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Title ORIGIN OF THE MINERAL DEPOSITS OF THE NORTH SANTIAM MINING DISTRICT, OREGON

Abstract Approved: Redacted for privacy
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This report deals with the origin of the mineral deposits of the North Santiam Mining district, Oregon. The district is one of a group of similar districts such as Quartzville, Bohemia, Blue River, and Buzzard, which occur at intervals throughout the Cascade Range in Oregon. It is located in the northeast corner of Marion County, Oregon about 50 miles by road from Salem, Oregon.

Six rock types are found in the district: (1) Black olivine basalt, (2) Pyroclastics composed of tuffs and agglomerates, (3) Andesite series composed of porphyritic gray andesites and rhyolites, (4) Dioritic intrusives, (5) Battle Axe lavas, (6) Tillite and recent alluvium. The topography of the district is rugged with erosion having proceeded to about the stage of maturity.

The gray porphyritic andesite lavas cover the major part of the district and it is in these rocks that the now known mineral deposits occur. Before the dioritic bodies were intruded, the andesites were fractured and fissured resulting in a parallel fracture system oriented from N 20° to 40° W. The parallel fractures greatly controlled the location and orientation of the small elongate dioritic bodies which were intruded into the andesite following the period of fracturing and fissuring.

Mineralization of the andesites closely followed the intrusion of the dioritic bodies, and can probably be divided into two stages.

The first stage was characterized by the hydrothermal alteration of the country rock with the formation of the hydrothermal minerals, epidote, chlorite, sericite, pyrite, quartz, and calcite. The hydrothermal alteration affected both the andesites and the dioritic intrusives, and though most prominent in the early stages of mineralization, was active throughout the process of mineralization. The second

stage of mineralization was characterized by the filling of open fractures and shear planes with the common base metal sulphides. The ore bearing solutions did not come from the small diorite intrusives exposed in the district. They were given off from a batholithic source magma and deposited under low temperature-pressure epithermal conditions. The veins are characterized by irregular form, coarse texture of ore, banding of ore, vugs, enclosed and silicified fragments of country rock, and narrow ore shoots. The common minerals are pyrite, chalcopyrite, sphalerite, galena, and specularite in a quartz and calcite gangue. The minerals were deposited in the following order: (1) pyrite, (2) quartz, (3) sphalerite, (4) galena, (5) chalcopyrite, (6) quartz, (7) pyrite, (8) calcite, (9) gypsum. The veins occur in shear zones where movement has sufficiently opened up the andesite country rock to permit the entrance of mineralizing solutions. The veins of the district show a possibility of areal zoning. The Rainbow #1 mine is the only mine in the district that is shipping ore at the present time (1941). The Columbia Mines and Development Company was doing some development at the time of this survey.

ORIGIN OF THE MINERAL DEPOSITS
OF NORTH SANTIAM MINING DISTRICT, OREGON

by

WILLIAM HAMILTON LEEVER

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FIELD WORK AND ACKNOWLEDGEMENTS

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The writers attention was first directed to the district by Dr. E. T. Hodge, to whom is here offered an expression of gratitude for his invaluable assistance with the research and the writing of this report. To Dr. W. D. Wilkinson and Dr. I. S. Allison for their valuable advice and criticism, the writer expresses his appreciation. Much credit is due Stewart M. Jones for his fine photographic work. The writer also wishes to thank Maurice E. Mercer and Miss Irene Hoover for their valuable advice and assistance. The writer appreciates the hospitality of Mr. Pickler of the Rainbow mine and Mr. Hewitt of the Columbia Mines and Development Company.

CONTENTS

ILLUSTRATIONS

SPECIAL FEATURES OF THE NORTH SANTIAM MINING DISTRICT

For the reader who may not have time to read this report in detail, the following special features of the district are listed.

1. The mineralization is not genetically due to the small dioritic intrusives found in the district.

2. The veins of the district are later than the diorite intrusives.

3. Hydrothermal alteration, in the first stages of mineralization, affected all of the andesite and diorite country rocks, with the formation of epidote, chlorite, pyrite, sericite and quartz.

4. The veins and intrusives were formed in and intruded into shear zones in the andesite flows.

5. The dioritic intrusives commonly have veins in their immediate vicinity.

6. The minerals are the common base metals such as chalcopyrite, sphalerite, galena, specualrite, quartz, and calcite, and had an epithermal origin.

7. The minerals were deposited in the following order: Pyrite, quartz, sphalerite, galena, chalcopyrite, quartz, and calcite.

8. Some evidences of areal zoning are found.

9. Fractures stained with iron and copper are important clues when looking for mineralized zones.

INTRODUCTION

Location

This report deals with the origin of the mineral deposits of the North Santiam Mining District, which lies in the Western Cascades in Oregon. Specifically, it is located in the northeast corner of Marion County, Oregon, lying between 44° 48' and 44° 55' north latitude and 122° 10' and 122°30' west longitude. Plate I. It contains approximately 100 square miles. The district is one of a group of similar districts such as Quartzville, Bohemia, Blue River, and Buzzard, which occur at intervals throughout the Cascade Range in Oregon from the Columbia River to the California line.

Roads

The North Santiam Mining District is served by a mountain road that extends from Mehama, on the Detroit branch of the Southern Pacific Railroad, to the center of the district, a distance of about 22 miles. The same forest road extends eastward from the district past Elk Lake to Detroit, a distance of 20 miles, but is passable only during the summer months. The district is about 50 miles by road from Salem.

Previous Work

Brief accounts of the district have been made by Stafford (13) and by Parks and Swartley(12). Callaghan visited the district in September, 1930 in connection with his survey of the metalliferous mineral deposits of the Cascades.(1) Williams(17) briefly described some of the features of the district. Unpublished reports have been made by engineers upon the various mines. W. L. Merritt made a report on the Columbia, or old Amalgamated mine. W. J. Emeldorff and J. H. Batchellor have made reports on the Rainbow, or Minnie E. mine.

Geology of the Cascades

The Cascade Range in Oregon, south of Mt. Hood is from 30 to 70 miles wide and forms the central part of a range of volcanic peaks that extends from the vicinity of Lassen Park to Mt. Baker near the Canadian border in Washington.

The Western Cascades in Oregon consist of a maturely dissected region with narrow canyons and steep walled ridges ridges and valleys. It is in this region that all of the so far discovered metalliferous deposits lie. The rocks consist of lava flows and fragmental rocks that range in age from Eocene to Pliocene though it is thought that most of the lava was erupted in Miocene time. Summits rise to altitudes of 2000 to 6000 feet and the relief ranges from 1000 to 4000 feet in a distance of two to four miles. The average elevation is 4500 to 5000 feet. The divides between stream drainages are sharp and narrow, with the stream pattern as a whole, dendritic, and the main drainage toward the west. Glaciers at one time were active and modified the higher summits of the range.

Plate I

STATE MAP

COUNTY MAP

INDEX MAPS SHOWING LOCATION OF NORTH SANTIAM MINING DISTRICT

GENERAL GEOLOGY

The general geology of the district is quite simple and very similar to that of the Santiam Basin which has been described at length by Thayer.(14)

Six series of rocks occur in the area. (1) Black basalt, (2) Pyroclastics, (3) Andesite series, (4) Dioritic intrusives, (5) Battle Axe lavas, (6) Tillite and recent alluvium. Plate II.

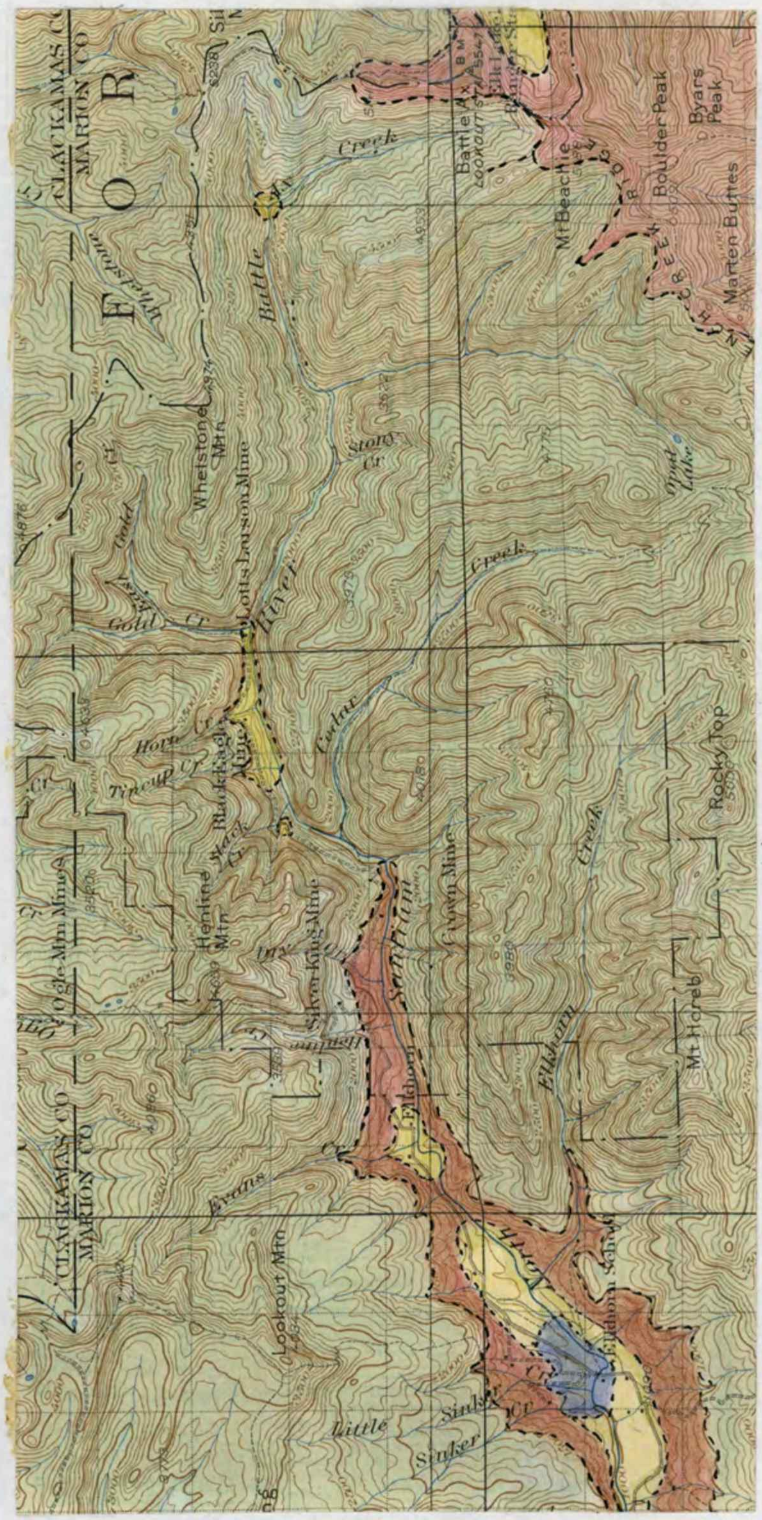
Mehama to Columbia Properties

Possibly the clearest way to describe the general geology of the region is to describe that encountered upon traveling up the Little North Santiam River from Mehama to the Columbia Mines and Development Company properties on the eastern side of the district.

From Mehama to the western edge of Elkhorn Valley, a distance of about 12 miles, the rocks are mainly lavas, tuffs, and breccias, called by Thayer, the Mehama Volcanics.(14) The canyon is steep walled and contains numerous terraces from 30 to 75 feet in height. Glacial till containing large boulders, some five feet in diameter, and lenses of clay are found in the canyon.

Immediately east of this canyon and extending for about six miles eastward, the canyon of the Little North Santiam widens out into a relatively flat bottomed

Plate II



Tillite & Alluvium
Recent and
Pleistocene

Battle Axe Lavas
Early Pleistocene

Andesite Series
Middle Pliocene

Pyroclastics
Early Pliocene

Black Basalt
Middle Miocene

N

Scale
$\frac{1}{125,000}$

RECONNAISSANCE GEOLOGIC MAP OF THE NORTH SANTIAM
MINING DISTRICT
From U.S. Geol. Sur. Map of the Mill City Quad, Oregon

steep walled valley, called Elkhorn Valley. The valley is about a mile wide, five miles long and has numerous alluvial terraces around its edges.

The walls of the valley are vertical cliffs of successive flows of gray andesite with numerous landslides and talus slopes. Plate III Fig. 1 shows the cliffs at Stack Creek which have the appearance of volcanic necks or plugs.

The rock in the zone below the andesites and above the floor of the valley is probably a tuff, agglomerate or some such soft pyroclastic. The Little North Santiam River in its process of downward cutting, reached the level of the soft material and began, by lateral planation, to widen its floor due to the less resistance to erosion of the soft material in comparison with the basalts below and the andesites above. The sside-ward cutting as well as downward cutting of the river in the soft material, resulted in the formation of the Elkhorn Valley.

East of Elkhorn Valley, the Little North Santiam River, for the remaining distance of about ten miles to the eastern edge of the district, has cut its canyon in gray andesite lavas. The walls of the canyon are quite steep, rising from elevations of less than 2000 feet to heights in excess of 4600

Plate III

Fig. 1 Vertical cliffs of sucessive andesite lava flows at headwaters of Stack Creek.

Fig. 2 Diorite dike one half mile east of Stack Creek.

feet above sea level in lateral distances of less than a mile and one half from the Little North Santiam River. Plate IV Fig. 1. Along the upper canyon, tillite and gravel beds are found "plastered" against the walls. Many of these deposits occur at the mouths of the small tributary streams. One such deposit, about 50 feet thick, is found at the mouth of Gold Creek and contains boulders up to 5 feet in diameter. Terraces or benches which are about 350 feet above the Little North Santiam River and have alluvial deposits on them, are found at the mouths of Stack and Horn Creeks. At the junction of Battle Axe Creek and Boulder Creek, the floor of the canyon is again widened out to form a small flat, covered with five to ten feet of alluvium. The streams have cut through this veneer of alluvium.and are now cutting into the gray andesite lavas beneath.

Drainage

The drainage of the district is to the west with most of the runoff being carried by the Little North Santiam River and its tributaries.

The gradient of the Little North Santiam River is quite steep, with a change in elevation from 2500 feet at Battle Axe Creek to 650 feet at Mehama in a distance of about 28 miles, giving an average gradient of 66 feet per mile. The gradient from Battle Axe Creek to Elkhorn Valley is much greater, with a change in elevation from about 2500 to 1400 feet in a distance of less than ten miles.

The dissection of the district has proceeded to about the stage of maturity, but has not yet entirely destroyed the original andesite lava surface represented by the elongate ridges to the east and south of the district. Plate IV Fig. 1.

Rainfall

The rainfall is that typical of the Western Cascades. The average yearly rainfall since 1910, as recorded at Detroit (15) is 63.91 inches. Snow during the winter months, closes the road east of the Rainbow #1 mine.

Glaciation

Hodge (9) states that there were five post-Pliocene stages of glaciation in the Cascades, the exact times of which are not known. All these five stages are not shown in the district, but fine evidence of at least one period of glaciation is given by the glaciated valleys in the eastern edge of the district. Plate IV Fig. 1. Some of the lakes that occur in the upper

Plate IV

Fig. 1 View looking southeast from Henline Mt. Rugged surface and steep timbered slopes are characteristic of the district. Old lava surface of andesite series represented by line x - y. Battle Axe Mt. (a) with Mt. Jefferson in the background. Typical U-shaped glaciated valley (b) with cirque head and truncated ridge (c). Battle Axe Flat (d). Ruth vein workings (e) and Blue Jay vein workings (f) of the Columbia Mines and Development Co.

tributary valleys of the Collowash River, to the east of the district, are undoubtably glacial lakes. The topography of the area in which the lakes occur, ahows reworking and revamping by mountain glaciers. Cirques, some with lakes in them, of which Elk Lake is a fine example, are found. Terraces and deposits of glacial till, scattered along the Little North Santiam Valley from Mehama to the eastern edge of the district, also are good evidences of late Tertiary glaciation.

Hodge (9) gives the cause of these terraces as temporary aggredation by the stream followed by renewed degredation as a result of the increase of the volume of water flowing down the stream during inter-glacial stages.

Table I

GEOLOGIC COLUMN

Recent	Alluvium
Pleistocene	Tillite
Early Pleistocene	Battle Axe Lavas
Late Pliocene	Diorite Intrusives
Middle Pliocene	Andesite Series
Early Pliocene	Pyroclastics
Middle Miocene	Black Basalt
Early Miocene	Mehama Volcanics
Oligocene	

VERTICAL STRATIGRAPHIC COLUMN

1000'- Recent Alluvium-2500' & Tillite

5200'

Battle Axe lavas - recent lavas capping Battle Axe Mountain and other flat topped ridges at elevations above 4500 feet along the headwaters of the Little North Santiam River.

4500'

Andesite Series - gray andesite lavas, rhyolites and some tuffs cover the major portion of the area.

1500'

Pyroclastics - tuffs, agglomerates, in the vicinity of Elkhorn Valley.

1200'

Black Basalt - schistose-like basalt in the bottom of the Little North Santiam Valley near the Elkhorn School.

1000'

Mehama Volcanics - at the lower end of Little North Santiam River near Mehama.

Rock Types

Mehama Volcanics:

The Mehama volcanics occur in the area west of Elkhorn Valley and are in the main, lavas, tuffs, and breccias. They are relatively unimportant to the mineral deposits of the district as the nearest claim is about seven miles to the east of their eastern edge. Thayer (14) has described these rocks in his paper on the Salem Hills and the North Santiam River Basin.

Black Basalt:

A dark colored basalt is found in the bottom of Elkhorn Valley along the Little North Santiam River near the Elkhorn School. The exact correlation of the basalt is not known, but it is believed to be middle Miocene in age. It is possibly a part of the Mehama volcanics, but Hodge suggests that the basalt is a southward extension of the Coriba. (8)

In the hand specimen, the rock is a coarse grained dark colored basalt, with a distinct schistose appearance, and shows very little alteration.

Under the microscope, the rock is a diabase basalt. Plate V, Fig. 1. Augite is the only ferro-magnesium mineral, except olivine, present and occurs in small euhedral crystals and angular grains.

Olivine, though not noticeable in the hand specimen, is found as scattered grains and granular masses throughout a groundmass composed mainly of small lath-shaped crystals of labradorite. Magnetite appears under the microscope as small scattered grains.

The Little North Santiam River, which is still cutting into the basalt, has so far exposed a thickness of about fifty feet.

Pyroclastics:

The reasons for the belief that a soft series of rock, probably tuffs and agglomerates, occupies the area extending eastward for six miles or seven miles from the western edge of Elkhorn Valley, are the following:

1. The lateral planation of the Little North Santiam River forming Elkhorn Valley.

2. A soft series of rocks, the Madras formation, is found above the Coriba and below the Cascan andesites in other localities in North Central Oregon. (8)

3. Thayer found tuffs and agglomerates in the Sardine series. (14 p.8)

The thickness of the pyroclastics is estimated to be 200 to 400 feet. The pyroclastics overlie the black basalt and the Mehama volcanics, and are in turn overlain by the andesite series.

Andesite Series:

Age: Gray andesite lavas, tuffs and rhyolites make up the greater part of the rocks in the district and it is in these rocks that the now known mineral deposits are found. Thayer (14) classes the andesites as a part of the Sardine series, but Hodge suggested that they are part of the Cascan formation. With respect to the other rocks of the district, the andesites are later than the Mehama volcanics, and earlier than the period of fracturing and fissuring, the dioritic intrusives, and the mineralization.

Petrography: Light colored, porphyritic, oligoclase andesite with a greenish cast due to the presence of epidote and chlorite, is the dominant rock of the series. Plate V, Fig. 2. Dominant labradorite or andesine flows also are found in the series, one of which occurs at the mouth of Gold Creek. Some of the plagioclases at the Silver Star and Rainbow mines are altered to sericite and kaolin.

Augite is the principal ferro-magnesium mineral, and it has been highly altered to chlorite and epidote. It is found as phenocrysts deeply embayed by replacement, and as small grains in the groundmass. Hypersthene andesite was found near the top of the divide on the northern edge of the district.

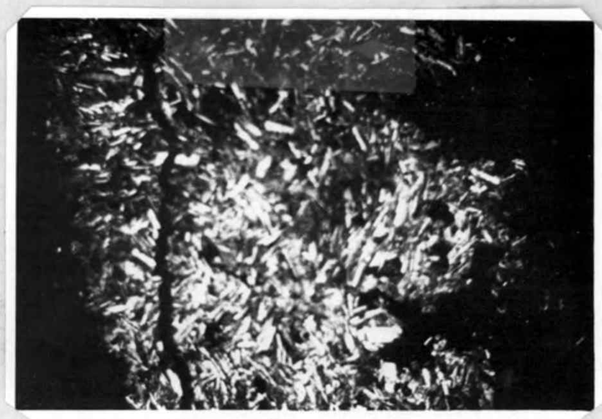


Fig. 1 Diabasic texture of black basalts. 16X with crossed nicols.

Fig. 2 Oligoclase phenocryst in porphyritic andesite. 16X with crossed nicols.

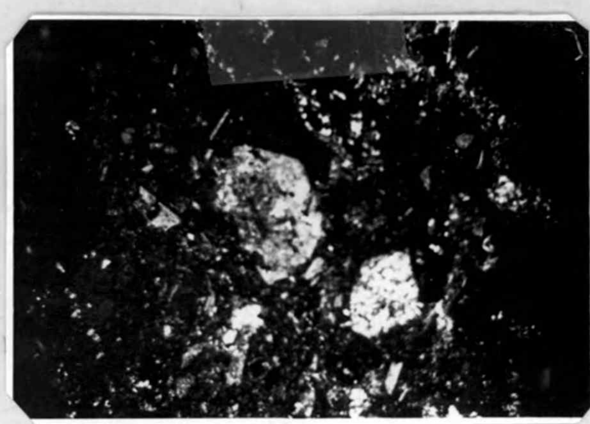


Fig. 3 Epidote replacement of oligoclase feldspar. 16X with crossed nicols.

Epidote, which is very prominent, is green in color and not generally found in the form of grains, but in areas representing replacement. These epidote replacement areas cover and extend into the plagioclases as well as the ferro-magnesium minerals. Plate V, Fig. 3.

The groundmass of the andesite is largely oligoclase with some secondary quartz. Magnetite occurs as scattered grains in the groundmass and also as an alteration product around the edges of the ferro-magnesium minerals. Pyrite, as anhedral to euhedral cubes, octahedrons, and as irregular grains, is widely scattered through the andesites. The pyrite is secondary as a result of hydrothermal alteration.

Flows with a high glass content occur at the cliffs in the fork of Battle Axe Creek and Boulder Creek. Because of the 70% glass content near the surface of each flow, the rock has been classes as and andesite vitrophyre. Plate VI, Fig. 1. The petrography, with the exception of the glass content, is about the same as the other oligoclase andesites found in the district. The glass is brown in color.

The rhyolites are either light gray or brownish in color, with oligoclase as the dominant plagioclase. Alteration of widely disseminated pyrite to limonite

Plate VI

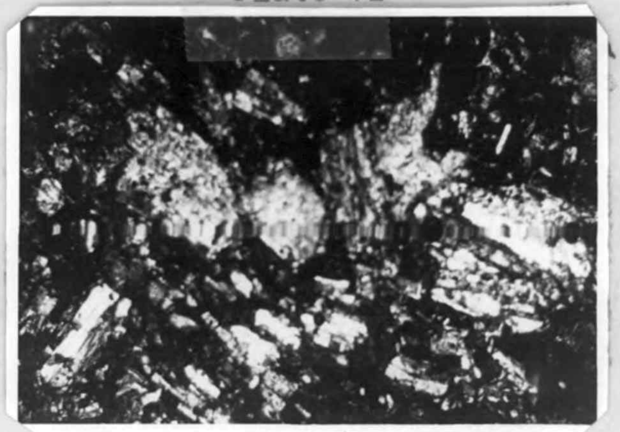


Fig. 1 Vitrophyre. Glass (Black) in groundmass of plagioclase feldspar. 16X Crossed nicols.

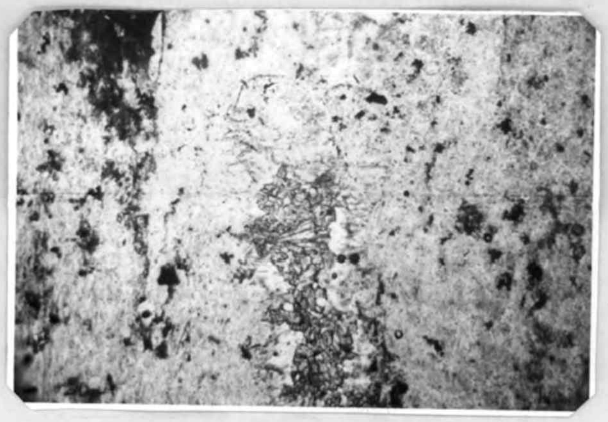


Fig. 2 Epidote replacement in rhyolite near Horn Creek. 16X with crossed nicols.

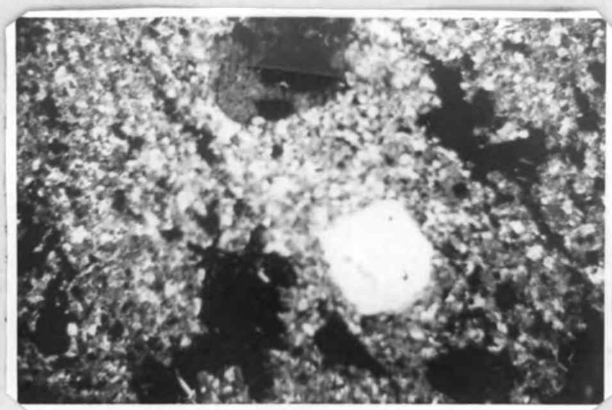


Fig. 3 Quartz phenocrysts in rhyolite from Columbia properties. 16X with crossed nicols.

has caused many of the rhyolites to have a brown speckeled appearance. Epidote replacement is noticeable under the microscope. Plate VI, Fig. 2. A dike of white rhyolite with phenocrysts of quartz is found near the Ruth vein of the Columbia Mines and Development Company. Plate VI, Fig. 3. Henline Mountain, above 2500 feet, is composed mainly of rhyolite which shows flow banding and flow structure.

Structure: The dip of the andesitic lavas vary over the district. The general dip north of the Little North Santiam River varies from 2° to 11° and averages about 5° in a north westerly direction; while south of the river, the dip is of about the same grade, but in a south westerly direction. A gently dipping anticline, striking in a northeast-southwest direction, can be proposed from these dips. The axis of the anticline roughly follows the course of the Little North Santiam River. It was suggested by Hodge, however, that this proposed anticline and the variation in the dip of the andesite series over the district is merely the initial dip at which the lavas came to rest when they poured out over the area. If the surface over which the lava flowed was topographically uneven, which is highly probable, this is a very plausible explanation for this variation in dip.

Dioritic Intrusives:

Small elongate dioritic intrusive bodies and dikes are scattered throughout the district. Their location is shown on Plate XXIV.

Age: The exact geologic age of the dioritic intrusive rocks is not known. Callaghan and Buddington class them as late Miocene. The writer believes them to be late Pliocene as they cut the andesite series, which probably is middle Pliocene. With respect to the other events which occured in the district, they are later than the fracturing and fissuring and younger than the mineralization.

Petrography: The dioritic bodies are light gray porphyritic rocks with plagioclase phenocrysts 1 mm. to 5 mm. in length in a medium grained groundmass. The rock, when wet, has a greenish cast, due to the presence of epidote and chlorite. Andesine is the dominant plagioclase. Quartz is found replacing plagioclase in small areas in the groundmass.

Augite is the principal ferro-magnesium mineral, but is highly replaced by epidote and chlorite. Magnetite occurs as an alteration product around the edges of the augite phenocrysts and as scattered grains throughout the groundmass.

Epidote, as in the andesites, is a prominent replacement mineral. It does not commonly occur as grains but as small replacement areas in the groundmass, in embayments in the plagioclase phenocrysts, and in the grains and phenocrysts of the ferromagnesium minerals. Chlorite is also present as a replacement mineral, but in less amounts than epidote. Small areas of low birefringence in the epidote appear to be clinozoisite. Pyrite grains, as a hydrothermal product, are widely scattered through the intrusive rocks.

Some of the dikes, as the one at Silver King prospect, are fine-grained with a small number of phenocrysts in the hand specimen and might technically be termed a dacite porphry, but the composition is essentially the same as the porphyritic diorite.

Structure: The intrusive masses are in general small and elongate in shape. They are seldom over 10 to 100 feet in width, but may extend for distances of 500 to 1000 feet. Most of the intrusives occur as dikes, Plate III, Fig. 2, and have a common strike in a northwesterly direction, the average of which is from N 20° to 40° W. The fractures and faults in the district were the chief factors in controlling the location and orientation of the intrusive bodies.

Battle Axe Lavas:

The Battle Axe lavas are probably the most recent igneous rocks, and cap the elongate ridges and peaks at the southeastern edge of the district. Battle Axe Mountain is made up of these recent lavas above an elevation of about 3000 feet. Plate IV, Fig. 1. These rocks, described by Thayer (14) are relatively of little importance to the mineral deposits of the North Santiam District.

SEQUENCE OF EVENTS

It is thought that the information concerning the district can be best presented in a chronological order. The outpouring of rock, intrusion, faulting, fracturing, and fissuring in the district took place during Tertiary time. The exact geologic age of each rock is not difinitely known, but an order or sequence of events that occurred in the district can be made from the relationships of one rock to another and from the relation of the faults and fractures to the rocks in which they are found.

1. Out-pouring and accumulation of the Tehama and other volcanics of the Western Cascades through Eocene and Oligocene times. (14 p. 3)

2. Accumulation of the black basalt in middle Miocene time.

3. Pyroclastics deposited in western part of the district, probably during early Pliocene time.

4. Accumulation of successive flows of gray andesitic lavas and tuffs during middle Pliocene time.

5. Deformation of the andesites producing the gently folded Little North Santiam anticline and fracturing the andesite flows with a resulting group of echelon fractures and small faults trending N 20° to 40° W. With the formation of these fractures

and faults, movement occurred along them producing slickensides and sheer zones.

6. Closely following was the intrusion of the elongate porphyritic diorite bodies, accompanied by some contact metamorphism, during the late Pliocene time.

7. Hydrothermal alteration of all earlier rocks.

8. Mineralization by the upwelling of mineral bearing solutions from an intrusive magma, producing sulphide ore deposits in the fractured zones.

9. Subsidence and readjustment after intrusion, resulting in lesser, but noticeable movement along the fractures and planes of former movement.

10. Outpouring of the Battle Axe lavas in early Pleistocene time.

11. Erosion with regional uplift.

12. Glaciation in Pleistocene time accompanied by the formation of U-shaped valleys, cirques, terraces, and other glacial deposits.

13. Continuous erosion, with the Little North Santiam River reaching temporary base levels and forming benches, terraces, and other deposits of alluvium in the Little North Santiam canyon, in recent times.

14. Weathering and leaching of veins, from the time of formation of the veins to the present day.

Fractures and Fissures

The first event of importance to the mineralization of the district, was the period of faulting, fracturing, and fissuring of the andesite series. It is herein discussed from a structural standpoint as the structural relationship between the veins and fractures is quite important.

Structure:

Faults in the district are important because of their relationship to the mineralization. See pp. 70. Major faults in the Cascades have been noted by Hodge,(7) Thayer,(14) and by Callaghan and Buddington (1). Due to the absence of beds which could be used for correlation to show the amount of offset, and also due to the fact that the amount of movement was not great enough to bring the rocks into juxtaposition, the actual amount of movement along the fault planes can not be determined. The faults dip steeply, 70° to 90°, mainly in a westerly direction, have a general trend of N 20° to 40° W, and are roughly parallel to the veins, elongate intrusive bodies and the major system of fractures in the district. This fact suggests a common agent or connection between agents responsible for the formation of faults, fractures and zones of weakness throughout the district.

There are two systems of fissures and fractures. The most prominent set has a strike of N 20° to 40° W and the minor set has a strike of about N 25° E.

Origin:

The early period of fracturing and fissuring occurred before the intrusion of the small elongate diorite bodies, because the fracture systems in the andesites do not extend into the diorites. The places of intrusion of the diorite bodies were probably controlled by the presence or absence of fractures. It is hard to definitely say whether the force responsible for the formation of the fractures was exerted by these small dioritic bodies themselves or whether the fractures and fissures were produced by forces exerted at an earlier date. It is the opinion of the writer that this last cause is the true explanation, as the parallel fractures occur in districts in which there are no visible intrusives. W. H. Emmons (4 p. 13) writes the following with respect to parallel veins.

> "The systems of rudely parallel veins are more common than all other vein systems combined. Some such systems are not connected with exposed igneous intrusives, but a very large number of them are. Most stock-like intrusives are distinctly elongated and many of the larger intrusives have finger-like projections extending outward from them. Veins associated with the small elongated stocks and cupolas generally lie nearly parallel to the long axes of the stocks, and veins in

> and near the finger-like projections of the larger bodies generally lie parallel to the long axis of the finger."

The fractures and veins in the district are roughly parallel to the elongated axes of the small dioritic intrusive bodies.

The systematized relationship of parallel fractures to elongate intrusives, suggest that the major pressure forming the fractures was a result of the intrusive thrust exerted by a large parent body of rock. As erosion has not been deep enough, the parent intrusive rock has not been exposed. It is only natural to suppose that if the thrust of the intrusive magma were in part the fracturing agent, some of the magma itself would fill the fractures. Consequently, some of the magma which was responsible for the formation of the fractures, forced its way upward along the fractures, and as a result are oriented parallel to the fractures in the andesites.

Many localities showing this parallel relationship between veins, and veins and fractures, are found along the Cascades and Sierras.(4) Some examples of parallel veins associated with elongate intrusive bodies include those of Phillipsburg, Montana(5), Grass Valley, California(10), Bridge River, British Columbia(11), and Rossland British Columbia(2). The Bourlomangue Batholith and its satellites in western Quebec show a relationship of veins to intrusives which is similar to the relationship shown in the North Santiam District.

Intrusion of Dioritic Bodies

Dioritic bodies were intruded following the fracturing and fissuring of the andesite flows. They commonly occur as dikes. Plate III, Fig. 2. Veins usually occur in the vicintiy of the intrusives, however, no mineralization is found in the vicinity of the dike near Stack Creek.

The dioritic bodies present a valuable clue when looking for mineralized localities in the district, as they usually are found in mineralized zones.

Mineralization

The next event was the filling of the fractures, fissures, and shear zones to form veins of complex, base metal, epithermal type. The mineralization can probably be divided into two stages. The first stage was the hydrothermal alteration of the rock in and near the highly fractured zones. The second stage was the deposition of the sulphide ore minerals and was dominantly characterized by the filling of open fractures.

Late Period of Movement

A second period of movement and shearing occurred after the intrusion of the dioritic masses and the later mineralization of the fractures. It was much smaller in extent and intensity than the first period, and as far as could be determined, was confined to the former planes of movement, as no off-setting of the small veins and veinlets, which would indicate movement along new planes, was noted. This later period of shearing is evidenced by the slickensides and shear planes present in some of the veins. Small veinlets of calcite in the Ruth vein of the Columbia Mines and Development Company have been spread out along the surface of the fractures. Plate VII, Fig. 2. In the Blue Jay vein, owned by the same company, movement along the old fractures after the mineralization of the fractures have produced slickensides in the country rock and soft calcite. At the Rainbow mine, slickensides occur in the chalcopyrite filled fractures. This late period of movement was probably due to the settling, contraction, cooling and general readjustment of the rock as the source magma of the mineral solutions gradually reached a state of rest; however, it is possible that it was associated with the eruption of lavas from the high peaks of the Cascades in late Tertiary time.

Battle Axe Mountain, to the woutheast of the district, is one of such peaks. Plate IV.

HYDROTHERMAL ALTERATION

Hydrothermal alteration is most prominent in the highly fractured zones and along the fault planes. Undoubtably the hydrothermal alteration of the country rock extends for considerable distances around the faulted and fractured areas, but as no systematic sampling of the country rock for great distances was made, it can not be definitely said that this is absolutely the case. Although hydrothermal alteration was dominant, prior to the period of sulphide mineralization, it was probably active throughout the process of mineralization. For example, in some of the veins, as at Hart Brothers claim on Gold Creek, the rock is highly altered to sericite and a soft clayey mass. The hydrothermal alteration was largely of a propylitic nature producing epidote, chlorite, sericite, pyrite, quartz and some calcite. Both the andesites and the dioritic intrusive rocks were affected by the alteration and as a result, both have a greenish color which is especially noticeable near places of metallic mineralization. Callaghan and Buddington state (1. p. 30),

> "The country rock is commonly greenish. This type of rock is most prominent in the mineralized areas but occurs to a moderate extent throughout the Western Cascades."

Fig. 1 Leached portion of vein from Peekaboo prospect. Honeycomb quartz (q) with pyrite crystals (black dots) remaining. Natural size.

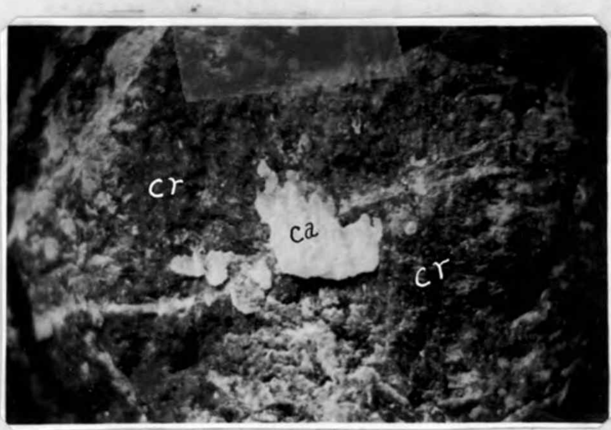


Fig. 2 Photomicrograph of calcite (ca) smeared by movement after mineralization. Andesite country rock (cr). Columbia property. 3X

Fig. 3 Breccia fragment from Gold Creek. Natural size

Epidote is a very prominent alteration product, generally being present in greater quantities in the country rock than chlorite. In personal communication, Hodge stated that this large amount of epidote present in the country rock is unusual for the common rocks found in the Cascades. Pyrite has been disseminated throughout the dioritic intrusive bodies and in large areas in the andesites. The pyrite is commonly in anhedral to euhedral striated cube and octahedral crystals. The crystals are small in size, averaging about 0.5 mm in diameter. A rhyolite dike of the andesite series from the Ruth claims contains striated pyrite cubes.

Near the more highly mineralized portions of the district, the plagioclases due to hydrothermal alteration, have been sericitized and kaolinized producing clay-like phenocrysts. This is especially true at the Rainbow #1 mine.

The greater part of the rock alteration in the district was due to hydrothermal effects extending from the veins, the fractures, and the fissures far out into the country rock. Both the dioritic intrusives and the andesite lavas are hydrothermally altered. There is no sharp break in the degree of alteration between them, but instead, it is continuous from the andesites into the dioritic bodies. The hydrothermal alteration is found, not only near the intrusive bodies, but also in areas in which there is no intrusive mass visible in the immediate vicinity.

Callaghan and Buddington (1 p. 84) state the following as to the contact metamorphism in the district.

> "Tourmaline-quartz-sericite hornfels occurs near the quartz diorite at the Crown mine and along the river near Stony Creek. Near Stony Creek, the tourmaline rosettes are as much as an inch in diameter, and the rock contains cavaties lined with quartz crystals. A hornfels taken from volcanic breccia at the crosscut of the Silver King mine contains dark spots 2 to 10 mm. in diameter which, under the microscope, are revealed as sheaf-like aggregates of magnetite in brown chlorite. Narrow zones of hornfels surrounds the smaller bodies."

It is true that at Stony Creek, the Crown prospect, and the Silver King prospect, there is evidence of contact metamorphism, but the evidences presented by these scattered localities are small in comparison to the widespread evidences of hydrothermal alteration.

Plate VIII

Fig. 1 Vein breccia cemented with quartz. Vugs (v) contain quartz and galena crystals. Ruth Vein of Columbia Mines and Development Co. 1/2 Natural size.

PARAGENESIS

The first minerals formed were the hydrothermal ones described above, viz. epidote, chlorite, calcite, sericite and perhaps quartz. All the later minerals were deposited in the veins.

The exact relationship between each mineral is rarely shown clearly. Some veins contain only two or three minerals, as at the Rainbow mine where chalcopyrite, calcite, and quartz are found; whereas other veins contain practically all the ore minerals found in the district, such as the Ruth vein of the Columbia Mines and Development Company which shows sphalerite, galena, chalcopyrite, quartz, calcite, and pyrite. By making a composite picture from all the mineral localities in the district, the relationship and succession of minerals can perhaps be made. Drawings and photomicrographs made from a detailed study of specimens showing the relationship of one mineral to another, are used to illustrate the succession of minerals.

Succession of Minerals and Mineral Events

1. The country rock was brecciated along the shear zones. Probably some of the breccia in the veins was produced as a result of the early quartz blocking off fragments of the country rock by filling the

fractures on all sides of the fragments. Plate VIII, Fig. 1 shows a typical, cemented by quartz, breccia.

2. Fine grained quartz, which surrounded fragments of country rock, was deposited, and in many veins, resulted in a quartz cemented breccia. The country rock fragments between the fissures were highly silicified. In the Hart Brothers claim, this early fine-grained quartz has a cherty appearance, and in many places, a green color due to the absorption of the andesite country rock which was highly chloritized and epidotized. Quartz undoubtably was formed at many stages during the process of mineralization, but this early quartz is much finer grained than the late quartz. Plate IX, Fig. 2 shows brecciated country rock from the Columbia properties, which is impregnated with early pyrite and cemented with fine-grained quartz. In places, it occurs as colloform microcrystalline quartz with Liesgang-like rings. Plate IX, Fig. 1. Some of this early quartz is possibly due to the hydrothermal phase of mineralization and hence a part of the same quartz which altered the country rock along the fissures and shear planes. Probably some pyrite accompanied the quartz, but it is not clearly shown.

3. Sphalerite was the next mineral to be

deposited. It forced its way along the fractures and open spaces, replacing the country rock and early quartz. Plate X, Fig. 1 shows sphalerite replacing the silicified country rock and in turn being replaced by chalcopyrite and quartz.

4. Galena deposition followed the sphalerite. In most cases, the galena seema to be replacing the sphalerite. Plate X, Fig. 2 shows islands of sphalerite in the galena, proving the galena in this case was later than the sphalerite. Plate XI, Fig. 1 shows fingers of galena extending into a sphalerite area.

5. Chalcopyrite, later than the galena, was the next mineral to form. The exact relationship between the chalcopyrite and galena is not always determinable, but the chalcopyrite is quite definitely later than the sphalerite. Plate XIII, Fig. 2. Galena cubes surrounded by chalcopyrite are shown in Plate XII, Fig. 1. Chalcopyrite veinlets cutting the early green quartz is shown in Plate XI, Fig. 2. Plate XI, Fig. 3 shows galena being replaced by chalcopyrite.

6. Quartz, as replacement and filling, was the next mineral after the chalcopyrite. This phase of quartz mineralization was much coarser than the early quartz, with vugs, crustification, and coarse grains being prominent. Quartz crystals are found implanted

Plate IX

Fig. 1 Photomicrograph of microcrystalline colloform quartz with Liesegang-like rings. Pyrite (py). Ruth Vein. 3X

Fig. 2 Vein breccia. Breccia fragments impregnated with pyrite. Ruth Vein. 1/2 Natural size.

Plate X

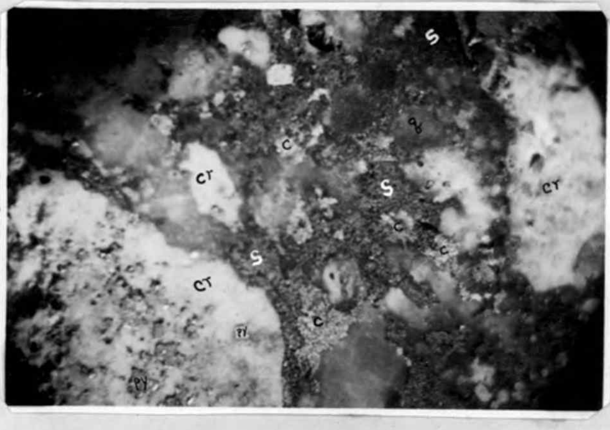


Fig. 1 Photomicrograph of sphalerite (s) replacing country rock fragments (cr) which are impregnated with pyrite (py). Chalcopyrite (c) replacing sphalerite. Quartz (q) replacing sphalerite, chalcopyrite and country rock. Ruth Vein. 3X.

Fig. 2 Photomicrograph of galena (g) replacing sphalerite (s). Islands of sphalerite in galena. Hart Brothers. 3X.

Plate XI

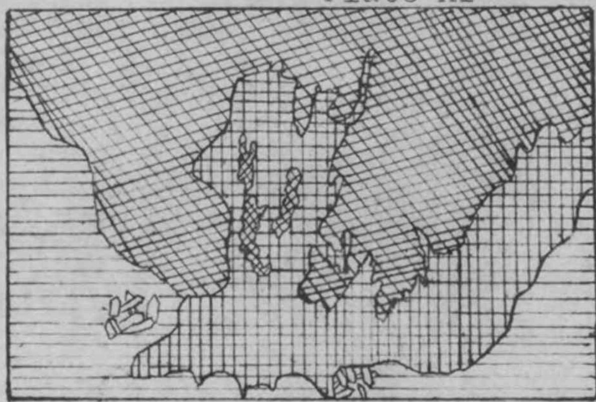
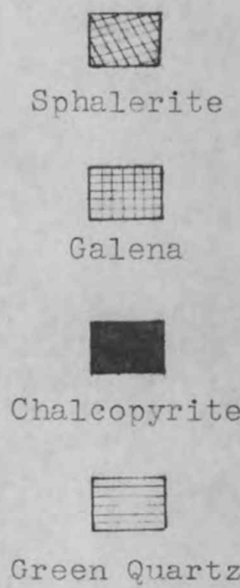


Fig. 1 Galena replacing sphalerite from Columbia property.



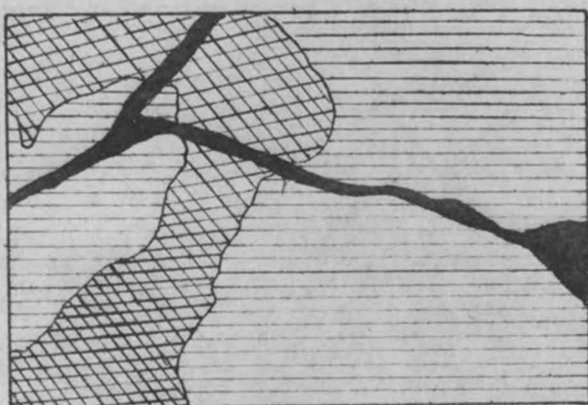


Fig. 2 Chalcopyrite cutting green quartz from the Rainbow #1

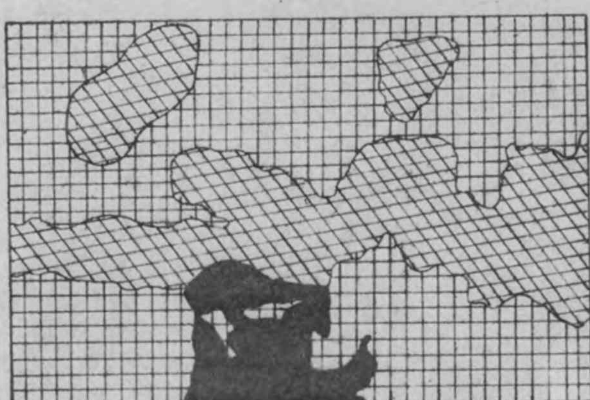


Fig. 3 Chalcopyrite replacing sphalerite and galena from Hart Brothers.

Plate XII

Fig. 1 Vug in country rock (cr) lined with quartz crystals (q), filled with cubic galena (g). Galena crystal surrounded by later chalcopyrite (c). Ruth Vein. 2 X

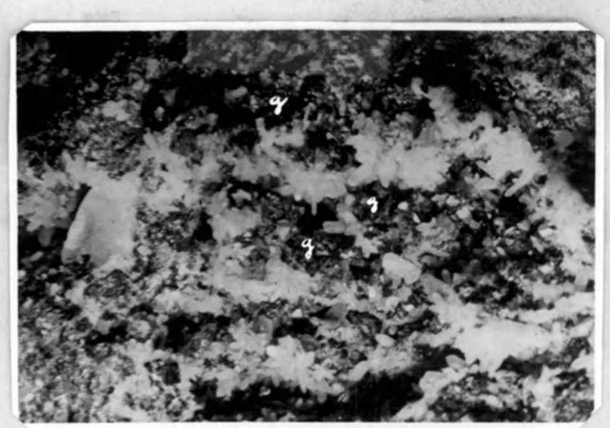


Fig. 2 Vug with quartz crystals (q) implanted on galena crystals (g). Ruth Vein. 2 X

Plate XIII

Fig. 1 Photomicrograph of galena (g) replacing sphalerite (s) and country rock (cr). Quartz (q) replacing sphalerite, galena and country rock. Ruth Vein. 3 X

Fig. 2 Photomicrograph of chalcopyrite (c) replacing pyrite (py) and sphalerite (s). Quartz replacing pyrite, sphalerite and chalcopyrite. Hart Brothers. 3 X.

on the surface of earlier minerals, especially the chalcopyrite, Plate XVII, Fig. 1, and galena, Plate XII, Fig. 2. This late quartz replaces sphalerite, galena, and chalcopyrite, and also forms veinlets which cut the earlier minerals. Plate XIV, Fig. 2. Although quartz deposition probably accompanied the earlier formation of sphalerite, galena and chalcopyrite, the late quartz, like the early quartz, is prominent and quite definite. Veinlets of the coarse quartz cutting veins and areas of the earlier green and fine grained quartz, proves at least two definite stages of quartz deposition. Plate XIV, Fig. 1 shows chalcopyrite replacing sphalerite and late quartz surrounding both of the earlier minerals.

7. Pyrite. Some pyrite either accompanied or closely followed the late quartz. Pyrite cubes of larger size than that of the early period, are found in the vugs and cavities in the later quartz veins. Pyrite, like quartz, probably was formed at numerous stages during the process of mineralization of the veins, but the hydrothermal stage and this late stage of pyrite deposition are the only two that can be placed in the succession column with any degree of accuracy. Plate IX, Fig. 2 shows the early pyrite in breccia fragments. Plate XV, Fig. 1 shows pyrite

Plate XIV

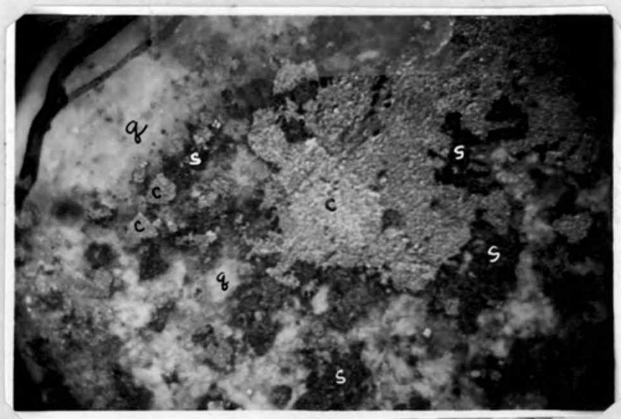


Fig. 1 Photomicrograph of chalcopyrite (c) replacing sphalerite (s) with quartz (q) replacing both minerals. Hart Brothers. 3 X

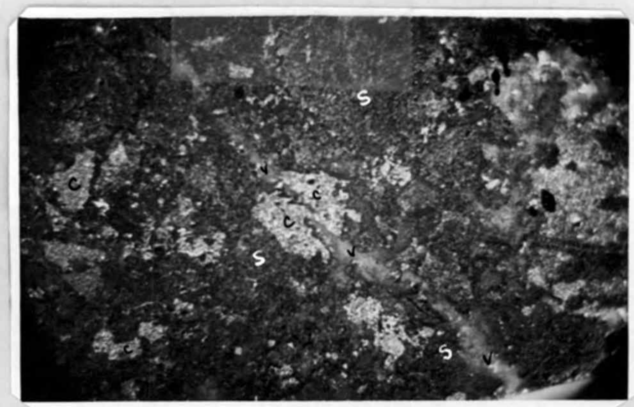


Fig. 2 Photomicrograph of sphalerite (s) and chalcopyrite (c) cut by quartz veinlet (v). Ruth Vein. 3 X

Plate XV

Fig. 1 Photomicrograph of pyrite veinlet in silicified country rock (cr) impregnated with pyrite crystals. Peekaboo. 3X

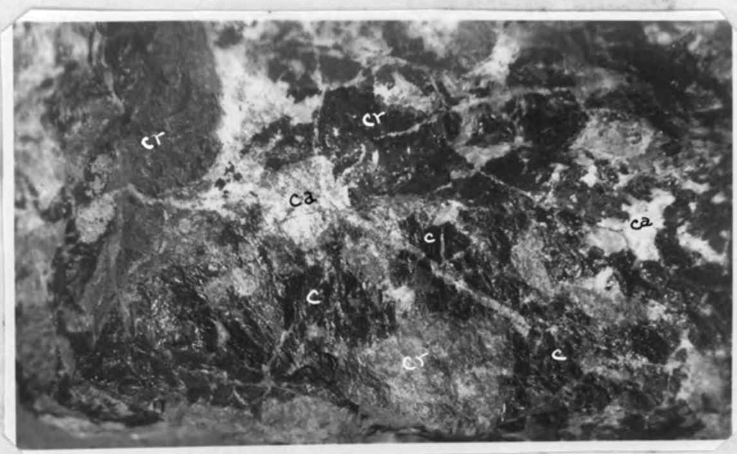


Fig. 2. Chalcopyrite (c) and country rock (cr) cut by calcite veinlets (ca). Rainbow #1 Natural size.

veinlets in silicified country rock.

8. Calcite was the next mineral to be deposited in the veins and occurs on the surfaces of most of the minerals. It is found in vugs, as veins, and as veinlets cutting earlier minerals. Calcite veinlets cutting country rock and chalcopyrite areas are prominent in the Rainbow #1 mine. Plate XV, Fig. 2. Calcite was found isolating pyrite and quartz crystals in the Billyboy prospect. Plate XV, Fig. 1.

9. Gypsum. Gypsum was the last mineral in the succession of minerals to be deposited in the veins. It occurs in vugs as implanted crystals and as a fine powdery film upon the surfaces of the other minerals. Small gypsum crystals are found on the gouge and wall rocks in most of the veins.

GENESIS OF ORE BEARING SOLUTIONS

The features of the veins and their field associations lead to the conclusion by the author that the mineral solutions rose from a cooling magma. It is quite definite that the mineralizing solutions did not come from the same source magma as the andesite series, since the veins occur in fractures in the andesites. W. H. Emmons(5 p. 12) writes the following concerning the association of late Tertiary mineralization with the country rock.

> "In areas of later Tertiary metallization, a majority of the deposits are associated with andesites. The andesites in many cases certainly did not supply the metalliferous solutions, for the andesite had already solidified before the deposits were formed. Both were evidently derived from deeper sources."

The deposits of the Western Cascades have been classed by writers(16) on the subject as being genetically associated with the dioritic intrusive bodies. Callaghan and Buddington state (1 p. 16),

> "Small intrusive bodies of dominantly dioritic rocks occur throughout the Western Cascades. They are believed to have a genetic relationship to the mineral deposits, though not all the intrusives have associated mineral areas."

The author believes that the vein ore solutions did not come from the small dioritic bodies exposed in the district. The most convincing argument in favor of this statement is field evidence. The veins themselves, in the field, do not extend from or definitely tie up with the intrusive bodies. It is true that the veins occur near and around the dioritic intrusives, but it is the authors belief that the ore bearing solutions followed the same zones of weakness to the surface as those which the dioritic magma followed. Callaghan and Buddington(1) state, p. 37

> "The vein solutions rose from a cooling magma at a considerable depth below the present outcrop, for the veins traverse both the intrusive bodies and volcanic rocks."

At Silver Star prospect, a small vein of quartz with some specularite was found in a dioritic dike. It can not be definitely said whether this vein cuts both the andesite and the diorite dike as little prospecting work has been done on the vein, and hence it could not be traced into the andesites.

Another convincing fact toward the conclusion that the veins solutions did not originate in the small dioritic bodies is the degree of alteration of both the andesite series and the dioritic intrusives. Just as the andesites were in the solid state before the intrusion of the small elongate dioritic masses, so were the dioritic bodies solid and chemically inert with respect to sending out ore bearing solutions and gases before the veins were formed. This is shown by the fact that both the andesites and the dioritic intrusive bodies are highly hydrothermally altered and hence the dioritic bodies were formed before the alteration took place.

It is difficult for the author to vizualize how the small dioritic bodies could have furnished the mineralizing solutions and still be hydrothermally altered along with the andesites, when this same hydrothermal alteration was the first phase of the mineralization. The exact relationship in age between the veins and the dioritic bodies can not be definitely stated, as no dikes were found which could be positively said to be cutting the veins, nor were there any veins found in the area which could be definitely placed as cutting the dikes. It is the author's conclusion, that the veins are later than the dioritic bodies and that the ore solutions did not originate in the intrusive rocks exposed in the district.

The vein ore solutions came up along the same zones of weakness as the intrusive magmas and deposited their mineral loads in the fissures, fractures, and shear planes in the andesite series. Although conditions probably varied somewhat during deposition of the ores, the condition of deposition was largely one of low temperature and pressure. Callaghan and Buddington found evidences of an initial high-temperature stage of mineral deposition of this type of deposit in the Western Cascades, especially in the Bohemia District. No good evidence of an initial high-temperature stage of mineral deposition was found in the veins of the North Santiam District. The ore minerals of the veins were deposited under epithermal conditions at depths probably less than 3000 feet, and the solutions probably originated from the same intrusive source as the dioritic magma, but were given off at a later stage. Most of the veins of the district show a crude banding and a coarse texture. Plate XVI, Fig.s 2 and 3 show banding of ore at Rainbow #1 and Hart Brothers claim on Gold Creek. Crustification, comb quartz, and vugs containing crystals of most of the minerals indicate the existance of the veins. Plate XVII Fig. 1.

The areal zoning of the mineralization in the district points toward a batholithic source of the ore solutions with the source nearest the surface in the central portion of the district. Plate XXI. The change in character of the mineralization away from this central area is probably due to the increasing distance between the source magma and the surface. This type of zoning is described by Emmons (3) p. 3 and is a plausible explanation for the zoning in the district, especially, as the solutions which deposited the minerals must have traversed rocks of essentially the same charcter along their paths through the

Plate XVI

Fig. 1 Photomicrograph of calcite (ca) isolating earlier quartz (q) and pyrite (py). Billyboy. 3X

Fig. 2 Banding of ore at Rainbow #1. Calcite (ca) country rock (cr), chalcoyrite (c). 1/2 Natural size

Fig. 3 Banding of ore at Hart Bros. Quartz (q) country rock (cr), sulphides (s). 3/4 Natural size.

Plate XVII

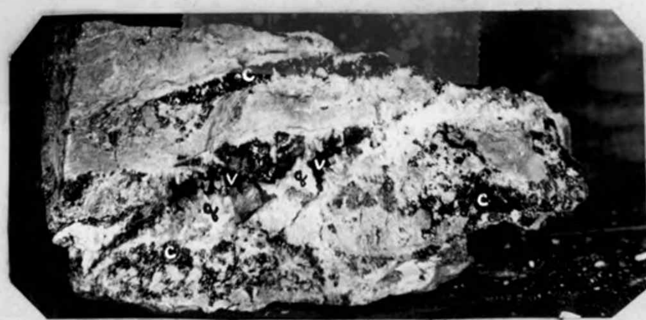


Fig. 1 Typical epithermal vein. Vug. (v) lined with quartz crystals (q). Chalcopyrite (c) with implanted quartz crystals. Rainbow #1. 1/2 Natural size.

Fig. 2 Sphalerite lump (s) surrounding fragment of country rock (cr) which is impregnated with pyrite (black dots). Quartz (q), calcite (c). Ruth vein. 1/2 Natural size.

andesite series.

The dikes and intrusives in the district show little sulphide mineralization outside of that due to the hydrothermal phase. The majority, if not all the veins, are found in the andesties. This fact can probably be explained in the following manner. The major period of fracturing and fissuring occurred prior to the intrusion of the dioritic bodies. After the intrusion of these bodies, no great pressure was applied to the district which resulted in the fracturing and shearing of the intrusives. Consequently, they are not fractured and sheared to as great an extent as the andesites. When the sulphide mineralizing solutions came upward along the planes of weakness, depositing ore minerals in the open fractures, they found conditions most favorable for mineral deposition in the larger openings in the fractures in the andesite flows. As these mineralizing solutions, due to their shallow depth, were not under any great pressures or high temperatures, they did not force new openings and dissolve new channels in the dioritic intrusive rocks.

Larger fractures are also more abundant in the andesites than they are in the rhyolites and hence, the greater amount of mineralization has taken place in the andesites.

MINERALOGY

The ores of the North Santiam Mining District are the common, complex, base metal type. Sphalerite, galena, chalcopyrite and pyrite are the common ore minerals seen in the hand specimen.

Gold and Silver:

The gold and silver content of the sulphide ores is very low. The average content of gold is about .03 ounces per ton and that of silver, about 1.50 ounces per ton. No gold or silver is seen in the hand specimen, but its presence is known by assays.

Sphalerite:

Sphalerite is one of the most abundant sulphides occurring in the veins and is the only zinc mineral found in the district. The color is dominantly a resinous yellow, but it also ranges from black to light green varieties. In the Silver King mine, both light and darker varieties are found in the same vein. It is usually found in masses and stringers without crystal form, but crystals, some of which show twinning occur in the vein of the Hart Brothers claim on Gold Creek. The sphalerite in many places is fractured and fissured, and cut by veinlets of quartz, calcite, galena, and chalcopyrite. The sphalerite, in general, contains little pyrite. Lumps and bands of pure sphalerite six inches wide were found at the Hart Brothers claim. Plate XVII, Fig. 2, shows a typical sphalerite lump surrounding a fragment of country rock. It is most prominent in the outer zone of mineralization. Plate XXI.

Chalcopyrite:

Chalcopyrite along with sphalerite is one of the most abundant sulphide vein minerals and is found in varying amounts in practically all the veins. It is the principal ore of copper and also the only primary copper ore found in the district. It commonly occurs as irregular lense-shaped masses and bands. Plate XVI, Fig. 2 and Plate XVII, Fig. 1. However, the chalcopyrite when found in vugs, occurs as poorly formed crystals. Plate XIX, Fig. 1. Sphenoidal crystals in vugs were observed by Callaghan and Buddington in the Blende Oro and Crown prospects. Anhedral sphenoidal crystals occur in the Ruth vein of the Columbia Mines and Development Company. Plate XVIII, Fig. 2. Chalcopyrite also occurs as scattered grains in silicified country rock fragments in the veins. Plate XIX, Fig. 2. Covellite, as an alteration product, is found in the Rainbow #1 mine as thin films on the surface of chalcopyrite. Oxidation and leaching of the chalcopyrite has produced malachite, chrysocolla and some azurite. Most of the veins show this to some extent, especially the Rainbow #1 and Crown mines. Though only a minor amount of these secondary minerals have been produced, they give the surface of many of the fractures in the shear zones a greenish and bluish color. This fact is especially true near the surface and proves a valuable clue in locating mineralized fracture zones in the heavily timbered country. Most of the quartz where the veins appear at the surface, has a green color due to the presence of malachite and azurite in its minute cavaties. Tenorite and chalcopyrite are present in small quantities in some of the weathered veins as a fine black powder. Chalcopyrite altering to iron oxides is prominent in the Rainbow #1 mine. Chalcopyrite was active as a replacement mineral, as areas of chalcopyrite are found replacing and encroaching upon areas of sphalerite and early quartz. Plate XIII Fig. 2.

The veins containing chalcopyrite as the dominant mineral are most prominent in zone I, Plate XXI, and are found at lower altitudes than the other sulphide veins. This is a peculiar occurrence and is not in keeping with its place in the succession of minerals, as chalcopyrite was one of the last sulphide minerals to be deposited, being later than sphalerite and

Plate XVIII

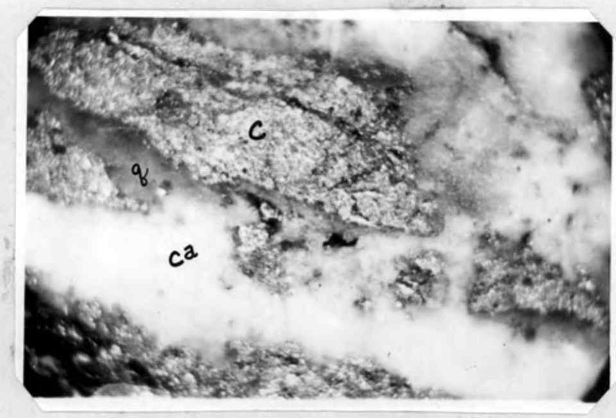


Fig. 1 Photomicrograph of banding at the Rainbow # 1. Chalcopyrite (c) Calcite (ca) Quartz (q) 3X

Fig. 2 Sphenoidal crystal of chalcopyrite (c) in quartz vug. Quartz (q) Ruth vein. 3X

Fig. 3 Photomicrograph of specularite (sp) with encroaching quartz (q). Ciorite dike near Silver Star. 3 X

Plate XIX

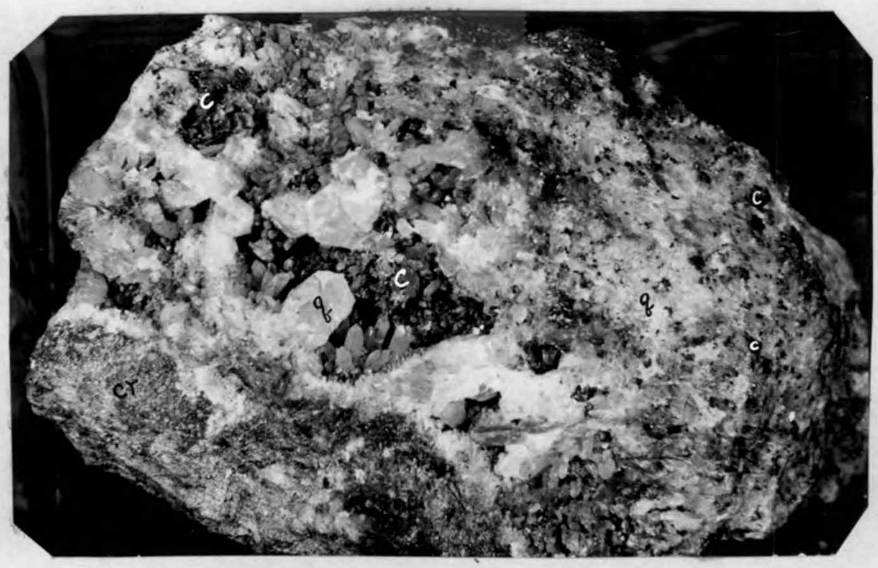


Fig. 1 Vein matter from Rainbow #1. Typical vug showing comb quartz (q). Chalcopyrite (c) with implanted quartz crystals. Country rock(cr) contains disseminated pyrite. Quartz (q) speckeled with chalcopyrite. 1/2 Natural size.

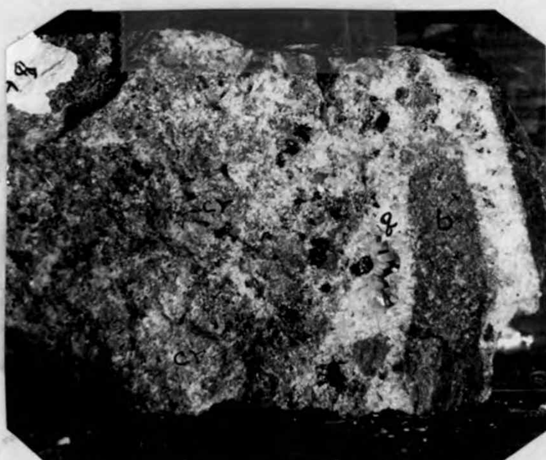


Fig. 2 Vein breccia from Rainbow #1 showing a typical elongate breccia fragment (b) with comb quartz (q). Characteristic silicified country rock (cr) containing chalcopyrite grains. 1/2 Natural size.

galena. The low altitude of chalcopyrite veins might be due to the chalcopyrite precipitating out of the ore solutions in greater quantities at a higher temperature and pressure when the ore bearing solutions were nearer the source magma. The dominant occurrence of chalcopyrite at lower altitudes indicates the possibility of the other sulphide veins grading into chalcopyrite veins at lower depths. However, the verification of this will have to wait for further development of the veins in depth. Veins characterized by chalcopyrite are more numerous in the North Santiam Mining District than in the other similar districts in the Western Cascades.(1 p. 85)

Galena:

Galena is the dominant and only primary lead mineral found in the district. It occurs intimately mixed with the other sulphides and in most veins, as coarse granular lumps in sphalerite or as crystals in vugs. In the Ruth vein of the Columbia Mines and Development Company, good cubic crystals were found in quartz vugs. Plate XII, Fig. 1. Some of the galena crystals found in these vugs have small quartz crystals implanted upon their surfaces. Plate XII Fig. 2. Galena cubes in the vugs also have grown around earlier quartz crystals on the walls of the openings, therely forming incomplete cubes of galena. In the Ruth vein of the Columbia Mines and Development Company, cubes of galena were found which were hollow in the center. The hollow center of one of the cubes had a peculiar L-shaped projection from one of the crystal walls. It is not definitely known whether these hollow center cubes were produced as a result of chemical solution or of incomplete crystal growth. The crystals of galena occurring in the vugs from the same vein are covered with a thin white film of gypsum. Galena is most prominent in the veins that occur at higher elevations and in the outer zones of mineralization, Zones III and IV, Plate XXI.

Pyrite:

Pyrite is perhaps the most common mineral found in the district. It not only occurs in the matrix of the veins, but also in the andesites, rhyolites, and diorites as widely disseminated striated cubes and octahedrons. Cubes and octahedrons also occur in the vugs in most of the veins. Pyrite crystals are very prominent throughout the vein matrix of the claims on Gold Creek and the Ruth veins of the Columbia Mines and Development Company. In the Ruth vein, pyrite cubes were found which had been altered to red cubes of hematite. The size of the pyrite grains and cubes are much larger when occurring in the vugs than when found in the vein matrix or disseminated in the country rock. Alteration of the pyrite to iron oxides has produced a rust yellow staining in the upper parts of most of the veins. Veinlets of pyrite cutting earlier quartz were found in the Peekaboo claim on Gold Creek, Plate XV, Fig. 1, and isolated pyrite crystals in calcite were found at the Billyboy claim on Gold Creek. Plate XVI, Fig. 1. No marcasite was found in the veins of the district, though Callaghan and Buddington noted marcasite intergrown with pyrite in the Bohemia district. Pyrite is most prominent in zone II, Plate XXI.

Iron Oxide:

Specular hematite occurs in the Silver Star and Mineral Harbor prospects. It is found in the dike at the Silver Star mine, Plate XVIII, Fig. 3, where it occurs as rude, thin bands in a quartz vein and is highly altered to limonite. Leaching of parts of the vein has stained the quartz crystals and country rock with limonite. Plate XX, Fig. 1. Most of the hematite has a metallic look, but it is also red, black, and earthy. Bladed specular hematite occurs in the vein matter at the Mineral Harbor prospect and is, in part, replaced by later sulphides.

Limonite occurs commonly as a stain in the leached and weathered parts of the veins. It is found as yellow, brown, and black varieties and is usually soft and earthy. Relatively hard limonite with a reddish brown color was found forming a "paint-thin" coating on the fragments of vein matter in the Ruth vein of the Columbia Mines and Development Company. Plate XX, Fig. 2. No large masses of either limonite or hematite were found in the district. Limonite and hematite are also found altering from both pyrite and chalcopyrite.

Quartz:

Quartz is the most prominent gangue mineral. It occurs as coarse crystals lining vugs, Plate XIX, Fig. 1, as a replacement and silicification mineral in the country rock, Plate XIX, Fig. 2, in micro-crystalline colloform masses showing Liesgang like rings, Plate IX, Fig. 1, and as implanted crystals on the surface of other minerals. Plate XII, Fig. 2. It also occurs as a fine-grained material forming veins, and in small veinlets cutting other minerals Plate XIV, Fig. 2. Quartz was probably formed inter-mittently throughout the process of mineralization. The early quartz is generally fine-grained, greenish in color, contains areas of silicified country rock, and is charged with alteration products. The later

Plate XX

Fig. 1 Leached portion of specularite dike near the Silver Star prospect. Hematite (H) Quartz (q) crystals (q). 1/2 Natural size.

Fig. 2 Paint thin coating of limonite (l) on vein matter from the Ruth vein. Sulphides--Chalcopyrite, sphalerite (S). Sericite (se). Silicified country rock (cr). 3/4 Natural size.

quartz is, in general, clear and coarse in texture, forms terminated hexagonal crystals, implanted crystals, sugary grains, vugs, and is found replacing earlier minerals with veinlets in many places cutting the earlier minerals. A leached quartz vein with honey-combed quartz was found at the Peekaboo claim on Gold Creek. Plate VII, Fig. 1. In the Rainbow mine, the quartz is found in veins banded by successive deposition of quartz, chalcopyrite and calcite upon the walls of the open fractures. Callaghan and Buddington state that relatively little quartz occurs with the chalcopyrite.(1 p. 85) This is not quite the case. At the Rainbow mine, which is in the central chalcopyrite zone, quartz is of about equal prominence with the calcite. Quartz, due to the fact that it was formed recurrently throughout the period of mineralization and was very active in the silicification of the country rock and vein fragments, is more prominent as a gangue mineral in the majority of the veins than calcite, which was deposited in the later stages of mineralization.

Calcite:

Calcite is an abundant gangue mineral and is the most common carbonate found in the district. It commonly occurs as a clear white variety, though Callaghan and Buddington state that a brown calcite containing oxides of iron and manganese was noted in the Black Eagle mine. It occurs as masses in the vein matter, Plate XVI, Fig. 2, as veinlets cutting earlier minerals, Plate XV, Fig. 2, as crystals in vugs, in areas surrounding and spreading out over galena and other earlier minerals, as in the Ruth vein of the Columbia Mines and Development Company, and as the latest mineral coating in crustified vugs and veins. A zonal structure was noted in the calcite from the Billyboy claim on Gold Creek. Small sharp crystals of "dog-toothed" spar were found in vugs in the Rainbow #5 and the Billyboy prospects. Veins with calcite as the major gangue mineral occur particularly in the outer zone of mineralization. Barite was not found in the district but some of the clacite gangue from the Blue Jay mine of the Columbia Mines and Development Company is heavier than pure clacite, and possibly contains some barite, though it was not revealed by microscope and chemical tests. Callaghan and Buddington state that siderite was not found in any of the veins.(1 p. 28) Chunks of siderite were found in the old dump at the Eagle mine by the author.

In the Ruth vein and Blue Jay vein of the Columbia Mines and Development Company, the calcite has been smeared by movements along the old fractures. Plate VII, Fig. 2. Slickensides have been produced in the clacite by this movement. The same feature was noted in the Rainbow mine with chalcopyrite in addition to calcite showing slickensides.

Adularia:

The author did not find adularia in any of the veins, but it was noted by Callaghan and Buddington from the Ogle Mountain prospect. (1 p. 28)

Epidote:

Epidote occurs as a loose aggregate of needles in the Ruth vein of the Columbia Mines and Development Company. Outside of this occurrence, it it limited to the hydrothermal alteration areas in the andesite series and dioritic intrusive rocks.

Sericite:

Sericite occurs commonly in a number of veins a s a soft clayey gouge or as a sericitic coating on the vein matter. Plate XX, Fig. 2. In the hand specimen, it is difficult to distinguish the sericite from kaolin, as both have a similar occurrence and are usually confined to the fractures and parts of the veins that are near the surfaces where water circulates through the gangue. This is especially true of the Rainbow #1 mine and of the Hart Brothers claim on Gold Creek. It is also found as an alteration product of the plagioclases on the walls of the veins and fractures.

PROPERTIES AND THEIR MINERALS ARRANGED IN A VERTICAL SCALE

3500	Ogle Mt. Calcite vein with galena, little sphalerite, pyrite, chalcopyrite, quartz, and ankerite.
	Crown - Chalcopyrite and quartz, little pyrite and sphalerite.
3000	
	Columbia - Sphalerite, galena, chalcopyrite, and little pyrite. Gangue of calcite and quartz, some epidote and chlorite.
	Mineral Harbor - Cherty quartz, chalcopyrite, specularite, galena and sphalerite.
2500	Hart Bros. - Sphalerite, galena, chalcopyrite, and little pyrite, with quartz and calcite.
	Silver King - Sphalerite, galena, little chalcopyrite, and pyrite. Quartz dominant over calcite.
2300	Peekaboo - Pyrite, little chalcopyrite with quartz and calcite.
	Rainbow #7 - Pyrite and quartz
	Rainbow #6 - Pyrite, little chalcopyrite and sphalerite with quartz and calcite
	Rainbow #5 - Pyrite, calcite and quartz
	Rainbow #4 - Quartz with a little pyrite.
2000	Rainbow #3 - Pyrite and quartz
	Silver Star - Chalcopyrite, quartz, with little epidote and specularite.
	Black Eagle - Chalcopyrite, quartz, with little sphalerite and galena.
1800	Rainbow #2 - Silicified vein with little pyrite.
	Rainbow #1 - Chalcopyrite, calcite equal to quartz, little pyrite.
1600	Wolz - Chalcopyrite, little sphalerite, pyrite, and comb quartz.
1500	Capital - Pyrite, sphalerite, little galena, and chalcopyrite, with quartz and some calcite.

Table III

VERTICAL RANGE OF MINERALS
Condensed, varies locally

3500	Galena, little sphalerite, less chalcopyrite, pyrite, cherty quartz. Little quartz and dominant calcite.
3000	Sphalerite, galena, chalcopyrite, and little pyrite. Chlorite gangue with calcite and quartz.
2500	Sphalerite and galena, with chalcopyrite and pyrite swinging back and forth locally. Quartz dominant over calcite.
2400	Sphalerite dominant with galena and chalcopyrite, little pyrite. Quartz dominant over calcite.
2300	Pyrite dominant, less chalcopyrite with calcite dominant, to equal to quartz.
1900	Chalcopyrite, quartz, with local specularite.
1800	Chalcopyrite dominant, little pyrite, with calcite dominant, to equal to quartz.
1600	Chalcopyrite, little pyrite and sphalerite. Quartz dominant.
1500	Local - pyrite and sphalerite, with little chalcopyrite and galena. Quartz dominant.

VEINS

Occurrence

The veins are commonly found in highly fractured zones which have been mineralized with the enclosing and silicification of fragments of country rock. The typical ore body consists of open fractures filled with sulphide minerals in a quartz or calcite gangue.

The veins commonly occur singly and not in systems, and are characterized by pockets and swells. A vein may carry mineable ore for a hundred feet and then become too narrow to be of mineable quantity, or become nearly barren with only gangue minerals continuing.

The important veins occur along faults, shear planes or fractures in the andesite lavas, or at the contacts of dikes and elongate bodies. Where the veins occur at the contacts of the andesites with the dikes or elongate dioritic bodies, a shear zone is generally present. In short, therefore, the ore deposits occur in fault or shear zones where minor movements have sufficiently opened up the andesite flows to permit the entrance of ore bearing solutions. Some of the faults have mineralized shear zones 8 to 12 feet wide, but the Rainbow #1 mine produces ore sufficient in grade to mine from a brecciated zone 8 to 24 feet wide that has been impregnated by the mineralizing solutions.

Characteristics

The forms of the mineralized bodies are very irregular. The irregularity in form and the erratic distribution of the mineralized bodies are probably due to two factors. (1) The broken structure of the andesites. (2) The time required for mineralization. The fact that the ore bearing solutions were under the effect of low pressure as well as low temperature at the time of deposition of the sulphide ore minerals is probably an equally important reason for the veins to assume an irregular and discontinuous form.

Probably minor earth movements were occurring throughout the district at intervals during the actual sulphide mineralization and continually opening up new channels or fractures in the andesites which could receive mineralization. These movements as new openings were formed also blocked off or partially closed the old ones. The exact cause for movement during the period of mineralization is not known. The fact that movement after mineralization did occur is known to be true for slickensides are found in the veins themselves. It is entirely reasonable that some of this movement could have occurred during the period of mineralization.

These factors of irregular and discontinuous openings in the rocks shifting the flow of mineralizing solutions from one fracture to another, aided in the formation of very irregular and discontinuous ore bodies.

The veins generally do not change direction abruptly, but have a prevailing strike and are not found coming in sharply from all directions. The common orientation of fractures was probably the main factor in controlling the scene of formation of the veins and ore bodies in the district.

In some veins a mineralized fracture separates into two parts thereby enclosing a fragment of highly altered country rock and then reunites forming a single vein. In other veins the fractures are very complex, criss-crossing, and thickening and thinning within a very few feet. The vein matter generally consists of breccia or altered country rock that has been highly fissured and cemented with quartz which is commonly in the form of comb quartz. Plate XIX, Fig. 2. Practically all the veins contain vugs lined with comb quartz and filled with sulphide and calcite crystals. The larger ore shoots, as the Ruth vein of the Columbia Mines and Development Company, are lenticular in the horizontal plane. The veins in general have a common strike of about N 20° to 40° W and a steep dip varying up to 35° from the vertical. In comparison to the Bohemia district, which has been the most extensively developed and has had the largest production of the group of similarly mineralized areas in the Western Cascades, Callaghan and Buddington state, (1 p. 86)

> "In general, the veins in the North Santiam District are less persistant, are narrower, and contain narrower shoots and less gold than those of the Bohemia District. The veins are also more scattered than those of the Bohemia District."

Classification of Veins

The percentages of the various sulphides found in the district vary locally. This variance in percentage is prominent enough to suggest a classification of the veins.

The common minerals of the veins are pyrite, chalcopyrite, sphalerite, galena, quartz, and calcite. At least three sulphides are characterestic of nearly all the veins, though the same three may not always be associated in all the veins.

Complex sulphide veins with sphalerite as the dominant sulphide and varying percentages of the other sulphides include the Ruth and Blue Jay veins of the Columbia Mines and Development Company, the Hart Brothers claims on Gold Creek, the Mineral Harbor, the Silver King, and the Capital vein.

Veins characterized by dominant pyrite with lesser percentages of other minerals include the Peekaboo, the Billyboy and the other Rainbow claims on Gold Creek.

Chalcopyrite veins are the Rainbow #1, the Silver Star, the Black Eagle and the Crown vein. The veins of this type that are found in the central part of the district, as the Rainbow and Silver Star, have their mineralization along faults which show alternately good hanging walls and foot walls.

Carbonate veins are the Elkhorn and Ogle Mt. veins.

Zoning

Areal:

The classification of veins just described, and their places of occurrence in the district suggest a possibility of areal zoning of mineral deposits. Due to incomplete prospecting of the present prospects, definite proof of the zoning, here suggested, cannot be given.

An areal sketch map with the zones and the veins found in these zones is given on Plate XXI. In areas where no claims are located and in which no prospecting has been done, or where the record of prospecting is not known to the author, dotted lines represent the boundaries between the zones, as their exact location is as yet probable.

Zone I is characterized by dominant chalcopyrite veins with locally little sphalerite, galena or specularite. The gangue is characterized by quartz equal to or greater than the calcite. The veins in this zone with the exception of the Crown vein, occur at lower elevations than the veins of the other zones.

Zone II is a transition zone between the zone of chalcopyrite mineralization and the outer zone of complex sulphide mineralization. It is characterized by veins of dominant pyrite with lesser amounts of chalcopyrite and locally a little sphalerite. The gangue ranges from dominant quartz to dominant calcite.

Zone III is characterized by complex sulphide veins. Sphalerite is the dominant sulphide with lesser variable amounts of chalcopyrite, galena, and pyrite. The gangue ranges from dominant calcite to dominant quartz. The amount of calcite in the gangue seems to be increasing.

Zone IV is the outer zone of mineralization. It is characterized by carbonate veins, but is the most incomplete of the four zones as to information available concerning it. Only one prospect, the Ogle Mountain mine, as far as is known by the author, occurs in this outer zone. The Elkhorn Creek vein on the southern edge of the district is a carbonate vein, but as it is quite distant from the center of the district, it is difficult to include it in the zoning. A specimen obtained from the Ogle Mountain vein by

Callaghan and Buddington (1) contained coarse calcite with abundant galena and lesser amounts of sphalerite, pyrite, chalcopyrite, and quartz, with some adularia. It is probable that if this outer zone were extensively prospected, it would be revealed that it contained veins with galena and calcite dominant, and lesser amounts of sphalerite, pyrite, chalcopyrite, and quartz.

The zoning in the district is rather incomplete with the pyrite zone appearing only at Gold Creek. As no prospects have been opened up south of the chalcopyrite zone, the zones can not be extended southward from this area. It can probably be safely said that the percentage of chalcopyrite increases as the percentage of complex sulphides decreases.

Vertical:

No good evidence of vertical zoning was noted within a single mine working. However, this might be due to the shallow depth of development of the veins, the Ruth vein being developed to the greatest depth, about 400 feet by actual workings.

By making a composite or single vein from all the veins in the district, a zoning with depth is suggested, as the zones progress in altitude from Zone I to Zone IV. To illustrate, the Rainbow mine in Zone I is at about 1600 feet elevation. The Billyboy

Plate XXI

SKETCH MAP SHOWING AREAL ZONING

claim in Zone II is at about 2000 feet elevation. The Ruth vein of the Columbia Mines and Development Company is in Zone III and has an elevation of about 2800 feet, and the Ogle Mountain vein in Zone IV is at about 3500 feet elevation. Starting with a complex sulphide vein with dominant galena and relatively high gold content, the vein changes with depth to a complex sulphide vein with dominant sphalerite and then to a dominant chalcopyrite vein, with low precious metal content. Tables II and III show the relation between the character of the veins and their elevations.

MINES AND PROSPECTS

Black Eagle

The Black Eagle claim is on the main road on the east side of Horn Creek in Sec. 24, T. 8 S., R. 4 E. An old cement foundation at the portal of the tunnel is all that remains of the former buildings. The claims are owned by the Hart Brothers, who also have claims on Gold Creek. There is an old mine dump and a house in which Mr. Hart lives, on the terrace to the south of the tunnel. The records show no production.[12] The main drift, about 400 feet long has its portal in a lense of poorly consolidated gravel. The drift is driven for 250 feet approximately due west and then veers to a N 10° W direction following small fractures mineralized with quartz. The drift is caved in about 30 feet beyond this point. Mr. Hart reports that there is about 1000 feet of workings. The principal vein matter is a breccia of silicified greensih andesite cemented by quartz, containing chalcopyrite with a little galena and sphalerite and almost no pyrite. Malachite, limonite and a little azurite resulting from weathering is found in the vugs and fractures. Quartz filled fractures are found on the east side of Horn Creek, but are very weak in sulphide mineralization, except for minor amounts of chalcopyrite.

The average strike of the mineralized fractures is about N 20o to 40o W. A few pieces of siderite were found in the old dump of the mine. Horn Creek follows the weakened mineralized zone for a distance of about one half mile in a N 20° W direction.

Capital

The Capital claim is about 150 yards from the road just east of Henline Creek, in Sec. 28, T. 8S., R. 4 E. The drift was inaccessible due to a cave in about ten feet from the portal. Callaghan and Buddington report a breccia or silicified andesite charged with sericite and mesitite, cemented with quartz. (1 p. 91) Sphalerite was the chief sulphide found in the excavation dump.

Columbia

The Ruth group of 18 claims, the Blue Jay group of 30 claims, and the 46 adjoining private claims, constitute the Columbia Mines and Development Company properties. They lie mainly on the south side of the Battle Axe Creek fork of the Little North Santiam River in the southeast corner of unsurveyed T. 8 S., R. 5 E., about 26 miles by road from Mehama. The main workings were formerly the property of the Lewis and Clark Mining and Milling Co. (13) The Amalgamated

Mining Company, as later owners, were active in 1930, shipping 43 tons of crude ore.(1) The present owners were carrying on some development work in 1940 but were shipping no ore. At the mouth of the Battle Axe Creek fork of the Little North Santiam River, there are about fifteen buildings, a small saw mill and the remains of a mill. There is a cook house, bunk house, shop, and other buildings near the portal of the 4th level.

The greater part of the development work has been done on the Ruth vein of the Ruth group. There are five levels on the Ruth vein following the vein which trends from N 60° W to west.

Level #1. Elevation, 2894 feet. Length, 90 feet, with a 40 foot crosscut at the southeast end. The vein shows here as mineralized fractures in a greenish andesite and is about 5 feet wide.

Level #2. Elevation 2864 feet. Drift, 80 feet long trending S 35° E in a greenish pyritic andesite. Vein is 20 to 24 inches wide and consists of vuggy quartz with sulphides. Pyrite and sphalerite dominant in equal proportions.

Level #3. Elevation, 2754 feet. Length, 135 feet. Vein here is from 10 to 16 feet wide, trending S 45° E. A raise between the 3rd and 4th levels follows the ore for about half the distance. The vein consists of brecciated, altered rock, with streaks of quartz, pyrite, sphalerite and a little galena and chalcopyrite.

Level #4. Elevation, 2660 feet. Length, over 2300 feet, including crosscuts. This is the main level, with most of the development work having been done on this level. The level enters the south side of the valley about 200 feet above Battle Axe Creek and trends generally S 50° E. The country rock is chiefly oligoclase andesite. A dike of rhyolite porphry crosses the drift about 50 feet from the portal. Ore has been developed and partially stoped from three district shoots on this level. The first ore body is intersected by the drift about 250 feet from the portal, has been stoped for a distance of about 50 feet above the level and is 100 feet long and from 3 to 12 feet wide.

The second ore body is opened by a crosscut from the main drift 600 feet from the portal and is followed by a drift for 300 feet. This ore body trends from N 50° W to West, dips 65° to the N.E. and ranges in width from 8 to more than 40 feet. A raise in the ore body has been put up for about 100 feet.

The third ore body is intersected by the main drift about 1120 feet from the portal of the drift, extends in a S. 55° E direction for 80 feet, and is nearly 6 feet wide.

The vein matter in the ore shoots, is predominately sphalerite, with galena, chalcopyrite and lesser amounts of pyrite. The sulphides occur irregularly through the vein matter and, in places, large lumps of solid sulphides are found. Plate XVIII, Fig. 2. The andesite in the vein matter has been epidotized, chloritized and highly silicified. The gangue is mainly a soft greenish mass of chlorite with some sericite and quartz. Calcite areas cementing the sulphides and lining the vugs, are prominent.

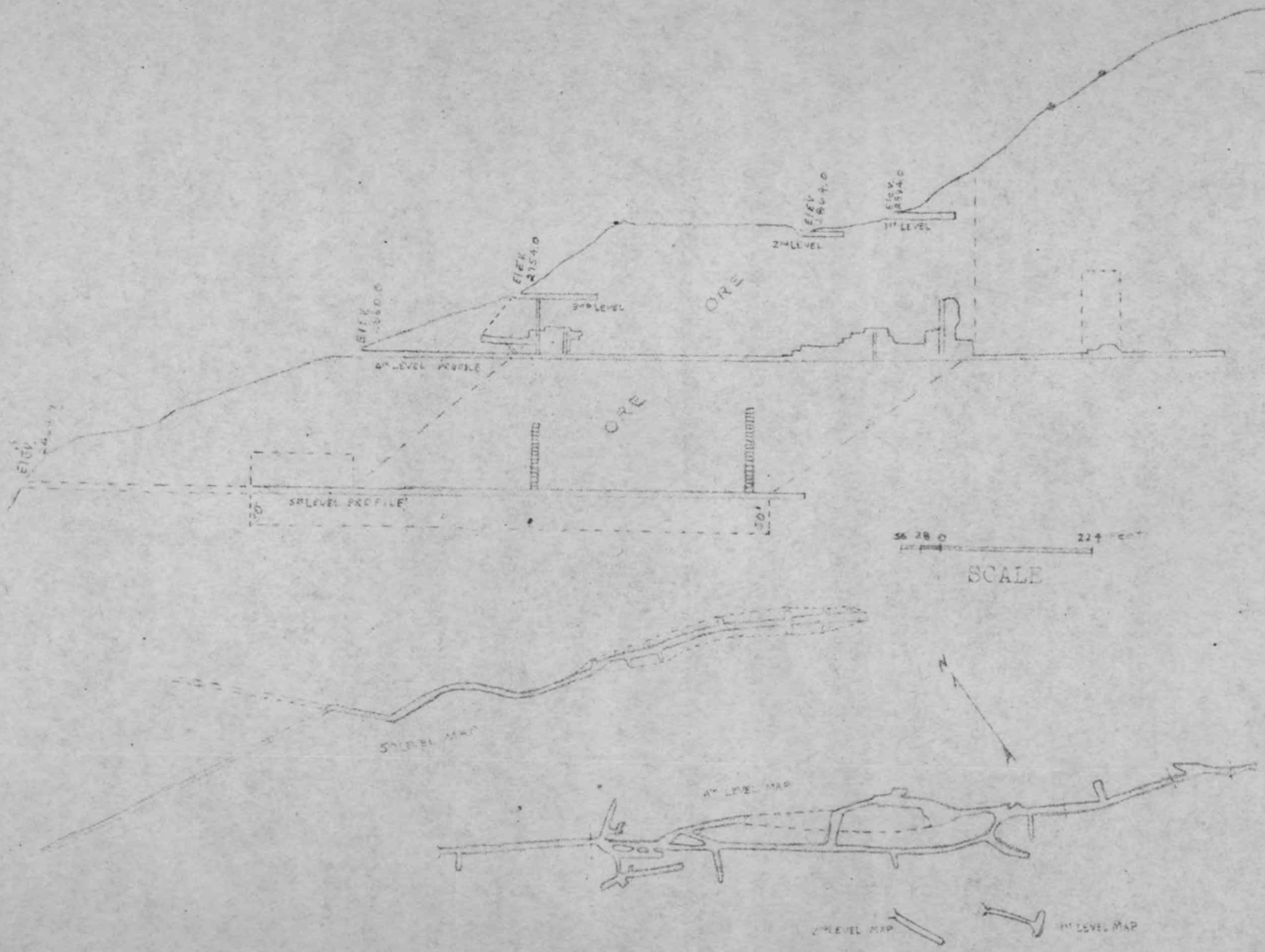
Level #5. Elevation, 2464 feet. A crosscut extends for 764 feet in a S 75° E direction before striking ore. The ore body is about 850 feet long and ranges in width from 6 to more than 20 feet. The ore is similar in character to that found in the fourth level. The owners state that diamond drilling for 50 feet below this level is still in ore.

Estimates of the engineers hired by the owners as to the amount of ore blocked out, vary from 302,800 tons to 349,500 tons.

Crown

The ten claims of the Crown Mining and Milling Company are located in the southeast corner of Sec. 33.,

Plate XXII



Ruth Vein of the Columbia Mine & Development Co.

T. 8 S., R. 4 E., just below Crown Peak on the north slope of the ridge between the Little North Santiam River and Elkhorn Creek. The workings are reached by trail, a mile and one half from the main road. There are two cabins on the north side of the river and the remains of an old cabin about 400 feet below the main crosscut. There is a partially completed bridge across the Little North Santiam just south of the main road.

The main workings which are about 1500 feet above the Little North Santiam River, were inacessible due to caving at the time of the writers visit, but are reported to consist of about 1000 feet of crosscut and drift.

The country rock is porphyritic andesite, with a dioritic intrusive body lying to the southwest. The crosscut is reported to intersect small veins near the contact of this dioritic mass.(1 p. 91) The mineralization consists of chalcopyrite and pyrite in quartz seams. Supergene alteration has produced malachite staining and some covellite on the surface of the chalcopyrite.

Hart Brothers

The Hart Brothers claims are on the Scranton fork of East Gold Creek in unsurveyed T. 8 S., R. 5 E. They are reached by trail about two miles from the mouth of Gold Creek. The claims were formerly the Blende Oro and (the Bimetallic and the Goldbug ?). The entry of the former Blende Orô is made in a northerly direction for 100 feet, intersects the vein and follows it in a N 30° W direction for about 100 feet. A 30 foot drift following a quartz seam is driven in a N 10° W direction from the vein crosscut intersection, but dead-ends in barren country rock. The country rock is andesite disseminated with pyrite and quartz. Indistinct hanging walls and foot walls along the vein suggests a fault. Sphalerite is the dominant mineral with lesser amounts of pyrite, galena, and chalcopyrite. The sphalerite is light resinous yellow to greenish in color. The sulphides occur in bands and irregular lumps, and the vein ranges from 1 foot to 4 feet in width and is opened up for about 100 feet along the strike. In places, bands of sphalerite 6 to 8 inches wide are found. Crystals of all the sulphides are found in the vugs, and some of the sphalerite crystals show twinning. Well formed pyrite cubes are disseminanted throughout the country rock fragments in the vein. Some recent calcite and quartz occur on the faces of the sulphides. The country rock fragments and walls of the vein are highly altered to sericite, with the gouge, a clayey mass, composed mainly of sericite and kaolinite. Cherty quartz fragments resulting from the alteration of fragments of country rock occur irregularly throughout the vein. Limonite altered from pyrite has, in places, stained the vein yellow.

The former Bimetallic vein is about 300 feet south of the former Blende Oro. The drift is on the west side of the creek and follows the vein in a N 30° W direction for about 250 feet along the contact of a diorite intrusive body. The vein consists of brecciated andesite cemented with comb quartz. Both the andesite and diorite are highly altered to sericite. Pyrite is the dominant sulphide with considerable amounts of chalcopyrite and less amounts of the other sulphides. The former Goldbug tunnel is driven presumably along same vein only on the east side of the creek. Sphalerite is dominant with less amounts of pyrite and chalcopyrite.

Ogle Mountain

The Ogle Mountain claims are in the south half of Sec. 9, T. 8 S., R. 4 E., near the Clackamas County line along the upper reaches of Ogle Creek, a tributary of the Mollala River. The workings were caved and inacessible at the time of this survey. The vein strikes about N 30° W and is in a country rock of porphyritic andesite. It is reported that the veins were worked primarily for gold.(12 p. 166)

Omcal

The Omcal group of 28 claims lie in the area south of Boulder Creek and extend east of Stony Creek in the south central part of unsurveyed T. 8 S., R. 5 E. The old Mineral Harbor tunnel running S 50° E at an altitude of 2600 feet is found on Stony Creek. The tunnel was caved and could not be entered. The vein is cherty quartz in a porphyritic andesite with some sphalerite, pyrite, and chalcopyrite.

Rainbow

The Rainbow group of claims formerly known as the Santiam Freeland Consolidated, Electric Mining and Smelting Company, Consolidated Copper and Power Company, Northwest Copper Company, and Lotz and Larsen, extends from the mountainside southeast of the mouth of Gold Creek in a north westerly direction to a point about a mile and one quarter up Gold Creek. All the claims are on the western edge of unsurveyed T. 8 S., R. 5 E. A road leads directly to the main tunnel of the Rainbow #1 mine about one quarter of a mile up the Little North Santiam River from the mouth of Gold Creek. The other. claims on Gold Creek are reached by the Gold Creek trail. The mine camp is situated on the terrace at the mouth of Gold Creek. The principal vein, the Rainbow #1, formerly called the Minnie E., crosses the river about one quarter of a mile east of Gold Creek, and is explored by drifts on both sides of the river. Plate XXIII.

There is about 1050 feet of drift on the south side of the river and 375 feet on the north side. From the portal of the drift on the south side of the river, the vein has an average strike of N 20° W and dips 65° N E for a distance of 120 feet, then turns to an average strike of N 45° W and a dip of 50° to 80° to the northeast. The vein follows a fault which shows alternately, good hanging and footwalls. On the north side of the river, the vein strikes N 20° W and dips 65° NE for a distance of 125 feet and then branches. One branch strikes N 40° W; the other branch, showing barren shear zones, strikes N 15° W.

The country rock is largely porphyritic oligoclase andesite, though on the north side of the river it has, in places, an agglomeratic appearance. Chalcopyrite is the main ore mineral with lesser amounts of pyrite. A little sphalerite has been reported by the owners. Calcite and quartz are the chief gangue minerals with some clay and sericite in the gouge. The wall rock shows altered plagioclase phenocrysts.

The ore minerals are scattered in small bands throughout the vein. The chalcopyrite varies from small seams one inch wide near the portal of the south drift, to seams 6 and 8 inches wide at the face of the drift. The foot wall shows little mineralization with most of the mineralization being in the hanging wall. A crosscut 350 feet from the portal of the drift shows the full extent of the shear zone in the hanging wall as about 45 feet, and a mineralized zone extending 16 feet from the footwall into the hanging wall. A shoot mearly 200 feet long, extending southeastward from a point 280 feet from the portal has been partially stoped by a raise. This shoot averages 5 feet in width, 2.41 ppercent of copper, 0.75 ounces of silver to the ton, and a trace of gold. Another shoot extending for about 760 feet from the portal, has been partly stoped by a 10 foot raise. The shoot, exposed at the face of the drift, has been opened for about 20 feet, is 7 feet wide and contains seams of pure chalcopyrite 6 to 8 inches wide along with seams of pure calcite.

In the west branch of the vein on the north side of the river, there is a shoot 100 feet long which is in some places 18 inches wide. A winze, which at the time of the author's visit was full of water, is reported by the owners to have exposed 14 inches of chalcopyrite 96 feet below the drift.

There is a small 60 ton mill at the portal of the north drift. The ore breaks fine in the blasting and needs no primary crushing. The mill has a 4½ X 16 Hardinge ball mill, a screw feed classifier, and four flotation cells. A 120 H.P. diesel engine provides the power for the mill and mine. The ore is hoisted by a bucket and cable from the ore bin at the portal of the south drift to the mill on the north bank. About 14 men were employed at the operations in April, 1941, and the mill was handling approximately 47 tons of ore per day. The first shipment of concentrates was ready to be made at this time.

Several of the tunnels on Gold Creek are believed locally to be on the same vein. One drift, Rainbow #3, on the west side of Gold Creek, about 1700 feet north of the camp, follows on altered pyritic zone six inches wide for 100 feet in a N 35° W direction. Another, the Rainbow #4, is about 100 feet south of the foot bridge and is reported to cut 80 feet to reach a gouge seam which contains a little sulphide ore and strikes N 20° W. The Billyboy claim on Gold Creek about one quarter of a mile above the foot bridge follows the edge of a dike N 10° W for 600 feet and then turns

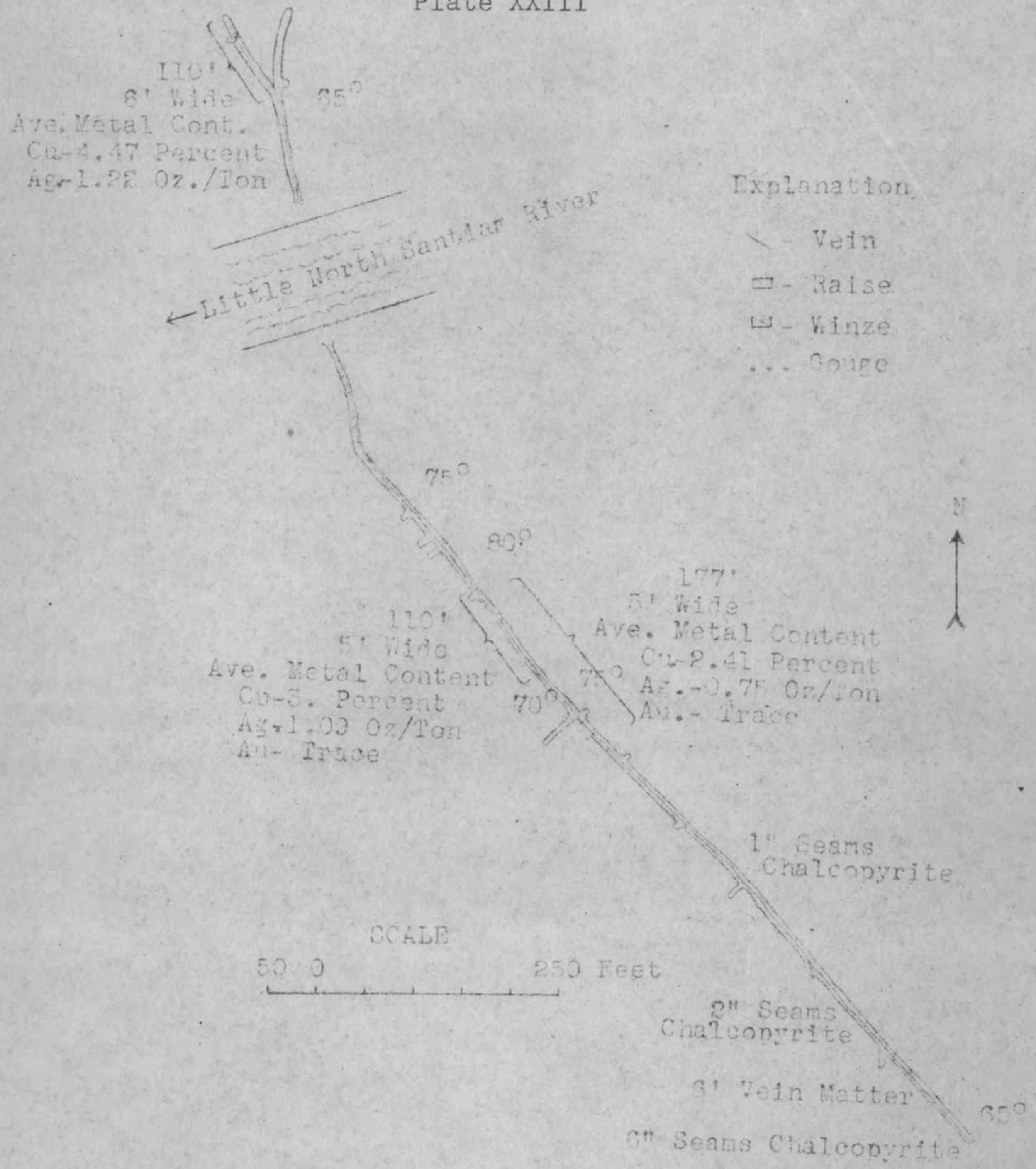
N 50° W direction for 900 feet where a footwall with slickensides dips 65° in a northerly direction. The mineralization is pyrite in calcite and quartz seams. The Peekaboo is a short distance north of the Billyboy. A drift is driven in a S. 10° E for 1500 feet. The vein strikes N 15° E and dips 45° to the southwest, and shows about 2 feet of leached pyrite and quartz. Lumps of leached, silicified andesite containing some chalcopyrite and lesser amounts of pyrite in a quartz gangue was found in the old dump. The other Rainbow claims, #5, #6, #7, are similar to the Billyboy and Peekaboo.

Silver King

The Silver King property is on Henline Creek in Sec. 28, T. 8 S., R. 4 E. There are the remains of a compressor shed and a water power plant at the mouth of a main crosscut. A road from the main road leads directly to the crosscut, but is impassible by car for the last one quarter of a mile. There is a falls about 100 feet high at the portal of the crosscut.

The crosscut is about 1800 feet long and is driven in a N 15° W direction, in a dark gray andesite. At intervals along the crosscut, small seams 1 to 2 inches in width, filled with a soft gouge are found. The seams carry a little sphalerite and galena in a

Plate XXIII



SKETCH MAP OF THE RAINBOW MINE

From Pace and Compass Traverse   Assays From Owners quartz gangue, strike N 10° W and dip 65° to the west. The prospects above the falls were inacessible at the time of the writer's visit. Callaghan and Buddington reported the vein to be about six feet wide at the surface.(1) The vein matter taken from the dump consisted of altered andesite fragments cemented with quartz. Sphalerite ranging in color from light green to nearly black, is the chief sulphide, but some galena and a little chalcopyrite and pyrite are found. Calcite veinlets with no sulphide mineralization are found in the andesite in the immediate vicinity of the crosscut.

A dike of diorite porphyry parallels the vein on the hanging wall side. About 1000 feet from the portal there is a fault which strikes north and dips 85° to the west. No hanging wall is visible, but the foot wall shows striae indicating horizontal movement.

Silver Star

The Silver Star claim is on the road west of Tincup Creek in the S.E. corner of Sec. 23., T. 8 S., R. 4 E. A newly built house stands on the terrace about 500 feet S.E. from the portal of the crosscut, and the owner was actively prospecting in 1941. A dioritic dike, striking North, occurs at the west end of the vein. A crosscut is driven N 25° W for

40 feet, intersects the vein and then follows the vein in a N 30° E direction for about 40 feet. From the crosscut, a drift is also driven in a S 80° W direction for about 10 feet, but has practically barren country rock in the face. The vein is mineralized along a fault with good hanging walls and footwalls which strike about N 30° E and dips 70° to the S.E. The vein is from three to fifteen inches in width, and the mineralization is chiefly chalcopyrite with some scattered specularite. Malachite and some azurite are found in the clay gouge, in places this consists of the main part of the mineralization. The wall rock is porphyritic andesite highly altered to epidote and kaolinite.

Wolz

The Wolz claim lies near the mouth of Gold Creek, about 300 yards from the road between Tincup and Stack Creeks, in the N.E. corner of Sec. 26, T. 8 S., R. 4 E. The vein strikes N 32° W and dips 70° to the N.E. The workings consist of a drift 30 feet long above an old cut and about 70 feet below another drift. The country rock is the typical green highly porphyritic andesite. Two thin seams with little mineralization occur in the drift. Some sphalerite and chalcopyrite disseminated in a fragmental country rock cemented with quartz occur in the open cut. The quartz is largely comb quartz.

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