UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary
GEOLOGICAL SURVEY
WALTER C. MENDENHALL, Director

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COPPER DEPOSITS IN THE SQUAW CREEK AND SILVER PEAK DISTRICTS AND AT THE ALMEDA MINE, SOUTHWESTERN OREGON WITH NOTES ON THE PENNELL & FARMER AND BANFIELD PROSPECTS

BY

PHILIP J. SHENON

WASHINGTON

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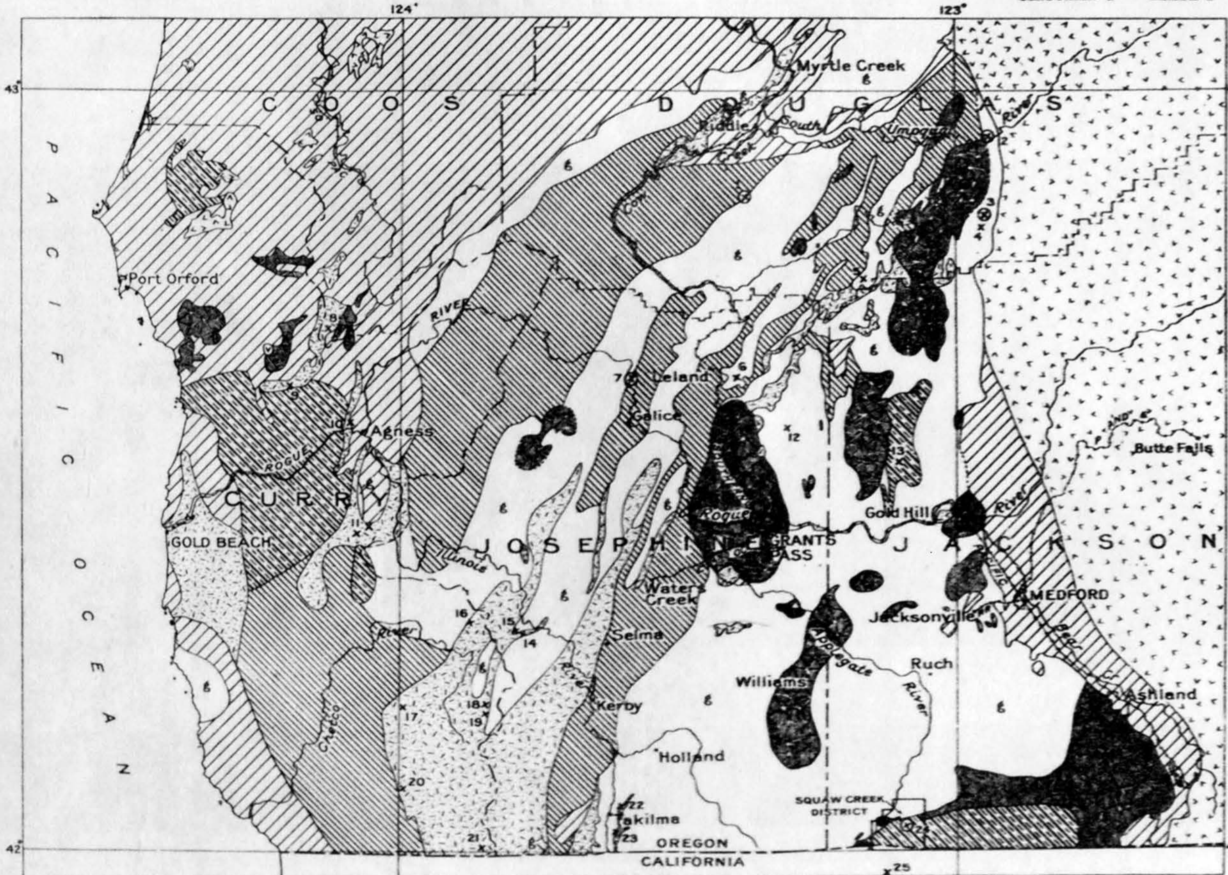


EXPLANATION

Sedimentary rocks

POST-JURASSIC: Quaternary, Tertiary, and Cretaceous

JURASSIC: Dothan and Galice formations

PRE-CAMBRIAN OR PALEOZOIC: Principally schists and phyllites, largely of sedimentary origin; some interbedded limestones

Igneous rocks

TERTIARY: Volcanic rocks

LATE JURASSIC OR EARLY CRETACEOUS: Serpentine

Quartz diorite, granodiorite, and related rocks

PALEOZOIC AND MESOZOIC: Greenstones with numerous lens-shaped areas of sedimentary rocks and some areas of altered rhyolite

⊗ Mine or prospect described in text

x Other mine or prospect

Base from U. S. G. S. $\frac{1}{500,000}$ map

GEOLOGIC MAP OF SOUTHERN OREGON SHOWING LOCATION OF COPPER MINES AND PROSPECTS

10 0 10 20 Miles

Geology compiled by G. W. Stose and P. J. Shenon.

Copper deposits in the Squaw Creek and Silver Peak districts and at the Almeda mine, southwestern Oregon, with notes on the Pennell & Farmer and Banfield prospects.

By Philip J. Shenon

Abstract

This report describes copper mines in the Squaw Creek district, in Jackson County, Oreg.; the Blue Ledge mine, nearby; the Silver Peak district, near Riddle, Oreg.; the Almeda mine, near Galice, Oreg.; and some outlying prospects. Of the total reported production of some $2,000,000 from copper mines in southwestern Oregon, the districts described are credited with about $181,000. However, considerable more production is expected from some of the mines in these districts whenever metal prices warrant operation.

Metamorphic rocks including schist, phyllite, and marble of Devonian age or older underlie most of the Squaw Creek area. These rocks are overlain by quartzite and argillite with limestone lenses, which have been tentatively classed as Carboniferous(?). Terrace and stream gravel complete the list of sedimentary rocks. The igneous rocks include medium and fine grained greenstones of probably Carboniferous or Jurassic age and serpentine, quartz diorite, and related rocks of Jurassic or early Cretaceous age.

The Pacific States Mines Co.'s property, in Oregon, and the Blue Ledge mine, in California but tributary to Oregon, are the principal mines in the Squaw Creek district. Both deposits occur as replacement bodies in schist. The layers of schist are not everywhere completely replaced but contain variable amounts of quartz and sulphides. Pyrite and chalcopyrite are the principal sulphides at the Pacific States mine, and pyrrhotite, pyrite, chalcopyrite, sphalerite, and galena at the Blue Ledge mine. The mineralized layers at the Pacific States property evidently contain a large tonnage of material that appears to be of very low average grade and some small shoots of better-grade ore; the Blue Ledge mine contains a considerable blocked out tonnage of better-grade ore.

The rocks in the vicinity of the Silver Peak mines consist of schists mapped by Diller as portions of the Dothan formation and greenstones of probable Jurassic age. Both are greatly altered in the vicinity of the mines. The principal properties of the district - the Silver Peak Copper and the Umpqua Consolidated mines - have partly developed the same ore bodies. The ore bodies occur in highly foliated schist as irregular-shaped masses of nearly solid sulphides and as disseminated deposits. Copper-zinc ore of good grade carrying gold and valued at about $73,000 has been shipped from these mines. In addition considerable ore is partly blocked out by underground openings. The principal ore and gangue minerals are pyrite, chalcopyrite, sphalerite, bornite, galena, chalcocite, tennantite, quartz, and barite. Bodies of nearly solid sulphide ore from 5 to 10 feet wide have been followed on the lower levels of the mines for a total horizontal distance of over 400 feet, and in at least two places ore con-

tinues beyond the present workings. Because of the length of the shoots and the hypogene character of the mineralization on the lower levels, it is believed that the ore continues downward for some little distance below the present lowest workings with but little change in the mineral content. The Golden Gate property, north of Silver Butte, has produced some ore, but at present very little of minable grade is developed. Bands of schist with disseminated sulphides similar to those at the Silver Peak Copper and Umpqua Consolidated mines have been prospected, and one shoot of good-grade gold ore has been mined.

The Almeda mine is one of the most extensively developed mines in southwestern Oregon. It is credited with a production in gold, silver, and copper valued at about $108,000. The ore is found in porphyritic dacite close to the contact with argillite. A wide intensely silicified zone containing some gold and known as the Big Yank lode contains shoots of better-grade ore. This better ore consists of the intensely silicified porphyritic dacite more or less extensively replaced by barite, pyrite, chalcopyrite, galena, sphalerite, chalcocite, and covellite. Covellite has been added by supergene processes. The silicified zone at the Almeda mine, known as the Big Yank lode, constitutes a tremendous reserve of very low grade material that should be given some consideration when metal prices justify. The feasibility of working material of this sort, even under favorable conditions, will depend largely upon the results of very careful and complete sampling. Mining at the Almeda mine has demonstrated the occurrence of good-sized bodies of better-grade ore which if mined with the lower-grade silicified material would tend to raise the average metal content or which under more favorable conditions might be worked in themselves.

The Banfield and the Pennell & Farmer properties are two outlying prospects that have been rather extensively developed. The Banfield property has a reported production of 52 tons containing 10,059 pounds of copper and 19 ounces of silver. At this property chalcopyrite and magnetite occur as irregularly distributed stringers, grains, and bunches in greenstone; at the Pennell & Farmer mine chalcopyrite occurs as streaks and grains along the foliation in a dark hornblende schist.

Introduction

Field work and acknowledgments.- This paper presents the results of investigations in several copper-mining districts in southwsetern Oregon by the United States Geological Survey, in cooperation with the State of Oregon. (See pl. 1.) Two other copper-mining districts in southwestern Oregon are described in another report.1/ The field work was done in 1930 under the supervision of J.T. Pardee by the writer, who was assisted by Duncan Johnson and Aubrey Walker in the Squaw Creek district and by Aubrey Walker in the Silver Peak district and at the Almeda mine.

The Squaw Creek district, including the property of the Pacific States Mines Co. in Oregon and the adjacent Blue Ledge mine in California, was examined during part of August, and the Silver Butte district and the Almeda mine early in September. Although in California, the Blue Ledge mine is more or less tributary to Oregon by reason of the fact that the natural route to it passes through that State.

The writer wishes to acknowledge the courtesies extended by all the mining men with whom the field party came into contact. In particular he wishes to thank Mr. C. C. Clark, of Medford; Mr. Harry Barr, of Watkins; Mr. Carl Vanstrand, engineer of the Blue Ledge mine; Mr. Harry Sordy, of the Almeda mine; and Messrs. J. E. Reeves, J.K. Elder, and W. A. Bradfield, operators in the Silver Peak district. Special acknowledgments are due to Mr. A. B. Yates, formerly geologist for the Homestake Mining Co., for permission to use maps of the Almeda mine in this publication and for information regarding the ore bodies.

Production of copper mines in southwestern Oregon.- Including the gold and silver content, the value of the ore produced by the copper mines of southwestern Oregon is estimated at nearly $2,000,000, distributed as follows:

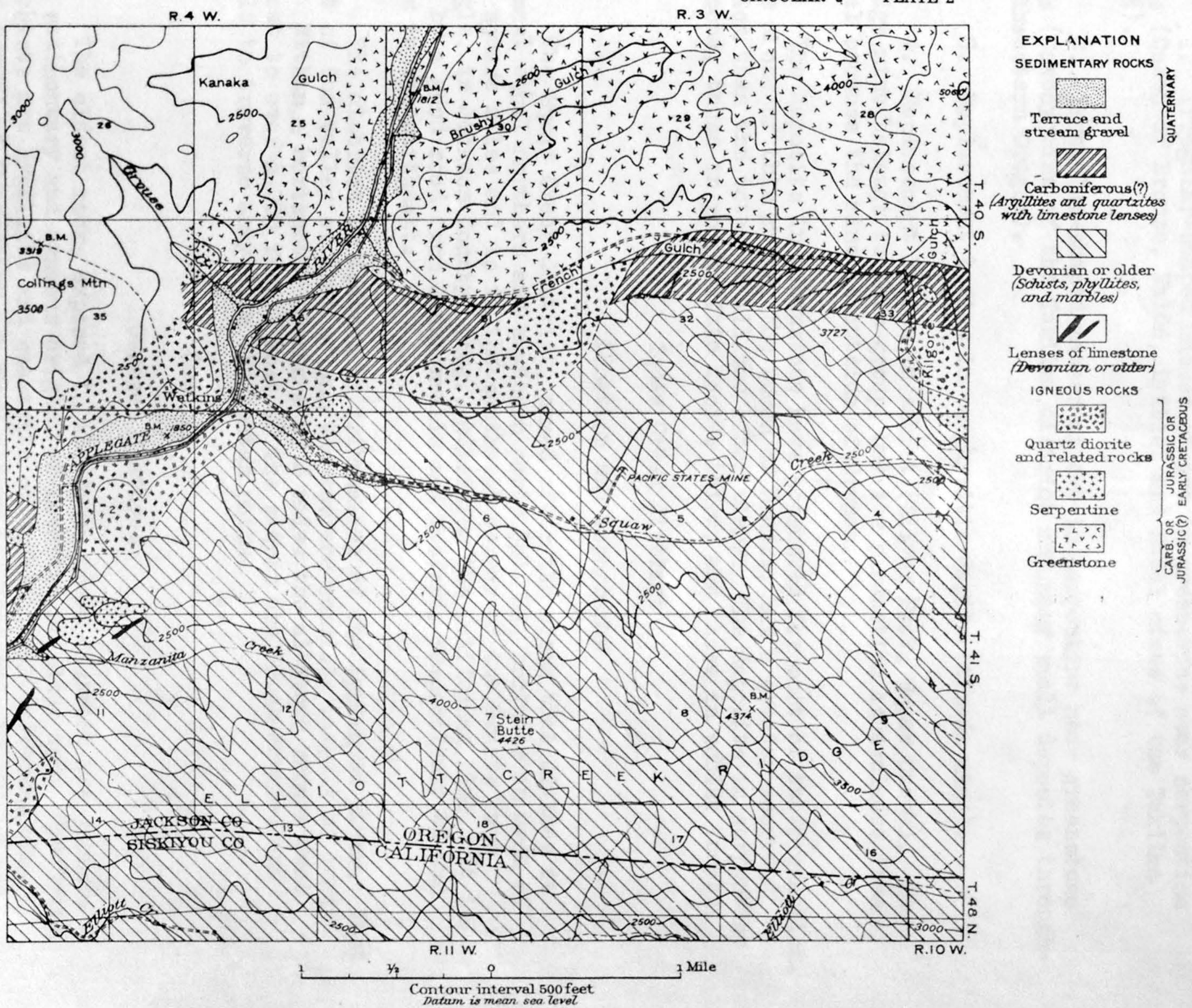
Reported production of copper-mining districts in southwestern Oregon a/

	Gold (ounces)	Silver (ounces)	Copper (pounds)	Estimated gross value
Takilma district	7,263	8,787	7,041,533	$1,700,000
Almeda mine	1,540	48,387	259,800	108,000
Silver Peak district	228	12,203	41,450	73,000
Other mines b/	268	732	81,192	20,000

a/ Figures from data furnished by Victor C. Heikes, of the U.S. Bureau of Mines.

b/ No records of many small copper mines are available, but their output would probably not swell the total of the fourth group above $100,000.

1/ Shenon, P.J., Geology and ore deposits of the Takilma-Waldo and Blue Creek districts, southwestern Oregon: U.S. Geol. Survey Bull. 846-B, 1933.



GEOLOGIC MAP OF THE SQUAW CREEK DISTRICT, OREGON-CALIFORNIA

As a means of comparison, the deposits may be classified as follows in four groups, based upon the character of the enclosing rock:

1. Irregular-shaped masses of ore in greenstone near serpentine contacts (Queen of Bronze, Waldo, Lyttle, and Mabel mines of the Takilma district).

2. Irregular-shaped masses of ore in serpentine near greenstone contacts (Cowboy mine of the Takilma district and many small deposits throughout southwestern Oregon).

3. Replacement bodies in porphyritic dacite (Almeda mine).

4. Replacement bodies in schist (Silver Peak, Squaw Creek). The Blue Ledge mine belongs to this group, but its production is excluded from the total because the mine is outside of Oregon.

The deposits in greenstone have accounted for most of the production. One mine alone of this group, the Queen of Bronze, has a greater recorded production than the total of all the other mines. The deposits in serpentine rank second, those in porphyritic dacite third, and those in schist fourth.

Squaw Creek district

Location and topography

The Squaw Creek district, named after the creek that divides it into almost equal northern and southern parts (pl. 2), includes an area of some 20 square miles and is in the southwest corner of the Grants Pass quadrangle, in Jackson County, Oreg., adjoining the California line. It is reached by a good road from Jacksonville and Medford, respectively 25 and 30 miles to the northeast.

The district is drained by tributaries of the Applegate River. East and west of the valley of that stream the surface consists largely of rugged slopes. Within a horizontal distance of 3 miles the altitude ranges from 2,000 feet to over 5,000 feet. Most of the slopes are brush-covered and difficult to traverse away from the beaten paths.

Geology

General features

The oldest rocks exposed in the Squaw Creek district are schists of both sedimentary and igneous origin, of Devonian or older age. Overlying these schists are argillite and quartzite of doubtful Carboniferous age. Sand and gravel of Quaternary age form narrow terraces and lowlands along the present streams.

The oldest purely igneous formations consist of fine and medium grained rocks classified as greenstones. These and the Carboniferous(?) argillite and quartzite are intruded by serpentine, which in turn is intruded by quartz diorite and related rocks.

Sedimentary rocks

Devonian or older schists

Several large areas in southwestern Oregon and northern California are underlain by schists and phyllites that lithologically are similar. (See pl. 1.) However, because these areas are widely separated and because fossils are absent or very poorly preserved, exact correlation is impossible. In northern California a group of rocks of these types are regarded as pre-Cambrian by Hershey,2/ who described them as the Abrams and Salmon formations. In the Port Orford region Diller has tentatively referred to similar rocks as pre-Devonian, and in the Riddle quadrangle he describes rocks of the same type which he assigns questionably to the Devonian.3/ Winchell4/ has correlated the schists and phyllites of the Squaw Creek district with the pre-Cambrian (?) Abrams mica schist (sedimentary) and Salmon hornblende schist (igneous) of Trinity County, Calif. Considerable doubt is entertained regarding the pre-Cambrian age of these rocks, and they are here tentatively classified as Devonian or older.

Within the Squaw Creek area these rocks consist chiefly of schists and phyllites but include also some lenses of limestone or marble and in places bodies of intrusive quartz diorite and other igneous rocks. Also locally the schists and phyllites contain seams and lenses of white quartz parallel with the foliation; and in a few places, as at the Blue Ledge and Pacific States mines, the schists have been partly or wholly replaced by sulphide minerals. Probably the most abundant type of rock is a medium to dark green schist composed largely of quartz, epidote, and chlorite. Rock of this type occurs throughout the Squaw Creek area but is particularly abundant in the eastern half. Another abundant type of schist is composed largely of fine-grained quartz with considerable sericite. Some of these rocks are extremely fine-grained and are most properly termed phyllites. All have marked schistose structure, and some are much contorted. These highly siliceous rocks are most abundant in the western part of the mapped area. Interbedded with the schists are dark-green fine-grained rocks with less pronounced schistose structure. They contain large crystals of green hornblende with shredded edges embedded in a groundmass composed of quartz, epidote, zoisite, and saussuritic material. The texture and composition of these rocks is characteristic of some of the recrystallized greenstones found elsewhere in southwestern Oregon. In addition to the rocks described, at least one and probably several layers of graphitic schist occur in the series. One layer is well exposed in California about 500 feet up Elliott Creek from the mouth of Joe Creek. Graphitic schist is also well exposed at the Blue Ledge mine and in the NE$\frac{1}{4}$ sec. 11, T. 41 S., R. 11 W., about 1 mile east of the mouth of Manzanita Creek. Near the west edge of the area mapped lenses of limestone are interbedded with schist. The largest lens occurs in the W$\frac{1}{2}$ sec. 11, where it crops out on the ridge northeast of Seattle Bar as a prominent ledge 200 to 300 feet wide. Two smaller

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2/Hershey, O.H., Metamorphic formations of northwestern California: Am. Geologist, vol. 27, pp. 225-245, 1901.

3/Diller, J.S., U.S. Geol. Survey Geol. Atlas, Port Orford folio (no. 89), p. 2, 1903; U. S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 2, 1924.

4/Winchell, A.N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.: Mineral resources of Oregon, vol. 1, no. 5, pp. 37, 38, Oregon Bur. Mines and Geology, 1914.

lenses were mapped near the mouth of Manzanita Creek. All have the same attitude as the schists. The limestone is bluish gray to white and in most places has a well banded structure defined by the presence of numerous small flakes of graphite that have tended to concentrate in layers. According to Diller5/ the largest of three lenses appears to overlie the schist. However, the rocks above and below this limestone lens are so similar to the other schists that they could not be separated by the writer on a lithologic basis. Furthermore, the two smaller lenses on Manzanita Creek are well within the schistose formation. In general, the schistosity of the rocks described above strikes east of north and the prevailing dips are 40°-50° W. Locally, however, intense folding has taken place.

The schists exposed within the area mapped are, in part at least, of sedimentary origin. The graphitic schists and the very highly siliceous schists and phyllites are undoubtedly metamorphosed sediments, and possibly the quartz-epidote-chlorite schists belong in the same category. The dark-green, less schistose rocks containing hornblende are most probably of igneous origin and may represent either intruded bodies or flows. The schistose group at Squaw Creek agrees fairly well lithologically with the Abrams mica schist as described in its type locality, but the thick series of hornblende schists described by Hershey as the Salmon formation apparently is not present. The hornblende schists that have been found in the Squaw Creek district are interbedded with siliceous schists and phyllites and are not known to occur as a distinct unit. Like the schist series in the Squaw Creek district, the Abrams schist in northern California includes lenses of blue crystalline limestone and white marble as well as graphitic schist. Hershey describes the graphitic schist as occurring with actinolite schist at the contact between the Abrams and Salmon schists. In the Squaw Creek district the schists dip to the northwest, and therefore the Salmon hornblende schist in its normal position should, if present, lie northwest of the schist that is correlated with the Abrams mica schist. A thick series of hornblende schist was not found to the northwest of the quartz-sericite schists and phyllites. As a result of study of the relation between cleavage and banding in certain slates associated with the schists near the Blue Ledge mine Winchell6/ has suggested that the series is overturned. If so, schist corresponding to the Salmon hornblende schist may occur to the east of the schists exposed in the Squaw Creek district and may be represented by the quartz-epidote-chlorite schists described above, which lie immediately below the graphitic schist near the mouth of Joe Creek.

The age of the schists is not known. The degree of metamorphism suggests that they are older than the argillite and quartzite which adjoin them on the west and north. Quartz diorite and peridotite intrude both argillite and schists, and therefore if both were of the same age, they should not show so marked a difference in degree of metamorphism. The age of the argillite beds has not been determined, but they belong to a belt of rocks (Diller's fourth belt)7/ that extends northward beyond the Little

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5/ Diller, J. S., Mineral resources of southwestern Oregon: U.S. Geol. Survey Bull. 546, p. 15, 1914.

6/ Winchell, A. N., op. cit.

7/ Diller, J. S., op. cit. (Bull. 546), p. 16.

Applegate River. Poorly preserved fossils have been found in limestone beds associated with these rocks, and according to Diller they suggest that this belt of rocks is Carboniferous. Therefore, as the schists appear to be older than the argillite and quartzite, which are of doubtful Carboniferous age, they may be tentatively referred to as Devonian or older.

Carboniferous (?) Rocks

Argillite and quartzite crop out north and west of the schistose rocks described above as Devonian or older. Of the two, argillite is the more abundant. Where fresh it is prevailingly dark gray, but along fractures it is stained brown by oxidation products. It commonly has a platy parting but no well-developed schistose structure. Near the contacts with quartz diorite, the argillite is in many places altered to an epidote-bearing rock. The quartzite is white or pink and relatively pure and near quartz diorite intrusive bodies is largely recrystallized. In places for example, in sec. 36, T. 40 S., R. 4 W., just south of French Creek the argillite and quartzite are much contorted. Limestone lenses occur with the formation. One small lens crops out on the west side of the Applegate River in sec. 2, T. 40 S., R. 4 W., and others were noted just west of the mapped area. The limestone lenses belong to Diller's fourth belt, for which poorly preserved fossils suggest a Carboniferous age.

Stream Gravel

Stream gravel occurs along the present streams and on remnants of terraces 15 to 50 feet above the present streams. The terraces are well exposed along the road between French Creek and Copper post office. The gravel is composed mostly of poorly sorted but well-rounded boulders of schist, quartzite, quartz diorite and related rocks, pegmatite, and quartz. Elevated terraces are common in southwestern Oregon and represent different stages in the uplift of the Klamath Mountains. In some places they have been mined for their gold content, but so far as known those in the Squaw Creek district have not been worked.

The gravel along the present streams is similar in composition to the terrace gravel. It has been mined at several localities in the Squaw Creek district.

Igneous Rocks

Greenstones

The term greenstone has been applied in southwestern Oregon to highly altered medium to fine grained igneous rocks which because of the presence of secondary chlorite, hornblende, and epidote show a green color. Rocks of this type are abundant in the northern part of the Squaw Creek district and occur interbedded with the Devonian or older schistose rocks. The greenstones differ somewhat from place to place within the area mapped, but most of them may be included in two general types, one of which is medium-grained, the other fine-grained. Both are dark green, and, as shown by the microscope, both have undergone considerable recrystallization. The feldspars are almost entirely changed to fine-grained saussuritic material, but some unaltered areas have the composition of andesine. Hornblende is abundant as large grains with shredded borders and as small flakes throughout the groundmass. Chlorite, sericite, epidote, zoisite, tremolite, and serpentine are present in variable amounts. Analyses of rocks of these types from other districts in southwestern Oregon show that they are much more basic than is indicated by the composition of the feldspars. In the Takilma-Waldo district,[8] for example, analyses show that both medium and fine grained greenstones with sodic feldspars have the composition of basalt. The greenstones of the Squaw Creek district are very much like those near Takilma; hence it is likely that the fine-grained greenstones are metabasalts and the medium-grained greenstones metagabbros.

Serpentine

Serpentine underlies several relatively small and irregular-shaped areas in the Squaw Creek district. The rock is similar to the serpentinized peridotite in other parts of southwestern Oregon. The original olivine and pyroxene are largely altered to a fine-grained felted aggregate of serpentine. However, some residual patches of the original minerals remain in most of the serpentinized bodies. Disseminated chromite and magnetite are fairly abundant. Near some intrusive contacts anthophyllite occurs largely as radiating fibers. Exposures of this mineral are found along the road on the east bank of the Applegate River just south of the California line. Thin sections show that some of the anthophyllite has developed directly from olivine. The outcrops of anthophyllite that were examined are small and considered as asbestos are of poor quality and, for the present at least, of no economic value.

The age of the serpentine in the Squaw Creek district was not closely fixed. It intrudes the argillite of supposed Carboniferous age and is cut by quartz diorite. The age of the serpentine elsewhere in southwestern Oregon has been determined as late Jurassic or early Cretaceous.[9]

Quartz diorite and related rocks

Many large and small areas in southwestern Oregon are underlain by quartz diorite or related rocks. These rocks are relatively of economic importance, not only because some may be utilized for building stone but also because many of the ore deposits in southwestern Oregon are believed to be closely associated with them in origin.

The quartz diorite in the Squaw Creek district is normally a light to dark gray rock of fairly coarse texture. In some places border phases are much darker and coarser-grained. Numerous irregular masses and dikes of aplite and pegmatite cut the quartz diorite. These dikes are well exposed along the Applegate River at the mouth of Squaw Creek, where the streams have stripped the overburden from the bedrock. The normal rock is composed principally of feldspar andesine, green hornblende, quartz, biotite, orthoclase, and megnetite, named in the order of abundance. The rock in general is quite free from hydrothermal alteration or dynamothermal effects.

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[8] Shenon, P.J., Geology and ore deposits of the Takilma-Waldo district, Oregon; U.S. Geol. Survey Bull. 846-B, 1933.

[9] Diller, J.S., U. S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 4, 1924.

The quartz diorite of the Squaw Creek district intrudes Carboniferous (?) argillite and quartzite as well as serpentine. Elsewhere in southwestern Oregon the age has been fairly well fixed as late Jurassic or early Cretaceous.[10]

Mines

Pacific States Mines Co.

Location and access. - The property operated by the Pacific States Mines Co. is in sec. 5, T. 41 S., R. 8 W., Willamette meridian, along Squaw Creek about 32 miles southwest of Medford. The road is narrow but serviceable and follows a water grade for practically its entire distance.

Most of the development work has been done on the Gold Nob, Pacific, and Iron Hand claims, named in order from east to west. Three short tunnels and several surface trenches have been excavated on the Gold Nob claim. On the Iron Hand, in addition to many surface trenches, two tunnels, 80 and 90 feet long, have been opened. The lode on the Pacific claim is developed by three adit levels and several surface cuts. The principal level, No. 3, includes a crosscut 320 feet long from which drifts that aggregate 350 feet have been driven northeast and southwest. (See fig. 1). Level 2 is 150 feet long and is 95 feet above level 3 and connected with it by an inclined raise. Level 1 is 32 feet long. In August 1930 development work was confined to drifting on level 3.

The ore at the Pacific States mine occurs as replacement bodies along certain beds of the schist. Several beds of schist distributed through a zone nearly a mile wide have been partly prospected, and all are more or less mineralized. The schist beds strike from N. 30° E. on the Iron Hand claim to N. 65° E. on the Gold Nob claim and dip 40°-65° NW. In some places the schist has been largely replaced by quartz and sulphides; in other places, even within the same bed, the sulphides are sparsely distributed. The more intensely mineralized beds range in thickness from a few inches to over 40 feet and consist of highly altered chlorite schist containing considerable quartz, some epidote and sericite, and sulphide in varying amounts. In general the thicker beds are less mineralized.

Pyrite and chalcopyrite are the principal sulphides, and sphalerite is present in small amounts. Pyrite is by far the most abundant sulphide except in some places--for example, in certain beds at the face of the south drift on level 2, where it is exceeded by chalcopyrite. Polished surfaces clearly show two stages of mineralization. Quartz and pyrite were deposited first, and after they were fractured, quartz, chalcopyrite, and sphalerite were introduced. The zone of oxidation is very shallow. Fresh-appearing sulphides occur a few feet beneath the surface.

Economic considerations.--The ore at the Pacific States mine has been formed by replacement of schistose beds of devonian or older age. Several beds have been more or less mineralized, including three that have been partly prospected on the Gold Nob claim and at least three on the Iron Hand claim, as well as several beds exposed by the Pacific workings. In some places chalcopyrite is plainly visible,

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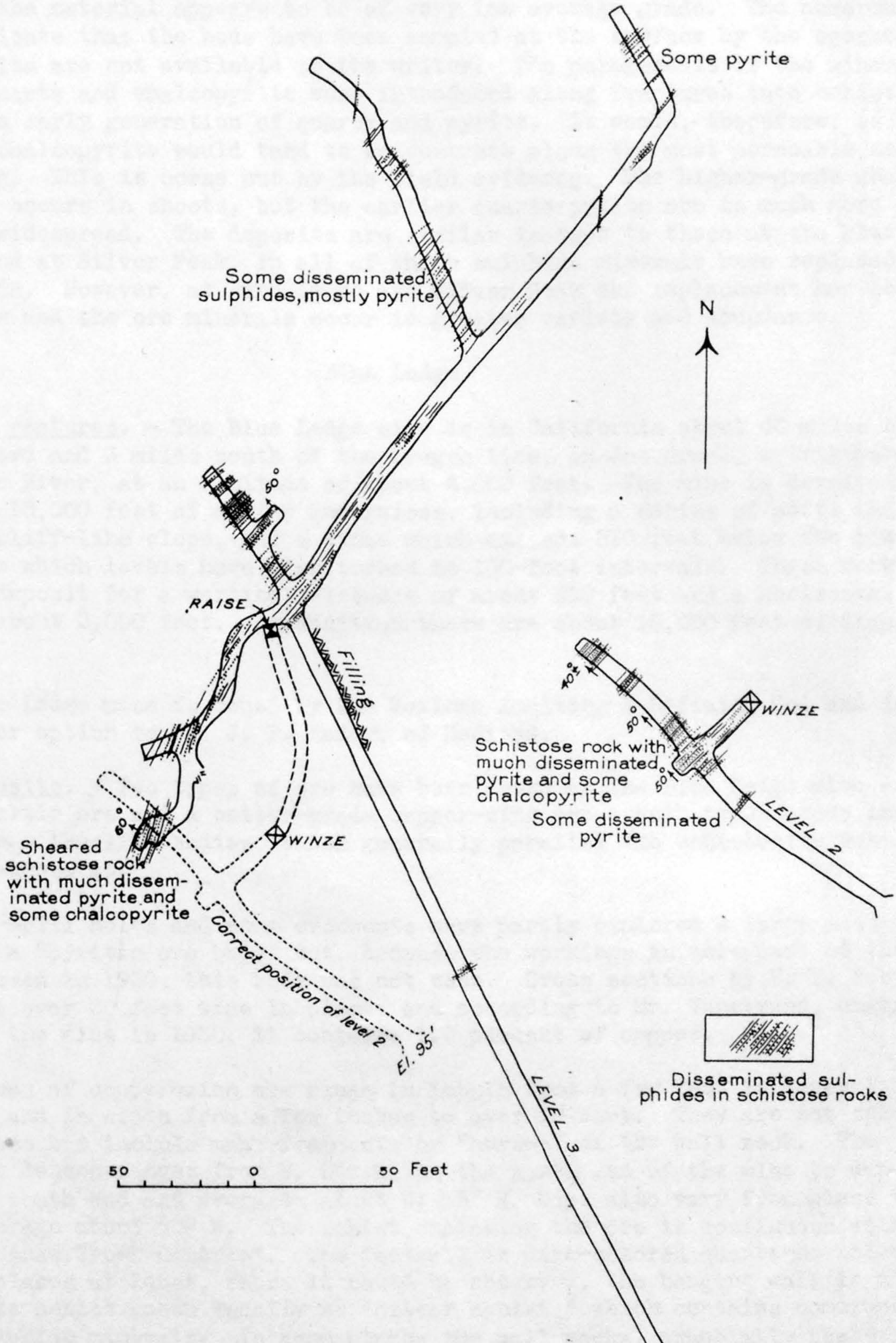
[10] Diller, J.S., op. cit. (Riddle folio), p. 4.


Some pyrite
Some disseminated sulphides, mostly pyrite
N
50°
RAISE
Filling
Sheared schistose rock with much disseminated pyrite and some chalcopyrite
60°
WINZE
Correct position of level 2
El. 95'
LEVEL 3
El. 00
40°
50°
WINZE
Schistose rock with much disseminated pyrite and some chalcopyrite
50
Some disseminated pyrite
LEVEL 2
Disseminated sulphides in schistose rocks
50 0 50 Feet

associated with pyrite. These mineralized beds evidently contain a large tonnage of ore, but the material appears to be of very low average grade. The numerous trenches indicate that the beds have been sampled at the surface by the operators, but the results are not available to the writer. The paragenesis of the minerals shows that quartz and chalcopyrite were introduced along fractures into schist containing an early generation of quartz and pyrite. It would, therefore, be expected that chalcopyrite would tend to concentrate along the most permeable zones of fracturing. This is borne out by the field evidence. The higher-grade chalcopyrite ore occurs in shoots, but the earlier quartz-pyrite ore is much more uniform and widespread. The deposits are similar in type to those at the Blue Ledge mine and at Silver Peak, in all of which sulphide minerals have replaced schistose beds. However, at Blue Ledge and Silver Peak the replacement has been more complete and the ore minerals occur in greater variety and abundance.

Blue Ledge

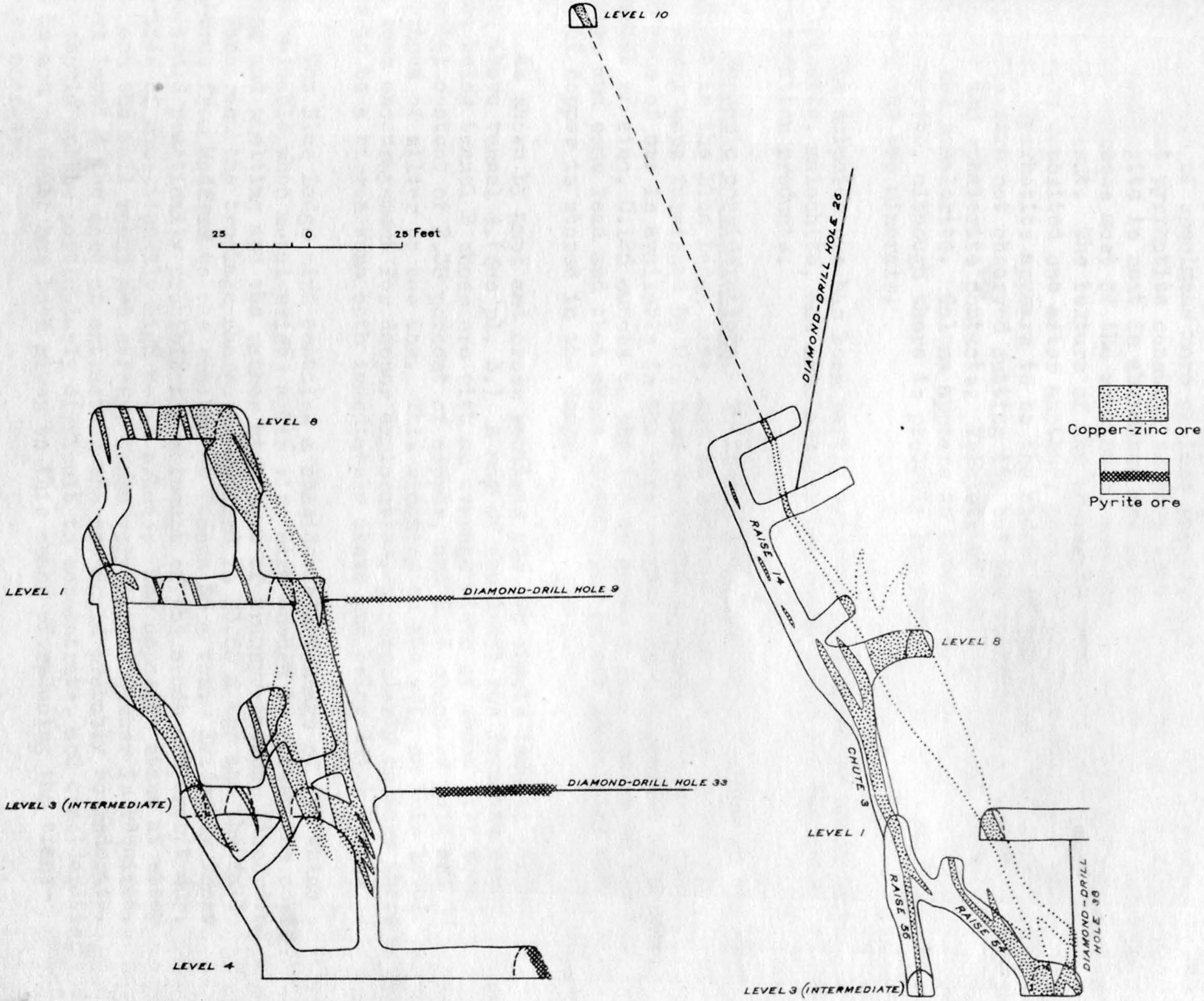
General features. - The Blue Ledge mine is in California about 40 miles southwest of Medford and 3 miles south of the Oregon line, on Joe Creek, a tributary of the Applegate River, at an altitude of about 4,000 feet. The mine is developed by more than 15,000 feet of drifts and raises, including a series of adits that penetrate a cliff-like slope, and a winze which extends 210 feet below the lowest adit and from which levels have been turned at 100-foot intervals. These workings explore the deposit for a vertical distance of about 800 feet and a horizontal distance of about 2,000 feet. In addition there are about 15,000 feet of diamond-drill holes.

The Blue Ledge mine is owned by the Mexican Smalting & Refining Co. and in 1930 was under option to Dr. J. F. Reddy, of Medford.

Ore deposits. - Two types of ore have been found at the Blue Ledge mine - a low-grade pyritic ore and a better-grade copper-zinc ore. Both types occur in schist as large lenslike bodies, which generally parallel the schistosity but locally cut across it.

Diamond-drill holes and some crosscuts have partly explored a large mass described as a "pyritic ore body" but, because the workings in this part of the mine were closed in 1930, this body was not seen. Cross sections by W. B. Robinson show it to be over 30 feet wide in places and according to Mr. Vanstrand, engineer in charge of the mine in 1930, it contains 1.5 percent of copper.

The lenses of copper-zinc ore range in length from a few feet to several hundred feet and in width from a few inches to over 12 feet. They are not solid sulphide masses but include many fragments or "horses" of the wall rock. The strike of the lenses ranges from N. 20° E. in the north end of the mine to due north in the south end and averages about N. 13° E. Dips also vary from place to place but average about 60° W. The schist enclosing the ore is continuous with that in the Squaw Creek district. The footwall is dark-colored quartz-hornblende schist. In places at least, where it could be observed, the hanging wall is a white sericite schist known locally as "silver schist," which contains numerous tiny lenses of sulphide minerals. In some places the wall rocks, especially the sericite schist, contain large cubes of pyrite.



EAST-WEST CROSS SECTIONS THROUGH BLUE LEDGE MINE

The chief ore minerals are pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena, and the gangue is for the most part altered wall rock and quartz with some calcite. Winchell 11/ reports primary tourmaline and biotite. The proportions of the sulphides vary from place to place. Polished sections of specimens more or less representative of the copper-zinc ore show that pyrrhotite constitutes more than 50 percent of the sulphide minerals. Sphalerite is next in abundance and makes up about 25 to 30 percent. Chalcopyrite composes most of the remainder, and only a very small amount of galena is present. The texture of the aggregate indicates that these sulphides were deposited one after another, probably without any lapse in the process. Pyrrhotite appears to be the oldest of the four. Veinlets of sphalerite were not observed cutting it, but its boundaries are much corroded at the sphalerite contacts. Veinlets of chalcopyrite cut both pyrrhotite and sphalerite. Galena appears to have formed somewhat later than chalcopyrite, although there is probably but very little difference in age between the two minerals.

The sulphide ore has been partly oxidized to a depth of about 50 feet. Limonite, malachite, and some azurite and black ozide are the more common oxidation products.

Economic considerations.- Evidently a considerable tonnage of ore is blocked out in the Blue Ledge mine, and in addition much ore is stored in dumps. Assay maps furnished by Mr. Carl Vanstrand indicate that more than 150,000 tons of ore is available in the mine, containing 4.4 percent of copper, 2.0 percent of zinc, 0.125 ounces to the ton in gold, 5 to 6 ounces to the ton in silver, and some lead and that about 50,000 tons of ore containing 3.3 percent of copper is stored in the dumps.

As shown by maps and cross sections the ore shoots tend to pinch out just above tunnel 4. (See pl. 3.) A map of the level run from the winze 200 feet below tunnel 2 shows ore with an average width of about 1.77 feet and a metal content of 2.38 percent of copper, and 0.02 ounce of gold and 1.002 ounces of silver to the ton. This widening in the vein on this level offers some encouragement for deeper exploration, particularly because there appears to be a barren zone both immediately above and below level No. 4.

The Blue Ledge mine contains a considerable tonnage of ore which will be valuable when metal prices again rise high enough to offset the costs of mining and smelting and the rather high cost of transportation. According to Mr. Vanstrand the truckage charge to Medford is $3.50 a ton and the railroad charge from Medford to the smelter at Tacoma $5 a ton. Evidently these charges would practically prohibit the shipment of the crude ore except during periods of exceptionally high metal prices. The deposits stand at steep angles, and the wall rocks are strong; hence very little timber is required, and above level 4 the cost of extracting the ore would probably be moderate. The ore should not be particularly difficult to concentrate, and consideration should be and no doubt has been given to this means of reducing the transportation charges.

11/ Winchell, A.N., op. cit., p. 130.

Location and access

The copper deposits of the Silver Peak district lie in the southern part of Douglas County, Oreg., in secs. 23 and 26, T. 31 S., R. 6 W. By air line the mines are about 7 miles directly south of Riddle, a shipping point on the Southern Pacific Railroad, but by road the distance is about 9½ miles. The road is steep and narrow but except during stormy periods is readily passable.

Topography

The surface of the Silver Peak district is made up chiefly of the steeply sloping sides of many valleys and intervening narrow ridges with fairly flat tops. Altitudes range from 4,000 feet on Silver Peak to less than 2,000 feet in some of the valleys slightly more than a mile distant. Silver Peak is the highest point in the immediate region, and from it a splendid view can be had of the surrounding country. The valley slopes are generally covered with dense growths of timber and underbrush, and hence most of the trails and roads tend to follow the wider valleys or ridge tops.

The three principal streams that rise on the slopes of Silver Peak--the West Fork of Canyon Creek, Middle Creek, and Russell Creek--flow respectively eastward, westward, and northward. This radial drainage pattern is of small extent, however, because all three streams join the Umpqua River. The streams have dissected the region to a stage in which the canyon areas prevail over the rather narrow divides, and the topography of the region can therefore be described as mature.

General Geology

The rocks in the vicinity of Silver Peak belong principally to the Dothan formation, described by Diller, 12/ and to a group of highly altered igneous rocks of several types which are termed greenstones because of their prevailing green color. The contact between the Dothan rocks and the greenstones is irregular but in general strikes northeast and, in the vicinity of Silver Peak, dips at steep angles to the southeast. No quartz diorite or related intrusive rocks are known to crop out in the immediate region.

Dothan Formation

The Dothan formation, of Jurassic age, in the Riddle quadrangle consists predominantly of sandstone but includes also shale, conglomerate, and chert. The strata are usually thin-bedded, yet in places beds about 100 feet thick are found. Some of the rocks have a schistose structure and many of them contain veinlets of quartz parallel to the schistosity. The sandstone is gray and weathers to a yellowish brown and where not strongly metamorphosed breaks with a somewhat rough surface. The shale is usually gray to dark gray and is distinctly slaty. The conglomerate, which occurs in thin beds, contains pebbles that are predominantly siliceous. The chert forms small lentils.

12/ Diller, J.S., U.S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 3, 1924.

Near the Silver Peak mines the Dothan formation is composed principally of dark-gray to almost black thin-bedded schist and highly altered fine-grained argillite. Many of the Dothan rocks are so completely altered that it is difficult to differentiate them in the field from the altered greenstones. Near the ore bodies the schist is bleached to light gray or almost white and, because of the abundance of sericite, has a talcose appearance. In addition, the ore-bearing schist commonly contains considerable quartz, barite, and disseminated sulphides. Strike faults are numerous, some of which agree with the dip of the formation and some do not. The schist lies between dark-gray rocks that are shown by the microscope to be very fine grained, highly altered argillites composed largely of small rounded quartz grains in a fibrous groundmass of sericite and chlorite. The quartz grains are small, on an average about 0.135 millimeter across, and many are partly recrystallized. In the argillite near the ore bodies there are numerous grains of disseminated sulphides.

Greenstones

Irregular bodies of greenstone are widely distributed in the Riddle quadrangle. According to Diller[13] they include altered gabbro, diorite, and diabase and finer-grained altered basaltic rocks, all of which show evidence of crushing and veining.

The greenstones in the immediate vicinity of the Silver Peak mines are prevailingly fine-grained, although some are porphyritic. All contain abundant epidote, fine-grained quartz, chlorite, zoisite, saussurite, and other alteration products. Some retain a suggestion of igneous texture, but others are entirely changed to rocks composed essentially of epidote and quartz. Ore was not observed in greenstone in the Silver Peak district, although elsewhere in southwestern Oregon ore is generally associated with that rock.

Ore deposits

Geographic distribution

Three mines have been worked in the vicinity of Silver Peak. Two of these, belonging to the Silver Peak Copper Co. and the Umpqua Consolidated Mining Co., lie south of Silver Peak. They include portions of the same ore body and for convenience are described together. The third, the Golden Gate mine, lies about half a mile to the north.

Deposits south of Silver Peak

History and development

The mines of the Silver Peak Copper Co. and the Umpqua Consolidated Mining Co. are on a steep slope south and slightly west of Silver Peak, at a mean altitude of about 3,300 feet. The property of the Silver Peak Copper Co. is in sec. 26, T. 31 S., R. 6 W., and that of the Umpqua Consolidated Mining Co., which adjoins it on the north, is in sec. 23[14]. Ore was first discovered here in 1910 by Robert Thomason, on what is now Silver Peak Copper Co.'s ground. [15] In 1912 J. E. Reeves purchased a patented timber claim which included a large portion of the ore that has

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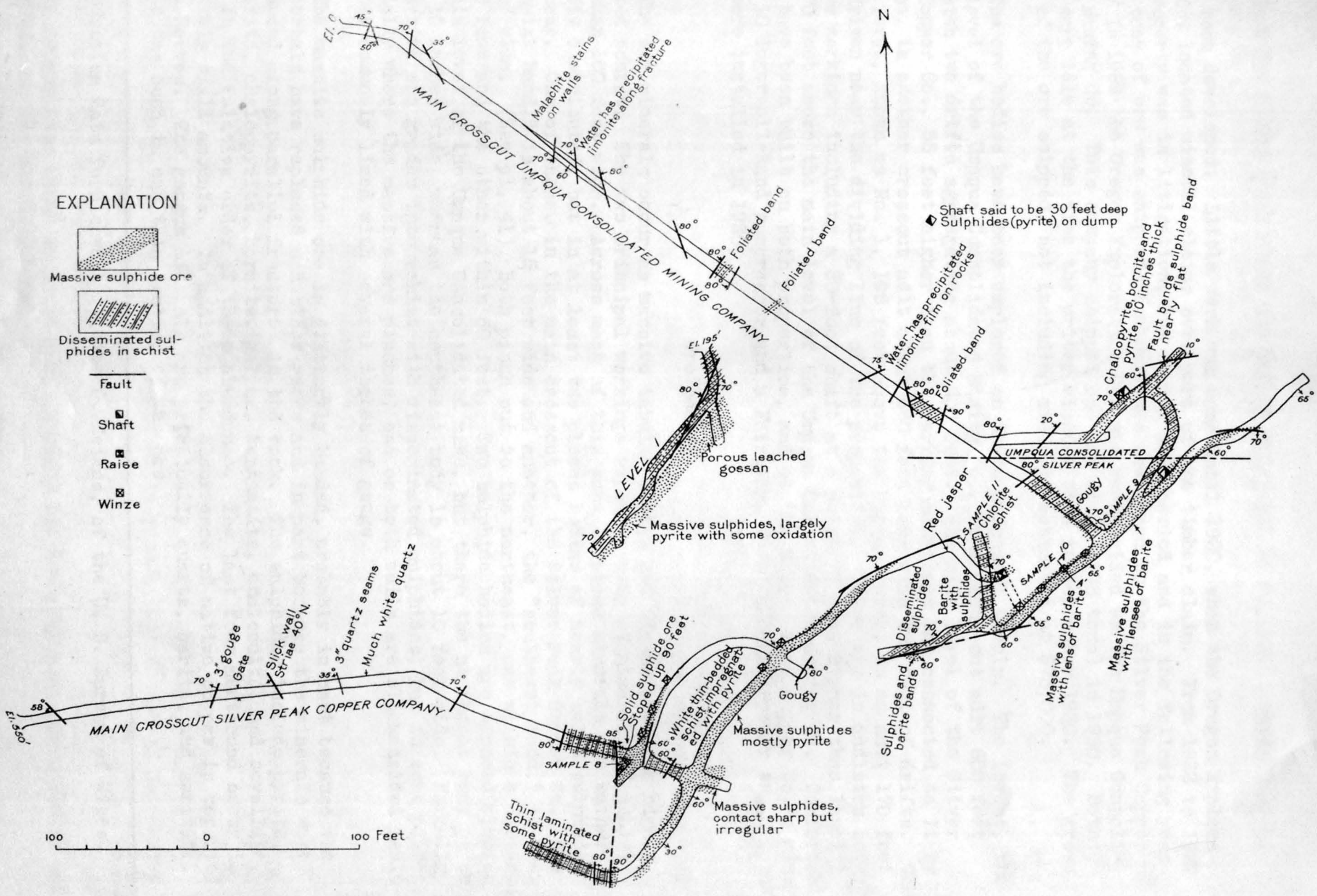
13/ Diller, J. S., op. cit. (Riddle folio), pp. 4-5.

14/ The broken line shown on plate 4 as dividing the two properties was pointed out underground as the boundary line.

15/ Historical data furnished by J. E. Reeves.



MAP OF THE UNDERGROUND WORKINGS OF THE SILVER PEAK MINING CO. AND UMPQUA CONSOLIDATED MINING CO.

since been developed. Little work was done until 1920, when the Oregon Exploration Co. located mineral claims over part of the timber claim. From 1922 to 1929 the property was in litigation, but during this period and in the following year 3,256 tons of ore was shipped from workings now owned by the Silver Peak Copper Co.[16/] In 1929 the Oregon Exploration Co. was reorganized as the Umpqua Consolidated Mining Co. This company shipped one car of ore (38 tons) in 1930. Both mines were idle at the time the writer visited them in September 1930. The gross value of the ore shipped, not including zinc, is estimated at $73,000.

The ore bodies have been explored on three principal levels. The lowest, the main level of the Umpqua Consolidated Mining Co., is a cross-cut adit 600 feet long with two drifts aggregating about 600 feet. The main level of the Silver Peak Copper Co., 55 feet higher than the working mentioned and connected to it by a raise, is another crosscut adit about 480 feet long with 550 feet of drifts. The third level, known as No. 1, 195 feet above the Umpqua level, is an adit 170 feet long driven near the dividing line of the properties. There are in addition several shallow workings including a 30-foot shaft at a point 75 feet higher than level 1 and 270 feet above the main level of the Umpqua Consolidated Mining Co. Comfortable camps have been built on both properties, and at the Silver Peak Copper Co.'s mine a No. 10 Ingersoll-Rand compressor and a Fairbanks-Morse 120-horsepower engine, both new, were installed in 1930.

Ore bodies

The ore minerals occur as massive tabular bodies and disseminated in highly foliated schist. The two principal workings expose a zone of mineralized schist more than 100 feet wide. Across most of this zone sulphide minerals are rather sparsely distributed, but in at least two places bodies of nearly solid sulphide ore occur. One of these, in the main crosscut of the Silver Peak Copper Co., the "northwest band," is about 15 feet wide and another, the "southeast band," is over 20 feet wide. (See pl. 41) Both pinch out to the northeast, one within a distance of 200 feet and the other within 60 feet. Two sulphide bodies are exposed also on the main level of the Umpqua Consolidated mine, but there the northwest body is only about 10 inches wide, whereas the southeast body is about 10 feet wide. Normally the massive ore grades into schist with disseminated sulphides, but in some places, especially where the massive ore pinches, one or both walls are slickensided fault surfaces commonly lined with several inches of gouge.

The massive sulphide ore is distinctly banded, probably in part because the ore minerals have replaced schistose rocks and in part because the minerals were introduced along parallel fractures in the rock. The sulphides include pyrite, sphalerite, chalcopyrite, bornite, galena, tennantite, chalcocite, and covellite, named in the relative order of their abundance. The last four mentioned occur in relatively small amounts. In addition the occurrence of native copper is reported by Mr. Reeves. The gangue minerals are principally quartz, barite, and sericite. Epidote was seen in one thin section of the ore.

16/ Production data furnished by Victor C. Heikes, of the U. S. Bureau of Mines.

At the surface oxidation is almost complete. Level 1, for example, follows a porous, iron-stained, and greatly leached gossan in which no sulphides are visible. A short distance from the portal sulphides become visible and are abundant near the face. Sulphides were struck also in the 30-foot shaft on the Umpqua Consolidated property. Traces of oxidation extend as deep as the lower levels, as shown by thin films of oxide minerals along fractures.

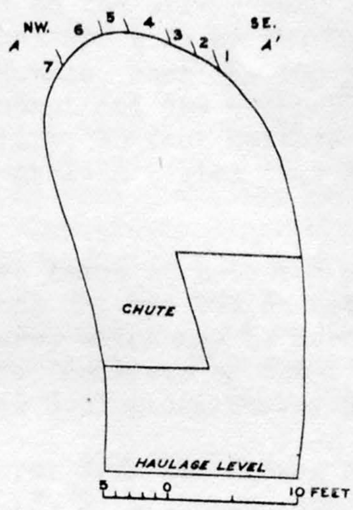


Figure 2.-Cross section through stope along line A-A, plate 4, Umpqua Consolidated level.

1. Massive sulphide band; mostly pyrite with a little visible bornite and other sulphides.
2. Massive barite with sulphide stringers.
3. Massive sulphide band; pyrite with considerable bornite and chalcopyrite and lesser amounts of other sulphides.
4. Massive sulphide band, largely pyrite.
5. Sulphide band with barite stringers.
6. Massive sulphide band, pyrite with considerable bornite; some chalcopyrite, and small amounts of other sulphides.
7. Massive sulphide with some small stringers of barite; this band itself consists of banded sulphides. Pyrite prevails in some bands, sphalerite in others. Bornite and chalcopyrite and small amounts of other sulphides occur with them.

Quartz was the first gangue mineral to be deposited. It is everywhere fine-grained but tends to be coarser in the fractures along which it was introduced. Barite was introduced next, then fracturing occurred, and pyrite was deposited. After a second fracturing sphalerite, tennantite, chalcopyrite, bornite, galena, and chalcocite were deposited as an overlapping series and probably in the order named, although the relation of galena and chalcocite was not well established. (See fig. 3.)

The mineral composition differs in the different ore bodies and within the layers of a single ore body, as shown, for example, by the northwest and southeast ore bodies in the Umpqua Consolidated mine. The sulphides of the northwest ore body are associated with abundant quartz but very little barite, whereas the southeast ore body contains much barite and smaller amounts of quartz. The southeast body in the stopes above the level consists of nearly solid sulphides with some layers of barite. The barite is lenticular in outline, and any one layer does not persist very far. The sulphides are distinctly banded. One stope shows seven distinct bands with parallel structure. (fig. 2). The composition of the northwest ore body resembles that of layers 3 and 6 of the southeast ore body as shown in the illustration. The ore exposed on the Silver Peak Copper level more nearly resembles the ore of the southeast ore body of the Umpqua Consolidated level. However, in some places -- for example, near the top of the connecting raise -- the copper sulphides are less abundant and the proportion of barite is greater than normal. At the turn in the drift, 30 feet northwest of the raise, the rocks are largely replaced by very fine grained silica that has irregular red jasperlike streaks.

Four carefully cut samples taken at selected places serve to show the relative proportions of the metals to one another but do not necessarily illustrate the average metal content of the ore, which may be more closely determined from the production figures that follow. Analyses of the samples made in the chemical laboratory of the United States Geological Survey are given below:

Analyses of ores from the Silver Peak district, Oreg.
[E. T. Erickson, analyst]

Sample no.	Silver (ounces per ton)	Gold (ounces per ton)	Copper (percent)	Zinc (percent)
8.......	0.59	0.09	4.05	5.5
9.......	.30	.01	.90	.9
10.......	4.58	.03	5.13	7.5
11.......	.46	.01	.93	.6

8. Silver Peak Copper tunnel, northwest ore body. Sample taken in stope 33 feet above tunnel level across 5½ feet of massive sulphide ore.

9. Umpqua Consolidated tunnel, main crosscut immediately northwest of massive sulphide band. Sample taken across 9 feet of schist with disseminated sulphides.

10. Umpqua Consolidated tunnel. Sample taken across 7 feet of massive sulphide ore in stope along line A-A' plate 4.

11. Silver Peak Copper tunnel, 30 feet northwest of top of connecting raise. Sample taken across 6 feet of intensely silicified rock containing some visible sulphides.

The results show that copper and zinc increase and decrease together, but indicate no similar relations between those metals and gold and silver or between the gold and silver themselves.

The following table is based on the production figures furnished by V. C. Heikes, of the United States Bureau of Mines:

Average metal content of ore from Silver Peak and ~~Umpqua~~ Consolidated mines

Year	Ore produced (tons)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
Silver Peak				
1926	389	0.12	7.3	6.0
1928	937	.044	2.7	6.7
1929	1666	.07	3.6	5.6
1930	264	.057	3.0	4.4
Umpqua Consolidated				
1930	38	.24	2.2	3.9

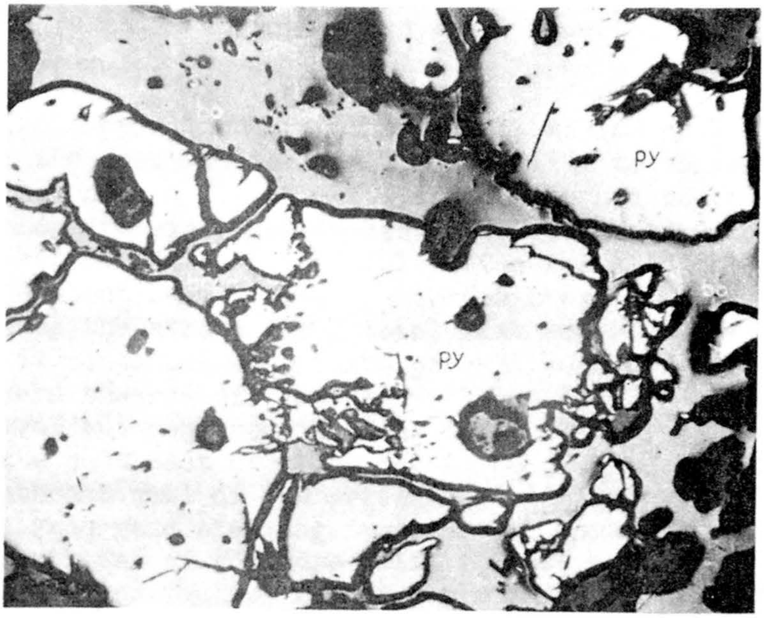
Origin of the ore

The mineralogy of the ores described above is evidence of their hypogene (deep-seated) origin -- that is, the mineral assemblage as shown by the careful observations of many geologists belongs to Lindgren's mesothermal type, deposited at moderate depths by hot solutions. The source of the solutions is not evident from the geology in the immediate vicinity of the deposit, but quartz diorite and related rocks, which are believed to be the sources of many ore deposits in southwestern Oregon, are exposed a few miles distant and are probably not far below the surface at Silver Peak.

The ore-bearing solutions, whatever their source, deposited gangue and sulphide minerals as they moved through the schistose rocks. The solutions apparently rose along planes of schistosity and replaced the adjoining material. Certain beds in the schist were apparently either more susceptible to replacement or were more readily penetrated by the solution than others, because solid sulphides occur interbedded with schist in which sulphides are sparsely distributed. The composition of the ore-bearing solutions probably changed during the period of deposition, because minerals of different composition have been deposited in an overlapping succession. Movements occurred within the rocks during the mineralization, once after the gangue minerals were deposited and again after the deposition of the pyrite. The later sulphides were deposited as a continuous series. After the deposition of the sulphides, strains within the rocks were relieved along faults, some of which have displaced the ore. More recently the sulphides near the surface have been oxidized, and much of the metal content of the outcrops has been removed by leaching. Erosion has kept pace fairly well with the oxidation, for at no place in the vicinity are oxide minerals known in abundance very far beneath the surface.

Economic aspects

The ore bodies at the Silver Peak Copper and Umpqua Consolidated mines have not been sufficiently developed to permit exact tonnage estimates, nor has the ground in the immediate vicinity been sufficiently explored to indicate the probility of undiscovered ore bodies nearby, but enough work has been done to demonstrate that fairly large bodies of good-grade massive sulphide ore are present. Also sampling shows that there is a possibility, when metal prices recover, of mining and milling lower-grade disseminated ore along with the higher-grade material.



A. Bornite (bo) replacing pyrite (py). Reflected light, Enlarged 100 diameters.

B. Sulphide ore, illustrating intimete relations of minerals. ba, Barite; sp, sphalerite; g, galona; py, pyrite; b, bornite; stippled areas, chalcopyrite. Enlarged 100 diameters.

Figure 3. - Photomicrographs of ores, Silver Peak mine.

Only a very small percentage of the sulphides found on the lower levels are supergene (descended from above), and therefore it follows that there is not much likelihood of any material change in the metal content of the ore for some little distance below the present deepest level. However, owing to the fact that the outcrop has been almost entirely oxidized and much of the metallic content removed, more or less sulphide enrichment is to be expected immediately below the zone of oxidation.

The facts available permit some conclusions as to the probable vertical and horizontal extent of the ore. Foliated schists similar to those containing the ore are exposed at the surface for some distance north and south of the known ore bodies. In places they are mineralized--for example, at the Golden Gate mine, to the north, described below. Some mineralization was also noted in a schist of similar appearance about half a mile to the southwest. Underground the ore has been followed along the strike for a total distance of over 450 feet, and in at least two places it continues beyond the present workings. Both bodies of solid sulphide ore were sheared off in the northeast drifts of the Silver Peak Copper Co.'s main level but continue into the walls to the southwest of the present workings. The southeast ore body on the Umpqua Consolidated level appears to turn into the southeast wall of the drift about 50 feet from the face. It appears also to have undergone shearing, and further work may prove that it is displaced. At the south end of the same drift the ore appears to end against an east-west, southward-dipping fault. Sulphide ore interlayered with barite is exposed on one side of this drift about 20 feet from the face, and it seems likely that the ore body may continue southwestward from this point. Thus the evidence underground does not suggest that the horizontal limits of the ore bodies have been reached. Even where the ore is sheared off by faulting there is no known reason why the segments may not be recovered. Outcrops of partly oxidized sulphide ore occur 140 and 270 feet above the ore bodies found on the two main levels. No raises have been driven through to the surface to prospect the ground between these outcrops, although at one place ore has been stoped above the Silver Peak Copper Co.'s level for a vertical distance of about 90 feet. It seems reasonable, however, to expect the ore to continue to the surface, though not necessarily as one continuous body, because of the possibility of fault displacement. It is generally recognized that there is usually a relationship between the horizontal extent of an ore body and its downward extension, and as the ore bodies under discussion are exposed on the lower levels over a horizontal distance of 450 feet without having ended, they can reasonably be expected to extend for some distance below the present workings.

Deposits north of Silver Peak

Most of the mining on the north side of Silver Peak has been done by N. A. Bradfield on the Golden Gate property. He located seven claims in 1919, and although lessees have since worked the property, he still retains the ownership. According to Mr. Bradfield[17] two cars of ore have been shipped. One car containing 36 tons gave gross smelter returns of $1,000, mostly in gold, and another car shipped by lessees is reported to have returned $1.76 a ton.

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[17] Personal communication.

In all, about 600 feet of underground development work has been done. Most of the work has been concentrated on the claims near the road in the vicinity of the Bradfield cabin; the remainder on claims about half a mile to the east.

The production has come chiefly from an open cut and some shallow workings close to the Silver Butte road. The ore occurring here is a dark grayish-green chlorite schist striking N. 30°- 60° E. and dipping 50°- 70° SE. A layer in the schist contains pyrite cubes and some stringers of chalcopyrite, and according to Mr. Bradfield free gold can be panned from some of the rock. The pyrite cubes range in size from those that are barely visible to some with faces over half an inch across. The cubes cut across the schistosity of the enclosing rock, thus indicating that they were formed later.

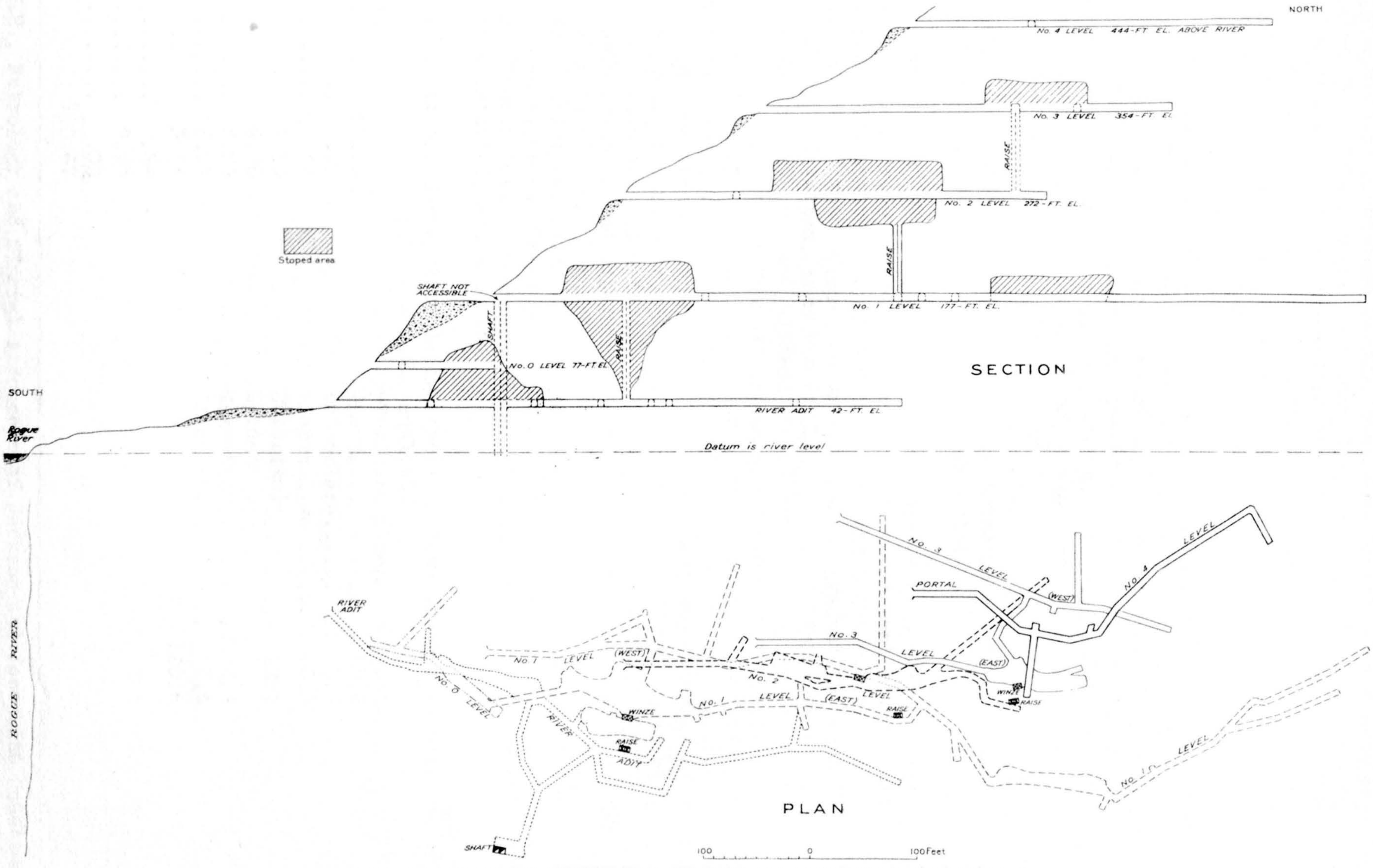
Two tunnels have been driven on a mineralized bed in foliated schist at a point several hundred feet east of the workings just described. The two tunnels, which differ in altitude by 90 feet, have explored the mineralized bed for a total distance of about 170 feet. The schist is similar to that containing the disseminated ore at the Silver Peak Copper and Umpqua Consolidated mines and probably was mineralized under similar conditions and at the same time. In contrast, however, very little quartz or barite was noted in the deposit at the Golden Gate mine.

Almeda mine, Josephine Co.

Location and access. - The Almeda mine is on the north bank of the Rogue River in the SE$\frac{1}{4}$ sec. 13, T. 34 S., R. 8 W. Willamette meridian, 26 miles below Grants Pass and 4 miles from Galice. Merlin, on the main line of the Southern Pacific Railroad 19 miles to the southwest, is the nearest accessible shipping point. A road to connect the mine with Leland, also on the Southern Pacific Railroad but only 10 miles distant, was started but never completed. High water carried away the bridge that once connected the mine with the Merlin road, and at present to reach the mine it is necessary to cross the Rogue River on an aerial tram or by boat.

History and production. - The Almeda mine has been known for many years because of the great extent of the mineralization and because some fairly large masses within the mineralized zone contain enough gold and other metals to attract notice. Consequently, a small smelter was built in 1908, but no production was reported until 1911. From 1911 to 1916, 16,619 tons of ore that yielded 1,539.87 ounces of gold, 48,387 ounces of silver, and 259,800 pounds of copper was produced. A total of 7,197 pounds of lead was also reported as produced from 5,189 tons of ore during 1913, 1915, and 1916. No lead was reported in 1911, 1912, or 1914. The gross value of the ore produced, on the basis of these figures, is, in round numbers, $108,000.

Development. - The Almeda mine is one of the most extensively developed mines in southwestern Oregon. A mineralized zone has been prospected for more than 1,000 feet along its strike and for about 900 feet vertically. Five adits have been driven, and a shaft with levels at intervals of 100 feet was sunk to a depth of about 450 feet below the Rogue River (pl. 5). The shaft is no longer accessible, but most of the workings above the river are open.



PLAN OF A PART OF THE UNDERGROUND WORKINGS AND LONGITUDINAL PROJECTION ON A VERTICAL NORTH-SOUTH PLANE THROUGH THE WORKINGS OF THE ALMEDA MINE

General geology. - The Almeda mine is near the contact of the Galice formation and a thick series of greenstone rocks. Near the contact both formations have been intruded by sill-like bodies of porphyritic dacite. At least six of these sill-like bodies are found in the Galice beds within a distance of 800 feet to the east of tunnel 1, and several of them are exposed in the greenstone rocks west of the Almeda mine. All of the formations strike approximately north and are vertical or dip at very steep angles to the east or west.

The Galice formation in the vicinity of the mine is composed principally of dark-colored argillite and slate which on the basis of fossils collected about 100 feet east of the mine have been assigned by Diller to the Jurassic period. The rocks are composed largely of subangular quartz and feldspar grains and sericite. The original minerals have clearly undergone considerable recrystallization, and near the ore bodies they are largely replaced by calcite and quartz and contain much disseminated pyrite.

The greenstones consist of greatly altered even-grained and fragmental igneous rocks containing much secondary chlorite and epidote.

The porphyritic dacite, where fresh, is a dark-colored rock with abundant large phenocrysts of dark-green hornblende, less abundant and smaller crystals of plagioclase, and a few scattered quartz phenocrysts which are noticeably rounded. The appearance of the porphyritic dacite changes gradually, depending upon the amount of mineralization, from the fresher rock just described to a rock in which the feldspars have been altered almost entirely to sericite, from that to a rock composed almost entirely of silica and fine-grained pyrite but retaining shadow outlines of the original texture, and finally to the sulphide ore, a rock composed essentially of fine-grained quartz, barite, and massive sulphides in varying proportions. The microscope shows that the feldspar of even the fresher-appearing porphyritic dacite is mostly altered to a mass of saussurite, calcite, zoisite, and epidote. Unaltered areas remaining here and there have the composition of andesine. In the fresher-appearing rocks the hornblende is only slightly altered, but near areas of mineralization it has been changed to masses of chlorite, epidote, and zoisite, and finally in the silicified rock it has been almost entirely replaced by fine-grained quartz. The groundmass of the fresher rock is composed of very finelygranular feldspar and quartz, saussuritic material, and chlorite.

Composition of the porphyritic dacite footwall from the Almeda mine.[18]
[S. W. French, analyst]

Analysis		Approximate mineral composition	
SiO_2	55.92	Quartz	15.6
TiO_2	.75	Orthoclase	2.3
Al_2O_3	19.66	Plagioclase	56.4
Fe_2O_3	1.94	Chlorite) Epidote)	22.1
FeO	4.76	Magnetite	2.8
MgO	5.27	Ilmenite	1.4
CaO	5.77		100.6
Na_2O	3.26		
K_2O	.38		
H_2O+	2.90		
H_2O-	.06		
	100.67		

[18]/Winchell, N.H., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.; Mineral Resources of Oregon, vol. 1, no. 5, p. 209, Oregon Bur. Mines and Geology, August 1914.

Although classified by Diller as a quartz porphyry or alaskite, the porphyritic rock described above is both mineralogically and chemically a porphyritic dacite.

Ore bodies

The ore bodies at the Almeda mine occur in a wide zone of intense silicification, known as the Big Yank lode (fig. 4), that follows close to the contact of porphyritic dacite and argillite (slate) of the Galice formation. According to Diller[19] who made a broad study of the general region, "the contact between the slates and the igneous rock, with which the Big Yank lode is associated, may be traced for over 20 miles in a direction about N. 30° E. from Briggs Creek Valley to Cow Creek at Reuben Spur. Although the general course is maintained with considerable regularity, there are many small variations, and the contact dips to the southeast in the same direction as the slates. The plane of the contact is generally a fault plane and is for the most part followed by the lode. The contact is apparently most irregular and the quartz porphyry [porphyritic dacite] most cut by shearing planes in the vicinity of the ore bodies."

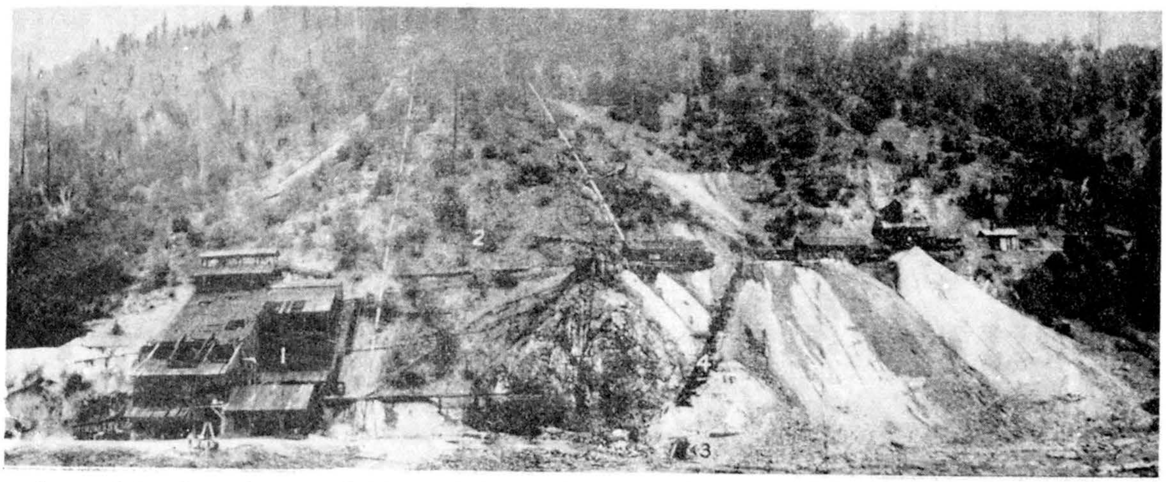


Figure 4. - Almeda mine and Big Yank lode, looking north. 1, Smelter; 2, Big Yank lode; 3, mouth of tunnel; 4, gravity plane.

The Big Yank lode, for the most part, consists of intensely silicified rock with variable amounts of pyrite, but in places masses of the silicified rock have been partly or wholly replaced by barite and sulphides, which constitute the richer ore shoots. The mineralized zone constituting the Big Yank lode varies in width from place to place but at the Almeda mine is about 200 feet wide. Two types of ore have been previously described; "siliceous gold-silver ore" and

[19] Diller, J. S. op. cit. (Bull. 546), pp. 74-75.

"copper ore with barite."[20] The "siliceous gold-silver ore" is the intensely silicified rock with variable amounts of pyrite described above; the "copper ore with barite" comprises those portions of the Big Yank lode that have been partly or wholly replaced by barite and sulphides.

The "siliceous gold-silver ore" consists largely of intensely silicified porphyritic dacite. The rock is composed almost entirely of quartz, but pseudomorphic outlines of the original texture are shown in thin sections (fig. 5). Although the quartz in general is fine-grained, it tends to be slightly coarser along veinlets. There are two and possibly three generations of quartz. One and possibly two preceded the sulphides, and one clearly cuts the sulphides. In general, the older quartz is very fine grained. It is traversed by some veinlets of coarser quartz that is believed to be of the same age, but because this coarse quartz crystallized in the fractures through which it was introduced, it tended to form larger grains than in the replaced wall rock. Barite is sparingly present in the "siliceous gold-silver ore." It was introduced after the older quartz but preceded the sulphides.

According to P. H. Holdsworth,[21] engineer for the Almeda mine in 1911, the average analysis of the "siliceous-gold-silver ore" is as follows:

Average analysis of siliceous gold-silver ore of Almeda mine

SiO_2	percent	62.9
FeO	do	11.5
CaO	do	2.1
BaO	do	8.1
Al_2O_3	do	5.6
S	do	8.3
Cu	do	.3
Au	ounces per ton	0.14
Ag	do	6.40

The gold and silver content shown above is higher than in the siliceous material collected by Diller in the west crosscut of the 500-foot level. He reports that assays of his specimens contain very little gold and only a trace of silver.[22] The writer cut three channel samples across the body of the "siliceous gold-silver ore" which are believed to be fairly representative of the places sampled but, like Diller's specimens, indicate only that this type of ore is low-grade material. The partial analyses of these samples made in the chemical laboratory of the United States Geological Survey given on page 30 are therefore not presented as representative of the average metal content for this type of ore throughout the mine.

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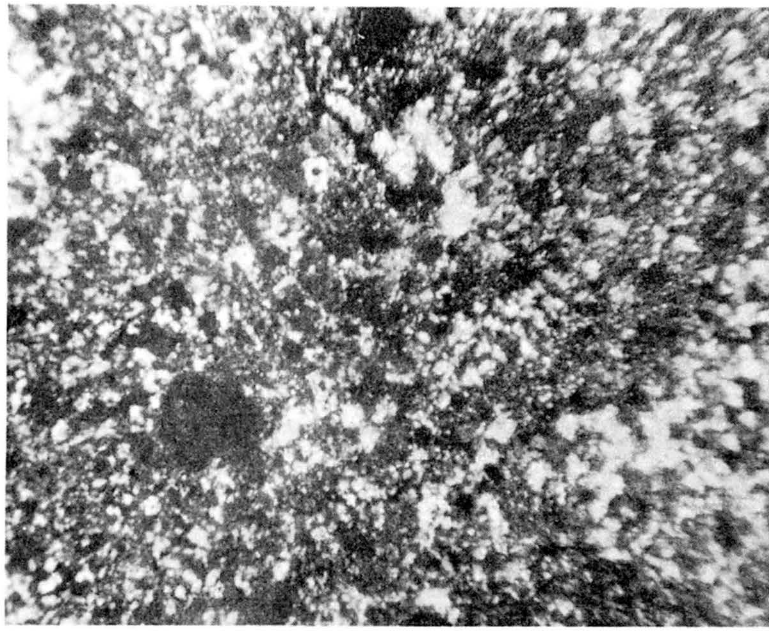
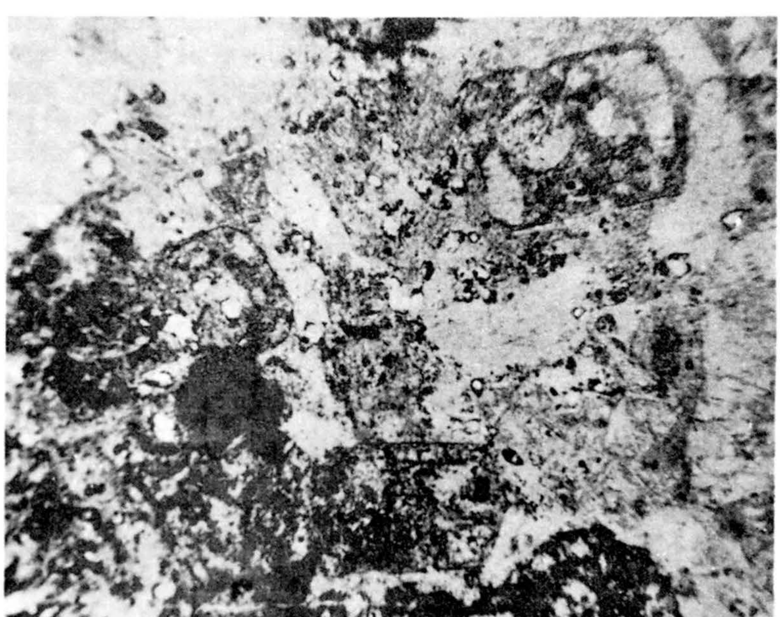
[20] Diller, J. S., op. cit., p. 75.

[21] Idem, p. 77.

[22] Idem, p. 78.



A. Silicified porphyritic dacite, "siliceous gold-silver ores. "Nicols crossed. Enlarged 41 diameters.



B. Same as A, showing outlines of silicified phenocrysts. Sulphide ore black. Plain transmitted light. Enlarged 48 diameters.

Figure 5. - Photomicrographs of ores, Almeda mine.

Partial analyses of "siliceous gold-silver ore" from the Almeda mine
[E. T. Erickson, analyst]

	17	18	13
Copper ....percent..	Less than 0.01	0.01	Less than 0.01
$BaSO_4$ .... do ..	.4	Trace	2.1
SiO_2 .... do ..	66.2	88.8	64.2
Gold .... do ..	Trace	Trace	Trace
Silver ....ounce per ton..	.17	.08	.01

17. From crosscut starting 200 feet from portal of west adit of level 1 and running west. Sample represents width of 10 feet; from face of crosscut to point 10 feet east of face.

18. Same crosscut as 17. Sample represents width of 20 feet, between points 34 and 54 feet east of face.

13. West crosscut 110 feet south of face of River level. Sample taken across 20 feet of ore.

The richer ore at the Almeda mine, the "copper ore with barite," occurs as shoots close to the contact of porphyritic dacite and argillite in the broad silicified zone described above. A longitudinal section of the mine workings above the Rogue River indicates that two mineralized zones have been partly mined but that most of the production has come from one that is more or less parallel with and from 20 to 50 feet below the surface (pl. 5). The other zone, which has not been developed sufficiently to determine its pitch, is about 250 feet below the surface. As shown by assays of samples collected by Diller, and P. H. Holdsworth, ore of good grade was found on the 300-foot level (below the Rogue River), but because the shaft is no longer accessible the relation of this ore to the shoots above is not known. The shoots of better-grade ore range in thickness from a few feet to 60 feet and in length from less than 100 feet to over 200 feet. The greatest known width is exposed on level 1, where the main ore shoot is 60 feet thick and 220 feet long. On the river level the greatest visible thickness is 15 feet, but the entire thickness is probably not exposed. According to Diller the thickness of the principal ore body on the 300-foot level (below the Rogue River) is about 15 feet.[23] He also reports the absence of a considerable body of ore at the contact by the shaft on the 500-foot level but states that, according to the pitch, the ore shoot found on the 300-foot level should project to a position south of the shaft on the 500-foot level.

The ore from the higher-grade shoots is composed principally of barite, quartz, and sulphides. The barite was introduced into the intensely silicified prophyritic dacite before the sulphides, and locally it has almost completely replaced the quartz. The sulphides, in turn, have replaced the barite as well as the quartz. Some specimens clearly show veinlets of sulphides cutting coarse-grained barite. The sulphides include pyrite, chalcopyrite, galena, sphalerite, chalcocite, and covellite. Pyrite is by far the most abundant. It occurs throughout the mineralized zone but is concentrated as massive bodies in the richer ore shoots. The pyrite is cut and replaced by all the other hypogene sulphides and by covellite, which is clearly supergene. In the better-grade ore exposed in the

[23] Diller, J. S., op. cit., p. 78.

accessible stopes tiny veinlets containing covellite are plainly visible cutting the other sulphides and the gangue minerals.

According to P. H. Holdsworth,[24] the "copper ore with barite" across widths of 6 to 20 feet was analyzed as follows:

Analyses of copper ore from Almeda mine

SiO_2	8.8 to 5.1
FeS_2	27.0 to 48.1
CaO	Trace to 0.8
$BaSO_4$	47.8 to 28.2
Al_2O_3	8.0 to 10.9
$CuFeS_2$	6.4 to 6.8

Assays of copper ore from Almeda mine

Cu	percent..	1.5 to 4.5
Au	ounces per ton	0.12 to 0.42
Ag	do	3.32 to 12.18

A partial analysis of a sample collected by Diller[24] on the 300-foot level just north of the crosscut from the shaft was made by Chase Palmer, of the United States Geological Survey, and the sample was assayed for gold and silver by E. E. Burlingame & Co., with the following results:

Analysis of ore from Almeda mine

SiO_2	percent..	0.31
$BaSO_4$	do	68.21
CaO	do	1.01
Cu	do	6.02
Au	ounces per ton..	0.10
Ag	do	7.78

Numerous faults cut both types of ore. Strike faults are made evident in places by gouge along the contact of the ore with the footwall argillite and by numerous gouge seams and shattering in the ore. Other faults, particularly those striking about N. 50° W., have offset the ore in many places. (See pl. 6.)

Both siliceous and copper-barite ores have greatly leached outcrops. The siliceous ore at the surface is a white rock, resembling quartzite. It contains many spots that are porous, owing to the removal of pyrite. The outcrop of the copper ore is strongly stained yellowish and brown by iron oxides and is composed largely of porous aggregates of barite and quartz. Oxidation is not abundant, however, in either type of ore at depths exceeding 50 feet below the surface. Sulphide enrichment is made evident in the stopes examined by the presence of tiny veinlets of covellite cutting both gangue and primary sulphide minerals.

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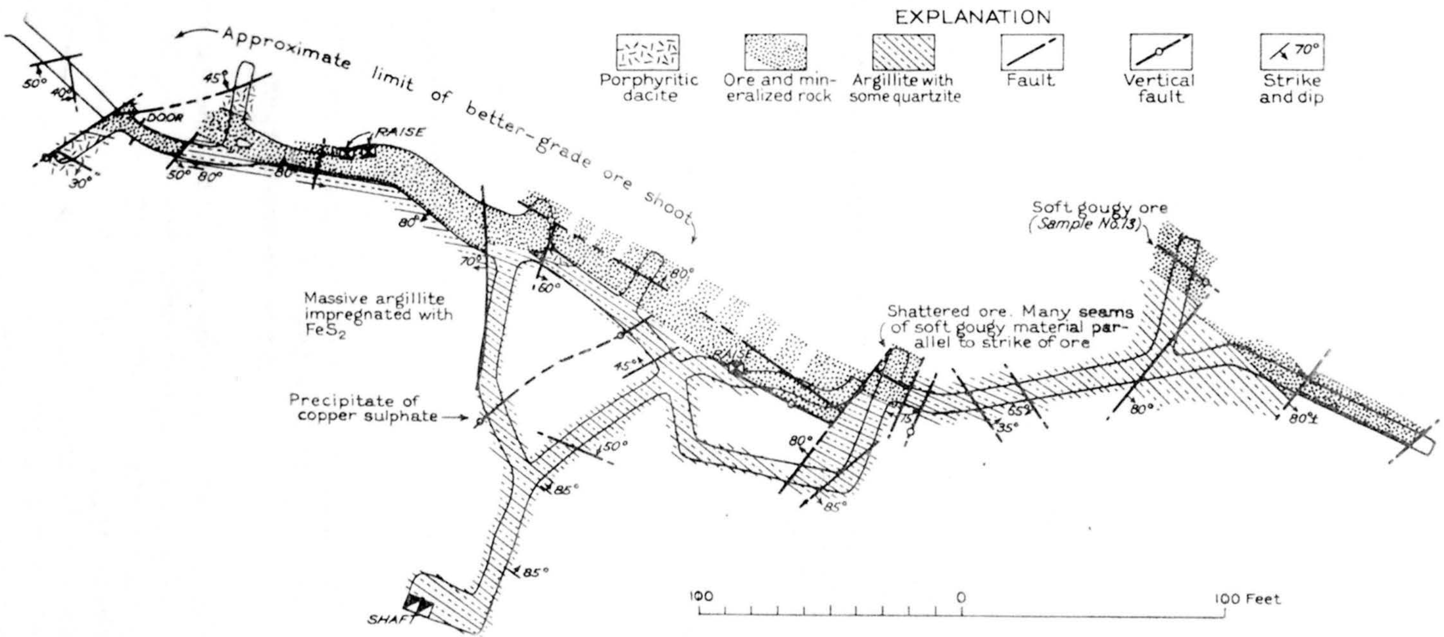
[24] Diller, J. S., op. cit., p. 76.



MAP OF THE RIVER LEVEL, ALMEDA MINE

Origin of the ore

The ore at the Almeda mine has been formed almost entirely by the replacement of porphyritic dacite close to the contact with argillite. Other bodies of porphyritic dacite have intruded argillite beds, but so far as known the only contact that has been extensively mineralized is the one at the Almeda mine known as the Big Yank lode. Both Diller[25] and Winchell[26] have stated that the Big Yank lode occurs along a zone of faulting. Faulting along the contact probably caused the development of the fractures through which the quartz has so plainly penetrated the rocks. Replacement occurred near the contact in both porphyritic dacite and argillite, but in the argillite to a much lesser degree. After intense silicification and possibly pyritization, the brittle silicified rocks were again fractured. Barite and probably additional quartz were introduced along the fractures and particularly along the zones of greatest shattering. After the barite, sulphides were introduced--pyrite first, and then the other sulphides, apparently as an overlapping series. Like the barite the sulphides tended to follow the zones of most intense shattering, which, as shown by the concentration of barite and sulphides, developed close to the contact of the prophyritic dacite and argillite, thus forming the higher-grade ore shoots. Faulting made evident by gouge, shattering, and displacement of the ore continued after the deposition of the sulphides. Ultimately erosion brought the ore bodies close to the surface, and oxidation attacked the sulphides. Much of the oxidized material was removed, and some of the metals were carried downward to be redeposited as supergene sulphides. However, erosion has nearly kept pace with oxidation, so that today there is but a thin zone of oxidized minerals.

The source of the ore minerals is purely speculative. Most of the sulphides at the Almeda mine are characteristically hypogene minerals and hence, in the light of our present knowledge, were derived from some magmatic source below. Diller states that the porphyritic dacites are thought to be genetically related to the granodiorite masses that are so extensive in southwestern Oregon.[27] With this assumption it may be expected that the ore-bearing solutions were derived from the same parent magma as the porphyritic dacite.

Economic considerations

Two possibilities must be considered in discussing the economic outlook for the Almeda mine--(1) the possibility of developing an enormous tonnage of very low grade ore that would be minable when metal prices recover; (2) the possibility of developing and working smaller shoots of higher-grade ore.

Without question there is, at the Almeda mine, an enormous deposit of silicified rock containing variable amounts of pyrite and some silver and gold. This is the "siliceous gold-silver ore" mentioned by Diller. When conditions are favorable for the exploitation of large low-grade deposits containing silver, gold, and copper, consideration should be given to the mineralized zone at the Almeda mine. The material, excluding the shoots of better ore, is certainly of low grade, but there is a possibility that under very favorable conditions a large part of the

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[25] Diller, J. S., op. cit., p. 74.

[26] Winchell, A.N., op. cit., p. 208.

[27] Diller, J.S., op. cit., p. 21.

mass might be workable. Only careful and complete sampling will determine the feasibility of such a venture.

Mining has demonstrated the occurrence of good-sized bodies of the richer ore. At least two have been partly developed. The larger and higher-grade body has been partly blocked out for a pitch length of about 800 feet. The smaller body lies about 250 feet north of the larger one and has been only slightly developed. It is not known by the writer whether the continuations of these bodies were found on the levels below the river.

The south ore body is practically as long on the river level as on level 1, 100 feet above, and if it has not been found on the 300-foot or shallower levels below the altitude of the Rogue River, the reason is probably because prospecting has not been carried far enough to the south. The north ore body has not been developed sufficiently to determine its pitch. However, it apparently has not been found on the River level. Diller has suggested that the ore found near the shaft on the 300-foot level might be the extension of this body. However, if the pitch is approximately constant, it should have been intersected by the River level. Therefore, it seems probable that the north ore body may have a steeper pitch than the south ore body and that the ore body on the 300-foot level may be a separate one. This inference is in accord with the interpretation of the origin of the ore - that is to say, the higher-grade shoots might be expected along the argillite contact wherever intense shattering formed permeable openings for the ore-bearing solutions to follow.

The shoots of richer ore have been found at or very close to the contact of argillite, and there is a possibility that careful study might reveal undiscovered shoots along the contact of the Big Yank lode. The outcrops of the better ore differ considerably from those of the lower-grade siliceous ore.

Sulphide enrichment undoubtedly increased the metallic content of the ore near the surface. Tiny seams filled with supergene covellite are plainly visible in all the stopes examined. It is clear, however, that sulphide enrichment has not been the chief factor in the formation of the better-grade ore shoots. Most of the minerals of the shoots are of hypogene origin, and hence their development was not dependent upon surface agencies. The supergene minerals have affected the shoots only by adding somewhat to their metallic content, particularly to the copper and possibly to the silver.

Apparently local smelting of the Almeda ore was not successful. The appearance of the slag indicates that considerable difficulty was encountered. The slag is stony, is not uniform in composition, and is shot through with metallic globules and some undissolved pyrite. According to Holdsworth[28] the composition of the slags from the Almeda matting furnace was as follows:

Composition of slags from Almeda furnace

	1	2	3	4
SiO_2...............	30.9	31.8	31.1	38.9
Al_2O_3.............	10.6	13.5	9.9	4.7
FeO...............	24.9	24.0	25.3	22.3
CaO...............	3.1	3.9	4.8	1.3
BaO...............	30.4	26.9	29.1	32.9

[28] Diller, J.S., op. cit., p. 8.

If a reasonable tonnage of ore of a grade indicated by the analyses of Holdsworth and Diller can be demonstrated the higher-grade shoots should receive serious consideration when metal prices justify it, in view of the recent improvements in metallurgy, particularly in flotation.

Outlying copper deposits

Banfield

The Banfield mine is about 5 miles southwest of Drew, at an altitude of 2,400 feet. It is said to have been located as the Rainbow lode, but it is now generally known by the name of H. Banfield, a former owner, who developed the deposit during a period of 20 years or more after 1900. A production of 52 tons of ore containing 10,059 pounds of copper and 19 ounces of silver was reported in 1928.[30] In July 1929 a small crew was employed in repairing a concentrating mill near the mine. According to J. T. Pardee, who visited the mine at that time, the deposit is opened by several adits at different levels, and the underground workings are rather extensive. The country rock is chiefly greenstone that belongs to the older or pre-Tertiary rock group of southwestern Oregon. The greenstone is intruded by a body of porphyry of undertermined extent. In a zone that trends north and is 20 or 30 feet wide the greenstone and porphyry are bleached nearly white by hydrothermal alteration. Within this zone chalcopyrite and pyrite are irregularly distributed as stringers, grains, and bunches. The sulphides are accompanied by abundant magnetite and, locally, bunches of quartz having a coarse texture like pegmatite. Microscopic examination of a specimen of sulphide ore by M.N. Short shows it to consist chiefly of chalcopyrite studded with small crystals of magnetite. Some pyrite also is present. These minerals are cut by veinlets of carbonate and quartz.

Pennell & Farmer

The prospect of Pennell & Farmer is on the South Umpqua River about 1 mile above Tiller. When seen by Mr. Pardee in July 1930, a shaft equipped with up-to-date hoisting machinery was being sunk on the north bank of the river, preparatory to exploring the deposit with crosscuts in depth. The country rock consists largely of dark-green hornblende and quartz and shows a decided schistose structure that trends northeastward. Small pink garnets are sparingly scattered through the rock, and locally much of the hornblende is altered to chlorite. Here and there for a short distance outcrops exposed along the stream at low water contain grains and streaks of chalcopyrite sparingly distributed along the schistosity. Except that in places the exposures of mineralized rock are a few feet wide, the extent of the deposit is not shown.

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[30] Personal communication from Victor C. Heikes, of the U. S. Bureau of Mines.