	4.7
	d	2.50'	0.06	5.2	0.67	7.0	5.3
23	a	3.00'	0.105	2.5	0.46	3.2	6.5
	a	2.58'	0.45	3.1	0.46	1.8	4.6
	b	1.75'	0.16	4.7	0.46	5.6	9.0
	c	0.92'	0.08	4.5	0.67	4.8	9.5
24	a	2.08'	0.01	1.0	0.15	0.0	0.4
	b	2.58'	0.07	4.8	0.72	7.2	3.2
	c	1.50'	0.01	0.2	0.10	0.4	0.4
25	a	2.00'	0.05	1.7	0.26	2.3	2.0
	b	2.08'	0.35	4.4	0.56	6.8	3.9
	c	2.33'	0.47	11.5	0.72	22.1	4.0
26		2.92'	0.245	4.8	0.62	4.4	5.75
27	a	2.00'	0.03	2.4	0.31	2.8	4.2
	b	3.00'	TR	0.2	0.10	0.0	0.0
28	a	1.92'	0.03	1.2	0.21	0.0	1.2
	b	3.08'	TR	0.4	0.05	0.0	0.7
29	a	2.00'	0.08	1.8	0.25	2.1	3.7
	b	3.58'	TR	0.6	0.10	0.0	0.0
30	a	2.00'	0.20	3.6	0.36	2.0	4.4
	b	2.75'	0.02	3.4	0.77	0.8	1.5
31		0.75'	0.10	5.0	0.41	0.5	3.0
32	a	1.83'	0.03	3.3	0.46	2.3	2.2
	b	2.00'	0.02	0.5	0.05	0.0	1.0
	c	1.00'	0.03	2.1	0.31	1.6	7.3
	d	1.58'	TR	0.3	0.10	0.0	0.0
	e	1.17'	0.02	9.5	3.35	0.4	0.0
33	a	1.50'	0.15	2.7	0.36	1.4	9.0
	b	1.75'	0.02	1.4	0.15	0.5	1.9
	c	1.25'	0.02	44.8	7.94	0.0	0.0
34	a	1.67'	0.03	6.4	0.72	6.3	3.2
	b	2.33'	TR	0.2	0.10	0.0	0.0
	c	0.92'	0.08	3.6	0.41	3.1	7.0
	d	2.25'	0.01	0.8	0.10	0.0	1.5
	e	1.08'	0.06	17.3	3.04	1.1	0.3
35		1.17'	0.06	1.9	0.25	1.9	2.8
36		1.08'	0.07	1.9	0.31	2.6	2.3
37	a	2.50'	0.01	2.7	0.21	1.2	1.2
	b	1.83'	0.06	4.6	0.36	7.5	5.5
	c	2.50'	0.005	0.7	0.10	0.5	0.2
	d	1.92'	0.09	3.7	0.77	9.2	6.1
	e	1.58'	0.10	5.4	0.72	1.4	2.2

ASSAYS – 160 FOOT LEVEL

NO		WID	OZ. AU	OZ. AG	% CU	% PB	% ZN
38	a	3.08'	0.03	5.7	0.57	9.8	3.5
	b	2.92'	0.16	4.0	0.41	3.1	4.3
	c	1.58'	0.02	1.1	0.15	0.4	0.2
39	a	1.25'	0.05	6.0	0.72	9.1	6.7
	b	2.58'	0.03	1.0	0.15	1.3	0.8
	c	2.17'	0.02	1.8	0.21	3.8	2.0
40		2.42'	0.005	0.3	0.10	0.0	0.3
41		2.58'	0.6	3.0	0.36	3.8	3.0
42		2.08'	0.8	3.3	0.31	3.4	4.8
43	a	3.33'	0.005	0.6	0.15	0.0	0.3
	b	3.00'	0.07	0.9	0.15	1.0	2.7
44	a	2.33'	0.005	1.0	0.36	0.0	0.8
	b	2.50'	0.03	1.5	0.25	1.4	3.2
45		2.92'	0.11	4.0	3.7	0.3	2.7
46		2.67'	0.17	7.1	0.41	3.8	5.3
47		3.33'	0.005	0.9	0.46	0.0	0.5
48		4.00'	TR	0.3	0.7	0.0	0.3
49		3.00'	0.05	3.1	0.31	0.0	3.4
50		2.17'	0.02	1.9	0.15	0.0	1.4
51		2.08'	0.02	3.5	0.56	0.5	1.0
52		2.75'	0.01	2.4	0.20	3.7	3.0
53		2.67'	0.01	2.0	0.20	2.9	1.9
54	a	1.67'	0.11	940	0.52	17.7	3.8
	b	2.67'	0.03	0.7	0.10	0.0	0.7
	c	3.17'	0.07	6.3	0.82	6.6	7.3
55	a	1.42'	0.02	5.9	0.46	19.0	7.4
	b	1.50'	0.20	1.5	0.10	0.4	1.0
56	a	1.50'	0.04	3.6	0.31	3.5	1.9
	b	2.50'	0.02	1.8	0.15	1.6	3.0
	c	2.75'	0.025	5.1	0.41	3.9	8.9
	d	1.42'	0.07	4.0	0.33	7.8	11.4
	e	1.83'	0.245	1.8	0.10	0.0	0.0
57	a	2.25'	0.04	4.2	0.46	4.0	3.2
	b	2.33'	0.01	1.6	0.21	1.8	4.3
	c	2.87'	0.03	1.0	0.10	0.0	0.0
58		4.17'	0.02	3.3	0.46	3.2	5.0
59		2.58'	0.15	1.8	0.20	1.1	3.3
60	a	4.42'	0.04	9.2	9.0	6.6	9.4
	b	1.42'	0.01	1.0	0.13	1.2	2.9
	c	2.92'	0.04	2.1	0.46	0.8	1.2
	d	1.17'	0.01	1.0	0.26	0.9	2.2
61	a	5.08'	0.04	11.0	1.75	6.3	18.3
	b	2.17'	0.03	1.4	0.15	1.8	1.4
	c	3.58'	0.04	3.4	0.41	3.9	8.8
62	a	1.75'	0.01	1.0	0.15	1.2	1.5
	b	2.75'	0.01	2.5	0.31	1.0	5.0
63	a	3.67'	0.08	8.4	0.72	16.6	6.2
	b	2.08'	0.07	0.9	0.10	0.6	0.4
	c	1.67'	0.06	5.8	0.67	20.2	5.0
64	a	3.58'	0.07	6.7	0.67	12.2	6.2
	b	3.67'	0.06	5.0	0.82	5.3	13.3
65		3.42'	0.03	8.0	0.67	6.3	7.0
66		4.33'	0.03	8.7	1.44	3.8	11.3
67		1.83'	0.185	1.0	0.15	0.0	1.0
68	a	2.08'	TR	0.5	0.10	0.3	0.3
	b	2.92'	0.06	5.1	0.67	6.3	12.0
69		2.17'	0.01	3.9	0.72	4.4	4.3
70	a	1.92'	0.01	1.8	0.36	0.0	0.8
	b	1.08'	0.03	2.2	0.33	3.2	5.6
71		1.75'	0.02	2.7	0.36	3.6	7.0

CHECK SAMPLES BY U.S. BUREAU OF MINES

2274	28 a	0.020	1.36	0.18	0.7	1.0
2275	28 b	0.10	0.30	0.03	0.3	0.8
2276	30 a	0.11	2.90	0.21	1.1	2.5
2277	30 b	0.025	1.25	0.07	0.3	3.7

Figure 9. - Elevation of Summit mine and sample plat of 160 ft. level.

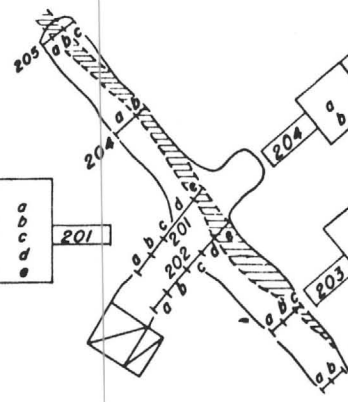
		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
205	a	1.25'	.03	1.1	.12	0.3	2.0
	b	1.5'	.19	2.7	.33	6.2	6.2
	c	1.25'	.005	0.7	.07	0.4	0.0

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
204	a	3.17'	.05	2.35	.25	0.6	3.1
	b	1.33'	.045	2.65	.39	1.2	12.8

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
203	a	1.58'	.12	3.3	.49	2.1	5.1
	b	1.75'	.06	0.75	.12	1.0	3.0
	c	0.58'	.02	4.3	.25	13.6	3.5
206	a	1.33'	.09	1.2	.25	0.3	2.1
	b	1.83'	.01	1.1	.20	0.5	0.0

	WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN	
	1.83'	.04	2.5	.36	0.5	1.0	a
	2.0'	.11	1.2	.12	0.0	0.0	b
	2.17'	.005	8.2	2.60	0.0	0.0	c
	3.17'	.06	.45	.10	0.0	0.6	d
	1.58'	.08	4.9	.43	12.3	5.8	e

201



200 FOOT LEVEL

38.5 FEET BELOW 160 FOOT LEVEL

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
202	a	2.00'	.06	2.45	.38	0.7	4.6
	b	3.08'	.09	6.5	1.59	0.0	0.0
	c	2.50'	.03	6.8	1.62	0.0	0.0
	d	2.00'	.005	1.5	.36	0.0	0.0
	e	2.08'	.07	6.65	.86	9.6	4.2

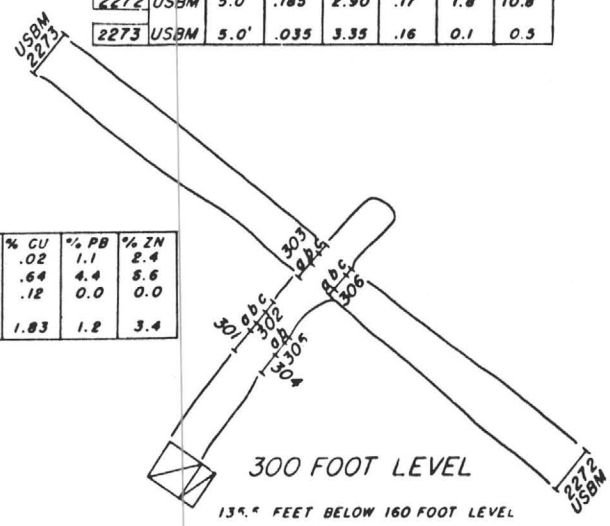
NOTE: SAMPLING, EXCEPT WHERE OTHERWISE NOTED, BY U.S.S.R. & M. CO., APRIL, 1942.

EXAMINATIONS BY U. S. BUREAU OF MINES IN AUGUST AND SEPTEMBER, 1943

WORKINGS ACCESSIBLE IN AUGUST, 1943; LOWER LEVELS FLOODED IN SEPTEMBER, 1943

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
303	a	1.67'	.02	0.7	.15	0.0	0.4
	b	1.33'	.07	1.6	.20	1.2	0.7
	c	1.17'	.15	3.05	.69	1.8	2.5
306	a	0.67'	.03	2.0	.46	0.7	1.0
	b	1.75'	.05	2.85	.41	1.2	1.5
	c	0.92'	.10	7.0	1.26	7.2	0.8
2272	USBM	5.0'	.185	2.90	.17	1.8	10.8
2273	USBM	5.0'	.035	3.35	.16	0.1	0.5

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
302	a	1.00'	.02	1.3	.02	1.1	2.4
	b	1.42'	.12	4.3	.64	4.4	5.6
	c	1.42'	.03	0.5	.12	0.0	0.0
301		2.33'	.10	7.6	1.83	1.2	3.4



300 FOOT LEVEL

135.5 FEET BELOW 160 FOOT LEVEL

		WID.	OZ. AU	OZ. AG	% CU	% PB	% ZN
305	a	1.5'	.08	2.6	.39	1.4	2.3
	b	0.67'	.09	6.0	.90	7.7	4.4
304		2.42'	.07	1.7	.30	2.1	5.5

ORE SHOOT NO. 2

USBM 2272 SAMPLE BY BUREAU OF MINES

0 10' 20' 30'
SCALE

MAP TRACED FROM SAMPLE PLAT FURNISHED BY U.S.S.R. & M. CO.

Figure 10. - Sample plats of 200 ft. and 300 ft. levels, Summit mine.

drift and has a second connection to the surface through a 365-foot adit. Drifts on the 200- and 300-foot levels are 50 and 65 feet long, respectively.

Sampling

Detailed sample plats of the 160-foot, the 200-foot, and the 300-foot levels were furnished by the U. S. Smelting, Refining & Mining Co. (figs. 9 and 10). A few check samples were cut by the Bureau of Mines' engineers.

Later Operation

The mine was leased by Ralph R. Langley of Kingman after it was released by the El Dorado Rover Mining Co. Langley assumed the unpaid balance due on the first R.F.C. loan to the former lessee. When the mine was visited by a Bureau of Mines' engineer[14] in December 1944, Langley had sunk a 50-foot winze on the 160-foot level, about 400 feet northwest of the main shaft, and drifted in both directions from the bottom of the winze. The winze is at the middle of the No. 1 ore shoot shown on figure 9. The sublevel is about 180 feet long. Ore was stoped continuously from this sublevel to the arch below the 160-foot level. This ore shoot was found undisturbed above the 160-foot level and was stoped to 20 feet from the surface. Langley reported that 3,800 tons of ore was mined from above the level. A total of 6,049 tons of ore was mined in the period from October 1943 through April 1946. This averaged 4.42 percent lead, 7.18 percent zinc, and 0.76 percent copper. The precious-metal content per ton was 0.0738 ounce gold and 5.82 ounces silver. The ore was shipped to the Keystone mill after that started operating. The truck haul is 8 miles with the grade against the load in the last 2.5 miles.

When the mine was visited on May 27, 1946, Langley had started drifting on the 300-foot level to continue the level about 500 feet northwest under the No. 1 ore shoot. The level had been advanced 65 feet northwest and also a little to the southeast.

Langley reported that they were entering good lead-zinc ore to the northwest and some copper ore to the southeast. He was beginning to stope this ore while the drift was being advanced.

Concentration Tests

Concentration tests of a bulk sample taken from stope chutes were made in the Bureau of Mines testing laboratory at Salt Lake City. Selective flotation, after grinding to minus 65-mesh, recovered 86.8 percent of the lead in a concentrate that assayed 61.1 percent lead, 7.4 percent zinc, 2.1 percent copper, 1.87 ounces per ton gold, and 34.46 ounces per ton silver; 68.7 percent of the zinc in a concentrate that assayed 3.0 percent lead, 50.0 percent zinc, 1.5 percent copper, 0.30 ounce per ton gold, and 7.2 ounces per ton silver.

14/ Chas. A. Kumke.

A third copper-iron concentrate assayed 24.0 percent copper, 0.27 ounce per ton gold, and 2.15 ounces per ton silver. The copper recovery in this concentrate was 65.4 percent.

ALPHA MINE

Location, Accessibility, and Ownership

The Alpha mine is situated about 1 mile from the Summit mine on the western slope and near the crest of the Cerbat Mountains in sec. 32, T. 23 N., R. 17 W. It is about 7 miles southeast of Chloride and 4 miles east of the old Kingman-Chloride highway. It is 4.5 miles by road from the highway to the Alpha mine. The road to the two mines was improved under the access road program prior to July 1, 1945.

The Alpha group of four claims is owned by Caroline Daniels Moore of Kingman. The mine has been leased to Ralph R. Langley, Box 455, Kingman, Ariz.

History

The mine was located in the late 1860's or early 1870's. It is reported that $200,000 worth of ore was taken from the mine and shipped. Part of this was from the oxidized zone and part from the sulfide zone. No records are available as to the grade or tonnage of the ore mined. The lower tunnel was partly cleaned out and retimbered with the aid of an R.F.C. loan. The greater part of the mine was accessible when the loan was exhausted and the work was suspended.

Description of the Deposit

The ore occurs as lenses in a fissure vein in granite. This vein strikes N. 60° W. and dips 50° to 65° northeast. It is continuous and has a considerable amount of gouge for the greater part of its length. There is very little metallization except in the sulfide lenses. The principal minerals are quartz, galena, sphalerite, chalcopyrite, and pyrite. From the work done so far, it appears that the lenses have no connection with each other and that they do not occur in any regular pattern.

Development and Mining

An adit was driven from the hillside a distance of 1,200 feet southeast on the Alpha vein (fig. 11). At a point 600 feet from the portal, a raise was driven 240 feet on the vein to connect with the upper adit or 200-foot level. This upper tunnel was driven from the surface a distance of 400 feet on the vein. From the lower level a stope over 300 feet long was carried to a height of 80 feet, according to mine maps. This stope has caved, and the back is inaccessible. A winze was sunk below the tunnel level, and it is reported that high-grade ore was taken from the winze and an adjoining stope. The winze is now flooded. A small stope has been mined from a sublevel off the raise to within a few feet of the upper tunnel. From the upper tunnel a

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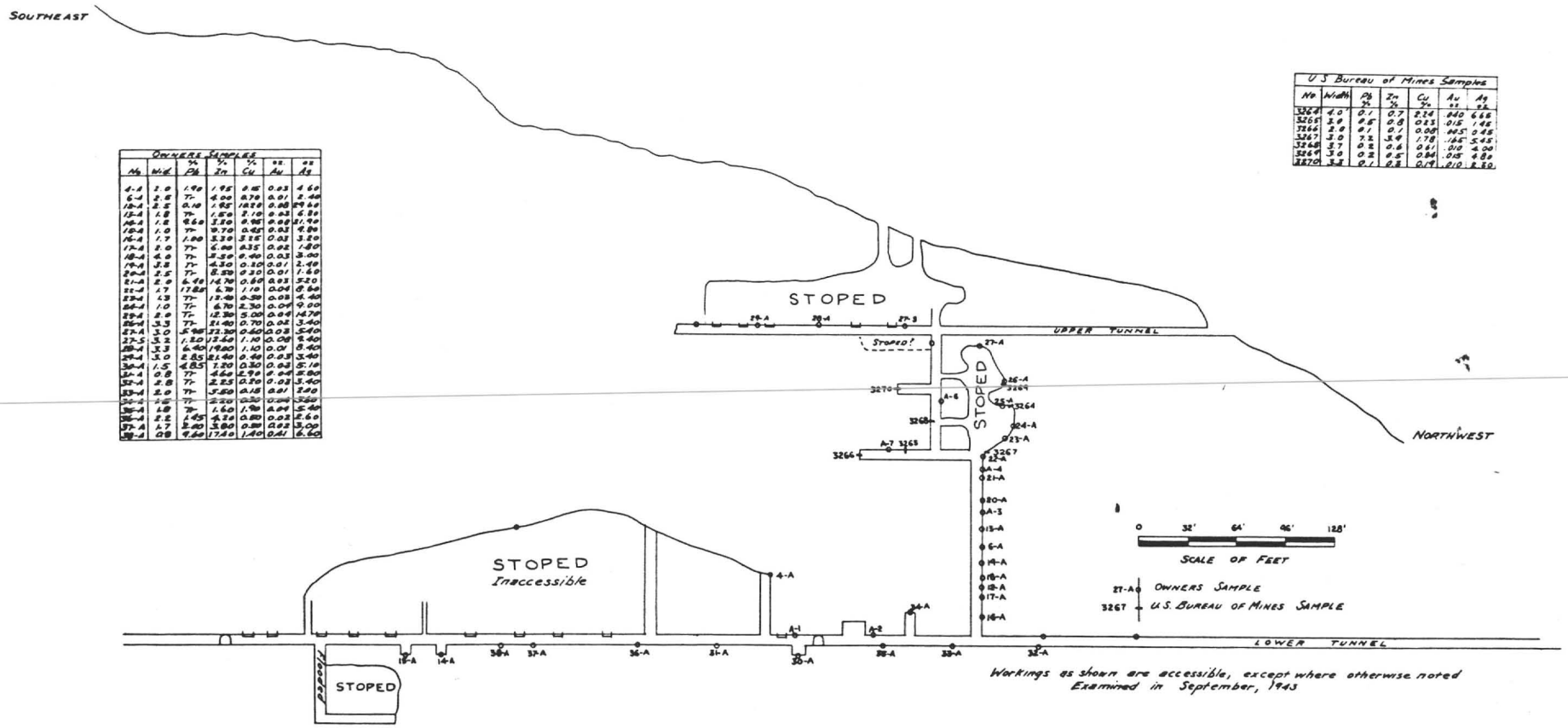


Owners Samples						
No	Width	% Pb	% Zn	% Cu	oz Au	oz Ag
4-A	2.0	1.90	1.95	0.05	0.03	4.60
6-A	2.5	Tr.	4.00	0.70	0.01	2.40
10-A	2.5	0.10	1.85	1.20	0.08	29.40
13-A	1.8	Tr.	1.50	3.10	0.03	6.80
14-A	1.8	9.60	3.80	0.95	0.08	21.00
15-A	1.0	Tr.	9.70	0.65	0.03	4.80
16-A	1.7	1.00	3.30	3.15	0.03	3.20
17-A	2.0	Tr.	6.00	0.35	0.02	1.80
18-A	4.0	Tr.	2.50	0.40	0.03	3.00
19-A	3.8	Tr.	4.30	0.30	0.01	2.40
20-A	2.5	Tr.	2.50	0.30	0.01	1.60
21-A	2.0	6.40	14.70	0.60	0.03	5.20
22-A	1.7	17.80	6.70	1.10	0.04	8.60
23-A	1.3	Tr.	12.40	0.50	0.03	4.40
24-A	1.0	Tr.	6.70	2.30	0.04	9.00
25-A	2.0	Tr.	12.30	5.00	0.04	14.70
26-A	3.3	Tr.	21.40	0.70	0.02	3.40
27-A	3.0	5.80	32.30	0.60	0.03	5.40
27-S	3.2	1.20	12.60	1.10	0.04	9.40
28-A	3.3	6.40	19.80	1.10	0.01	8.40
29-A	3.0	2.85	21.40	0.40	0.03	3.40
30-A	1.5	4.85	7.20	0.30	0.03	5.10
31-A	0.8	Tr.	4.60	2.70	0.04	5.80
32-A	2.8	Tr.	2.25	0.50	0.03	3.40
33-A	2.0	Tr.	5.80	0.15	0.01	2.00
34-A	1.5	Tr.	2.20	0.30	0.04	3.60
35-A	1.8	Tr.	1.60	1.70	0.04	5.40
36-A	2.2	1.45	4.20	0.80	0.03	2.60
37-A	1.7	2.20	3.80	0.80	0.03	3.00
38-A	0.8	4.60	17.40	1.40	0.01	6.60

U S Bureau of Mines Samples						
No	Width	% Pb	% Zn	% Cu	oz Au	oz Ag
3264	4.0	0.1	0.7	2.24	.040	6.66
3265	2.0	0.5	0.8	0.23	.015	1.45
3266	2.0	0.1	0.1	0.08	.005	0.45
3267	2.0	7.2	3.9	1.78	.165	5.45
3268	3.7	0.2	0.6	0.61	.010	4.00
3269	3.0	0.2	0.5	0.84	.015	4.80
3270	3.2	0.1	0.8	0.19	.010	2.50

Figure 11. - Section in plane of vein - Alpha mine, Mohave County, Ariz.
Traced from map by Ralph Langley.

stope 150 feet long was mined to a height of 30 to 60 feet. This stope breaks through to the surface. Some ore was stoped from below the upper tunnel, and the stope was filled with waste. No work is being done at the present time, and most of the machinery has been removed from the property.

Sampling

A copy of Langley's assay map of the Alpha mine was furnished to the Bureau of Mines and is included in this report. Most of these samples were taken at irregular intervals, and some of them were taken so as to include small bunches of high-grade ore. Seven samples were cut by the Bureau engineer to check the other sampling. The samples from the north side of the small stope off the main raise are mill-ore grade. The Bureau samples were cut across the entire exposed width of the vein. The two sets of samples are shown on the assay plat (fig. 11).

Detailed data on the sampling follow:

Bureau of Mines Samples

No.	Location	Description	Length, feet	Assays				
				Percent			Ounces	
				Pb	Zn	Cu	Au	Ag
3264	N. side of stope below 200-ft. level, N. side	Heavy sulfides on foot and hanging wall	4.0	0.1	0.7	2.24	0.040	6.65
3265	Sublevel, 17 ft. south of raise.	Oxidized, little sulfide	3.0	.5	.8	.23	.015	1.45
3266	Sublevel breast.	Oxidized, altered granite	2.0	.1	.1	.08	.005	.45
3267	Sublevel, N. end at top of ladder.	1 foot with heavy sulfide	3.0	7.2	3.9	1.78	.165	5.45
3268	Raise, 25 ft. above sub-level, S. side	Oxidized, some sulfides on footwall	3.7	.2	.6	.61	.010	4.00
3269	Stope below 200-foot level, N. side above platform.	Little sulfide	3.0	.2	.5	.84	.015	4.80
3270	Sublevel, 38 feet below 200-foot level.	Little sulfide, partly oxidized	3.3	.1	.3	.19	.010	2.30

Later Operation

One shipment of 64.8 tons of ore was made to the Keystone mill in 1945. This averaged 3.94 percent lead, 5.05 percent zinc, and 0.50 percent copper, with 0.07 ounce gold and 7.30 ounces silver per ton. Mr. Zlatnik, of the Keystone mill, reported that the ore responded exceptionally well to selective flotation. No work has been done at this mine in 1946.

GOLCONDA MINE

The Golconda mine was one of the two deep mines of the district. The shaft was sunk to a depth of 1,600 feet, and extensive stoping was done above the 1,400-foot level. Production ceased when the mill burned in 1917. Total production to that time is reported at $6,500,000 in lead, zinc, gold, and silver.15/ The mine has been idle since 1917, although good ore was reported on the 1,400-foot level. The workings are badly caved, and the mine stands full of water to the adit on the 600-foot level.

DE LA FOUNTAIN MINE

The De La Fountain claim is situated near the summit of the Cerbat Range, about 15 miles by road north of Kingman. It is owned by Messrs. Farley, Thomas, and Stevens of Flagstaff, Ariz., and is leased to L. M. Dickens of Kingman. The mine was operated recently and yielded two carloads of sorted ore in the last few months. The reported metal content of these shipments was 14 percent lead, 28 percent zinc, 0.02 ounce gold per ton, and 2.0 ounces silver per ton.

It is reported that four levels were opened in the course of the early mining. Only one is accessible. There are three stopes on this level, testifying to more substantial production during the earlier operation. The remaining ore on this level is in small pillars and along some of the stopes margins. The two carloads of sorted ore shipped by the present operator were gleaned from these stopes. Four samples, taken from such remnants of ore in the stopes averaged 3.6 percent lead and 14.2 percent zinc, with negligible gold and silver over widths of 1 to 4 feet.

JIM KANE MINE

Location, Accessibility, and Ownership

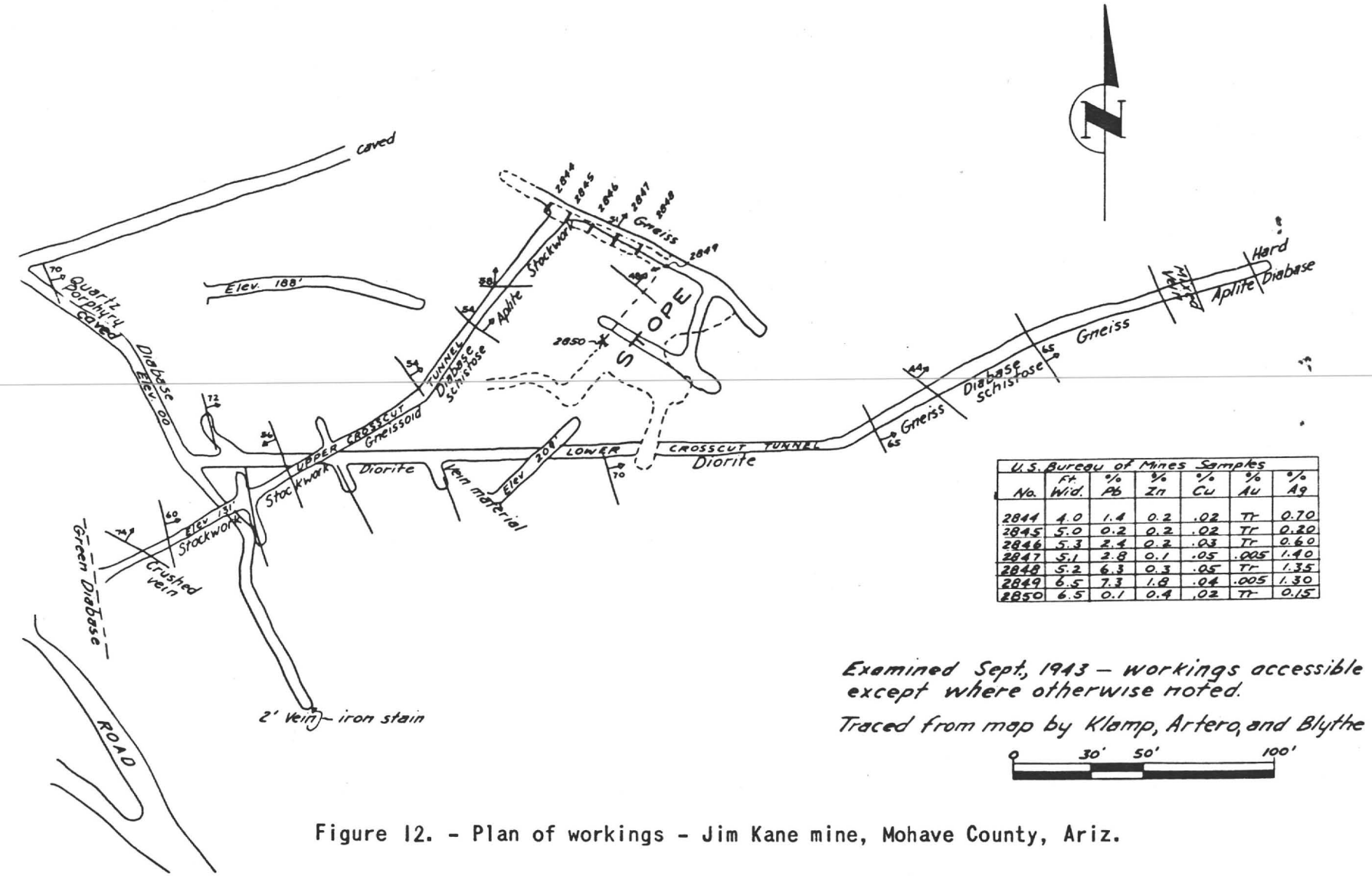
The Jim Kane mine is in Cerbat Canyon near the summit of the Cerbat range, 5.1 miles east of paved highway U. S. 93. The road to the property is in fair condition, but the grades are steep and the curves are sharp in the last 2 miles.

The group of 11 claims is owned by Jim Kane, of Kingman, who lives on the property.

History

A small shaft was sunk to a depth of 30 feet during the early mining in this district. Jim Kane relocated the claims in 1915 and has held them to the present time. The California Chemical Spray Co. leased the property in 1939 and drove some drifts from the lower tunnel. After 6 months work they gave up the lease. No work is being done at present. It is reported that a

15/ Arizona Bureau of Mines, Arizona Metal Production: Bull. 140.



U.S. Bureau of Mines Samples						
No.	Ft. Wid.	% Pb	% Zn	% Cu	% Au	% Ag
2844	4.0	1.4	0.2	.02	Tr	0.70
2845	5.0	0.2	0.2	.02	Tr	0.20
2846	5.3	2.4	0.2	.03	Tr	0.60
2847	5.1	2.8	0.1	.05	.005	1.40
2848	5.2	6.3	0.3	.05	Tr	1.35
2849	6.5	7.3	1.8	.04	.005	1.30
2850	6.5	0.1	0.4	.02	Tr	0.15

Examined Sept., 1943 – workings accessible except where otherwise noted.

Traced from map by Klamp, Artero, and Blythe

0 30' 50' 100'

Figure 12. - Plan of workings - Jim Kane mine, Mohave County, Ariz.

few cars of ore were milled at a local mill, and some ore was shipped direct to the smelter, but no figures were available as to the amount or grade of this production. Kane stated that a carload of ore had been shipped from the claim south of his house, which assayed 47 percent lead and 42 ounces per ton silver. This ore was packed out by burros. He also reported that during the first World War several hundred pounds of steel galena was sold for radio crystals at $0.25 to $1 per pound.

Description of the Deposit

The ore occurs in brecciated and altered gouge material in a fault zone striking N. 60° W. and dips 60° northeast. This zone varies in width from 1 foot to 20 feet. The country rocks are amphibolite and gneiss intruded by dikes and irregular masses of younger granite porphyry. In the one accessible stope the galena occurs in small bunches and in small streaks in altered granite. Several tons of high-grade galena ore have been sorted and stored in the stope. The ore is very spotty, and hand sorting would be necessary to obtain a milling grade of ore. There are several minor fault zones of similar character that have been partly exposed in the workings (fig. 12). Small showings of lead and zinc minerals occur in these, but in general the small bunches of ore are more scattered than in the major fault zone described above. A little beryl has been found in two small outcrops of pegmatite on the claim at the south end of the group. Mr. Kane stated that he had picked up 20 or 25 pounds of crystals. Two small pieces were found on the outcrops by the Bureau engineers. The pegmatite does not seem to be a continuous dike, but rather two separate bunches. Both of the detached outcrops are small.

Development

The underground workings are shown on figure 12, traced from an undated map by Klamp, Artero, and Blythe of the Producers Mining Co.

Sampling

The prospect was thoroughly sampled by the Producers Mining Co. A copy of their assays, supplied by Mr. Kane, is attached.

Table 4. - Producers Mining Co. samples from Jim Kane mine

No.	Description	Width, feet	Ounces Au	Ounces Ag	Percent Pb	Percent Zn
2801	Dump at incline shaft.....	-	0.01	1.70	3.07	5.80
2802	Dump at 30 foot crosscut tunnel.....	-	.02	1.40	5.40	6.60
2803	Dump at 70 foot crosscut tunnel.....	-	.01	1.00	4.60	2.70
2804	Mill dump at middle tunnel.....	-	.01	0.60	3.20	1.10
2805	Grab of high-grade from dump.....	-	.04	7.50	59.30	3.60
2806	Face of north drift from stope.....	3.0	.02	2.70	1.56	1.20
2807	Cut north drift from stope, middle tunnel	4.0	.005	Trace	Trace	.60
2808	do.....	4.0	.01	.90	0.25	1.15
2809	do.....	5.0	.01	.90	3.54	.80
2810	do.....	5.0	.01	3.90	2.25	1.30
2811	do.....	8.0	.03	1.30	6.00	1.40
2812	Cut sample stope, north end hanging wall.	5.0	.04	29.40	3.65	1.30
2813	Cut sample stope.....	6.0	.01	.70	2.10	.80
2814	Cut sample stope, footwall.....	3.0	.01	1.30	5.80	3.80
2815	do.....	4.5	.005	.50	1.30	1.00
2816	do.....	3.0	.01	2.40	10.30	1.80
2817	do.....	4.0	.02	1.00	3.55	2.60
2818	do.....	4.5	.01	1.50	8.10	3.10
2819	do.....	5.5	.01	1.30	7.65	.70
2820	do.....		.005	.40	0.55	.50
2821	do.....	4.5	.02	.30	Trace	1.00
2822	Cut sample stope, hanging wall.....	4.0	.08	6.10	5.50	4.25
2823	Cut corner south drift from stope.....	3.5	.02	2.30	11.35	2.90
2824	Cut at corner E. side S. drift 4 ft. S. of manway.....	5.5	.03	3.80	7.80	1.90
2825	Cut in raise in hanging wall.....	2.0	.01	.20	3.00	.90
2826	Below 2825.....	2.0	.01	.50	2.50	1.20
2827	Below 2826.....	3.0	.04	4.30	13.60	3.80
2828	Cut 10 feet south of 2824.....	5.0	.02	1.10	1.80	2.50
2829	Cut 10 feet south of 2828.....	3.0	.02	2.30	0.25	.40
2830	Cut at face south drift.....	2.0	.02	2.00	5.75	1.00
2831	Grab from muck pile at face.....		.01	.90	Trace	.50
2832	Grab from pile in stope.....		.04	8.80	17.90	3.90
2833	No. 1 underhand middle tunnel 30 ft. from portal.....	3.5	.01	.80	5.50	1.80
2834	No. 1 underhand middle tunnel 30 ft. from portal.....	4.0	.01	.40	3.60	1.30
2835	No. 2 underhand, 60 feet from portal.....	1.3	.02	1.70	1.65	1.90
2836	do.....	3.0	.02	1.60	4.60	1.00
2837	Cut in bottom No. 1 drift south middle tunnel.....	5.0	.01	.20	1.40	2.50
2838	Cut at No. 1 chute, middle tunnel.....	9.5	.01	2.00	Trace	.70
2839	Cut face of 30 foot crosscut tunnel.....	2.3	.02	3.90	15.65	7.80
2840	Cut incline shaft on pillar.....	3.0	.01	1.00	4.80	11.20
2841	Cut from north incline shaft.....	2.5	.01	2.00	14.60	6.70
2842	Chip from outcrop south of middle tunnel.	2.5	.01	Trace	Trace	1.70

Table 4. - Producers Mining Co. samples from Jim Kane mine (continued)

No.	Description	Width, feet	Ounces Au	Ounces Ag	Percent Pb	Percent Zn
2843	Cut from incline raise.....	4.3	0.02	2.60	4.75	4.00
2844	do.....	3.0	.01	.80	4.30	5.40
2845	Cut from incline raise, north side.....	4.5	.01	1.10	11.70	5.30
2846	Cut from incline raise F. W.	2.0	.02	2.50	10.10	8.60
2847	Cut from tunnel 5.....	7.0	.01	.20	Trace	2.50
2848	do.....	5.0	.01	.30	do.	1.40
2849	Grab from dump tunnel 5.....		.01	.20	do.	1.10
2850	Cut incline raise above 2846.....	4.0	.01	.30	2.30	1.20
2851	Cut incline raise above 2850.....	2.0	.005	.10	.50	2.30
2852	Cut hanging wall 5 feet south 2851.....	2.0	.01	2.40	16.60	5.10
2853	Cut incline raise 10 feet 2843.....	3.2	.01	1.00	4.20	4.40
2854	Cut middle tunnel St. 15, north corner...	4.0	.01	.70	3.80	Trace
2855	Cut middle tunnel St. 15, south corner...	3.5	.01	.70	2.10	0.70
2856	Cut south drift 12 feet south of st. 15..	3.0	.01	.90	5.80	Trace
2857	Cut south drift 35 feet south of st. 15..	4.5	.02	3.30	Trace	do.
2858	Cut south drift 40 feet south of st. 15..	4.2	.02	4.50	2.00	0.60
2859	Cut middle tunnel st. 16, corner crosscut	2.5	.02	3.80	4.80	3.80
2860	Chip from boulders tunnel #5.....		.005	Trace	Trace	Trace
2861	Cut, face of open cut below tunnel #5....	2.3	.02	20.30	3.60	3.70
2862	Cut, outcrop below Kanes house.....	2.5	.005	.10	Trace	2.90
2863	Car sample from #1 chute.....	-	.01	1.60	10.70	.50
2864	Car sample from #2 chute.....	-	.01	3.10	17.10	4.20
2865	Cut, upper north tunnel.....	3.0	.01	1.80	7.20	2.40
2866	do.....	3.0	.01	1.60	9.60	5.50
2867	do.....	4.3	.01	3.60	6.80	4.20
2868	do.....	3.5	.01	1.50	4.00	7.20
2869	Cut, pit 300 feet north upper tunnel.....	3.0	.005	Trace	Trace	1.40
2870	Grab dump on Silver Queen claim.....	-	.01	3.90	0.10	1.00

These assays were copied from a sheet furnished by Jim Kane, who stated that they were copies of the samples taken and assayed by the Producers Mining Co.

Seven check samples were cut in the main stope. These agreed fairly closely with the Producers Mining Co. samples.

No.	Location	Description	Length feet	Assays Percent Pb	Zn	Cu	Ounces Au	Ag
2844	Stope drift, north breast	Altered granite and schist, some sulfide	4.0	1.4	0.2	0.02	Trace	0.70
2845	Stope drift, 10 ft. from N. breast	do.	5.0	.2	.2	.02	do.	.20
2846	Stope drift, 20 ft. from N. breast	do.	5.3	2.4	.2	.02	do.	.60
2847	Stope drift, 30 ft. from N. breast	do.	5.1	2.8	.1	.05	0.005	1.40
2848	Stope drift, 40 ft. from N. breast	do.	5.2	6.3	.3	.05	Trace	1.35
2849	Stope drift, 50 ft. from N. breast	do.	6.5	7.3	1.8	.04	0.005	1.30
2850	Stope, northwest side	do.	6.5	.1	.4	.02	Trace	.15

CHICAGO GROUP

The Chicago group of four claims is situated on the north side of Cerbat Canyon, about 12 miles by road south of Chloride. The group is owned by J. A. Bell of Summerton, Ariz., and B. Ableman of Chloride.

There are a number of short tunnels, shallow shafts, and pits, all on oxidized outcrops of veins. One sample of oxidized vein material was cut at the bottom of a 30-foot shaft. The sample, taken over 2.5 feet, assayed 0.4 percent lead, 0.2 percent zinc, 0.06 percent copper, 1.9 ounces per ton silver, and a trace of gold.

CERBAT MINE

Location, Accessibility, and Ownership

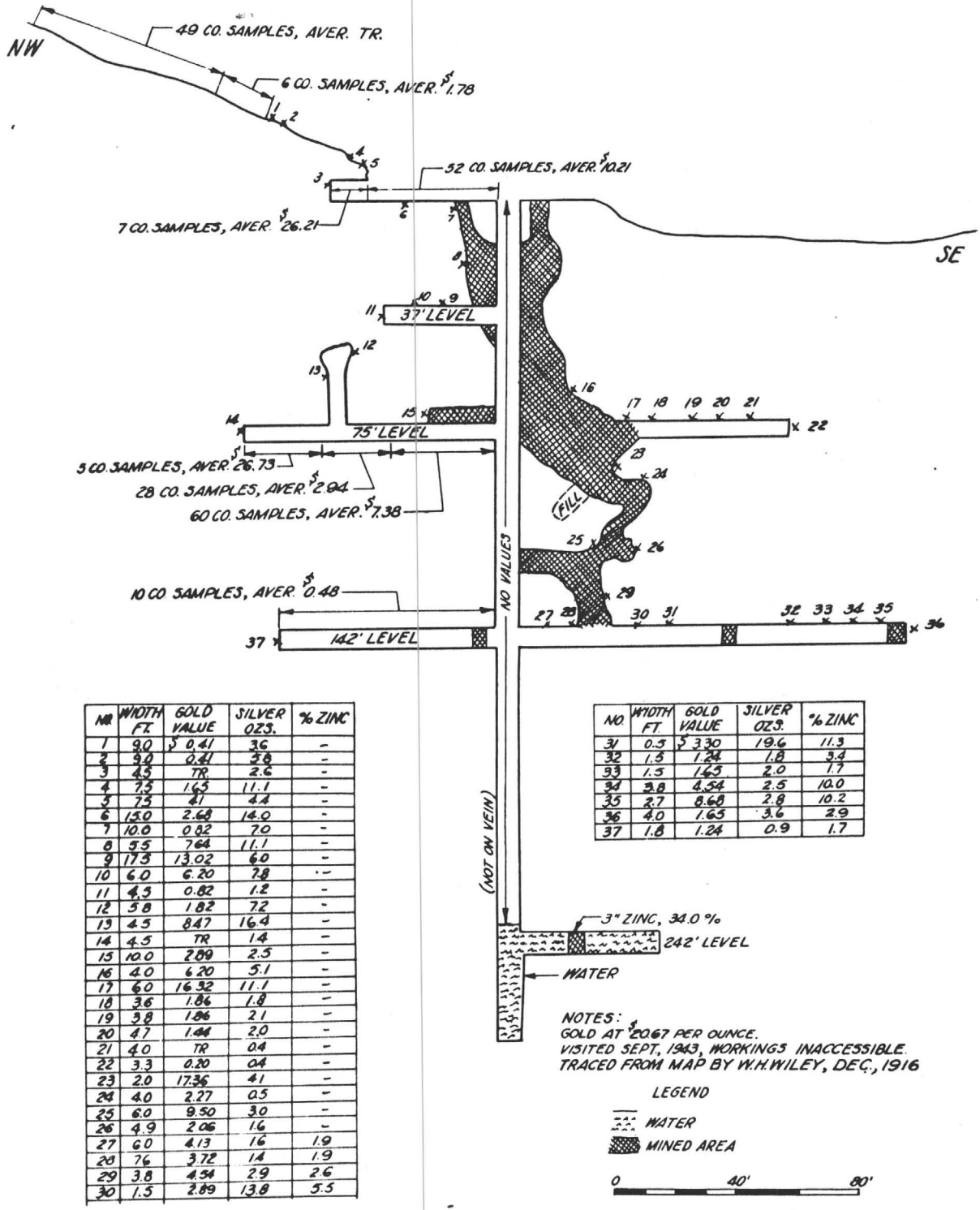
This property is on a western spur of the Cerbat Range north of Kingman and south of Chloride. The mine is reached by turning to the east off paved U. S. Highway 93, 7.7 miles south of Chloride and following a dirt road 3.7 miles, and then turning left on a branch road that leads to the Cerbat mine about 1 mile north. The last mile of the road is impassable.

There are five claims in the group, owned jointly by F. A. Morrison, of Kingman, who is in charge of the property, and the Pelton brothers. Three of the claims are patented and two are unpatented.

History

The property was worked intermittently during the period 1869 to 1906 for gold and silver. It was credited with a production of $200,000 in gold and $50,000 in silver.16/ The mine was acquired by the present owners in

16/ Arizona Bureau of Mines, Arizona Metal Production: Bull. 140. ser. 19.



NO.	WIDTH FT.	GOLD VALUE	SILVER OZS.	% ZINC
1	9.0	$ 0.41	3.6	-
2	9.0	0.41	3.8	-
3	4.5	TR.	2.6	-
4	7.5	1.65	11.1	-
5	7.5	4.1	4.4	-
6	15.0	2.68	14.0	-
7	10.0	0.82	7.0	-
8	5.5	7.64	11.1	-
9	17.5	13.02	6.0	-
10	6.0	6.20	7.8	-
11	4.5	0.82	1.2	-
12	5.8	1.82	7.2	-
13	4.5	8.47	16.4	-
14	4.5	TR	1.4	-
15	10.0	2.89	2.5	-
16	4.0	6.20	5.1	-
17	6.0	16.32	11.1	-
18	3.6	1.86	1.8	-
19	3.8	1.86	2.1	-
20	4.7	1.44	2.0	-
21	4.0	TR	0.4	-
22	3.3	0.20	0.4	-
23	2.0	17.36	4.1	-
24	4.0	2.27	0.5	-
25	6.0	9.50	3.0	-
26	4.9	2.06	1.6	-
27	6.0	4.13	1.6	1.9
28	7.6	3.72	1.4	1.9
29	3.8	4.54	2.9	2.6
30	1.5	2.89	13.8	5.5

NO.	WIDTH FT.	GOLD VALUE	SILVER OZS.	% ZINC
31	0.5	$ 3.30	19.6	11.3
32	1.5	1.24	1.8	3.4
33	1.5	1.65	2.0	1.7
34	3.8	4.54	2.5	10.0
35	2.7	8.68	2.8	10.2
36	4.0	1.65	3.6	2.9
37	1.8	1.24	0.9	1.7

Figure 13. - Longitudinal elevation - Cerbat mine.

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(Arizona -- State B... Mines)

ARIZONA ZINC AND LEAD DEPOSITS

PART I

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VIDANO CLAIMS

Two and one-half miles north of Bagdad and west of the Hillside mine road (Fig. 38), several quartz veins, 3 inches to 1 foot wide, occur in the granite. They have a general north strike and steep dip east and west. Eight unpatented claims, Vidano 1 to 8, are held by annual assessment work by Bert Vidano. Several trenches, shafts, and short adits have been excavated along the veins. Most of the vein outcrops are barren except for a little limonite and malachite stain. Locally sulfides occur in the quartz and a shipment in 1936 of hand-sorted galena is reported to have contained gold, silver, and copper, in addition to the lead.

CHAPTER XI.—WALLAPAI MINING DISTRICT, MOHAVE COUNTY, ARIZONA[1]

By McClelland G. Dings[2]

INTRODUCTION

The Wallapi mining district, northwestern Arizona, is in Mohave County about 15 miles north of Kingman. The district is about 10 miles long and 4 miles wide, trending northwest obliquely across the Cerbat Mountains. It includes the principal mining camps of Chloride, Mineral Park, Cerbat, and Stockton, all of which are nearly deserted, except Chloride.

The topography is moderately rugged with maximum relief of about 3,500 feet; the highest point is Cherums Peak, altitude 6,973 feet. The Cerbat Mountains rise sharply from the detritus-filled valleys bordering the mountains on the east and west.

HISTORY AND PRODUCTION

Between 1863 and 1900 many of the deposits were discovered by prospectors in quest of silver and gold which occur in the oxidized parts of the fissure veins; the silver is commonly in very rich concentrations. Cerargyrite, argentite, native gold, and galena were the principal ore minerals recovered in the early days. Improvement in transportation facilities and in milling methods led to subsequent production of base-metal ores. At first galena with a low silver content was mined, but later sphalerite also became an important ore mineral of the district. Zinc-lead production reached its peak during the years 1915 to 1917 when metal prices were high and there was large-scale production from the Tennessee and Golconda mines. In October, 1917, a fire destroyed the Golconda mill and other surface equipment, and since then the

[1]Published by permission of the Director, U.S. Geological Survey. Manuscript received March 31, 1949. A detailed report is in preparation pertaining to the field work done in the district from February to June, 1943.
[2]Geologist, U.S. Geological Survey.

mine has produced only on an intermittent and small scale. The Tennessee mine, however, has produced for many years except for occasional short periods during which operations were not in progress.

There are about 225 mines, plus an estimated 1,000 shallow pits, shafts, and prospects in the district. Most of the mines are old and largely or entirely inaccessible. Only a few reached depths below the oxidized zone which commonly ranges from 50 to 200 feet.

The total value of gold, silver, copper, lead, and zinc produced in the district from 1901 to 1946 was $23,984,960.[3] Several million dollars may be added to this total for the value of ore produced prior to 1901 when no accurate records were kept. The largest past producers have been the Tennessee and Golconda mines, whose combined output has accounted for about 87 per cent of the total value of the lead and zinc produced.

GEOLOGY

The rocks of the district consist of pre-Cambrian crystalline rocks, chiefly of granitic composition, cut by large masses of Mesozoic (?) granite (Fig. 45). Dikes are scattered throughout the area. Some are parallel to the prominent northwest-trending system of veins, but others trend in various directions. Remnants of volcanic rocks of probable Tertiary and Quaternary age are around the margins of the Cerbat Mountains but are not present in the area shown on Figure 45.

The pre-Cambrian rocks consist of a complex of amphibolite, hornblende schist, biotite schist, chlorite schist, diorite gneiss, granite and associated pegmatitic bodies, granite gneiss, schistose granite, granitic schist, and garnetiferous schist. Granite and amphibolite are the most widespread types, and the granite is predominant.

The amphibolite, which is one of the oldest rocks in the area, is a dark green to black, fine to medium-grained rock commonly epidotized and cut by granite pegmatite intrusions. It is widely distributed throughout the area but is particularly conspicuous near Chloride and in the low hills between Cerbat Canyon and Mineral Park Wash.

The pre-Cambrian granites are represented by many types. Some of the bodies are distinct and separate intrusions but others are probably differentiation facies. Typically the rock is light-gray, medium-grained, gneissoid granite containing a small amount of mafic minerals, chiefly biotite. Weathered surfaces are usually light buff, less commonly reddish brown.

Near Mineral Park in the central part of the district a large granite stock has intruded the pre-Cambrian granites, gneisses, and schists. Its age is tentatively assigned to late Jurassic or early

[3]Production data furnished by C. E. Needham, U.S. Bur. of Mines, Salt Lake City, Utah.

Cretaceous, the same as the batholiths of California and western Nevada. The granite is essentially medium-grained, slightly porphyritic, and intensely altered, although there are many facies of fine or coarse grained granite, granite porphyry, porphyritic granite, and granite pegmatite. Numerous small stocks and irregular bodies of greenish-black gabbro and associated diabase dikes occur most commonly in the southern part of the district. These are probably differentiation facies of the granite stock. Mineralizing solutions that formed the veins in the district are believed to be genetically related to the late Mesozoic (?) granitic intrusion.

Dikes of many different compositions are widespread. In thickness they range from a few inches to 300 feet. Some extend along strike for only a hundred feet or less whereas others, notably the rhyolites, extend for long distances (Fig. 45). The most abundant dike rocks are granite pegmatites of both pre-Cambrian and late Mesozoic (?) age, and dikes formed from them are usually narrow and of short lateral extent. Aplites are not common. Other dike rocks, some of which are abundant locally, include lamprophyre, andesite, diabase, porphyritic granite, granite porphyry, and rhyolite, and are probably differentiation products of the late Mesozoic (?) intrusion.

The structure of the rocks is complex. Gneissic and schistose structures are common; the prevailing schistosity strikes northeast with steep dips either northwest or southeast. Large and small folds, generally with northeast trends, are common. The most prominent fold is near Chloride where the outcrop pattern of the amphibolite indicates a northeast-plunging anticline. Prominent joint systems, sheeting, and small shear zones, commonly with northwest strikes, are abundant. Faulting is widespread and is usually well expressed by a prominent system of northwest-trending fault fissures in which many of the later veins are located. The dips of the fissures are generally steep, and northeast dips predominate. In places the fault fissures are in conjugate systems. The fissures show much branching and in a few places considerable horsetailing. Gouge and breccia, as well as numerous tear faults in the walls, are present along some fault fissures. The direction of the striations along the walls of the faults is nearly horizontal in places, but a greater number of striations show dips ranging from horizontal to parallel with the dip of the steep fault surface.

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University of Arizona Bulletin

ARIZONA BUREAU OF MINES

(Arizona -- State B... Mines)

ARIZONA ZINC AND LEAD DEPOSITS

PART I

ARIZONA BUREAU OF MINES, GEOLOGICAL SERIES No. 18,
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VIDANO CLAIMS

Two and one-half miles north of Bagdad and west of the Hillside mine road (Fig. 38), several quartz veins, 3 inches to 1 foot wide, occur in the granite. They have a general north strike and steep dip east and west. Eight unpatented claims, Vidano 1 to 8, are held by annual assessment work by Bert Vidano. Several trenches, shafts, and short adits have been excavated along the veins. Most of the vein outcrops are barren except for a little limonite and malachite stain. Locally sulfides occur in the quartz and a shipment in 1936 of hand-sorted galena is reported to have contained gold, silver, and copper, in addition to the lead.

CHAPTER XI.—WALLAPAI MINING DISTRICT, MOHAVE COUNTY, ARIZONA[1]

By McClelland G. Dings[2]

INTRODUCTION

The Wallapi mining district, northwestern Arizona, is in Mohave County about 15 miles north of Kingman. The district is about 10 miles long and 4 miles wide, trending northwest obliquely across the Cerbat Mountains. It includes the principal mining camps of Chloride, Mineral Park, Cerbat, and Stockton, all of which are nearly deserted, except Chloride.

The topography is moderately rugged with maximum relief of about 3,500 feet; the highest point is Cherums Peak, altitude 6,973 feet. The Cerbat Mountains rise sharply from the detritus-filled valleys bordering the mountains on the east and west.

HISTORY AND PRODUCTION

Between 1863 and 1900 many of the deposits were discovered by prospectors in quest of silver and gold which occur in the oxidized parts of the fissure veins; the silver is commonly in very rich concentrations. Cerargyrite, argentite, native gold, and galena were the principal ore minerals recovered in the early days. Improvement in transportation facilities and in milling methods led to subsequent production of base-metal ores. At first galena with a low silver content was mined, but later sphalerite also became an important ore mineral of the district. Zinc-lead production reached its peak during the years 1915 to 1917 when metal prices were high and there was large-scale production from the Tennessee and Golconda mines. In October, 1917, a fire destroyed the Golconda mill and other surface equipment, and since then the

[1]Published by permission of the Director, U.S. Geological Survey. Manuscript received March 31, 1949. A detailed report is in preparation pertaining to the field work done in the district from February to June, 1943.
[2]Geologist, U.S. Geological Survey.

mine has produced only on an intermittent and small scale. The Tennessee mine, however, has produced for many years except for occasional short periods during which operations were not in progress.

There are about 225 mines, plus an estimated 1,000 shallow pits, shafts, and prospects in the district. Most of the mines are old and largely or entirely inaccessible. Only a few reached depths below the oxidized zone which commonly ranges from 50 to 200 feet.

The total value of gold, silver, copper, lead, and zinc produced in the district from 1901 to 1946 was $23,984,960.[3] Several million dollars may be added to this total for the value of ore produced prior to 1901 when no accurate records were kept. The largest past producers have been the Tennessee and Golconda mines, whose combined output has accounted for about 87 per cent of the total value of the lead and zinc produced.

GEOLOGY

The rocks of the district consist of pre-Cambrian crystalline rocks, chiefly of granitic composition, cut by large masses of Mesozoic (?) granite (Fig. 45). Dikes are scattered throughout the area. Some are parallel to the prominent northwest-trending system of veins, but others trend in various directions. Remnants of volcanic rocks of probable Tertiary and Quaternary age are around the margins of the Cerbat Mountains but are not present in the area shown on Figure 45.

The pre-Cambrian rocks consist of a complex of amphibolite, hornblende schist, biotite schist, chlorite schist, diorite gneiss, granite and associated pegmatitic bodies, granite gneiss, schistose granite, granitic schist, and garnetiferous schist. Granite and amphibolite are the most widespread types, and the granite is predominant.

The amphibolite, which is one of the oldest rocks in the area, is a dark green to black, fine to medium-grained rock commonly epidotized and cut by granite pegmatite intrusions. It is widely distributed throughout the area but is particularly conspicuous near Chloride and in the low hills between Cerbat Canyon and Mineral Park Wash.

The pre-Cambrian granites are represented by many types. Some of the bodies are distinct and separate intrusions but others are probably differentiation facies. Typically the rock is light-gray, medium-grained, gneissoid granite containing a small amount of mafic minerals, chiefly biotite. Weathered surfaces are usually light buff, less commonly reddish brown.

Near Mineral Park in the central part of the district a large granite stock has intruded the pre-Cambrian granites, gneisses, and schists. Its age is tentatively assigned to late Jurassic or early

[3]Production data furnished by C. E. Needham, U.S. Bur. of Mines, Salt Lake City, Utah.

Cretaceous, the same as the batholiths of California and western Nevada. The granite is essentially medium-grained, slightly porphyritic, and intensely altered, although there are many facies of fine or coarse grained granite, granite porphyry, porphyritic granite, and granite pegmatite. Numerous small stocks and irregular bodies of greenish-black gabbro and associated diabase dikes occur most commonly in the southern part of the district. These are probably differentiation facies of the granite stock. Mineralizing solutions that formed the veins in the district are believed to be genetically related to the late Mesozoic (?) granitic intrusion.

Dikes of many different compositions are widespread. In thickness they range from a few inches to 300 feet. Some extend along strike for only a hundred feet or less whereas others, notably the rhyolites, extend for long distances (Fig. 45). The most abundant dike rocks are granite pegmatites of both pre-Cambrian and late Mesozoic (?) age, and dikes formed from them are usually narrow and of short lateral extent. Aplites are not common. Other dike rocks, some of which are abundant locally, include lamprophyre, andesite, diabase, porphyritic granite, granite porphyry, and rhyolite, and are probably differentiation products of the late Mesozoic (?) intrusion.

The structure of the rocks is complex. Gneissic and schistose structures are common; the prevailing schistosity strikes northeast with steep dips either northwest or southeast. Large and small folds, generally with northeast trends, are common. The most prominent fold is near Chloride where the outcrop pattern of the amphibolite indicates a northeast-plunging anticline. Prominent joint systems, sheeting, and small shear zones, commonly with northwest strikes, are abundant. Faulting is widespread and is usually well expressed by a prominent system of northwest-trending fault fissures in which many of the later veins are located. The dips of the fissures are generally steep, and northeast dips predominate. In places the fault fissures are in conjugate systems. The fissures show much branching and in a few places considerable horsetailing. Gouge and breccia, as well as numerous tear faults in the walls, are present along some fault fissures. The direction of the striations along the walls of the faults is nearly horizontal in places, but a greater number of striations show dips ranging from horizontal to parallel with the dip of the steep fault surface.

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Bulletin 750—B

RIGIN OF CERTAIN RICH SILVER ORES NEAR CHLORIDE AND KINGMAN, ARIZONA

BY

EDSON S. BASTIN

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NOTE.—Owing to the fact that only a few papers were available for th "Contributions to economic geology" for 1923 they will be combined wit those for 1924 in a single volume, and no separate volume for 1923 will b published.

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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.

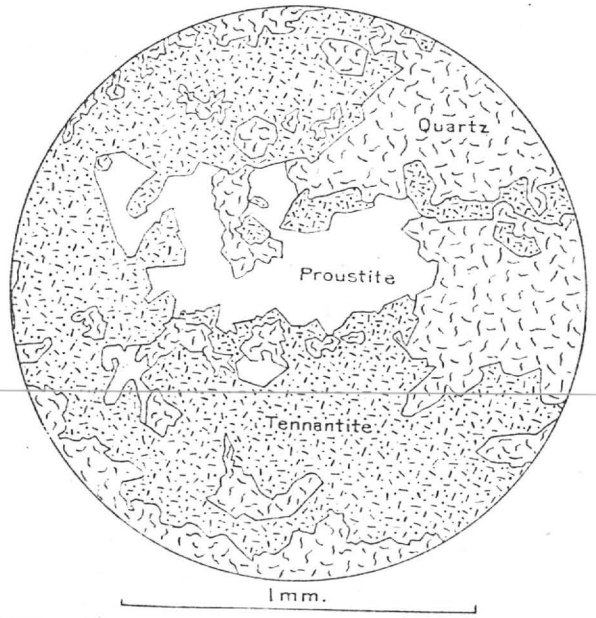

FIGURE 2.—Primary (hypogene) intergrowth of proustite with tennantite and quartz, Empire No. 2 mine, Chloride, Ariz.

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

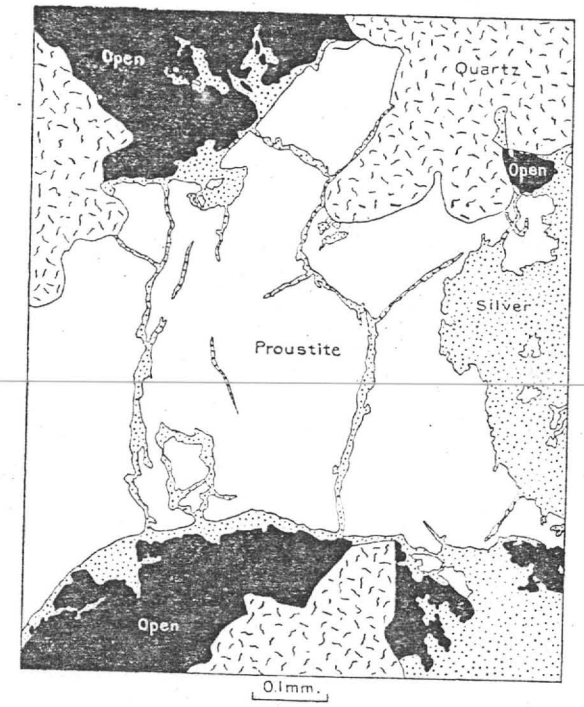

FIGURE 3.—Replacement of proustite by native silver, George Washington claim, Mineral Park, Ariz.

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 compatible 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 inaccessible 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	219	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.

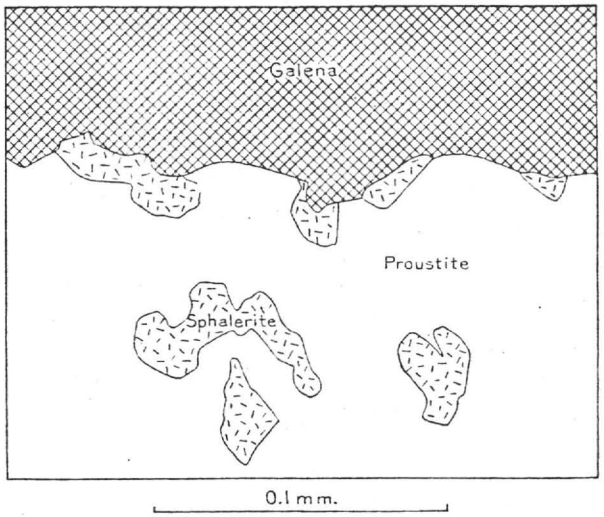

FIGURE 4.—Contact relations of proustite and sphalerite with galena, Queen Bee mine, Mineral Park, Ariz.

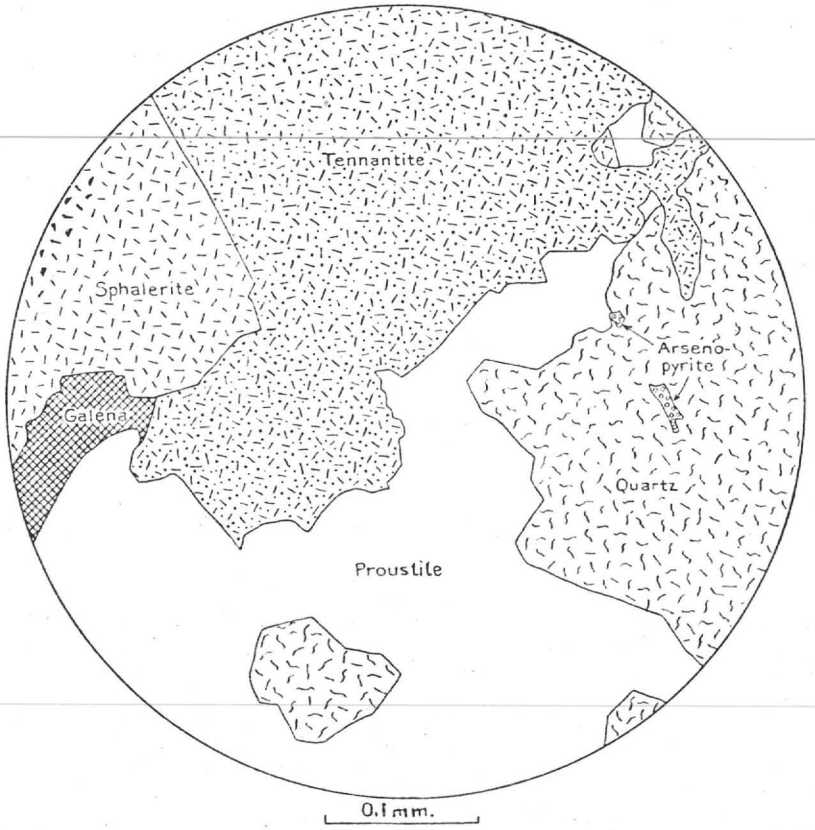

FIGURE 5.—Primary (hypogene) association of proustite and tennantite, Queen Bee mine, Mineral Park, Ariz.

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.

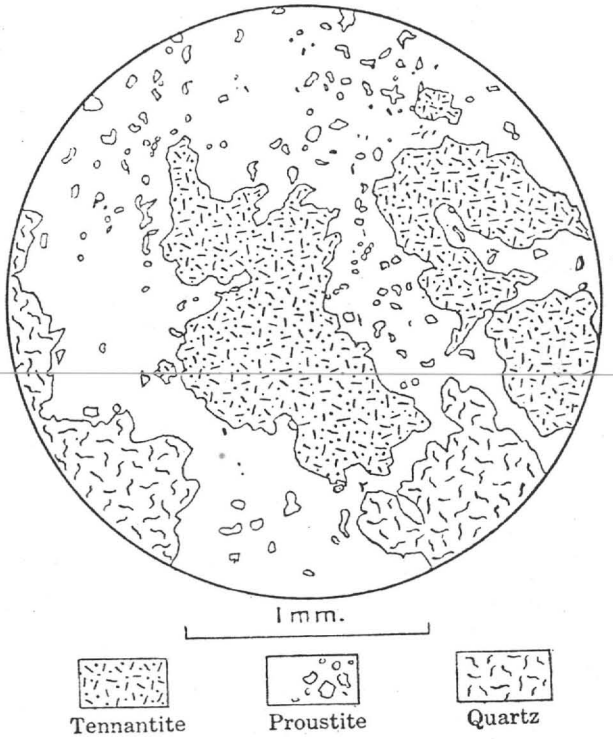

FIGURE 6.—Proustite crowded with inclusions of sphalerite and chalcopyrite and bordering tennantite essentially free from such inclusions, Queen Bee mine, Mineral Park, Ariz.

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).

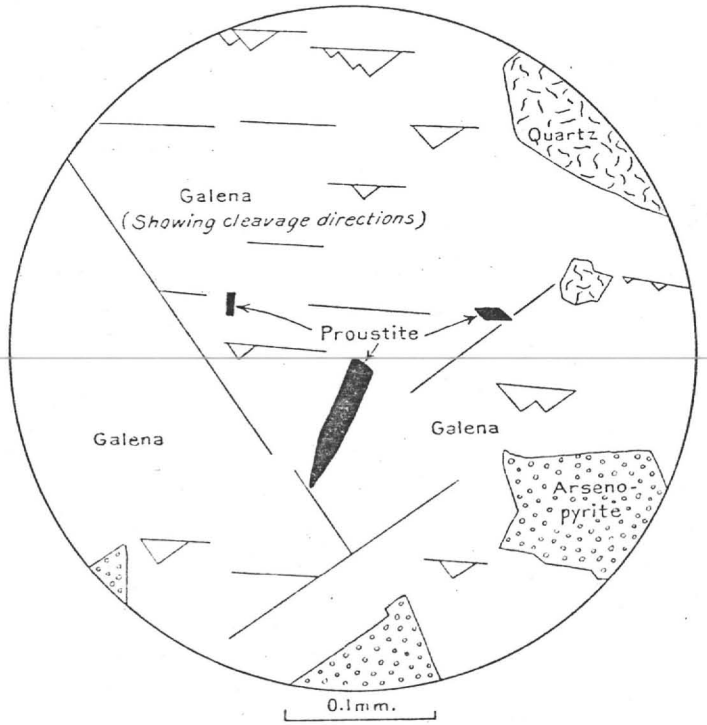

FIGURE 7.—Inclusions of primary proustite in galena, Queen Bee mine, Mineral Park, Ariz.

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

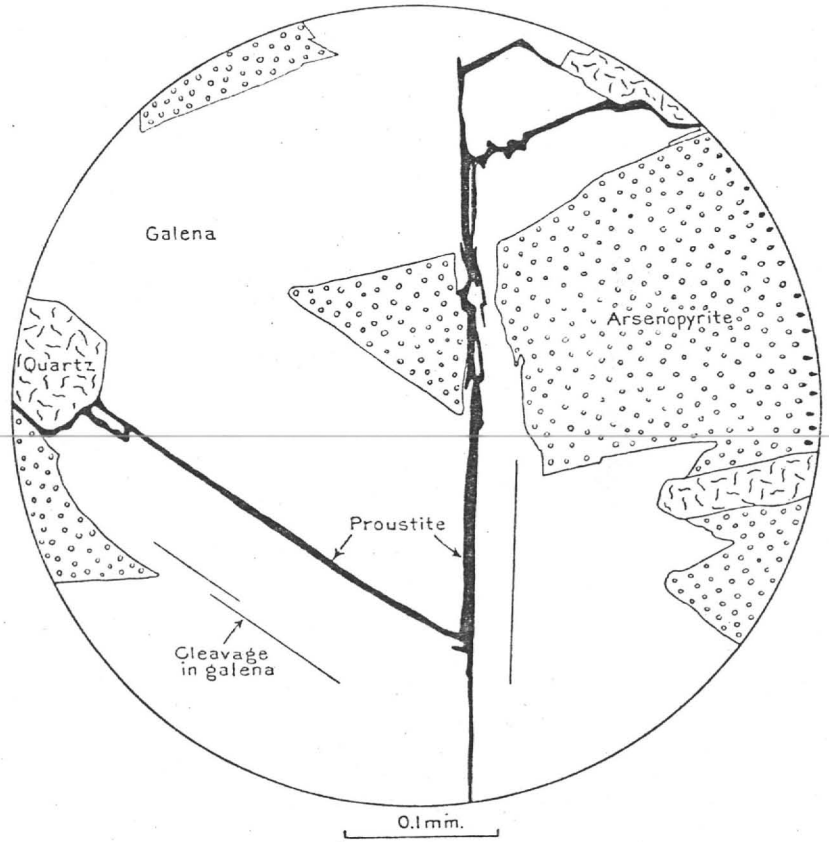

FIGURE 8.—Veinlets of proustite following cleavage planes in galena and contacts between galena and quartz, Queen Bee mine, Mineral Park, Ariz.

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 lath-like 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.

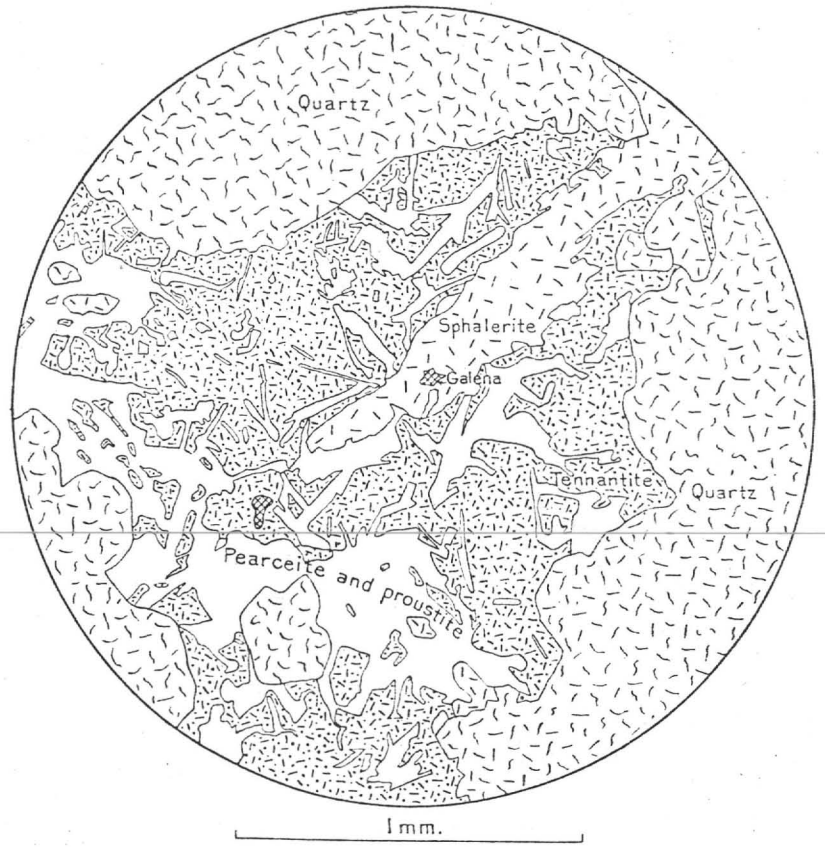

FIGURE 9.—Primary intergrowth of proustite and pearceite with tennantite, Kay mine, Mineral Park, Ariz.

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.

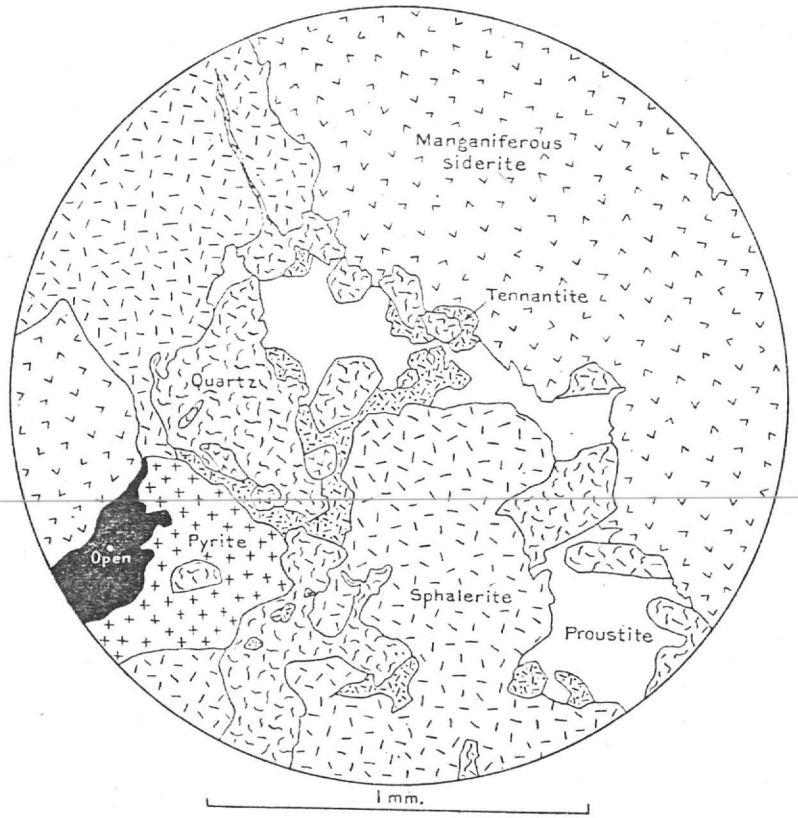

FIGURE 10.—Primary intergrowth of proustite with tennantite, sphalerite, etc., Mineral Park, Ariz.

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.

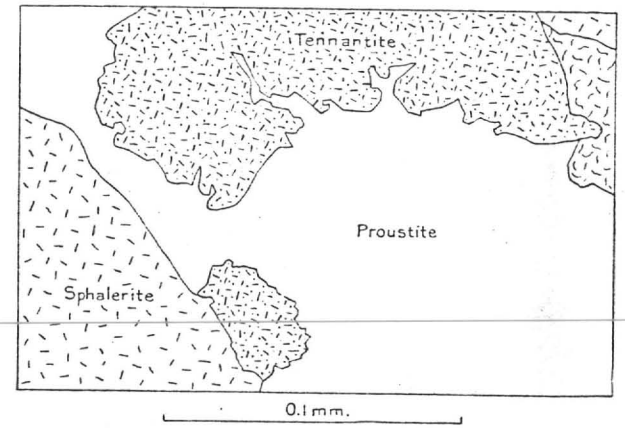

FIGURE 11.—Primary association of proustite and tennantite, Mineral Park, Ariz.

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.

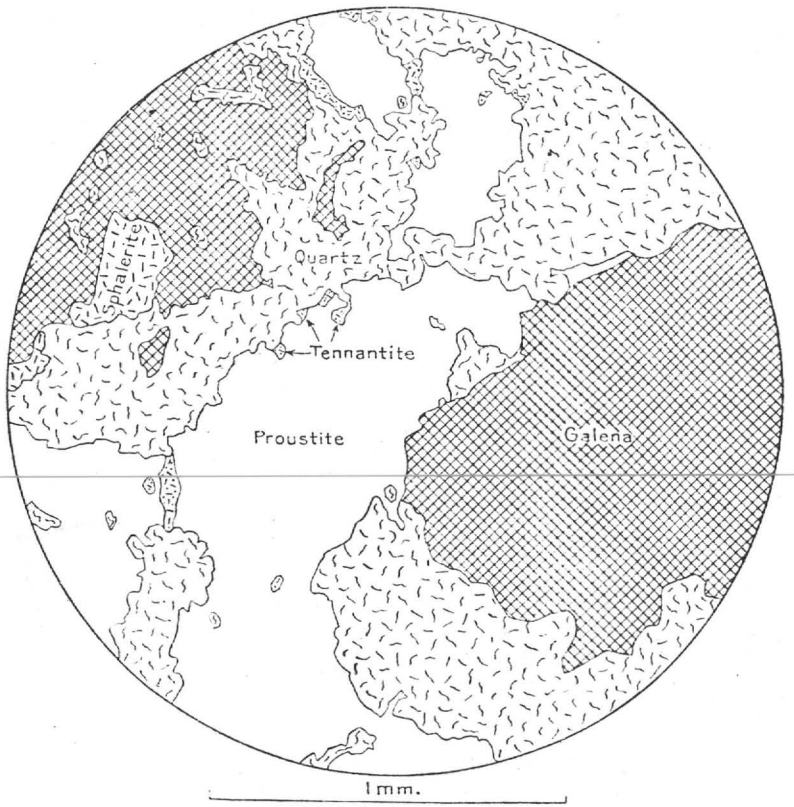

FIGURE 12.—Primary proustite in association with galena, tennantite, and quartz, Cupel mine, Stockton Hill, Ariz.

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 signifiance 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.

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Bulletin 750—B

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

BY

EDSON S. BASTIN

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NOTE.—Owing to the fact that only a few papers were available for th "Contributions to economic geology" for 1923 they will be combined wit those for 1924 in a single volume, and no separate volume for 1923 will b published.

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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.

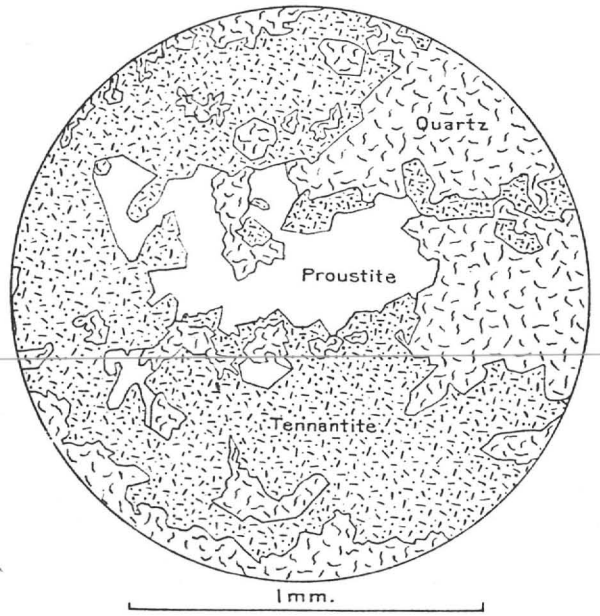

FIGURE 2.—Primary (hypogene) intergrowth of proustite with tennantite and quartz, Empire No. 2 mine, Chloride, Ariz.

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

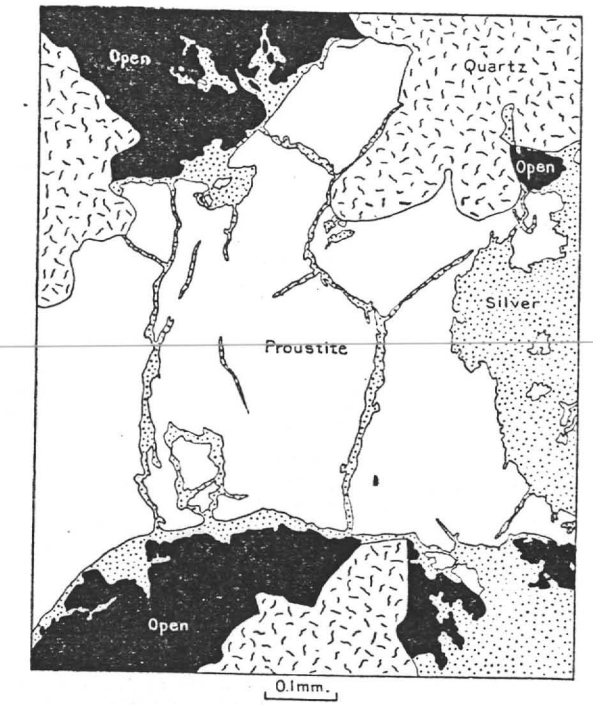

FIGURE 3.—Replacement of proustite by native silver, George Washington claim, Mineral Park, Ariz.

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 compatible 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 inaccessible 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.

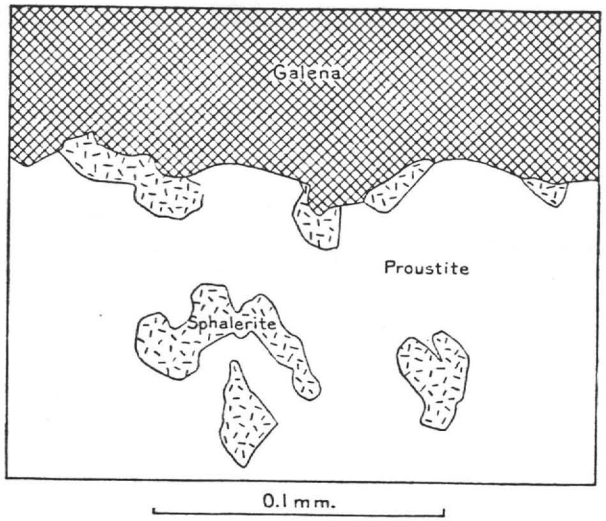

FIGURE 4.—Contact relations of proustite and sphalerite with galena, Queen Bee mine, Mineral Park, Ariz.

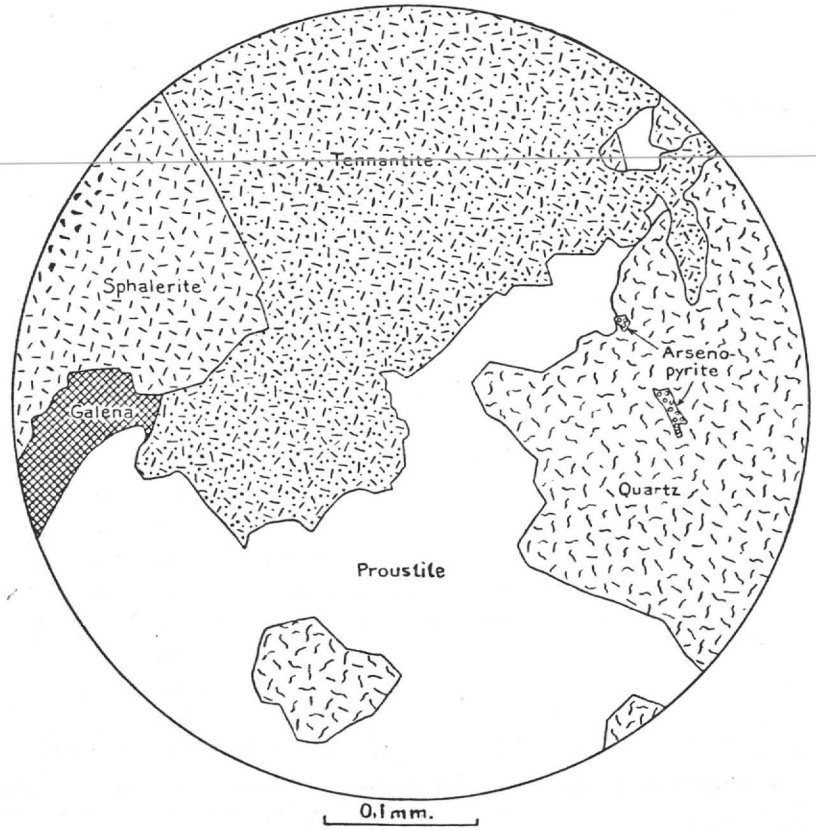

FIGURE 5.—Primary (hypogene) association of proustite and tennantite, Queen Bee mine, Mineral Park, Ariz.

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.

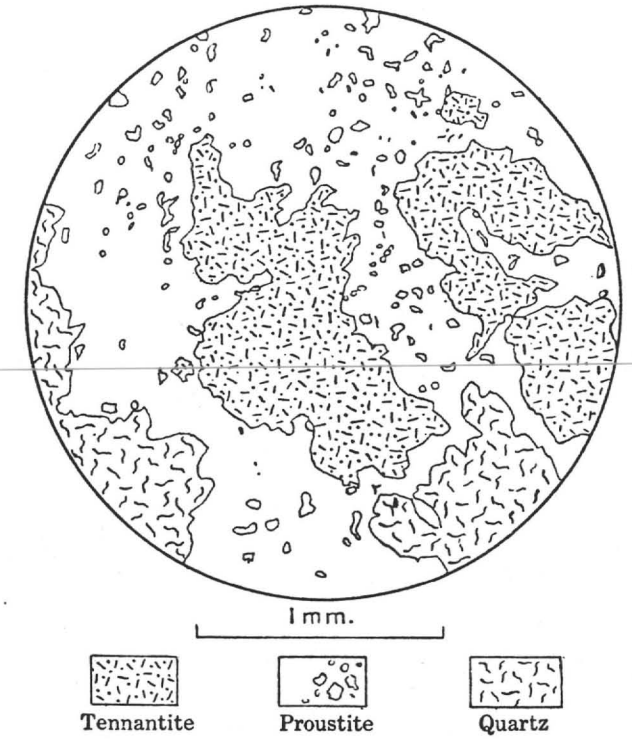

FIGURE 6.—Proustite crowded with inclusions of sphalerite and chalcopyrite and bordering tennantite essentially free from such inclusions, Queen Bee mine, Mineral Park, Ariz.

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).

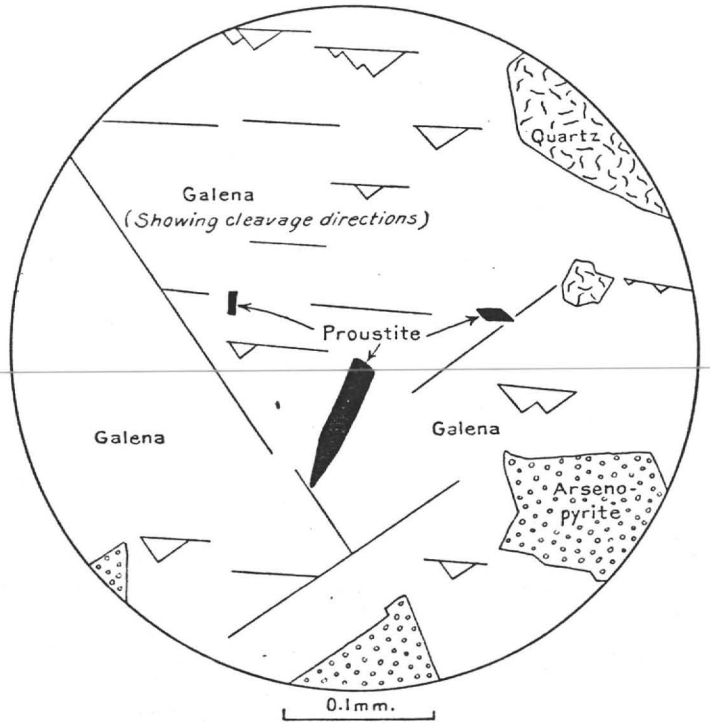

FIGURE 7.—Inclusions of primary proustite in galena, Queen Bee mine, Mineral Park, Ariz.

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

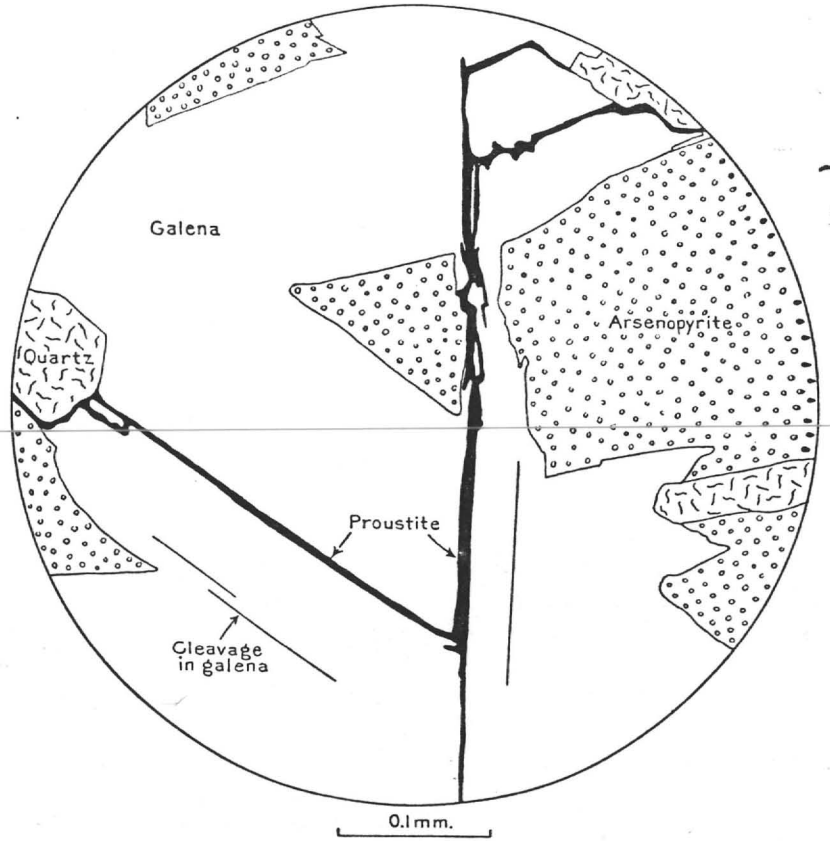

FIGURE 8.—Veinlets of proustite following cleavage planes in galena and contacts between galena and quartz, Queen Bee mine, Mineral Park, Ariz.

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 lath-like 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.

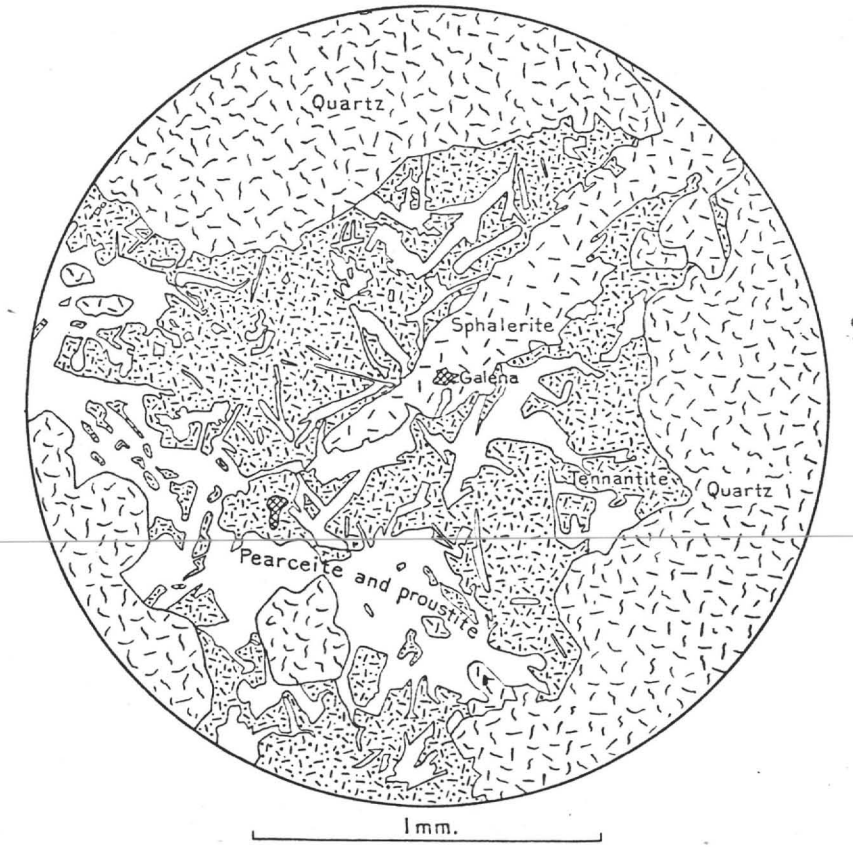

FIGURE 9.—Primary intergrowth of proustite and pearceite with tennantite, Kay mine, Mineral Park, Ariz.

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.

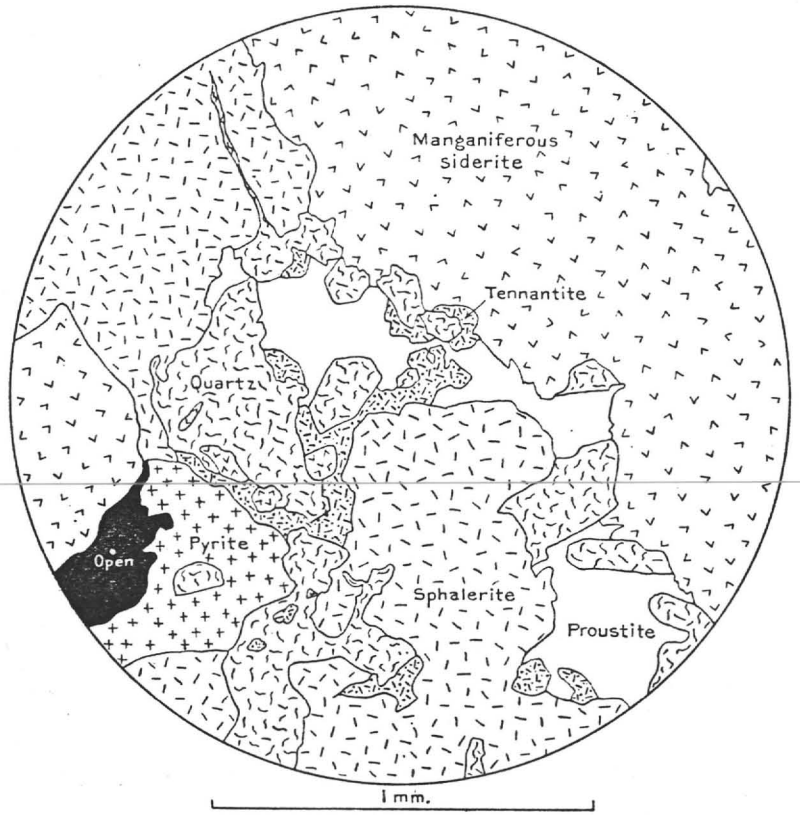

FIGURE 10.—Primary intergrowth of proustite with tennantite, sphalerite, etc., Mineral Park, Ariz.

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.

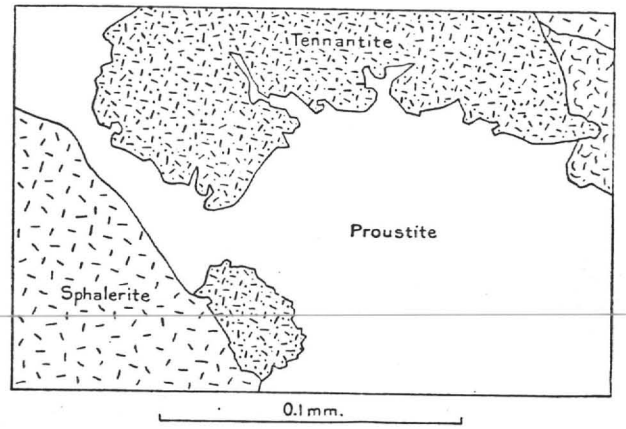

FIGURE 11.—Primary association of proustite and tennantite, Mineral Park, Ariz.

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.

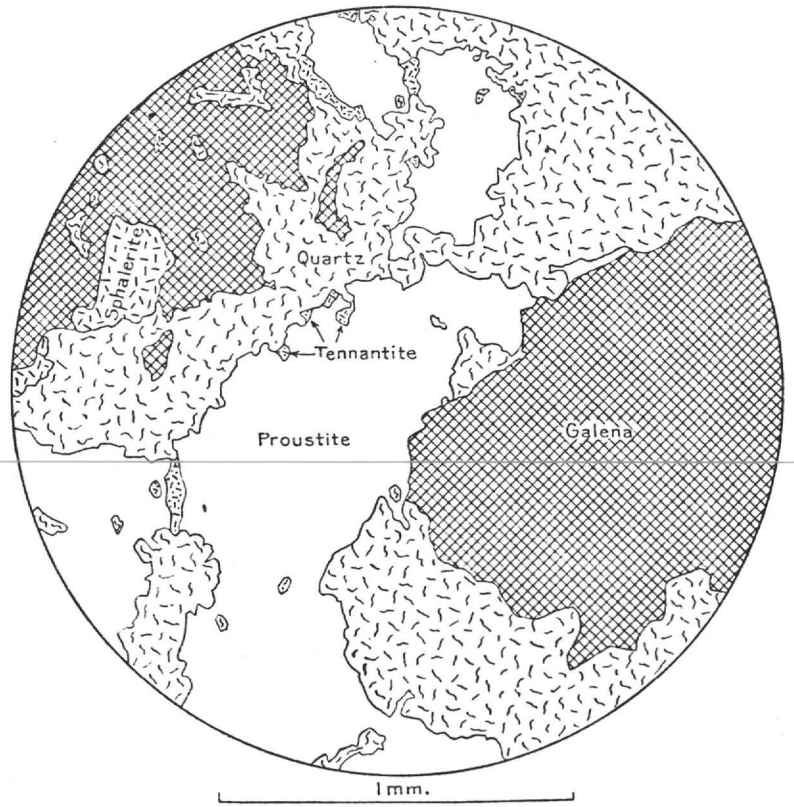

FIGURE 12.—Primary proustite in association with galena, tennantite, and quartz, Cupel mine, Stockton Hill, Ariz.

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 signifiance 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.

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

BULLETIN 340

CONTRIBUTIONS TO ECONOMIC GEOLOGY 1907

Part I.—METALS AND NONMETALS, EXCEPT FUELS

C. W. HAYES AND WALDEMAR LINDGREN
GEOLOGISTS IN CHARGE

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A. S. C. TEMPE, ARIZ.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

It is developed by crosscut tunnels and drifts, mostly within a vertical range of 100 feet. The country rock is sheared pre-Cambrian biotite granite. The vein has a width of about 40 feet, and dips steeply southwestward into the mountain. It seems to consist mainly of an altered and replaced crushed aplitic granite or rhyolite dike. The values favor the foot-wall side of the vein, being greatest near its contact with the granite. This mine produces gold-silver-lead ore. The last carload shipment made at the time of the writer's visit averaged: Gold 3.16 ounces and silver 8 ounces per ton, and lead 17.5 per cent.

Rural and Buckeye mines.—These two mines are located in the northeastern part of the Mineral Park district, at an elevation of about 5,000 feet. They are but a few hundred feet apart and are situated on the same vein, the Rural being on the west and the Buckeye on the east side of the same gulch. The principal developments in the Rural consist of a 200-foot shaft and about 100 feet of drift, and in the Buckeye of 750 feet of drift, toward the face of which the vein is faulted off to the north by a lateral throw of about 75 feet. The Rural shaft contains water. The vein in the Rural mine dips southward at angles of about 80°, but in the Buckeye it dips to the north at angles of about 70°. It is 2 to 8 feet thick and is associated with a dike of the aplitic granite intruded into the country rock, which is pre-Cambrian schist. It locally shows a 4-inch to 20-inch ore shoot, mostly iron and copper pyrites, with streaks of arsenopyrite, black oxide of manganese, and some chert and quartz, the quartz being more prominent in the Buckeye than in the Rural. The walls are generally frozen. The ore contains silver, gold, and copper, with the values high in gold.

Golden Star mine.—The Golden Star (formerly Lone Star) mine is located about a mile northeast of Mineral Park, on open ground. It produced rich sulphides of silver, containing gold and lead, from 1870 until 1902, when the ore seems to have fallen off in grade and become base and refractory. The mine is developed principally by a shaft 300 feet in depth and two levels, with 600 feet of drift on each level. The ore is stoped down to the 100-foot level. The vein dips steeply to the south. It is 2 to 4 feet in width, and the ore is all low grade. The total production is stated to be $375,000.

Ark and San Antonio mines.—The Ark mine, located about 2 miles southwest of Mineral Park at the west base of the mountains, is developed by a 250-foot shaft and three levels, comprising about 1,300 feet of workings. It produces considerable water. The vein, which is 5 or 6 feet in width, dips steeply to the northeast. The ore is of a sulphide character and contains gold, silver, and copper. It runs about 175 ounces of silver and 3.15 ounces of gold per ton. The production is about $150,000. Adjacent to the Ark mine is the San Antonio, which has produced $75,000.

CERBAT DISTRICT.

General outline.—The Cerbat district, an area about 4 miles in diameter, is situated south of the Mineral Park district, in the foothills at an elevation of 3,500 to 5,000 feet, 3 miles east of the Arizona and Utah Railroad. It has produced more than $2,000,000. It is drained principally by Cerbat Wash, which leads westward into Sacramento Valley. The mines north of this wash are gold bearing: those to the south yield silver and lead. The principal mines are the Golden Gem, Vanderbilt, Champion, Oro Plata, Paymaster, Cerbat, New London, St. Louis, Flores, and Twins, the three first named being among the most important present producers.

Golden Gem mine.—The Golden Gem mine, located on Cerbat Wash, is developed principally by a 430-foot shaft and four levels comprising 1,200 feet of drift and stopes. The stoping is on the 130-foot level, and extends 166 feet horizontally and from 62 to 81 feet vertically. This mine yields considerable water. The vein dips steeply to the northeast. It ranges from 6 to 14 feet in width, and usually carries 2 to 6½ feet of pay ore running from $10 upward per ton. The values favor the foot wall. The gangue is quartz. The ore is gold ore and carries also silver, locally 60 ounces per ton, lead 5 to 6 per cent, antimony and zinc a trace, and some iron pyrites. The production to date is $190,000. A 40-ton mill is now turning out about $350 worth of concentrates a day from ore formerly left on the dump.

Idaho mine.—The Idaho mine adjoins the Golden Gem on the west, and the ore is similar to the Golden Gem ore. The mine has been worked in a small way since 1871, and the total production is reported to be about $200,000.

Cerbat mine.—The Cerbat mine, located about a mile northeast of the Golden Gem mine, is 200 feet in depth. The vein is 4 to 10 feet thick, and the total production is stated to be about $300,000 in gold and silver.

Paymaster mine.—In the Paymaster mine, about 1¼ miles northeast of the Golden Gem mine, the vein dips steeply to the north. The ore contains silver and gold, runs high in values, and carries much ruby silver. The production to date is said to be $200,000. Considerable water is found in this mine.

Oro Plata mine.—The Oro Plata mine, located about a mile northeast of the Paymaster mine, is 280 feet deep and is developed by about 7,000 feet of underground work. It produces considerable water. The pre-Cambrian country rock is here intruded by the aplitic granite. The ore values are chiefly in gold and sulphide of silver, with locally some lead. They run about $37 per ton. The total production is given as $500,000.

STOCKTON HILL DISTRICT.

General outline.—The Stockton Hill district joins the Cerbat district on the east, being situated on the opposite slope of the mountains, about 10 miles north of Kingman. It is about 4 miles in diameter and ranges from 3,500 to 5,500 feet in elevation. It is generally rough, but the mines are all accessible by wagon roads, in the main of easy grade. The drainage issues eastward into Hualpai Valley. The principal camp is Stockton Hill, situated in the eastern part of the district. The veins in general strike northwestward. The district contains about 10 mines, of which the principal are the Banner Group, Treasure Hill, Little Chief, Cupel, Prince George, De la Fontaine, C. O. D., and '63.

Banner Group mine.—The Banner Group mine is situated near the center of the district. It is developed by more than 2,000 feet of underground work, including the "tunnel" or drift, which extends in 1,600 feet on the vein. The vein dips steeply to the northeast. It is 6 to 8 feet in width, and the ore shoot is 2 to 2½ feet thick and favors the foot-wall side. In some localities the ore consists of pure galena, but usually it contains gold, silver, zinc, iron, and copper, the gold in places amounting to several ounces per ton. The amount of zinc increases in the deeper north portion of the mine. The production is reported to be many thousand dollars in gold, silver, and lead, the zinc thus far being culled and left on the dump. The ore is shipped to the Needles smelter.

Treasure Hill mine.—The Treasure Hill mine is located in the foothills in the southeastern part of the district. It is developed by inclined shafts and drifts, and yields a large supply of good water. The veins, six in number, dip steeply to the northeast. They average about 5 feet in thickness at the surface and widen downward. They are associated with what seems to be a small stock of the aplitic granite, and the two next to it are now being worked. The ore favors the hanging wall and occurs in shoots 100 to 200 feet in extent, with intervening clay or talcose gouge and sulphides. It runs about 100 ounces of silver and $5 to $16 in gold per ton, and 7 to 10 per cent of lead. The total production is stated to be $100,000.

Cupel mine.—The Cupel mine is situated at Stockton Hill camp. It is now being reopened and an excellent 200-ton mill and plant of the Joplin type have just been installed. It is developed to a depth of 400 feet, principally by shafts, drifts, and stopes, and is said to yield about 25,000 gallons of water per day. It is located on three veins, whose general trend is northerly. The ore in general contains ruby and horn silver, together with black sulphide of silver, but in some places is rich in high-grade galena and carries about $5 per ton in gold. About 2,000 tons of ore said to run from $6 to $7 per ton lie on the dump. The production to date is reported to be about $500,000.

Prince George mine.—The Prince George mine, located about one-fourth mile southeast of the Cupel mine, is developed by a 180-foot shaft and drifts, and is said to yield about 2,000 gallons of water a day. The vein dips steeply to the north and is about 12 feet thick. The total production is about $100,000.

De la Fontaine mine.—The De la Fontaine mine, located at the west side of the district, on the crest of the range, is 400 feet deep, and comprises about 1,400 feet of drift. The vein is 7 to 10 feet in width, and dips steeply to the north. The ore runs about 35 per cent in lead and zinc, and contains some gold. Good ore bodies, 2 to 4 feet thick and of considerable extent, are blocked out in the lower 300 feet of the mine.

'63 mine.—The '63 mine, located in the southern part of the district, is 200 feet deep and is stated to have produced a total of $500,000, mostly in rich silver ore.

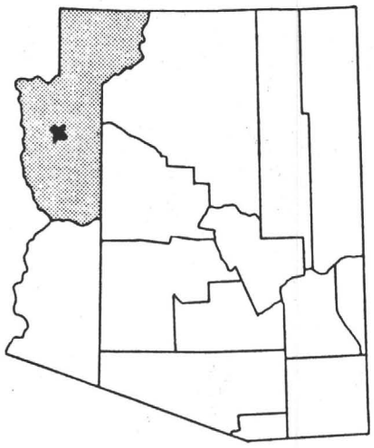
Little Chief mine.—The Little Chief mine, located one-fourth mile west of Stockton Hill camp, is about 100 feet deep and contains about 1,000 feet of underground work. The vein, supposed to be one of the veins of the Treasure Hill mine already described, dips steeply to the northeast. The production, amounting to many thousand dollars, is all shipping ore, averaging in silver about 350 ounces and in gold 5 to 10 ounces per ton, with 8 to [illegible] per cent of lead.

C. O. D. mine.—The C. O. D. mine, located 2½ miles north of Stockton Hill camp, in the upper part of C. O. D. Gulch, is developed by a shaft 400 feet deep, drifts, and stopes, on and between two main and two subordinate levels, aggregating in all about 2,500 feet of underground work. The principal surface equipments consist of a 50-ton concentrating mill and engines. The vein dips steeply northward, and is about 7 feet thick. The ore, whose principal value is in silver, runs about as follows: Silver, 160 ounces per ton; gold, 2 ounces per ton; lead, 12 per cent; with some zinc and a little copper. Except the low-grade ore, it is mostly worked out for a distance of about 400 feet on either side of the main shaft, beyond which good ore is reported. The mine closed down late in 1904 and is now full of water. The total production is reported and in part verified by smelter return sheets to be $1,300,000, that of silver alone amounting to about $1,000,000.

GOLD BASIN DISTRICT.

The Gold Basin district is situated in the eastern part of the White Hills, in the Gold Basin mining district. It extends over a hilly area about 6 miles in diameter, sloping and draining to Hualpai Wash on the east, and ranges from 2,900 to 5,000 feet in elevation. The water

INDEX MAP OF ARIZONA
Showing Location of



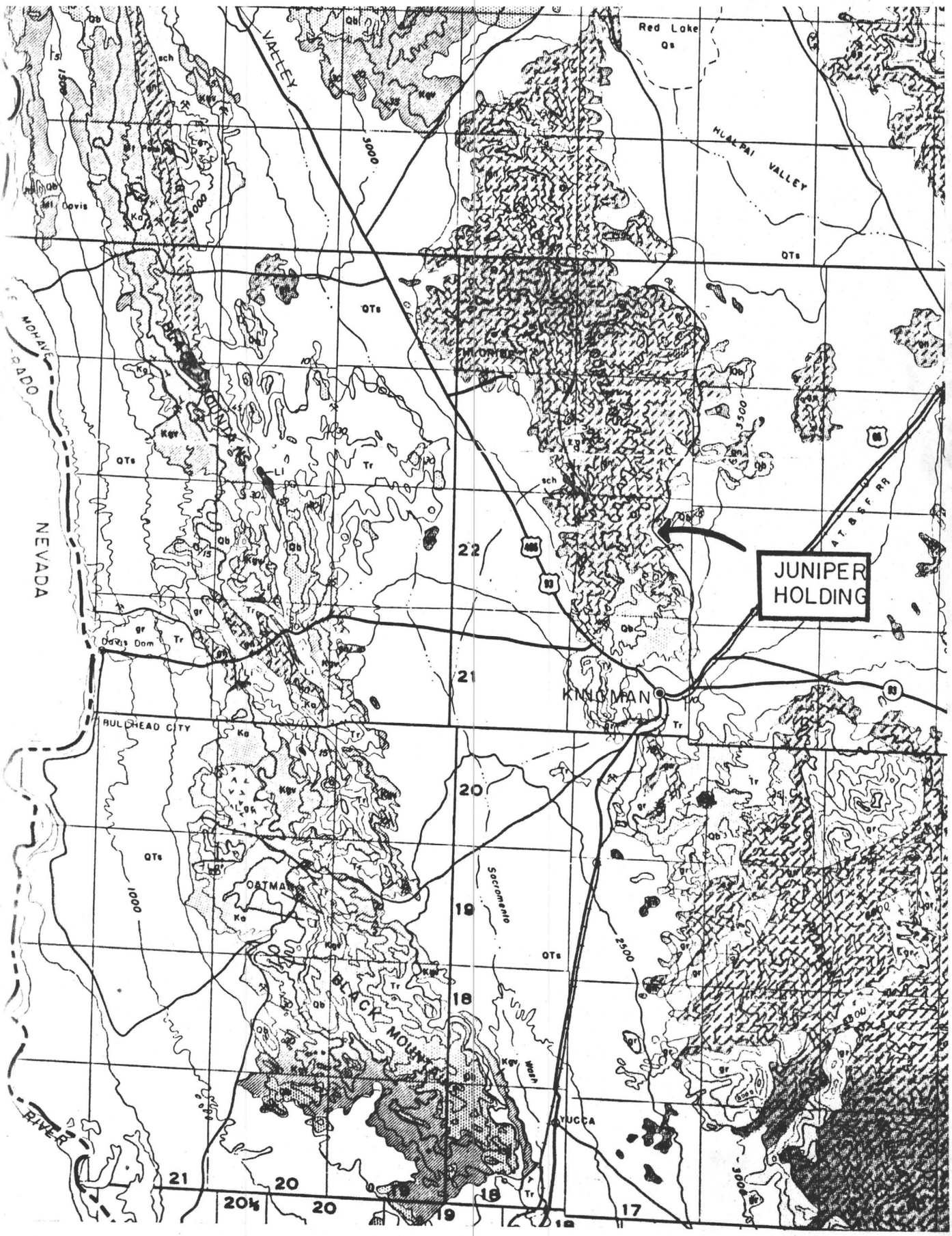
EXPLANATION

Qb

Basalt
Locally includes tuff and agglomerate.

gn

Granite gneiss



MINING LEASE AND PURCHASE AGREEMENT

This Agreement, made and entered into this the _____ day of June, 1980, by and between Severt H. Reither, Margaret Reither and Frank Reither, sometimes doing business as Continental Divide Distributing Company, of Route 2 Box 418, Aitkin, Minnesota 56431, hereinafter called "Lessors" and Desert Metals, Inc., T. W. Anderson, President, P. O. Box 3081, Scottsdale, Arizona 85257, hereinafter called "Lessee".

WITNESSETH:

Lessors, for and in consideration of the payments of the royalties and performance of the terms, covenants and conditions set forth herein for the Lessee to be kept, paid and performed, does by these presents grant and lease to said Lessee, all these certain mining properties belonging to and represented by Lessor situated in Mohave County, Secs. 6 & 7, R-17-W, T-22-N, G.&.S.R.M., Cerbat Mining District, Arizona and named as follows:

T.W. Anderson witnessed claim notice 1973

1. Friday, #1
2. Friday, #2
3. Friday, #3
4. Friday, #4
5. Friday, #5
6. Friday, #6

566-57

LOCATION
166-384
385
386
387
~~388~~
389

These claims are contiguous and south of the Golconda & Mexican Mines. A map to be included in this Agreement as Exhibit "A".

Lessors also agree that any right title and interest in and to any surrounding mineral properties to above claims should be a part of this Agreement, should Lessee feel it necessary to properly re-stake, acquire or renew ownership thereof.

TERMS AND CONDITIONS

1. From the date of this Agreement, Lessee is hereby granted a period of time up to and including 15 Dec., 1980 during which he will have the free, exclusive, quiet and unrestricted right to, re-stake claims, explore, drill, excavate, assay, test and search for economical and mineable ore, rehabilitate surface and sub-surface workings, build test or experimental ore processing facilities, use water found thereon, block out, remove and stockpile ore reserves, ship limited amounts of ore for test purposes, etc., so long as said process and practices are done in a good and workmanlike manner and would not be detrimental to future operation and mine safety within these claims;

2. For the privilege of having this period of free examination time, the Lessee agrees to furnish Lessors an original copy of all evaluation work accomplished, including maps, reports, assays, determinations on ore processing and feasibility studies, drill logs, etc., if requested;

3. Lessors do, by their signatures hereto, state, declare and guarantee that they are the sole owners of these six (6) unpatented mining claims and that they are free and clear of any liens or encumbrances of any kind or nature and that this condition shall continue so long as this Agreement is in effect.

4. It is mutually agreed herein that the purchase price of these six (6) unpatented mineral claims shall be Four Hundred Thousand Dollars ($400,000.00), payable at a minimum advance royalty of $200.00 (Two Hundred Dollars) per month, commencing on or before 15 Dec. 1980 or 5% of the "Gross Proceeds" of all the ore or minerals produced from these claims whichever is greater. At the end of 12 (twelve) months from the date of this signing or 15 June 1981, the minimum advance royalty shall increase to $400.00 (Four Hundred Dollars) per month or 5% of the gross production, whichever is greater. These payments shall be paid into escrow account of Lessor at the First National Bank of Crosby, MN, by Lessee, within thirty (30) days after receipt of settlements. The books and records of operator will be open at any reasonable time for Lessors or their agent's inspection, should any doubt be expressed as to payments due Lessors. The first Two Hundred Dollars ($200.00) monthly payment shall be due on or before the 15th day of Dec. 1980 and each month thereafter and increasing to $400.00/mo., as stated above.

On or before the expiration of this examination time Lessee and/or his agent shall submit written notice to Lessor of their intentions to abandon or continue occupancy of these mineral claims. Should Lessee be satisfied to continue occupancy, exploration, development and exploitation of these claims, they shall arrange a mutually acceptable escrow account to facilitate payments to Lessor as herein agreed, along

with escrow instructions specifying same;

6. It is also agreed by Lessors that they will place a good and negotiable quit claim deed to said claims in said escrow same to be released to Buyer or his assigns when the agreed sales price has been paid into escrow to account of Sellers;

7. Lessee hereby agrees to use his best efforts to get good and qualified associates and/or assigns to complete the necessary test work in the agreed examination period and begin payments when due;

8. It is fully understood by Lessors that Lessee and/or his assigns, agent, associates or designates shall have the exclusive, unrestricted and quiet enjoyment and occupancy of said claims and improvements, so long as they meet all the terms and conditions of this Agreement as listed herein;

9. Lessee hereby agrees to hold Lessors harmless from any lawsuits, causes of action or any such legal hassles resulting from his occupancy, possession or operation of said claims and also agrees to post notices of non-liability in conspicious places upon the claims for the protection of Lessors;

10. Lessors hereby agree to allow Lessee to take claims to patent if he so desires, but ownership shall be retained by Lessor with same rights of purchase by Lessee as set up herein, until fully paid;

11. It is agreed that the title of all mining machinery, equipment, fixtures and structures erected or placed upon said mining claims and premises by Lessee shall be reserved to said Lessee and remain the Property of Lessee, subject to removal at his will, during the continuance of this Agreement, and ninety days thereafter.

12. Lessee hereby agrees to carry adequate Workmen's Compensation Insurance for the protection of all workmen employed on said mining premises and claims, or in the mining operations.

13. Since the claims are unpatented, annual assessment work must be performed on same. Lessee agrees to perform, and record, all work necessary to keep each claim valid including paying taxes due thereon.

14. Lessee may cancel or terminate this Lease, or Purchase Agreement upon thirty (30) days' notice in writing to that effect mailed to Lessor, at any time during the length of this Lease without penalty.

15. If Lessee fails, neglects, or refuses to pay rents and royalties as herein provided, and such defaulting continues for thirty (30) days after written notice has been received by Lessee to rectify such default, Lessor may re-enter said premises for his sole occupancy.

16. This Lease may be assigned in whole or in part by Lessee, and upon such assignment, the assignee shall be solely responsible to Lessors for such assignee's pro rata portion of any or all of the obligations or liabilities under this Lease and Agreement, and Lessee shall proportionately be relieved of any or all of said obligations or liabilities. Lessors in turn, shall accept and grant all rights and obligations of Lessee as stated herein of and to Assignee as if he were original Lessee.

17. Lessee further agrees to perform all mining operations in a good and workmanlike manner to properly and adequately timber, where necessary, all shafts, tunnels and all underground excavations for the safety of the workmen and the preservation of said premises as a mine in a manner commensurate with good and economical mining practices. Lessee agrees that he will operate said mine in full compliance with all State of ~~Colorado~~ ARIZONA and Federal Mining Laws.

This Agreement shall be binding upon and inure to the benefits of the heirs, administrators, executors, assigns and successors in interest of either Lessor or Lessee.

IN WITNESS WHEREOF, the parties hereto have signed this Mining Lease and Purchase Option the day and year herein above first written.

LESSEE:	LESSORS:
DESERT METALS, INC. T. W. Anderson, President	SEVERT H. REITHER
	MARGARET REITHER
	FRANK REITHER (TRUSTEE)
	LORRAINE REITHER

STATE OF)
) ss.
County of)

This instrument was acknowledged before me this _____ day of _____, 1980 by T. W. ANDERSON, President, DESERT METALS, INC.

_____
Notary Public

My Commission Expires:

_____

STATE OF MINNESOTA)
) ss.
County of)

This instrument was acknowledged before me this _____ day of _____, 1980 by SEVERT H. REITHER AND MARGARET REITHER.

_____
Notary Public

My Commission Expires:

_____

STATE OF COLORADO)
) ss.
County of)

This instrument was acknowledged before me this _____ day of _____, 1980 by FRANK REITHER & LORRAINE REITHER.

_____
Notary Public

My Commission Expires:

_____

PROFORMA

The following is based upon June 25, 1980 gold and silver prices and assuming the processing of 50 tons per day of an average ore.

15 oz/ton ag x $15.95/oz x 1000 ton/month	=	$239,250
.07 oz/ton av x $622.50/oz x 1000 ton/month	=	43,575
		$282,825
Refining-smelting fee 6% – 400 T/mo @ $40/ton		(16,970)
		$265,855
10% Royalty		(26,586)
		$239,269
* Monthly operations: Mining, milling, transportation		(120,000)
		$119,269
20% interest to PRO and others		(23,854)
Monthly Net Income		$ 95,415

10% lead
20% zinc
4% Copper

X 90% disc. & penalities

Considering a three month delay in the set-up of the mill-concentration facilities, the payout will be in 8 months.

Startup Cost	$400,000	
Three months' operations	360,000	
	$760,000	÷ $95,415 = 7.96 months.

*

CAMERON, C. J., STRUCKMEYER, V. C. J., and HAYS and HOLOHAN, JJ., concur.

GEOMET EXPLORATION, LTD., a corporation, Appellant,

v.

LUCKY Mc URANIUM CORPORATION, a corporation, Appellee.

No. 14470-PR.

Supreme Court of Arizona, En Banc.

Oct. 9, 1979.

Rehearing Denied Nov. 6, 1979.

Subsequent locator appealed from a decision of the Superior Court, Yuma County, Cause Nos. C-38435 & C-38533, William W. Nabours, J., granting exclusive possession of certain unpatented mining claims to prior locator. The Court of Appeals, 123 Ariz. App. ——, 601 P.2d 1344, affirmed and review was granted. The Supreme Court, Hays, J., held that the actual occupancy requirement of pedis possessio would not be discarded in favor of constructive possession to afford a potential locator protection of contiguous, unoccupied claims as against one who entered peaceably, openly, and remained in possession searching for minerals.

Reversed and remanded with directions; opinion of Court of Appeals vacated.

1. Mines and Minerals ⇐17(1)

Regardless of compliance with statutory requisites such as monumenting and notice, one cannot perfect mining location, under either federal or state law, without actual discovery of minerals in place. A.R.S. § 27-201.

2. Mines and Minerals ⇐27(1)

If first possessor should relax his occupancy or cease working toward discovery of minerals, and another enters peaceably, openly, and diligently searches for minerals, first party forfeits right to exclusive possession under requirements of pedis possessio.

3. Ejectment ⇐9(1)

In possessory action, party with better right is entitled to prevail.

4. Mines and Minerals ⇐29(6)

Pedis possessio protects only those claims actually occupied, provided also that work toward discovery is in progress, and does not extend to contiguous, unoccupied claims on group or area basis.

5. Mines and Minerals ⇐29(6)

Prior to discovery of minerals, only right one has to exclude another flows from pedis possessio and not from statutory law.

6. Mines and Minerals ⇐27(1)

Potential locator must enter mining claim in good faith; "good faith" may be defined as honesty of purpose and absence of intent to defraud.

See publication Words and Phrases for other judicial constructions and definitions.

7. Principal and Agent ⇐69(1)

Agent is duty bound not to acquire private interest antagonistic to that of his employer.

8. Mines and Minerals ⇐27(1)

Mere knowledge of previous mining claim, in and of itself, does not constitute bad faith so as to bar entry to subsequent locator.

W. T. Elsing, Phoenix, Thomas R. Young, Lakewood, Colo., for appellant.

DeConcini, McDonald, Brammer & Yetwin, P. C. by John C. Lacy and Kenneth L. Allen, Tucson, for appellee.

HAYS, Justice.

Geomet appealed from a decision granting exclusive possession of certain unpatented mining claims to Lucky Mc Uranium Corporation. The Court of Appeals affirmed, 1 CA–CIV 4125, filed June 12, 1979, 123 Ariz. —, 601 P.2d 1344 (1979). Geomet petitioned for review and we granted review under A.R.S. § 12–120.24 and Rule 23 of the Rules of Civil Appellate Procedure. We now vacate the opinion of the Court of Appeals.

By use of modern scintillation equipment in September of 1976, plaintiff/appellee, Lucky Mc Uranium Corporation, detected "anomalies" (discontinuities in geologic formations) indicative of possible uranium deposits in the Artillery Peak Mining District in Yuma County, land in the federal public domain. In November, 1976, Lucky proceeded to monument and post 200 claims (4,000 acres), drill a 10-foot hole on each claim, and record notices pursuant to A.R.S. §§ 27–202, 27–203 and 27–204.

Subsequently, defendant/appellant, Geomet, peaceably entered some of the areas claimed by Lucky and began drilling operations. Employees of Geomet were aware of Lucky's claims but considered them invalid because there had been no discovery of minerals in place and Lucky was not in actual occupancy of the areas Geomet entered.

Lucky instituted a possessory action seeking damages, exclusive possession and a permanent injunction against trespass by Geomet or its employees. There was insufficient evidence to establish a valid discovery, but the trial court found that Lucky was entitled to exclusive possession and a permanent injunction. Although Geomet pointed out that, prior to discovery of minerals in place, the doctrine of *pedis possessio* requires a prospector to be in actual occupancy of the claim and diligently pursuing discovery, the court based its reasoning on the economic infeasibility of literal adherence to the element of actual occupancy in view of modern mining techniques and the expense involved in exploring large areas.

Additionally, the court found that Geomet had entered the land in bad faith, knowing that Lucky was claiming it.

We must decide a single issue: Should the actual occupancy requirement of *pedis possessio* be discarded in favor of constructive possession to afford a potential locator protection of contiguous, unoccupied claims as against one who enters peaceably, openly, and remains in possession searching for minerals?

PEDIS POSSESSIO

Mineral deposits in the public domain of the United States are open to all citizens (or those who have expressed an intent to become citizens) who wish to occupy and explore them "under regulations prescribed by law, and according to the local customs or rules of miners in the several mining districts, so far as the same are applicable and not inconsistent with the laws of the United States." 30 U.S.C. § 22 (1970).

[1] The doctrine of *pedis possessio* evolved from customs and usages of miners and has achieved statutory recognition in federal law as the "law of possession," 30 U.S.C. § 53 (1970):

> No possessory action between persons, in any court of the United States, for the recovery of any mining title, or for damages to any such title, shall be affected by the fact that the paramount title to the land in which such mines lie is in the United States; but each case shall be judged by the law of possession.

Regardless of compliance with statutory requisites such as monumenting and notice, one cannot perfect a location, under either federal or state law, without actual discovery of minerals in place. *Best v. Humboldt Placer Mining Co.*, 371 U.S. 334, 83 S.Ct. 379, 9 L.Ed.2d 350 (1963); 30 U.S.C. § 23 (1970); A.R.S. § 27–201. Until discovery, the law of possession determines who has the better right to possession.

The literal meaning of *pedis possessio* is a foothold, actual possession. Black's Law Dictionary 1289 (rev. 4th ed. 1968). This actual occupancy must be distinguished from constructive possession, which is based on color of title and has the effect of en-

larging the area actually occupied to the extent of the description in the title. *Id.* at 1325. A succinct exposition of *pedis possessio* is found in *Union Oil Co. v. Smith,* 249 U.S. 337, 346–48, 39 S.Ct. 308, 310–11, 63 L.Ed. 635 (1919):

> Those who, being qualified, proceed in good faith to make such explorations and enter peaceably upon vacant lands of the United States for that purpose are not treated as mere trespassers, but as licensees or tenants at will. For since, as a practical matter, exploration must precede the discovery of minerals, and some occupation of the land ordinarily is necessary for adequate and systematic exploration, legal recognition of the pedis possessio of a bona fide and qualified prospector is universally regarded as a necessity. It is held that upon the public domain a miner may hold the place in which he may be working against all others having no better right, and while he remains in possession, diligently working towards discovery, is entitled—at least for a reasonable time—to be protected against forcible, fraudulent, and clandestine intrusions upon his possession.
>
> . . . . .
>
> Whatever the nature and extent of a possessory right before discovery, all authorities agree that *such possession may be maintained only by continued actual occupancy by a qualified locator or his representatives engaged in persistent and diligent prosecution of work looking to the discovery of mineral.* (Emphasis added.)

[2] If the first possessor should relax his occupancy or cease working toward discovery, and another enters peaceably, openly, and diligently searches for mineral, the first party forfeits the right to exclusive possession under the requirements of *pedis possessio. Cole v. Ralph,* 252 U.S. 286, 295, 40 S.Ct. 321, 325, 64 L.Ed. 567 (1920); *Davis v. Nelson,* 329 F.2d 840 (9th Cir. 1964).

[3] Arizona has recognized *pedis possessio* and the concomitant requirement of actual occupancy for a century. *Field v. Grey,* 1 Ariz. 404, 25 P. 793 (1881). In *Bagg v. New Jersey Loan Co.,* 88 Ariz. 182, 188–89, 354 P.2d 40, 44 (1960), we said: "Location is the foundation of the possessory title, and possession thereunder, *as required by law and local rules and customs,* keeps the title alive, ..." (Emphasis added.) It is perhaps more proper to speak of a possessory right than a title because, until discovery of mineral and issuance of a patent, absolute title in fee simple remains in the United States. *Bagg, supra,* at 192, 354 P.2d 40; *Bowen v. Chemi-Cote Perlite Corp.,* 102 Ariz. 423, 432 P.2d 435 (1967). Since this is a possessory action, the party with the better right is entitled to prevail. *Rundle v. Republic Cement Corp.,* 86 Ariz. 96, 341 P.2d 226 (1959).

Conceding that actual occupancy is necessary under *pedis possessio,* Lucky urges that the requirement be relaxed in deference to the time and expense that would be involved in actually occupying and drilling on each claim until discovery. Moreover, Lucky points out that the total area claimed —4,000 acres—is reasonable in size, similar in geological formation, and that an overall work program for the entire area had been developed. Under these circumstances, Lucky contends, actual drilling on some of the claims should suffice to afford protection as to all contiguous claims. Great reliance is placed on *MacGuire v. Sturgis,* 347 F.Supp. 580 (D.C.Wyo.1971), in which the federal court accepted arguments similar to those advanced here and extended protection on a group or area basis. Geomet counters that *MacGuire, supra,* is an aberration and contrary to three Wyoming Supreme Court cases upholding the requisite of actual occupancy. *Sparks v. Mount,* 29 Wyo. 1, 207 P. 1099 (1922); *Whiting v. Straup,* 17 Wyo. 1, 95 P. 849 (1908); *Phillips v. Brill,* 17 Wyo. 26, 95 P. 856 (1908).

[4] To adopt the premise urged by Lucky eviscerates the actual occupancy requirement of *pedis possessio* and substitutes for it the theory of constructive possession even though there is no color of title. We are persuaded that the sounder approach is to maintain the doctrine intact. In *Union*

Oil, supra, the Court considered the precise question of extending protection to contiguous claims and refused to do so:

> It was and is defendant's contention that by virtue of the act of 1903, one who has acquired the possessory rights of locators before discovery in five contiguous claims . . . may preserve and maintain an inchoate right to all of them by means of a continuous actual occupation of one, coupled with diligent prosecution in good faith of a sufficient amount of discovery work thereon, provided such work tends also to determine the oil-bearing character of the other claims.
>
> . . . . . .
>
> In our opinion the act shows no purpose to dispense with discovery as an essential of a valid oil location *or to break down in any wise the recognized distinction between the pedis possessio of a prospector doing work for the purpose of discovering oil and the more substantial right of possession of one who has made a discovery* . . . . . *Union Oil,* 249 U.S. at 343, 353, 39 S.Ct. at 309, 312. (Emphasis added.)

We have canvassed the Western mining jurisdictions and found the requirement of actual occupancy to be the majority view. *Davis v. Nelson, supra; United Western Minerals Co. v. Hannsen,* 147 Colo. 272, 363 P.2d 677 (1961); *Adams v. Benedict,* 64 N.M. 234, 327 P.2d 308 (1958); *McLemore v. Express Oil Co.,* 158 Cal. 559, 112 P. 59 (1910).

There are always inherent risks in prospecting. The development of *pedis possessio* from the customs of miners argues forcefully against the proposition that exclusive right to possession should encompass claims neither actually occupied nor being explored. We note that the doctrine does not protect on the basis of occupancy alone; the additional requirement of diligent search for minerals must also be satisfied. The reason for these dual elements—and for the policy of the United States in making public domain available for exploration and mining—is to encourage those prepared to demonstrate their sincerity and tenacity in the pursuit of valuable minerals. If one may, by complying with preliminary formalities of posting and recording notices, secure for himself the exclusive possession of a large area upon only a small portion of which he is actually working, then he may, at his leisure, explore the entire area and exclude all others who stand ready to peaceably and openly enter unoccupied sections for the purpose of discovering minerals. Such a premise is laden with extreme difficulties of determining over how large an area and for how long one might be permitted to exclude others.

We hold that *pedis possessio* protects only those claims actually occupied (provided also that work toward discovery is in progress) and does not extend to contiguous, unoccupied claims on a group or area basis.

Lucky calls our attention to former A.R.S. § 27-203(B), under which a potential locator was allowed 120 days to sink shafts to a specified depth.* The contention is that during that period, Lucky should have been granted exclusive possession in order to discover mineral in place, and, since Geomet entered certain claims before the expiration of the 120 days, Lucky did not have the benefit of the full term in which to make discovery.

[5] We point out, however, that the first statute concerning location of claims, A.R.S. § 27-201, reads as follows:

> *Upon discovery of mineral in place* on the public domain of the United States the mineral may be located as a lode mining claim by the discoverer for himself, or for himself and others, or for others. (Emphasis added.)

* At the time this action was tried, A.R.S. § 27-203(B) read, in pertinent part:

> The locator of a lode claim shall within one hundred twenty days from the time of the location sink a location shaft on the claim . . . . . .

Subsequent amendment by Laws 1978, Ch. 177, § 3, deleted the requirement of sinking a shaft or drilling.

Discovery is the *sine qua non* that lends validity to other statutory procedures designed to complete a location. A.R.S. §§ 27–202 *et seq.* We have on two occasions held that acts of location confer no right in the absence of discovery. *State v. Tracy,* 76 Ariz. 7, 10, 257 P.2d 860, 862 (1953); *Ponton v. House,* 75 Ariz. 303, 306, 256 P.2d 246, 247 (1953). It is certainly true that, even after discovery, one may be held to have abandoned a location or forfeited his rights for failure to comply with additional statutory requirements. A.R.S. § 27–203(E). But *prior to discovery,* the only right one has to exclude others flows from *pedis possessio* and not from statutory law.

[6] Finally, Lucky asserts that Geomet cannot invoke *pedis possessio* because Geomet, knowing that Lucky claimed the area, entered in bad faith. Lucky relies principally on *Bagg v. New Jersey Loan Co., supra,* and *Woolsey v. Lassen,* 91 Ariz. 229, 371 P.2d 587 (1962). It is true that a potential locator must enter in good faith. *Union Oil Co. v. Smith, supra.*

There is language in our decisions that appears to indicate that mere knowledge of a prior claim constitutes bad faith. Although we are sure that our holdings were sound in the cases Lucky cites, certain statements may have been an inadvertent oversimplification of the issue of good faith and we take this opportunity to clarify the point.

In general terms, good faith may be defined as honesty of purpose and absence of intent to defraud. *People v. Bowman,* 156 Cal.App.2d 784, 320 P.2d 70 (1958); *Thurmond v. Espalin,* 50 N.M. 109, 171 P.2d 325 (1946).

Both *Bagg* and *Woolsey, supra,* dealt with those who had discovered minerals in place and were in actual occupancy when others attempted to usurp their claims. These facts immediately distinguish them from the instant case, in which Lucky had neither made discovery nor was in actual occupancy of the areas Geomet entered.

[7] While acting as agent to oversee claims of the Arizona Mining Company, Mr. Bagg attempted to locate claims for himself. An agent is duty-bound not to acquire a private interest antagonistic to that of his employer. *See Mallamo v. Hartman,* 70 Ariz. 294, 219 P.2d 1039 (1950); Restatement (Second) of Agency §§ 387, 393, 395 (1957).

Woolsey concerned a claim against a previous locator who had already discovered mineral and was in actual possession under a lease from the state. Under the circumstances, the challenger simply could not prove a superior right to possession.

[8] In summary, both cases differ significantly from this case in their factual framework and did not depend for their resolution solely upon the element of knowledge. We stand by our conclusions in those cases but wish to emphasize that mere knowledge of a previous claim, in and of itself, does not constitute bad faith. *Columbia Standard Corp. v. Ranchers Exploration & Development, Inc.,* 468 F.2d 547 (10th Cir. 1972); *Adams v. Benedict, supra; Walsh v. Henry,* 38 Colo. 393, 88 P. 449 (1907).

Since Geomet's entry concededly was open and peaceable, we hold that the entry was in good faith.

In conclusion, Lucky was not in actual occupancy of those areas Geomet entered and *pedis possessio* affords Lucky no protection as to those particular claims. Geomet is entitled to the exclusive possession of the disputed claims.

We reverse the trial court, order that the injunction be quashed, and remand for proceedings consistent with this opinion.

CAMERON, C. J., STRUCKMEYER, V. C. J., and HOLOHAN and GORDON, JJ., concur.

WEST KEY NUMBER SYSTEM

GEOMET EXPLORATION, LTD., a corporation, Appellant,

v.

LUCKY Mc URANIUM CORPORATION, a corporation, Appellee.

No. 1 CA-CIV 4125.

Court of Appeals of Arizona, Division 1, Department B.

June 12, 1979.

Rehearing Denied July 10, 1979.

Review Granted Sept. 6, 1979.

Prior locator sued subsequent locator seeking exclusive possession of certain unpatented lode-mining claims. The Superior Court, Yuma County, Cause Nos. C-38435 and C-38533, William W. Nabours, J., rendered judgment for the prior locator and subsequent locator appealed. The Court of Appeals, Ogg, C. J., held that where the prior locator had noticed, posted and recorded uranium claims, ten-foot holes had been drilled in each claim, the locator was drilling deep exploration holes on other claims in the area, the subsequent locator was aware the disputed claims were claimed by the prior locator, the geology of the area claimed was similar and the size of the area was reasonable, an overall work and exploration program was in effect and was being diligently pursued, and prior locator had spent approximately $48,000 on the area and somewhere between $65,000 and $70,000 on overall exploration of the 200 claims, the doctrine of pedis possessio protected the prior locator's claims.

Affirmed.

Judgment vacated, Ariz., 601 P.2d 1339.

1. Mines and Minerals ⇐27(1)

Elements usually required to determine if one should be given protection of doctrine of pedis possessio are actual, physical occupancy of ground, diligent, bona fide work directed toward making discovery, and exclusion of others; this protected status may exist only for reasonable time.

2. Mines and Minerals ⇐38(15)

In action to determine right to possession of unpatented mining claim, as between prior locator in possession and subsequent locator, evidence of prior locator will be viewed in most favorable light.

3. Mines and Minerals ⇐27(1)

Where prior locator had noticed, posted and recorded uranium claims, ten-foot holes had been drilled in each claim, locator was drilling deep exploration holes on other claims in area, subsequent locator was aware that disputed claims were claimed by prior locator, geology of area claimed was similar and size of area was reasonable, and overall work and exploration program was in effect and was being diligently pursued, and prior locator had spent approximately $48,000 on area and somewhere between $65,000 and $70,000 on overall exploration of the 200 claims, doctrine of pedis possessio protected prior locator's claims.

W. T. Elsing, Phoenix, Thomas R. Young, Lakewood, Colo., for appellant.

DeConcini, McDonald, Brammer & Yetwin, P.C. by John C. Lacy and Law Offices of Kenneth L. Allen by Kenneth L. Allen, Tucson, for appellee.

OPINION

OGG, Chief Judge.

In this case we have two competing uranium mining companies claiming mining rights to the same land in the public domain. We must determine which company has the superior right of possession.

The plaintiff/appellee, Lucky Mc Uranium Corporation, brought an action against the defendant/appellant, Geomet Exploration, Ltd., seeking exclusive possession of certain unpatented lode mining claims in Yuma County, and an order restraining Geomet from trespassing upon them. Geomet answered and counter-

claimed, contending it was entitled to exclusive possession. After a trial to the court, judgment was entered for Lucky and Geomet appealed.

There is little dispute on the facts but a wide divergence of opinion on their legal significance. The geology of the area consists of an upper formation of an alluvial fan. There are fifty feet of gravel with a basaltic flow from about 50 to 75 feet in depth. Below that are sandstones and shales, interspersed with more basaltic flows. Indications of mineralization are found from 500 feet to 1400 feet deep.

In August and September of 1976, Lucky, by the use of sophisticated scintillation equipment, operated from an airplane and from the ground, found anomalies that were indicative of a uranium deposit. On approximately November 3, 1976, after extensive investigation and reconnaissance activity, Lucky moved onto the disputed property and located 200 mining claims. The claims were monumented by a team of surveyors with 2" × 2" wooden posts four to five feet in height with tags indicating the corner and name of each claim. Lucky drilled ten foot holes on each claim which were one and three-quarters to two inches in diameter. Lucky also, in compliance with Arizona mining statutes, recorded notices of the unpatented claims.[1]

After extensive reconnaissance in the area, Geomet, on December 14, 1976, started a drilling operation on one of the Lucky claims. Thereafter Geomet located seven claims on a portion of the two hundred Lucky claims. Employees of Geomet were aware of the prior claims of Lucky, but took the position that Lucky had made no discovery of minerals in place and therefore none of the Lucky claims were valid under state or federal mining law. The pertinent part of 30 U.S.C. § 23 reads:

> [B]ut no location of a mining claim shall be made until the discovery of the vein or lode within the limits of the claim located.

A.R.S. § 27-201 reads:

> Upon discovery of mineral in place on the public domain of the United States the mineral may be located as a lode mining claim by the discoverer for himself, or for himself and others, or for others.

Geomet claims it discovered mineral in place on all seven claims by drilling and detecting signs of mineralization from 500 feet to 1420 feet in depth. This was accomplished by running a scintillation probe down the drilled hole which detected an anomaly on the gamma ray log. Jerry H. Jackson, the district geologist for Lucky, testified that in his opinion Geomet had only found indications of a valuable mineral deposit, and that a gamma ray blip indicating an anomaly does not constitute a discovery. It was his opinion that an assay was the only sure method to determine the discovery of a valuable mineral. Loren Smith, the Geomet geologist, testified Geomet did not run any assays for uranium because the samples were too diluted by the deep drilling operation.

From the testimony of the experts and a reading of the mining articles and cases cited to us, it appears the search for uranium is a search for "anomalies". "Anomaly" is a term used to describe a physical difference between rock types or discontinuities in geologic formations. Indications found by locating anomalies are merely the prelude to the vital discovery eventually made by drilling or shaft sinking to reveal an actual deposit of uranium. *See* Ladendorff, *Enlarging Prediscovery Rights of Mineral Locators*, 6 Rocky Mtn.Min.L.Inst. 1 (1961). We point out this rather technical material to emphasize that the search for uranium is a far cry from the old prospector on a burro searching with pick and shovel for an outcrop of valuable mineral. Some of the mining practices formulated under the General Mining Law of 1872 have little practical validity when applied to the modern search for uranium.

1. Lucky complied with the Arizona requirements for mining locations as set out in A.R.S. §§ 27-202, 27-203 and 27-204.

F.Supp. 580 (D.Wyo.1971). *MacGuire* is a case involving a dispute over the right to possession of unpatented uranium claims under a similar fact situation. There the district court ruled that the original locator of eight groups of unpatented uranium lode claims was entitled to exclusive possession on a group or area basis so long as the locator remained in possession. The court justified the decision from the facts that the geology of the area claims was similar, the size of the area claimed was reasonable, the mining laws of Wyoming had been complied with, and where the overall work program was in effect for the entire area claimed and was being diligently pursued. The court found the nature of the uranium ore claimed and the cost of development would make it economically impractical to develop the mineral if the locator was awarded only such claims on which he was actually present and currently working.

Geomet also infers that the doctrine of pedis possessio only protects a prior locator from a violent, forcible, fraudulent or surreptitious intrusion. Geomet points out that it entered upon the disputed claims openly and peacefully, and that therefore Lucky cannot invoke the doctrine. Although there are cases that seem to lend support to such a position, we do not believe such position to be well reasoned. It is our opinion that a peaceful and open intrusion is just as damaging to one's pre-discovery rights as a violent or surreptitious intrusion. *See* Fiske, *supra* at 200.

For the reasons stated herein, the judgment of the trial court is affirmed.

SCHROEDER, P. J., and JACOBSON, J., concur.

WEST KEY NUMBER SYSTEM

From a reading of the conflicting testimony of the mining experts in this case, the trial court could make the determination that both parties had found indications of a valuable deposit of uranium, but as of the date of trial, neither party had made a valid discovery of valuable mineral in place.

This brings us to the determinative issue in the case. Was Lucky as the first prospector on the land entitled to retain exclusive possession as against Geomet under the mining doctrine of pedis possessio?

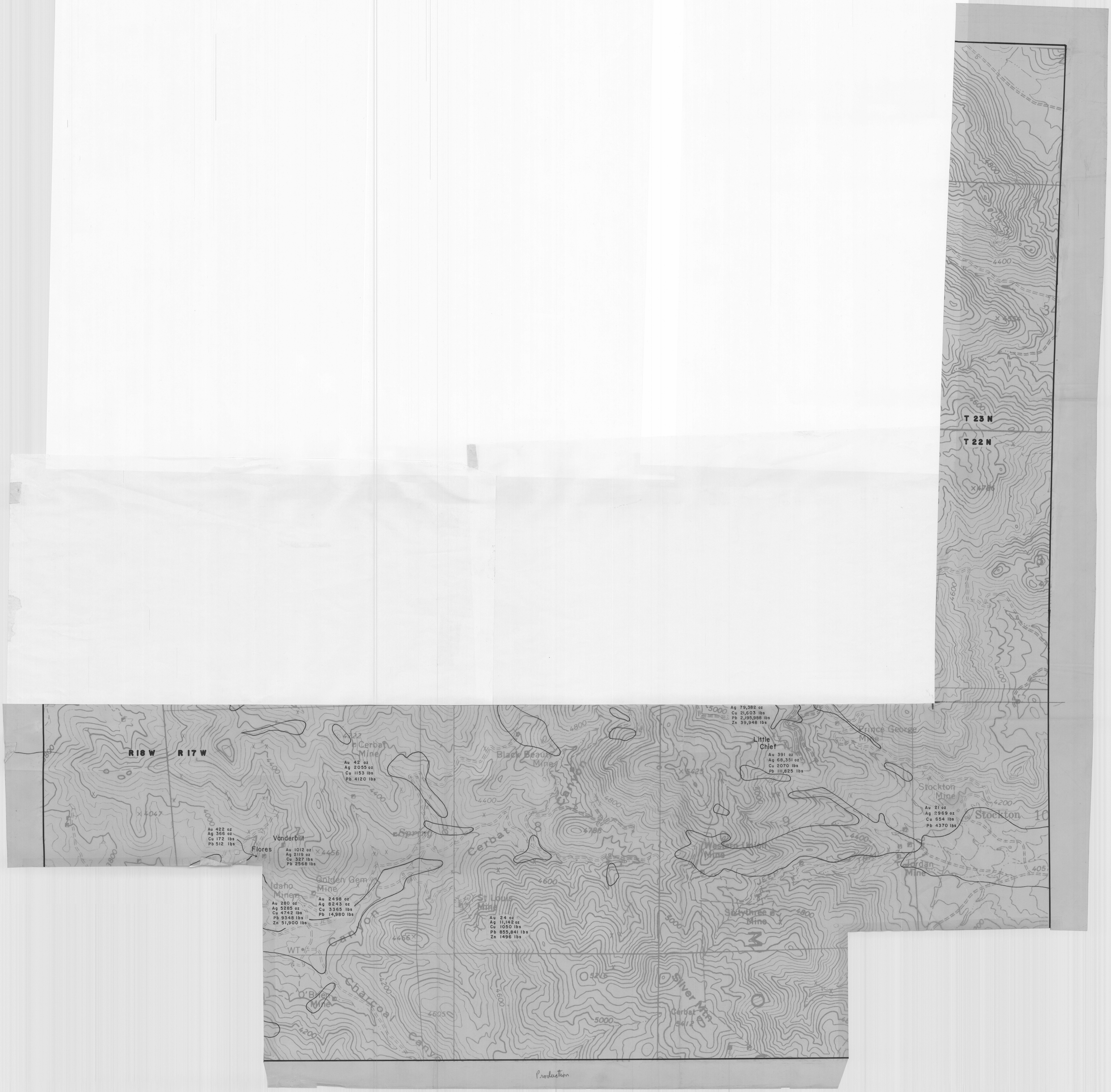
[1] The doctrine of pedis possessio pertains to possessory rights existing prior to the discovery of valuable mineral. The doctrine is not statutory but has developed through case law as part of local mining customs and rules. The key United States Supreme Court case expounding this doctrine is *Union Oil Co. of California v. Smith*, 249 U.S. 337, 39 S.Ct. 308, 63 L.Ed. 635 (1919). The doctrine set down in that case provides that if a qualified person in good faith enters unappropriated public domain for the purpose of mineral exploration, he is entitled to exclusively hold the land, where he is searching and working, against those having no superior right. He will be protected against all intrusions so long as he remains in continuous, exclusive occupancy and diligently works toward making a discovery of valuable mineral. The courts have consistently upheld this concept as a means of protecting the good-faith prospector and encouraging exploration, even though the concept resulted in a pre-discovery limitation upon the openness of public land to all would-be discoverers. The application of the doctrine must be carefully applied to prevent misuse by protecting a non-diligent or bad-faith prospector at the expense of the legitimate prospector. The three basic elements usually required to determine if one should be given the protection of the doctrine are: (1) actual, physical occupancy of the ground; (2) diligent, bona fide work directed toward making a discovery; and (3) exclusion of others. This protected status may only exist for a reasonable time. *See* Fiske, *Pedis Possessio—Modern Use of an Old Concept*, 15 Rocky Mtn.Min.L.Inst. 181 (1969).

[2] In an action to determine the right to possession of an unpatented mining claim, as between a prior locator in possession and a subsequent locator, the evidence of the prior locator will be viewed in the most favorable light. *Bagg v. New Jersey Loan Co.*, 88 Ariz. 182, 354 P.2d 40 (1960).

[3] Viewing the evidence in such a light and also most favorable to upholding the judgment of the trial court, we find that Lucky was entitled to the protection of the doctrine of pedis possessio, and that the trial court did not err in granting Lucky the right of possession to the disputed claims.

Lucky was in actual physical occupancy of the claims. The claims had been noticed, posted, and recorded, and ten foot holes had been drilled on each claim pursuant to the requirement of Arizona mining statutes. Lucky was drilling deep exploration holes on other claims in the area, and Geomet was aware the disputed claims were claimed by Lucky. The geology of the area claimed was similar, and the size of the area was reasonable. An overall work and exploration program was in effect and was being diligently pursued. Lucky had spent approximately $48,000 in the conflict area and somewhere between $65,000 and $70,000 on the overall exploration of the two hundred claims. Lucky attempted to exclude others by posting, staking and recording the claims. Agents of Lucky advised agents of Geomet that Geomet was trespassing upon the Lucky claims.

Geomet argues that the doctrine of pedis possessio cannot be used by Lucky because Lucky was not in actual physical possession of the seven disputed claims and the fact Lucky may have been systematically drilling on other claims is immaterial. We disagree. Most mining experts agree that the effective exploration for significant deposits of uranium at considerable depth can only be conducted over a wide area during an extended period of time, according to a comprehensive technological plan. Ladendorff, *supra*. We agree with the reasoning of the court in *MacGuire v. Sturgis*, 347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Little Chief
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Prince George Mine
Stockton Mine
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St Louis Mine
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Sixty-three Mine
Silver Mtn
Cerbat
Jordan Mine
O'Brien Mine
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Production