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TIN DEPOSIT AT MAJUBA HILL PERSHING COUNTY, NEVADA

BY

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TIN DEPOSIT AT MAJUBA HILL, PERSHING COUNTY, NEVADA

By Ward C. Smith and V. P. Gianella

ABSTRACT

The tin and copper deposits at Majuba Hill, Pershing County, Nevada are in a partly brecciated plug of Tertiary rhyolite porphyry, which is altered nearly everywhere to quartz and sericite and in some places is intensely tourmalinized. The tin mineral, cassiterite, appears to be associated with the alteration, for the single concentration of it was formed by replacement of altered breccia. Brecciated and altered rock is, however, only a general guide to potentially tin-bearing ground, and not a specific guide to ore shoots, for most of such rock appears to contain only small amounts of cassiterite, widely and unevenly distributed. The known deposit, which is exposed only underground, is at most 20 by 20 by 10 feet in size, and may contain about 12,000 pounds of metallic tin. The deposit is cut off by a normal fault, which apparently is of small displacement, and the footwall segment has not been found.

The copper deposit is in the same normal fault, about 300 feet south of the earlier-formed tin deposit. From it about 4,000 tons of 12 percent copper ore was mined in 1915-18, but none has been mined since and no copper ore is now in sight.

INTRODUCTION

Majuba Hill ^{1/} is in the Antelope Range, Pershing County, Nevada, about 35 miles north of Lovelock and 20 miles west of Imlay, in sec. 2, T. 32 N., R. 31 E., Mount Diablo base and meridian (fig. 4). It is in the Antelope (or Cedar) mining district.

The presence of tin at Majuba Hill was known to local prospectors, according to George Copley ^{2/} of Imlay, at least as early as 1907, when a piece of cassiterite-bearing float was found on the hill. The outcrop from which the piece came was never

^{1/} On the Lovelock topographic map; the hill is incorrectly marked "Majuba Mountain." The name is derived from Majuba Hill in South Africa, a battleground of the Boer War.

^{2/} Personal communication.

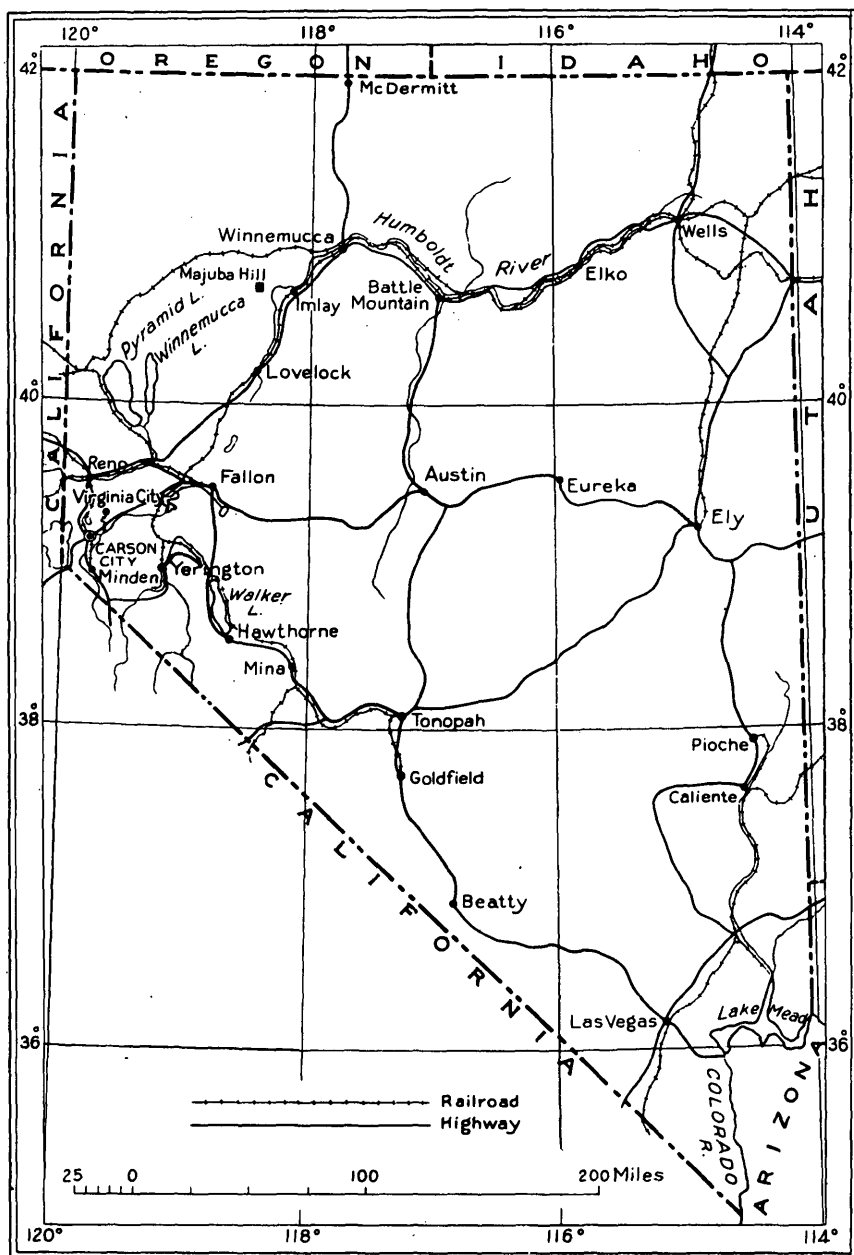


Figure 4.--Index map showing location of Majuba Hill, Nevada.

found, but in 1917 a tin deposit was discovered underground in the Majuba Hill mine during exploration for copper. The deposit is small, and no tin ore has ever been shipped from it. The Majuba Hill copper deposit, located in 1907 by A. J. McCauley,^{3/} was mined from 1915 to 1918 and produced about 4,000 tons of ore with an average content of 12 percent copper.

After 1918, the mine remained idle until early in 1941, when its owners, C. A. Copley and A. L. Gilmet, granted an option to the Freeport Sulphur Company,^{4/} under which prospecting for tin started anew.

Descriptions of the tin deposit were published ^{5/}during the period of copper mining, but they are very brief; in order, therefore, to obtain more detailed information Majuba Hill was examined by the Geological Survey in the spring of 1939, under an allotment of Public Works funds. Geologic maps of Majuba Hill (pl. 9) and of the mine workings (pl. 10) were prepared by Ward Smith of the Geological Survey, and petrographic and mineralogic studies were made by V. P. Gianella of the Nevada Bureau of Mines.

The authors are indebted to Mr. Fred De Longchamps of Reno for a map of the underground workings, and to Miss Jewell J. Glass and Mr. Charles Milton of the Geological Survey for mineral determinations and analyses. Mr. Milton Steinheimer assisted in the field work.

GEOLOGY

The rocks of the Majuba Hill area (see pl. 9) include (1) Triassic (?) sedimentary rocks, (2) dikes of andesite, dacite, and latite, and (3) intrusive bodies of rhyolite porphyry, the

^{3/} Vanderberg, W. O., Reconnaissance of mining districts in Pershing County, Nevada: U. S. Bur. Mines Inf. Circ. 6902, pp. 8-11, 1936.

^{4/} Eng. and Min. Jour., vol. 142, No. 4, p. 91, 1941.

^{5/} Knopf, Adolph, Tin: Mineral Resources U. S., 1917, pt. 1, p. 65, 1921. Idem, 1918, pt. 1, pp. 26-27, 1921.

main body of which is the host of the tin and the copper deposits. Part of the area is thinly covered with alluvium and fan-glomerate. The main body of rhyolite porphyry, after being somewhat silicified, was in part brecciated, and then extensively altered to quartz, sericite, tourmaline, and fluorite. Cassiterite appears to be associated with this widespread alteration, for the only tin ore deposit that has yet been found is in thoroughly altered breccia; but since much of the rhyolite thus brecciated and altered contains only a little unevenly scattered cassiterite, neither the brecciation nor the alteration are guides to tin ore. A normal fault, referred to in this report as the Majuba fault, cuts off the tin deposit, and the footwall segment of the tin ore has not been found. The copper deposit is in the Majuba fault and, therefore, formed later than the tin.

Triassic (?) sedimentary rocks

The oldest rocks in the area mapped are slightly metamorphosed, Triassic (?) sedimentary rocks at least 5,000 feet thick. About 90 percent is slate and phyllite, which are readily recognized by their bedded character, cleavage, and prevailing dark-blue, black, and gray colors. The remainder consists of dark hornfels layers and rather widely spaced, thin, lenticular layers of brown quartzite. The slates contain sericite and sparsely disseminated pyrite cubes, and near the main intrusive body they are tourmalinized. The beds strike northeast and dip from vertically to about 60° NW. Brief observations at scattered localities in the Antelope Range indicate that this attitude, and also the low degree of metamorphism, are typical of the Triassic (?) rocks throughout the range and are not, like the tourmalinization, local features found only adjacent to Majuba Hill. Possibly some of the sericite and pyrite was introduced by the solutions that altered the rhyolite porphyry. No fossils have

been found in the rocks, but they are lithologically similar to some of the Triassic rocks of the Eugene Mountains, the next range to the east.

Andesite, dacite, and latite dikes

The andesite, dacite, and latite dikes which are abundant south of Majuba Hill are not differentiated on the geologic map. Most of the dikes are parallel to the bedding of the Triassic (?) rocks, or nearly so. The andesites are hornblendic, plagioclase-rich rocks distinguished in the field by their gray-green color and blocky jointing. Some are porphyritic; others, which might be called diorites, are evenly granular. The dacites and latites are blocky to imperfectly platy rocks, mostly light brown or tan on weathered surfaces, obviously crystalline but so much altered as to make identification difficult. The dacite and latite, and to a less extent the andesite, contain much secondary sericite, chlorite, calcite, and quartz, and alignment of these minerals accounts for the platy structure. The character of the alteration in these dikes suggests that they may be pre-Tertiary.

Rhyolite porphyry

The irregularly shaped intrusive mass that underlies Majuba Hill is about 4,000 feet in diameter. Rhyolite porphyry also forms long apophyses extending northeastward and southwestward from the main body, along the bedding of the Triassic (?) rocks. Several short dikes of this porphyry are not visibly connected with the main intrusive body. Nearly all the rhyolite porphyry is silicified and sericitized, and large parts of the main body are tourmalinized, in places very intensely. The rhyolite porphyry probably is of Tertiary age.

Bold outcrops of rhyolite porphyry are conspicuous features of the barren hillsides. The rock weathers pale buff or reddish

brown but is medium gray when fresh. The phenocrysts are short bipyramids of quartz and prisms of orthoclase and albite. In most of the rhyolite the phenocrysts are abundant and attain diameters up to half an inch, but in a few parts of the main body and in some dikes they are scarce or very small. No dark minerals were seen, but zircon crystals of microscopic size are abundant.

Breccia

Breccias of diverse origins make up a considerable part of the Majuba Hill intrusive, and are of special interest because the cassiterite-rich shoot is in breccia. In one variety, the angular fragments are slate, phyllite, and hornfels, in a matrix of uncrushed rhyolite porphyry. Masses of such breccia are exposed at several places along the margin of the intrusive and clearly represent broken country rock invaded by rhyolite porphyry. A second variety of breccia is distinguished by the presence, among the common angular fragments, of many well-rounded ones, some of which are as smooth as stream-worn cobbles or pebbles. These well-rounded fragments may consist of any rock found nearby, but a large part of them consist of felsitic rhyolite. The matrix of the breccia is light-colored, except where tourmaline is abundant, hard, fine-grained, and completely lithified, so that in hand specimens the matrix seems to be much the same as the groundmass of typical uncrushed rhyolite porphyry. Thin sections show, however, that the matrix consists of finely crushed quartz enclosed in secondary quartz and sericite. It is evident that rhyolite porphyry was silicified before this early brecciation as well as afterward. This breccia evidently was formed partly by crushing and partly by a process akin to rolling or milling. Some small masses of breccia exposed on the south side of Majuba Hill probably mark faults, for they have a thin, tabular shape and lie between parallel walls of unbrec-

ciated rhyolite. Larger masses of similar breccia are irregular in shape and apparently are not distributed in a systematic fault pattern.

The lithified breccias just described are readily distinguished from small masses of unconsolidated breccia along faults that formed after the quartz-sericite-tourmaline mineralization. The breccias along these faults are characterized by an incoherent matrix of crushed rock, and by the presence among the broken fragments of all kinds of mineralized material.

Alteration of the rhyolite porphyry

The alteration of the rhyolitic rocks may be summarized as follows: The main intrusive was partly silicified, then brecciated, and afterward extensively replaced by quartz, sericite, tourmaline, and fluorite. Apparently quartz was formed at all stages accompanying the early sericite and the later tourmaline. Fluorite, nowhere more than a minor constituent, was formed late. The scant evidence from microscopic veinlets and drusy cavities indicates that finally deposition of the minerals ended in the order: sericite, tourmaline, quartz, fluorite. As a result of the alteration, the rhyolite porphyry and breccia are rather generally changed to quartz and sericite, and locally made into black tourmaline-quartz rock. Cassiterite appears to have formed at a late stage in this process, and is distributed even more sporadically than the tourmaline.

Quartz and sericite are the most abundant rock-forming minerals at Majuba Hill, but in the field they attract little attention because tourmaline is so much more conspicuous. A fine-grained aggregate of quartz and sericite makes up the groundmass of the rhyolite porphyry and the matrix of the lithified breccias, and in some specimens quartz and sericite form imperfect pseudomorphs of feldspar phenocrysts. The quartz-sericite

matrix contains more or less disseminated tourmaline and fluorite and is cut by microscopic quartz-tourmaline-fluorite veinlets.

Black tourmaline is widely but very unequally distributed in the central mass of rhyolite porphyry and also is abundant in the adjacent hornfels. The amount of tourmaline in the rhyolite porphyry varies widely. Some light-colored rhyolite contains only a few rosettes of tiny crystals; some has been converted to a black tourmaline-quartz aggregate in which quartz phenocrysts are almost the only discernible remnants of the original rock. Among the partly tourmalinized rocks a striking variety is rhyolite porphyry profusely spotted with black tourmaline-quartz pseudomorphs of feldspar phenocrysts. This rock provides compelling evidence that the solutions soaked through the rhyolite porphyry, without being confined to open channels. Tourmaline is notably abundant in both matrix and fragments of the early lithified breccia, all of it apparently introduced after brecciation, for no crushed tourmaline was seen. The abundance of tourmaline does not imply, necessarily, that only the breccia offered channels for mineralizing solutions, inasmuch as some unbrecciated parts of the intrusive are thoroughly altered and contain much tourmaline.

Where channels were present, they, of course, influenced the progress of mineralization, as can be seen at outcrops of rhyolite porphyry that display a network of tourmaline-quartz veinlets, some paper-thin and others thicker than the intervening joint blocks. In general, the joint blocks retain their angularity even where alteration is intense, so that parts of the rock look like breccia, although they were but little affected by movement and crushing. The veined rock suggests that most of the tourmaline was introduced late in the process of alteration.

That the rock was permeable when invaded by solutions is shown also by several pockets partly filled with feltlike

masses of loose tourmaline needles, and by a few drusy cavities lined with tourmaline, quartz, and fluorite crystals evidently deposited in the order named.

TIN AND COPPER DEPOSITS

Cassiterite appears to be widely scattered in very small amounts and is abundant only in one small shoot, in which it was deposited principally by replacement of altered rhyolite porphyry breccia at a late stage in the quartz-sericite-tourmaline mineralization. This shoot is in the hanging wall of the Majuba fault, and the displaced footwall portion has not been found. The copper ore was deposited later as lenses in the fault, about 300 feet from the tin deposit. The dominant minerals in each deposit are different, although there are a few grains of cassiterite in the sulphide copper ores, and perhaps some sulphide minerals in the tin ore. The tin and copper deposits appear to be products either of two separate mineralizations or of two distinct phases of a protracted mineralization, and their situation on the same fault is a coincidence.

Majuba Hill mine workings

The distribution of the tin and copper deposits can be better understood after studying the Majuba Hill mine workings, maps of which form plate 10.

The oldest and highest adit, at an altitude of 6,451 feet, is 100 feet long, and a diagonal crosscut of the same length extends from it across the Majuba fault.

The workings on the middle adit level, at an altitude of 6,250 feet have a total length of over 1,600 feet. The adit is parallel to the fault and in the footwall, and it is connected by two crosscuts with 400 feet of drift along the fault. It was from this level that the copper deposit was mined. The main copper stope extends up along the fault from the south end of

the drift, and is accessible through a manway raised from the adit. A smaller stope below the drift is caved. The northern end of the drift passes through the tin shoot about 800 feet from the adit portal. A 20-foot raise, a winze now filled to within 15 feet of the drift bottom, and short lateral workings explore the tin shoot and adjacent ground.

The lowest of the three adits, at an altitude of 5,774 feet, is 2,000 feet long and cuts across the fault. Lateral workings with a total length of 450 feet were driven in prospecting for copper shoots on the fault, but no copper ore is in sight.

The Majuba fault

The normal fault which displaces the tin deposit strikes N. 50°W. and dips 45°-60° SW. Underground (see pl. 10) it is marked by a zone of sheared rhyolite and gouge which in places attains a thickness of 15 feet. The fault is exposed only in a pit northeast of the highest adit and cannot be identified elsewhere, although projection of the fault plane indicates that it should pass through the saddle above the mine workings.

Apparently the amount of displacement is small. In the drift that extends northwestward along the fault from the end of the west crosscut on the lowest level (see pl. 10), flutings show that the hanging wall moved obliquely downward and southward at an angle diverging 35° from a line pointing straight down the dip. The amount of displacement in this direction is certainly over 30 feet but probably less than 150 feet, as indicated by the offset of the contact between slate and rhyolite porphyry that is exposed in the footwall, on the east side of the drift. There are only slates in the hanging wall, on the west side of the drift, but no slates appear in the lateral that extends southward from the west crosscut. The contact can be employed as a datum plane for the fault displacement only with considerable uncertainty, because the intrusive contact cuts

across the bedding and probably is irregular, if considered over long distances. Other levels, however, afford no better information as to the amount of displacement.

The tin deposit

Mineralogy

The ore mineral of the tin deposit is cassiterite (tin dioxide), and the gangue minerals are the quartz, sericite, tourmaline, and fluorite which make up the altered rhyolite porphyry. Ore specimens from the drift are thickly coated with iron oxides, which also pervade the enclosing rock, and cassiterite-rich pieces can be distinguished from barren rock only by their high specific gravity. Specimens from the winze have less iron stain but are coated with a thin film of green scorodite. In broken or washed pieces, the cassiterite displays its characteristic dark-brown and yellow-brown colors and brilliant luster.

Hard, compact pieces of the richest ore consist of cassiterite grains either grown together solidly or intergrown with a little quartz and tourmaline. Such material grades into barren quartz-sericite-tourmaline rock, this gradation being the best evidence that cassiterite replaced altered rhyolite porphyry. Generally the quartz, tourmaline, sericite, and cassiterite of the massive specimens are intimately intergrown, and their relative ages are indeterminate or debatable, but some thin sections show that cassiterite-quartz veinlets cut through tourmaline crystals, indicating that at least part of the cassiterite formed late in the mineralization.

Some cassiterite is present in the copper sulphide ores. One specimen of chalcocite from the south end of the main copper stope was found by Milton to contain many microscopic grains of cassiterite and some of tourmaline. It is probable, however, that these grains are remnants of the altered rhyolite that was

replaced almost entirely by the copper sulphide minerals. Three selected specimens of sulphide minerals from a 6-foot mass exposed in the manway to the copper stope contained 0.50, 0.60, and 0.74 percent tin, according to reliable assays.^{6/} Chemical tests of other specimens from the same body of sulphides showed no tin, and in these the microscope revealed neither cassiterite nor tin-bearing sulphides. The presence of scattered grains of cassiterite in some specimens and not in others would account for these discrepancies.

Porous specimens of the tin ore consist partly of drusy crusts of well-formed cassiterite and quartz crystals and partly of an open meshwork of quartz aggregates and euhedral quartz crystals with a little tourmaline. The crusts appear to have lined cavities in altered rock, the quartz later than the cassiterite; and the quartz crystals in the open meshwork appear to be cavity-fillings also. Some of the porous material seems to have been leached by solutions.

The black tourmaline associated with the cassiterite is identical with that found in barren rock both near and at a distance from the tin shoot. The mineral forms slender needles, in radiate clusters or felt-like aggregates. Fluorite is present but is not more abundant than in other altered parts of the rhyolite porphyry.

No sulphide minerals were found in the tin-rich rock. The abundance of iron oxide and scorodite in part of it suggests that some sulphides such as arsenopyrite, may have been present, although this is not certain, for these oxidation products occur throughout the mine.

Distribution of cassiterite

All the cassiterite seen in place was in the tin shoot in the middle adit, in the hanging wall of the Majuba fault. Rich

^{6/} D. L. Evans, personal communication.

specimens were collected along the east wall of the drift for a distance of 10 feet, at several points up to 12 feet above the floor; on the south wall and pillar across a width of 9 feet; and from the winze, 6 feet below the drift. The largest piece seen in the drift was 6 inches long, but one mass in the winze was 24 inches long and 8 inches thick.

Minute grains of cassiterite were found in one specimen of chalcocite collected from the south end of the main copper stope, but a search by Miss Glass for cassiterite in several specimens from other parts of the mine was unsuccessful. Six specimens (not channel samples) selected as representative of diverse types of tourmalinized rock were crushed and the heavy minerals separated with bromoform and methylene iodide. A single grain of cassiterite was found in one concentrate, but it probably came from a high-grade specimen previously crushed. The locations from which the specimens were collected are shown on the map of the mine (pl. 10). Because so few samples were tested, the results have only limited value, but they do show that cassiterite is not a constant companion of tourmaline, and that abundant tourmaline is not an indicator of cassiterite. If cassiterite is at all widespread outside the known ore shoot, its distribution must be very sporadic.

Although no cassiterite was found elsewhere by the writers, its presence in other parts of the mine is indicated by assays that show small amounts of tin. One grab sample of altered rhyolite taken along the last 200 feet to the face of the lowest tunnel contained 0.12 percent tin,^{7/} and other assays ^{8/}are said to show that tin is present elsewhere.

Localization

Evidence as to the distribution of cassiterite is so scanty that conclusions regarding its localization cannot be positive.

^{7/} D. L. Evans, personal communication.

^{8/} F. L. De Longchamps, personal communication.

The fact that the single known deposit of tin ore in the hill is in altered and brecciated rhyolite porphyry suggests that alteration and brecciation were factors in the localization of the cassiterite, but until other tin shoots are found in similar material it remains possible that this association is fortuitous. As cassiterite was deposited largely by replacement, its localization may or may not be directly related to channels such as breccias or fissures. As tourmaline was introduced most abundantly late in the mineralization, it might be expected that, if cassiterite also is a late product, tourmalinized rock would be more likely than other varieties to contain cassiterite. Actually, however, cassiterite occurs only sporadically even in the tourmalinized rock.

Size and grade of the ore body

The single known body of tin ore is, as now exposed, about 20 feet long by 10 feet wide and extends about 20 feet vertically. Its shape is unknown, but if, for the purpose of rough calculation, it is considered rectangular, it has a maximum volume of 4,000 cubic feet and contains, at most 320 tons of rock. The tin content ^{9/} of samples cut from the faces is shown in the accompanying table. The average tin content is probably at least

Assays of tin ore

Location	Length of sample (feet)	Tin (percent)
North side.....	4	9.16
Do.....	4	.03
South side.....	1.5	5.52
Do.....	5.0	1.56
Do.....	5.0	3.12
Winze.....	2.0	6.50

2.0 percent, which indicates a total of more than 12,000 pounds of tin in the block. As the sporadic distribution of the cassiterite makes even sizable samples unrepresentative, the aver-

^{9/} D. L. Evans, personal communication.

age content of tin may be somewhat different from that estimated from these assays.

This body is the only reserve of potential tin ore now in sight, and because it is so small it could not be mined at a profit. Utilization of it depends, therefore, upon finding additional ore reserves by prospecting.

Suggestions for prospecting

Prospecting for additional tin ore might be aimed at (1) locating the offset part of the high-grade shoot, (2) discovering additional shoots, (3) developing a large body of low-grade ore.

The chances for success seem best for the first named objective, but even for this the uncertainties are rather discouraging. The offset footwall portion of the shoot is to be sought west of the normal fault, on the middle adit level. The amount of displacement is more than 30 feet, but probably less than 150 feet. The uncertainties connected with these figures have been emphasized, but assuming, in the absence of better information, that they have some validity, they indicate that the footwall part lies northeast of the part now exposed in the hanging wall a distance of 30 to 150 feet up the fault plane. A further hazard in prospecting for the footwall part of the shoot is the chance that, even if found, it may be small and end abruptly, for there is no assurance that the shoot was originally of great extent.

Unless a promising continuation of the known shoot is found, discovery of additional deposits is the only chance for profitable mining. The small size of the known shoot, and the absence of specific guides for finding new ones, makes prospecting for new bodies of high-grade ore highly speculative. The reports of small amounts of tin from several places suggest that there is a very remote chance of finding, through diamond drilling or underground prospecting, a sizable deposit of low-grade ore. Such

prospecting could be guided only by the generalization that tourmalinized parts of the rhyolite porphyry are most likely to contain tin. The first step would be adequate sampling of tourmalinized areas on the surface and underground, and only if this sampling provides encouraging leads would further work be justified.

The copper deposit

The 4,000 tons of 12 percent copper ore mined in 1915-18 came from two stopes, a large one above the middle adit and a small one below. Only the upper stope is now accessible. This extends 75 feet up the dip of the Majuba fault, and is 10 to 20 feet wide by 60 feet long. Mining has left only small remnants of the ore. At the sides of the stope there are a few lenses 1 to 3 inches thick and as much as 5 feet long, lying parallel to the fault in sheared rhyolite porphyry. These consist chiefly of chalcocite and cuprite. One 6-foot mass of sulphide minerals is exposed in the manway, 35 feet west of the main stope. No other concentrations of copper sulphides were seen, although small amounts of supergene minerals derived from the copper ore are widely scattered through the mine workings.

Mineralogy

Specimens from the manway are composed of a granular aggregate of chalcopyrite, pyrite, and arsenopyrite, all of which are fissured and seamed with chalcocite. A small amount of covellite is associated with the chalcocite. The lenses of chalcocite and cuprite in the main stope, on the other hand, contain only scattered specks of chalcopyrite, pyrite, and arsenopyrite. Associated with the ores are azurite, brochantite, chalcantite, chrysocolla (?), and malachite, all of which are common oxidation products of copper ores.

Scorodite, olivenite, chalcophyllite, and torbernite, also derived from the sulphide ores, are widely scattered through the mine. Scorodite, a hydrous ferric arsenate, is notably abundant in the winze at the tin shoot, where it forms a thin coating on jointed masses of ore and rock. Thicker parts of the incrustation display mamillary forms and fibrous structure. Olivenite, chalcophyllite, and torbernite are found as well-formed crystals on joint faces. Olivenite, a basic copper phosphate, is plentiful in the two upper levels of the mine, in acicular crystals that range in color from pistachio green to nearly black. Chalcophyllite, a hydrous copper arsenate of variable composition, was found on the dump of the highest adit. The mineral is bright green and of platy habit. Torbernite (hydrous phosphate of copper and uranium) occurs only sparingly, but numerous crystals were found in the lowest adit, 1,800 feet from the portal. The crystals are green and platy, somewhat like those of chalcophyllite; they are rectangular and have striated surfaces.

Origin

The normal fault localized the deposition of the ore. Chalcopyrite, arsenopyrite, and pyrite, the primary minerals, were deposited in thin lenses along fissures in the faulted rhyolite porphyry, and in a few thicker masses that locally replaced the rock. These primary sulphides were replaced by secondary minerals, which were of higher copper content and consequently enriched the ore.

Reserves

There are no copper reserves in sight, because mining in 1915-18 exhausted the known ore bodies. Prospecting for additional ore would involve further exploration of the fault, but previous work of this type has been unsuccessful.

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