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# A PRELIMINARY REPORT ON THE COPPER-COBALT DEPOSITS OF THE QUARTZBURG DISTRICT, GRANT COUNTY, OREGON

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

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## Abstract

The copper- and cobalt-bearing veins of part of the Quartzburg district are in fracture zones trending about N. 70° E. in folded Permian(?) metavolcanic rocks on the southwest side of a quartz diorite stock. Along many of the veins fine-grained tourmaline and quartz have replaced the country rock. The primary ore minerals are chalcopyrite, glaucodot, safflorite, and cobaltite. The copper- and cobalt-rich parts of the deposits appear to be in separate ore shoots. Gold content is generally higher in the cobalt-bearing parts of the veins than in the copper-rich parts.

The Standard mine has developed part of one vein zone. Several other vein zones that crop out may contain as much copper as the Standard vein zone. Further bulldozing and diamond drilling on the surface, and more geologic mapping, sampling, and diamond drilling underground are suggested as means to explore for more ore deposits.

## Introduction

Because of the strategic shortage of cobalt in the United States, the copper-cobalt deposits of the Quartzburg district were examined, starting in 1951. This report is limited to that part of the district where the copper-cobalt deposits are best developed, namely along Standard Creek, in the northern half of section 12 and the southern half of section 1, T. 12 S., R. 33 E., Willamette Meridian, Grant County, Oregon. The area is about seven miles by gravel and dirt road north of Prairie City, which is on U. S. Highway 28. The neareast railroad is about 40 miles southwest, at Seneca, Oregon. Baker, Oregon, served by the Union Pacific Railroad, is approximately 80 miles northeast of the district.

The Quartzburg district, in the western part of the Blue Mountain section of the Columbia Plateau physiographic province, is mostly in the drainage of Dixie Creek, on the south side of the divide between the John Day River and the Middle Fork of the John Day River. The part of the district described here lies mostly on the east side of Standard Creek, the largest southwest-flowing tributary to Dixie Creek. Altitudes range from approximately 4420 feet on Standard Creek to 5880 feet on Standard Ridge. Although the sides of the canyon slope about 25°, soil cover is extensive and outcrops are sparse.

Rainfall in the valleys is between 10 and 12 inches per year but in the mountains it is several times this amount. The principal streams, including Dixie, Standard, and Copperopolis Creeks, contain at least some water most of the year. Most of the district has a fairly thick cover of mixed conifers, except for some south facing slopes where sagebrush, mountain mahogany and other similar brush grows. Alders, aspens, and willows form dense thickets along the streams. Intensive lumbering has removed the conifers in a few places.

In 1900 W. Lindgren briefly examined the Quartzburg district during his study of the gold deposits of the Blue Mountains (Lindgren, 1901); Swartly (1914) examined the district in 1913, and in 1930 Gilluly, Reed, and Park (1933) studied the district in more detail. During the early part of World War II the U. S. Bureau of Mines studied the Standard mine and sampled the accessible faces. Publication of the maps made then has been approved by the U. S. Bureau of Mines.

Most of the field work was done during the summer of 1951; mapping and geochemical work was done by J. W. Hosterman and Frank W. Dickson, assisted by W. A. Roberts and J. E. Grant, under the supervision of J. S. Vhay. In September 1956, after considerable bulldozing had been done on the hillside around the Standard mine Vhay made a detailed map of this area and of new underground workings.

In this preliminary report on the copper-cobalt deposits of the district, only the Permian(?) metavolcanic rocks and the intrusive rocks will be described; no further mention will be made of other formations present elsewhere in the district (serpentine, gabbro, Late Cretaceous conglomerate and sandstone, and Tertiary volcanic rocks) nor of the other ore deposits in the district (gold deposits, mostly southwest of the area covered by plate 1).

## Geology

The area is underlain mostly by Permian(?) metavolcanic rocks, which have been intruded by a mass of quartz diorite and a few siliceous dikes (see plate 1). The Quaternary formations, which are not shown on plate 1, consist of siliceous volcanic ash which is as much as 20 feet thick along the lower side of the canyons, and present stream alluvium, which locally is over a hundred feet wide in small gravelly bottoms.

### Permian(?) metavolcanic rocks

Metavolcanic flows and pyroclastic rocks underlie all except the northeast quarter of the area on plate 1. The thickness of these rocks is not known as neither the top nor the bottom of the unit was recognized, and no stratigraphic sequence was worked out. Their age is also unknown, but they are similar in lithology to and thus are probably correlative with the Permian rocks in the John Day quadrangle (Thayer, 1956) and the Clover Creek greenstone of Permian age (Gilluly, 1937, p. 26) in the Baker quadrangle.

The Permian(?) metavolcanic rocks consist predominantly of dark greenish-gray andesite, which locally is porphyritic. The phenocrysts are andesine that, like the plagioclase in the groundmass, are partially altered to a mixture of albite, epidote, calcite, and sericite. The pyroxene is mostly altered to chlorite and calcite; some amphibole is present. Included in the metavolcanic rocks is a very dark greenish, almost black metabasalt in which the labrodorite is altered to a mixture of albite, clinozoisite, and sericite, and most of the pyroxene is altered to chlorite. The metavolcanic sequence also includes some lighter colored rocks that are considerably recrystallized and replaced by sericite, chlorite, and calcite, and are probably altered rhyolite or dacite.

## Intrusive rocks

The intrusive rock in the northeast quarter of plate 1 is quartz diorite which locally contains dioritic facies and granite aplitic facies. The quartz diorite is a fine- to medium-grained, equigranular, light-grey to pinkish-gray rock, which, near its contact with the metavolcanic rocks, is porphyritic with a fairly fine-grained matrix. The quartz diorite is composed chiefly of oligoclase and hornblende and lesser amounts of quartz, biotite, and perhaps a little orthoclase. Magnetite, zircon, and apatite are accessory minerals. In most places the minerals are unaltered, but in places the plagioclase is partly altered to sericite and the mafic minerals to chlorite. The quartz diorite appears similar to the intrusive rock on Canyon Mountain, in the Strawberry Range, south of John Day, which Thayer (1956) believes to be pre-Late Triassic in age.

A few feldspar porphyry dikes, only two of which are shown on plate 1, cut the metavolcanic rocks, and are believed to be considerably younger than the quartz diorite. The chemical composition of these dikes was originally probably close to quartz latite; now they are highly altered and composed chiefly of sericite, carbonates and probably a clay mineral.

## Structure

The Permian(?) volcanic sequence was tightly folded, metamorphosed, and faulted to a certain extent before the intrusion of quartz diorite. Renewed fracturing took place after intrusion and was followed by the emplacement of the porphyry dikes. As shown elsewhere in the district there was tilting and further faulting after the deposition of the Tertiary volcanic rocks.

Because of the lack of recognizable key horizons, the structure of the metavolcanic rocks is not known, but steeply dipping and overturned tuff beds in these rocks at a few places in the district indicate that the rocks have been intensely folded. That further deformation took place after the quartz diorite was emplaced is indicated by the fact that some mineralized fractures occur within the quartz diorite. All the mineral deposits in the district were formed probably later than the intrusion of the quartz diorite.

The faults and veins[1] shown on plate 1 consist of a group with an average trend of about N. 70° E. (abundantly exposed on the hillside around the Standard mine mostly because of the amount of bulldozing there, see plate 2), a few with north or north-northeast trend, and very few with east trend and with northwest trend.

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[1] All the veins are believed to lie along fractures which have had at least some movement, and therefore represent faults or fault zones.

The faults with an average trend of about N. 70° E. are abundant in the bulldozed area and are important economically in that they contain most of the copper and cobalt deposits. By far the greater number of these faults trend between N. 65° E. and N. 75° E.; a few extremes as low as N. 55° E. and as high as N. 85° E. are present. The dips of the zones are predominantly between 75° and 85° southeast; at a few places dips as low as 60° southeast are present, and a few zones standing vertically or dipping steeply northwest were observed.

The zone of faulting along which the Standard mine is located is exposed for over 2200 feet. That on which the Side Issue adit is located is probably exposed for about 1500 feet, and the Juniper vein for about 1200 feet. Though exposed for shorter distances, other zones trending N. 70° E. are presumed to have similar or greater lengths. As exposed in the trenches, most of the fault zones show widths of fracturing between 10 and 20 feet. In places the zones of gossan plus altered rock, which probably represent hydrothermal alteration along and within fractures, are up to 70 feet wide. About half of the larger zones exposed (plate 2) show gouge from a few inches to about one foot wide somewhere along their length. Nearly all the fracture zones apparently had at least some movement along them, even though gouge was not observed in the trenches or underground. The amount of offset on the N. 70° E. group of faults is unknown because of the lack of key beds or other structures older than this group.

As seen underground the Standard zone consists in places of a single fracture joined at low angles by branching fractures; in other places it consists of a series of fractures, over a width of five feet.

On the surface the same zone in some trenches consists of parallel fractures (plus gossan and altered rock) spaced over a width of 10 to 15 feet.

Of the north to north-northeast trending faults only the one passing about 200 feet east of the Juniper portal, 250 feet east of the No. 1 level of the Standard mine, through the upper level of the Johnson mine, and across the road above the Johnson mine is known for any extent (plate 2). Two faults on Cougar Ridge and one on Copperopolis Ridge are seen in small adits. Three are exposed only in the bank of the "cat road" going north-northeast from just above the Standard No. 1 portal.

The strike of these faults or fault zones is between N. 10° W. and N. 30° E., the only one with a strike more easterly than N. 15° E. being the northern part of the long one described above. Dips are between 60° and 85° east, except for two faults that stand vertically.

The fault mentioned above as passing east of the Juniper and Standard mines trends about N. 14° E. in its southern half and then about N. 30° E. (see plate 2). Its known length is about 2000 feet and it probably extends considerably farther both to the south and to the north-northeast. Its width is about 10 feet as exposed in the Juniper mine and in the No. 1 level of the Standard mine (plate 3); in the No. 2 level of the latter mine it is nearly twenty feet wide and consists of a zone of intensely sheared rock containing some quartz, pyrite, and probably other vein minerals. In the accessible level of the Johnson mine two to five feet of quartz and gossan are present in the fracture zone. On the road above the Johnson mine up to four feet of gossan and quartz lies in a probably somewhat wider fracture zone.

This north-northeast trending fault zone is younger than the set of faults having an average N. 70° E. trend, and offsets them about 30 feet north on the east side.

The amount and direction of movement on the other faults of north to north-northeast strike is unknown. Their widths as exposed are between two and four feet, and except for the two zones on Cougar Ridge, which are explored by adits about 150 feet long, each of them is seen at only one exposure.

Only four faults with a northwest trend were observed. The one best exposed, in the trenches around level 5 of the Standard mine (plate 2) and in level 5, has an extremely altered porphyry dike along it, and the adjacent country rock is also somewhat altered for a few feet out from the dike contacts. The dike shows shearing on both walls and also within it. Apparently the dike was injected into a fault zone which had some renewed movement after the intrusion of the dike. This fault has an over-all trend of about N. 56° W.; in level 5 it has a strike of N. 61° W. and dips 65° NE. In the top trench a strike of N. 59° W. and a dip of 55° NE. were observed. This fault, and the dike, are exposed in the trenches over a distance of about 650 feet. The widths on the surface, where exposures are poor because of the deep weathering of the dike, are from 10 to 15 feet; in level 5 the fault zone plus the dike is only about 6 feet wide. No offsets of any markers, such as beds or veins, were observed, but consideration of the relations between level 6, level 5, and a surface exposure between the two levels suggests strongly that this fault offsets the Standard vein zone about 18 feet to the northwest on its northeast side. As this fault appears to be later than both the N. 70° E. group and the long north-northeast fault that goes through the accessible level of the Johnson mine (it contains much less mineralized material), it is shown on plates 1 and 2 as offsetting all the other faults.

Only three easterly trending faults show on plate 1. One is exposed in a trench in the northeast corner of plate 2 (near survey point 5332) where fractures in a zone about 30 feet wide strike between N. 88° W. and N. 80° E. and dip 85° to 88° to the south. The fractures contain some gossan and the country rock between them has been somewhat tourmalinized. This zone of mineralized fractures probably represents merely a local variation in strike of the N. 70° E. group, inasmuch as the hydrothermal alteration along it is similar to that in the N. 70° E. group. The other two east-trending zones of fracture are on Copperopolis Ridge, and are exposed only in a couple of prospect pits. One stands vertically, the other dips 85° to the south. Nothing is known regarding their length, width, character, or direction of movement.

## Mineral deposits

### History

Placer mining for gold in the Quartzburg district began about 1862 and has continued intermittently, at least on a small scale, to the present time. Mining of the gold-quartz veins began about 1880, and although many of the early-discovered gold veins were worked out down to creek level by 1914 (Swartley, 1914, p. 196), some lode mining continued up to 1942 when gold mining was discouraged by the government (order L208) during World War II.

Exploration of copper-cobalt veins began about 1900 at the Standard and Copperopolis mines; between then and 1908 a little copper and cobalt were produced from the former and a little copper from the latter. In 1923 and during the years 1933 to 1935 a little more copper was produced at the Standard mine. Starting about 1955 R. E. Summers did considerable bulldozing around the Standard mine, and he has shipped some copper ore from two new levels on the Standard vein zone.

## Types of deposits

In general two types of mineral deposits have been explored in the district. The faults averaging N. 70° E. (plate 1) carry in places copper, cobalt, and gold, with the gold accompanying the cobalt minerals generally. The known zones containing these metals are limited mainly to the area covered by plate 1. Gold-quartz veins, carrying only minor amounts of base metals are present in the north to north-northeast trending fault zones (mostly occurring southwest of the area of plate 1), and are present on some of the northeast- and east-trending faults. The stope in the upper level of the Johnson mine (plate 3) is on such a vein. As this preliminary report is concerned mainly with the copper-cobalt deposits of the district, no further description will be made of the gold-quartz veins.

## Copper-cobalt deposits

The copper-cobalt deposits occur along the fault zones trending on the average N. 70° E. The wallrock of all the known deposits is the Permian(?) metavolcanic rock. Two veins explored by adits, now caved, do cut the quartz diorite (see plate 1), but no copper minerals were recognized on the dumps. As more quartz porphyry dikes are present than shown on plates 1 and 2, it is possible that this rock may contain copper-cobalt deposits somewhere in the area. The vein material was deposited partly as filling in the fractures and the brecciated zones along the fault zones, and partly by replacement of the wall rock along the fractures.

The best exposed vein zone, the Standard vein, is exposed intermittently over a distance of about 2200 feet; the Side Issue zone is exposed over a distance of about 1500 feet, and the Juniper for about 1200 feet. A number of others are exposed for distances of from 800 feet down to about 200 feet. Others are exposed in only one trench and so nothing is known about their length. In the trenches the combined width of the gossan plus the altered rock along the veins is generally between 10 and 20 feet. A few zones are up to 30 feet wide, and one, near the north edge of plate 2, shows about 70 feet of iron-stained altered rock plus numerous stringers of gossan. Narrower veins, down to a few inches thick, are exposed in places. Underground single veins are from a few inches up to about four feet thick, but it is suspected that in many places a vein zone consists of two or perhaps more similar parallel veins.

The gangue of the veins consists mainly of quartz[/], and lesser

[/] The description of the primary minerals is based on samples collected from the Standard mine.

amounts of pyrite, dolomite, or calcite, and in places tourmaline. Much country rock, replaced in large part by fine-grained quartz and tourmaline, is present within the vein zones. The ore minerals are mainly chalcopyrite and glaucodot; a little safflorite and cobaltite are also present. The chalcopyrite and the cobalt minerals appear to be concentrated in different parts of the veins, although some copper is generally present in the parts of the vein high in cobalt, and some cobalt may be present where the vein is high in copper. Judging from the assays of samples taken by the U. S. Bureau of Mines, it appears that most of the gold in the veins is more closely associated with the cobalt minerals than with the chalcopyrite.

Two types of hydrothermal alteration of the wall rocks along the veins are present. One is the replacement by fine-grained tourmaline and quartz, similar to that in pieces of country rock found within the veins, which produces a dark-gray to black dense rock; this material may be present in bands three to ten feet wide on both sides of the veins. At the broad zone at survey point 4925, near the north edge of plate 2, this tourmalinized and silicified material occupies most of the 70-foot wide zone of mineralized rock. This dark hard altered rock, usually somewhat iron-stained, is resistant to weathering and stands up in the trenches above the gossan in the vein. The second type of hydrothermal wall rock alteration is the introduction of disseminated pyrite and replacement of the country rock minerals by sericite. It is present to at least a certain extent along all the veins, whether or not the tourmaline-quartz type of alteration is present. Where the tourmaline-quartz type of alteration is present the quartz-sericite type extends out farther from the vein. Near the surface, as shown in the trenches, quartz-sericite rock weathers to a somewhat iron-stained, soft, clay-like material.

Tourmalinization and silicification of the wall rock along the fractures, and probably the deposition of quartz and tourmaline in veins, took place first. Then glaucodot and pyrite as well as minor amounts of cobaltite were deposited in the veins. Safflorite may have been deposited at this time also, but it may have formed by alteration (the subtraction of sulfur) during the later deposition of chalcopyrite. The chalcopyrite was deposited after a period of fracturing which re-opened parts of the vein zone. Quartz was deposited, or at least re-crystallized, during all stages of deposition, and the calcite or dolomite appears to be late. When the pyrite and sericite formed in the wall rocks is not known, but it is believed to have been later than the formation of the tourmaline.

The weathered outcrops of these veins are shown on plate 2/. The

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/ The letters by each exposure of vein material or altered rock on plate 2 indicate what was observed there.

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gossan material in the veins consists of both reddish brown (hematite) and yellowish brown (goethite) iron oxides. Scorodite, or a similar iron arsenate, is probably present but has not been identified as yet. The somewhat iron-stained dark gray or black rock along the veins is the tourmaline-quartz wall rock replacement material. Outside of the tourmaline-quartz rock, or along the veins when it is not present, is the iron-stained, soft, claylike material resulting from the weathering of the pyrite-sericite type of altered wall rock. In many places, numerous veinlets of gossan which represent small veins branching from the main vein cut the claylike material. Malachite, chrysocolla, and probably other copper minerals of the oxidation zone are seen in many of the vein zones exposed in the trenches (plate 2). Although no cobalt minerals were recognized on the surface, spot geochemical testing of the soil shows several anomalously high areas in addition to the outcrop area of the Standard vein, where high values would be expected.

Plate 2 shows that although some gossan was observed at almost all exposures, only about one-quarter of them showed vein quartz present. At almost half of them tourmaline and fine-grained quartz are present; this tourmalinized and silicified rock is probably even more abundant than is indicated on plate 2. Copper minerals characteristic of the oxidized zone were observed in about one-third of the exposures. This means that copper is present, at least in places, in about half of the larger vein zones shown.

### The Standard mine and neighboring workings

Plate 3 shows a composite plan of the Standard mine (levels 1 to 4 from the U. S. Bureau of Mines), and of other workings in the vicinity (shown in their correct positions and at the same scale as plate 2), and the geology of the accessible levels, those of the Standard mine being on offset plans. Plate 7, U.S.G.S. Bulletin 846-A (from D. F. Hewett's notes), as well as the sections made by the U. S. Bureau of Mines in 1943, permits a rough calculation of the area of the stopes in the Standard mine, most of which are indicated on plate 3. In places the stopes are as much as five feet wide, but assuming an average width of 3.5 feet for them, calculations show that the total tonnage removed to be about 10,000 tons. The amount of copper, cobalt, and gold recovered from this ore is not known. The other underground workings (plate 3) show but little ore removed. A little stoping was done in the Juniper mine, none was observed in the Grover Cleveland or Willie Boy adits, and the Side Issue adit, with a small dump, is inaccessible.

The Standard mine is almost entirely in the metavolcanic rocks, which are strongly tourmalinized and silicified along the main vein zone. The Bureau of Mines mapping shows that three quartz porphyry dikes (not shown on plate 3) are cut by the long crosscut to the southeast on level 1. The Standard vein lies in a fairly continuous zone of apparently relatively weak fracturing. The zone is made up of a number of more or less parallel fractures in some places and of only one or two fractures in other places. Along this zone of fracturing the tourmalinized and silicified rock is fairly continuous. The concentrations of either chalcopyrite or of cobalt minerals, rich enough and wide enough to be mined at a profit, however, occur only where some factor such as change of attitude or the low-angle intersection of fractures formed ground open enough for filling or fractured enough for replacement.

The mineralogy of the vein has already been described on page 13. In general the ore shoots on level 1 are high in cobalt and gold, whereas those on level 2 and presumably on levels 3 and 4 are higher in copper and contain but little gold.

## The Copperopolis Mine

The only other known copper deposit in this area is explored by the Copperopolis mine (plate 1). This deposit lies along a N. 60° E. fault zone and is a chimneylike mass of quartz-tourmaline rock underground, about 40 feet in diameter; on the surface, according to Gilluly, Reed, and Park (1933) it is a long, oval-shaped body, "about 1000 feet long and 75 feet wide at the widest place . . .". The body consists mostly of milky quartz plus some tourmaline. In this are scattered pockets of pyrite and chalcopyrite. In places small amounts of cobaltite are present. Gilluly, Reed, and Park (1933) report that small amounts of magnetite, hematite, tetrahedrite, bornite, galena, and sphalerite are also present. A chemical analysis of material from the mine shows 0.70 percent $WO_3$, suggesting the presence of a tungsten mineral. The Copperopolis mine exposes the replacement body fairly well, but copper was mined in only one small stope; presumably the whole quartz-tourmaline body is rather low grade.

## Exploration possibilities

Additional exploration along several vein zones in the Quartzburg district might indicate the presence of undiscovered copper-rich ore shoots or cobalt-gold ore shoots. A few favorable areas are discussed below.

The copper-bearing gossan zone appearing on plate 2 at survey points 4819, 4983, and 140 feet east of 5022 was not recognized in the longest southeast crosscut of level 1 of the Standard mine. Geologic mapping plus some sampling of the crosscut should show up this mineralized zone if it extends down to that depth.

The Willie Boy adit (plate 3) should cut several broad mineralized zones which are exposed on the surface along the road between survey points 4802 and 4847.5. These contain gossan and tourmalinized rock with malachite and other secondary copper minerals. Additional mapping and sampling in the adit might indicate the presence of these zones.

The gossan about 20 feet north-northwest of survey point 5007 is believed to be the hanging wall part of the main Standard vein; a projection of this to the altitude of level 5 (4909 feet) comes about 20 feet south of the workings, between the portal and the siliceous dike. Therefore it is suspected that the underground workings in this interval are on north branches of the main Standard vein. Some bulldozing south of the portal, and diamond drilling (or crosscutting) underground would be necessary to check this possibility. Similarly, projecting the outcrop of the hanging wall of the Standard vein exposed on the road above level 1 down to that level suggests that between the portal and the main north-northeast fault the underground workings are on a minor vein parallel to and about 15 feet north of the main vein. This would best be checked by diamond drilling south from the wide place on the drift roughly half way in to the drift on the north-northeast fault.

On plate 2 about nine vein zones are shown that contain at least some oxidized copper minerals. A few of these vein zones are almost as continuous as the Standard vein, and their oxidized outcrops contain about as much evidence of copper mineralization as does the outcrop of the Standard vein. A few of these zones may contain copper-rich ore shoots or cobalt-gold ore shoots. Exploration possibilities along these zones include:

(1) further bulldozing along those zones which show copper minerals,

(2) short diamond drill holes from the surface to test below the zone of oxidation,

(3) diamond drilling in level 1 of the Standard mine and in the Willie Boy adit to further test at depth those zones which look favorable on the basis of the surface work, and

(4) reopening and mapping and sampling the caved adits in the area and the inaccessible parts of the Standard mine.

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