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Geology and Ore Deposits of the Salt Chuck-Rush and Brown Mine Area Prince of Wales Island, Alaska

Judson H. Whitman

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GEOLOGY AND ORE DEPOSITS
OF THE
SALT CHUCK - RUSH AND BROWN
MINE AREA
PRINCE OF WALES ISLAND,
ALASKA

BY
JUDSON H. WHITMAN

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
May 1, 1948
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GEOLGY AND ORE DEPOSITS
OF THE
SALT CHUCK - RUSH AND BROWN
MINE AREA
PRINCE OF WALES ISLAND,
ALASKA

BY
JUDSON H. WHITMAN

INTRODUCTION

LOCATION

The Salt Chuck, Rush and Brown, and adjacent mines and claims form an area of approximately 15 square miles near the head of Kasaan Bay about 10 miles northwest of the village of Kasaan on Prince of Wales Island in southeastern Alaska. It is an area of moderate relief in which the hills rise from the waters edge to heights of some 500 feet. Most of the area is covered with dense vegetation and muskeg.

SCOPE OF REPORT

It is proposed to combine data from the United States Geological Survey, technical publications, mine operators and personal observations about the area in an attempt to produce a clearer picture of the general geology and particularly the
occurrence of ore deposits.

Geologic study was begun by the writer in the summer of 1947 and continued up to the time of the writing of this thesis, which was done as one of the requirements for a Bachelors degree in Geological Engineering at the Montana School of Mines. Throughout this period the author was an associate of Montana Lease which was doing development work on the Rush and Brown mine. This provided an excellent opportunity for observing the geology as it was exposed by the advance of underground workings.

FIGURE 1.-Index map of Southeastern Alaska

on the Rush and Brown mine. This provided an excellent opportunity for observing the geology as it was exposed by the advance of underground workings.
ACKNOWLEDGEMENTS

The author wishes to express his gratitude to Dr. E. S. Perry, of the Montana School of Mines, for his many valuable suggestions regarding the writing of this thesis, and his assistance in identification and analysis of minerals and rock specimens. To Mrs. Bula C. Murphy, of the United States Geological Survey, Alaskan Section, who extended cooperation in providing copies of governmental literature pertaining to the area, the writer is most grateful.

OUTLINE OF GEOLOGY

The area is underlain principally by graywackes, greenstones, and propylites which have been intruded by mafic and ultramafic igneous bodies. Outcrops are scarce and confined mainly to stream beds, steep slopes and places where some mining activity has been carried on. Foliation in the metamorphic rock is generally obscured.

The principal ore deposits are veins containing pyrite, chalcopyrite and pyrrhotite. Some deposits of copper-bearing magnetite have been noted. Most of these are small, however, the one at the Rush and Brown mine is of considerable extent and has been mined for its copper and precious metal content. Also, there are occurrences of disseminated bornite in certain of the mafic plutons which carry also disseminated grains of some of the platinum metals, principally palladium. This type
of mineralization is most outstanding at the Salt Chuck mine. Small occurrences of native copper have also been noted in this mine.

GEOGRAPHY

TOPOGRAPHY

Relief

The relief of the immediate area is relatively moderate, ranging from sea level to some 500 feet, at distances of two miles from the nearest open water, which is known as the Salt Chuck.

The Salt Chuck is a salt-water lagoon which can accommodate shallow draft boats and barges at high tide. At times the tide varies the water level as much as 20 feet. Further inland the terrain becomes mountainous with peaks attaining 3,000 feet. The region contains abundant features of glaciation, such as U-shaped valleys, cirques, hanging valleys and glacial grooves and striations on many of the rocks.

Drainage

Due to the large amount of precipitation the area is profusely covered with muskegs, some of which become deep enough to form lakes during the wetter seasons of the year. Most of these lakes and swamps have been formed by glacial action, primarily by dams of glacial moraine. There are many intermittent streams which drain into these muskegs and
PLATE I

A. View of the Salt Chuck at low tide looking north and showing mill and residences of the Salt Chuck mine.

B. Same view as "A" at high tide.
lakes. These streams run continuously except during July and August when precipitation is at its minimum and during the winter months of January and February when most precipitation is in the form of snow. At the end of February and the cold weather these streams again become active. In the area there are two larger streams which flow the year round, one of which at times approaches the proportions of a river.

CLIMATE

The climate is moderate with the great amount of precipitation being the outstanding feature. The precipitation is 150 inches annually, principally in the form of rain. The season of least rainfall is from April to July. September through January are the months of greatest precipitation. The area is affected by the Japanese current which keeps the temperature much more moderate than would be expected in a latitude of 55½°. The mean annual temperature is 45°F. Winter temperatures seldom reach zero and summer temperatures sometimes climb to 90°F. The mean temperature of the three summer months is about 55°F.; and of the three winter months about 35°F. The prevailing winds come from the southwest and bear moisture from the sea, which condenses as fog or rain over the land. This abundant moisture is a drawback to outdoor activity but has the advantage of supplying water power which can be utilized in mining enterprises.
VEGETATION

The growth of timber and vegetation in the area approaches that of a tropical region due to the moist and temperate climate and the long daylight periods of summer in this latitude. The timber is almost entirely of coniferous species, principally hemlock, spruce and cedar. The area lies in the Tongass National Forest. Ferns, bushes, shrubs and mosses grow profusely at elevations below 1,500 feet. In places these form a dense and almost impassable undergrowth and are a great hindrance to surface geology study.

COMMERCIAL CONDITIONS

Ketchikan, recording office and commercial center of the district, is approximately 45 miles by water in a southeasterly direction from the area under discussion. It has a population of 5,000 and has all the modern municipal improvements. It is an important salmon fishing and packing center.

Pan American World Airways serves Ketchikan with two flights daily, to and from Seattle, some 750 miles to the south, requiring 3½ hours for the trip. Three American and two Canadian steamship lines provide 52 hour transportation to Vancouver or Seattle, averaging approximately a ship every other day. The closest railroad is at Prince Rupert, British Columbia, 125 miles to the south, five hours by steamer from Ketchikan. Local transportation is provided by launches and charter aircraft.
PLATE II

A. View at head of Salt Chuck looking west and showing the topography.

B. A portion of the road connecting the Rush and Brown mine with the mill of the Salt Chuck mine showing the abundance of vegetation.
Most mining camps maintain radio-telephone connections with Ketchikan and ultimately the entire world.

DESCRIPTIVE GEOLOGY

GENERAL FEATURES

The Salt Chuck-Rush and Brown mine area displays striking features of all phases of metamorphism. This metamorphism, in fact, is so intense that it makes identification of minerals and determination of original rocks extremely difficult, especially without the aid of a petrographic microscope. All three of the principal classifications of metamorphism are apparent, that is, contact, regional, and hydrothermal.

Approximately one-third of the area under discussion is covered with what definitely can be distinguished as basic igneous rocks, ranging from diorite to peridotite. Two small outcroppings of Paleozoic limestone occur in the area. Most valleys and depressions are filled or covered with Quaternary alluvium and glacial debris. Among these glacial remains are erratics of several types of sediments; conglomerates, banded sandstones, and quartzites and granite.

The remainder of the area is composed of metamorphic rock which has been described as being sedimentary in origin by Wright (7) and as of igneous origin by Warner (6) and others. Although various writers classify this same rock type differently, the author believes that both classifications are plausibly
correct. The problem involved depends upon the material in question undergoing katamorphic action prior to hydrothermal metamorphism. If katamorphism took place as suggested the resulting rock is undoubtedly properly classified as a graywacke, as done by Wright (7). However, if the weathering was not involved, then the rock is definitely a greenstone or propylite as suggested by Warner (6). This question will be discussed more fully in this paper under metamorphic rocks.

STRUCTURE

There are two prominent joint systems in the area, one striking N.10°-30° E. and dipping 60°-80° E., and the other striking N.20°-40° W. with steep dip to the east. Some of these joints traverse country rock and ore bodies alike, indicating that they were developed subsequent to ore deposition. However, some of the ore bodies are replacements in shear zones of these structures indicating that some of the ore deposition was subsequent to jointing. The vein of the prospect, located approximately a quarter of a mile southwest of the Salt Chuck mine, which strikes N.10° E. and dips 80° to the east is an example of this conformity of veins to joint systems. Many lamprophyric dikes in and around the Rush and Brown mine also follow the trend of these joint systems indicating that they are the youngest rock of the area. The vein of the Rush and Brown mine which strikes N.60° E. and dips about 60° S.E. occupies a shear
zone which does not coincide with the more prominent systems of jointing. Ore deposition appears to have been subsequent to the earlier jointing, perhaps coinciding with the last stages of intrusion --- the lamprophyric dikes. In addition to the more prominent and subsidiary joint systems, the metamorphic rocks of the area have undergone intense fracturing and brecciation. Subsequent cementing which apparently was coincidental with hydrothermal activity, was accomplished nearly wholly by calcite. Very little or no quartz is found as cement.

Northeast of the main workings of the Rush and Brown mine, the metamorphics are intruded by a large southeasterly trending body of gabbro and diorite which grades locally into pyroxenite. The southern part of this body was cut by the Sawmill Tunnel through the portion 800 to 900 feet from the portal and what appears to be an apophysis was encountered between two fault zones both striking nearly North-South and dipping nearly vertical at distances of 1350 feet and 1380 feet from the portal. Throughout the length of the tunnel and in the mine, small mafic dikes, generally trending N.10° to 20°E, and with a steep dip, cut all other rocks indicating that they are the youngest rocks of the region.

According to Wright (7) the structure of the stratified rocks, namely the limestone and probably the graywackes, is that of a closely folded synclinorium in which the beds generally
GEOLOGIC MAP
OF
SALT CHUCK-RUSH & BROWN
MINING AREA
PRINCE OF WALES ISLAND
ALASKA

LEGEND

Qal Quaternary alluvium and glacial gravels
DI Devonian? limestone
M Metamorphics
I Igneous
B Occurrences of disseminated bornite

Adit
Mine
Prospect
Glory hole
Road

Scale
April 1948
J.H. Whitman

-12-
strike northwest and dip to the northeast. The line of contact of the igneous rock follows to some degree these bedding planes which also roughly parallel one of the prominent joint systems.

SEDIMENTARY ROCKS

A minor portion of the area is comprised of sediments. Stream valleys are covered with unconsolidated alluvium and glacial gravels. Limestones outcrop about 2,000 feet southeast of the Rush and Brown mine and approximately 4,000 feet east of the Salt Chuck mine. The occurrence of a highly altered conglomerate has been noted in the vicinity of the Rush and Brown mine.

Conglomerates

In most of the stream beds, particularly in that which drains Lake Ellen, are found fragments and boulders of conglomerate. Wright (7) and Warner (6) mention the occurrence of conglomeratic material in situ near the Rush and Brown mine. The author has found some highly altered conglomeratic material in the footwall near the point where the Sawmill Tunnel hits the vein of the Rush and Brown mine. The stream bed occurrences are probably eroded material from that locale in the vicinity which have not been noted. It is also likely that some of these boulders are a part of glacial debris.

The conglomerate, like most of the rocks of the area, has undergone metamorphism, undoubtedly of the hydrothermal type as
it is highly epidotized. Most of the pebbles are basic igneous fragments, with some limestone and large crystals of hornblende. The groundmass has a fine-grained quartzitic appearance. The enclosed fragments vary in size from 1 millimeter to 5 or 6 centimeters in cross section with some attaining 10 centimeters. Nearly all are angular to sub-angular indicating that consolidation quickly followed weathering.

Limestones

The limestones of the area which, as mentioned before, outcrop approximately 4,000 feet east of the Salt Chuck mine, and about 2,000 feet southeast of the Rush and Brown mine, are assumed to be of Devonian age. Wright (7) has found many fossils of this age in other outcroppings of limestones at several places on Kasaan Peninsula. The beds in the area under discussion are entirely recrystallized and there is no evidence of organic remains. The limestones are white to light gray in color. The outcroppings are of such meager extent that very little regarding the character of the rock can be determined.

IGNEOUS ROCKS

The intrusive rocks that apparently underlie all of the area invade all other types of rocks, therefore, are among the youngest. They are all basic in composition, varying from diorite to pyroxenite and peridotite. They occur in the form of huge plutons several miles in extent, and in dikes only a few inches
wide. In texture they vary from phaneritic to aphanitic.
Porphyries of several types have been found.

Diorite

The principal intrusive rock of the Salt Chuck-Rush and Brown area is a diorite. It is the most acid rock of the area and nearly the most acid of the entire Kasaan Peninsula. Undoubtedly, the original magma was slightly more acidic, probably syenitic in composition with the diorite being the principal differentiate.

Megascopic descriptions of some diorite samples are given below:

100. Diorite, from the Sawmill Tunnel, about 1340 feet from the portal. The rock seems to consist of approximately 50 percent dark and 50 percent light-colored minerals, with crystals ranging between 2 millimeters and 5 millimeters in diameter. The light mineral appears to be a feldspar, probably a plagioclase. The dark minerals are principally hornblende, with minor amounts of biotite and magnetite.

150. Diorite, from the bedrock on which the mill of the Salt Chuck mine stands. The rock is medium- to fine-grained, closely approaching the texture of an andesite. It contains about 40 percent dark minerals, probably amphibole and/or pyroxene, with about 5 percent of the dark minerals being biotite. The light mineral is probably a feldspar.
Gabbro

Gradual differentiation from diorite to gabbroic rock occurs continually throughout the area of igneous rock. Descriptions of several samples of this rock are given here:

250. Gabbro, from the north side of the Salt Chuck mine glory hole. This is a medium- to fine-grained nearly black rock. In a hand specimen a few crystals of augite can be distinguished so it is assumed that the majority of the dark minerals are augite. A few specks of biotite are also noticeable. Upon powdering the rocks some dark material can be picked up with a magnet; this probably is magnetite. The light mineral, presumably feldspar, cannot be identified megascopically.

251. Gabbro, from 200 yards west of the Salt Chuck mine glory hole. This specimen is very similar to number 250, but the magnetite is somewhat more abundant, occurring in megascopically visible crystals which can be chipped off with a knife blade. These crystals are highly magnetic.

252. Gabbro, from 200 yards west of the Salt Chuck mine glory hole. This specimen is from a spot only a few feet distant from number 251, however, it differs from it as it contains several small occurrences of bornite. This bornite occurs in thin flakes and accounts for approximately 2 to 5 percent of the rock.
201. Gabbro, from a stream cut one quarter of a mile northeast of the Rush and Brown mine. This rock is fine-grained nearly aphanitic in texture, but with the aid of a hand lens, a pyroxene, probably augite, can be distinguished as can some olivine. No biotite is apparent. The dark minerals make up about 50 percent of the rocks; the small green crystals of olivine about 5 percent and the remainder which is light-colored is probably feldspar. Perhaps this rock could best be described as a dolerite.

Basalt

205. Basalt - Porphyry from the Sawmill Tunnel. At infrequent intervals along the length of the Sawmill Tunnel, small dikes of basaltic material are found cutting the greenstones and diorites. One such sample of this material is classed as a basalt - porphyry. It is a very fine-grained black rock with the only visible crystals being olivine about 2 millimeters in diameter.

Pyroxenite

Especially in the immediate vicinity of the Salt Chuck mine, differentiation of the igneous rock is very pronounced. Where used herein, pyroxenite refers to those differentiates which are considerably darker in color than the gabbros. Microscopic study would undoubtedly disclose a more accurate and fitting classification. The area cut by the haulage tunnel of the
Salt Chuck mine is composed of rock classified as a pyroxenite by Gault (4) on a War Minerals Investigation Preliminary Map, compiled in 1942-43.

351. Pyroxenite. Specimen from 500 feet from the portal of the Salt Chuck mine haulage tunnel. It is a coarse-grained rock which has undergone moderate alteration. It contains 70 to 75 percent dark-colored minerals, chiefly augite with some biotite, perhaps 5 percent of the rock, and another 5 percent of chlorite. The chlorite, however, is probably an alteration product as specimens of similar rock nearby do not contain this mineral. There are also a few small specks of what appears to be epidote. The feldspar, 15 percent of the rock, is quite light and appears fresh and unaltered. About 5 percent of the rock is composed of bornite. This rock is typical of the ore of the Salt Chuck mine. The bornite seems to show a marked preference for the pyroxenite and gabbro over diorite and greenstone.

METAMORPHIC ROCKS

The area contains a large amount of metamorphic rock, most of which has been termed "Kasaan Greenstone" by Brooks (1) in his report on the Ketchikan district in 1901. Since that time some disagreement has arisen as to his classification of this rock. Wright (7) suggests that they are all greywackes, however, examinations by the writer during the driving of a portion of the
Sawmill Tunnel leads to the belief that the metamorphics are composed of propylites, greenstones, and graywackes. The line of distinction between greenstones or propylites and graywackes is rather uncertain. If the original rock underwent weathering and subsequent deposition occurred without transportation, which is indicated in some instances, the metamorphic resultant would be classed a graywacke. On the other hand if metamorphism affected the original rock, in its original state, the altered resultant would be classified as greenstone or propylite, which is apparent in some instances.

In the vicinity of the Rush and Brown mine there is a large area of this metamorphic rock which has undergone a great deal of stress apparently due to igneous intrusion causing severe fracturing which in places reaches the stage of brecciation. These fractures are tightly cemented, principally by calcite. It is difficult to determine whether these angular fragments are due to the processes of weathering or dynamic forces. Foliation in all the metamorphics is obscured as is bedding, flow structure and certain other features which would indicate a sedimentary or igneous body as the original. At one place in the tunnel the metamorphics grade gradually into an unaltered diorite and subsequently grade from this diorite back to a metamorphic with the same characteristics. This would seem to present evidence that at least part or portions of the meta-
morphics are properly termed propylite or greenstone. In another portion of the tunnel, structure suggestive of bedding is noticeable. The metamorphics appear to be bedded with what conceivably might have once been a limestone, but alteration is so intense that no definite determination can be made. Bedding is suggested by a series of alternate beds of light-and dark-colored material, the light material being high in carbonate content. This nearly horizontal bedding effect, however, is present only for a very short distance—about 20 feet. It seems to gradually disappear at either end. Instead of stratification, this phenomena could easily be interpreted as a locale of greater calcite deposition along a parallel system of fracture planes.

A more definite classification of these rocks would involve examination and analyses which are beyond the scope of this report. For the sake of simplicity these metamorphic rocks will in this paper hereinafter be called "Kasaan Greenstone", using the nomenclature of Brooks (1) who was the first to study the rock.

A description of any one of a number of samples of this greenstone will suffice for any of the rocks which occur over the entire area. Following is such a description:

504. Greenstone, from the Sawmill Tunnel at a point 1300 feet from the portal. In a hand specimen this rock has
a very definite and characteristic light green color. It is highly fractured. Fractures tend to occur in flat planes, but with no apparent pattern or system. All fracture planes are cemented tightly with milky-white calcite. Adjacent to the calcite, along some of the cracks, are bands of epidote. The epidote shows crystal forms on the faces toward the calcite. Numerous small specks of sericite can be distinguished throughout the rock. A powdery-white material, probably kaolin, is also present. Alteration has been so intense that the minerals of the main rock cannot be identified.

Other samples of the greenstone follow the same general pattern as the description given but with the addition of several other minerals.

In some instances fractures are filled with serpentine. It occurs in the massive state and has been noticed in bands up to three inches in width. In places the rock appears to be sprinkled haphazardly with unaltered pyrrhotite but close examination reveals that it occurs along minute fracture planes.

Also occupying fractures but appearing to spread outward into the rock from these fractures is a pink material with the appearance of orthoclase, but with a much deeper color than is usually associated with this mineral. Dr. E. S. Perry, of the Montana School of Mines, made examination of some of this material under the petrographic microscope and the following
are his findings:—

"The pink material appears to have originally been orthoclase, but it is also much altered with the development of sericite, perhaps 20 percent. The sericite grains are scattered through the pink. This pink material may originally have been phenocrysts in an igneous rock."

This type of alteration is known as saussuritization, the pink mineral taking on the name saussurite, a variety of zoisite. According to Clarke (3) this type of alteration is very common in gabbroic rocks and results in an excess of calcite, which possibly may have been one source of the abundant calcite present as the cementing material of the fractured rock.

Occasionally narrow bands, up to a foot wide, of light gray and very fine-grained crystalline materials are found cutting the greenstones, with no apparent regard to the fracturing. Small black blotches are scattered throughout this material. They are darkest at the center of their cross sectional area - about 5 millimeters - and gradually blend into the gray of the rock. In describing this rock, Dr. Perry said, "The gray rock is intensely altered. A very fine intergrowth of quartz and feldspar, with much kaolin and sericite and some calcite. Grain size is from 1/25 to 1/2 millimeter. Grain boundaries are very irregular and confused due to alteration products. The plagioclase appears to be toward the acid end. The black grains are pyrrhotite which appears to be
altering to an oxide which looks like limonite. Alteration of the rock is too far along to definitely determine the original rock, but it was probably a fine-grained felsite. The alterations may be classed as normal hydrothermal." Based on these findings and the apparent disregard of the material in following either minor fracturing or the joint system of the rock, the writer suggests that these may have been small intrusive dikes of acidic rock, perhaps aplite, intruding the original rock, which was basic in character, being extremely lacking in quartz. These also might be interpreted as quartzitic fragments in graywacke.

506. Greenstone, from a cut in the road about one half of a mile southeast of the portal of the Sawmill Tunnel. This specimen is rather unique, in that, it contains large metacrysts of hornblende, or more properly uralite, which is a fibrous variety of hornblende, the result of alteration of the pyroxene content of the original igneous rock. This uralization has caused the formation of large outstanding euhedral crystals of uralite. Other than this paramorphism, the greenstone is essentially the same as the specimens previously described.

Differentiation in the original rock is apparent in the greenstone, as in some places it becomes very dark, nearly black. A more complete study of these metamorphics would undoubtedly lead to classifications of greenstones, propylites, and graywackes.

ORE DEPOSITS

SALT CHUCK MINE

The Salt Chuck mine is about one half of a mile northeast of
Lake Ellen and one half of a mile north of the head of the Salt Chuck. Mining was originally begun on what was considered a low grade copper deposit, but subsequently it was discovered that the ore was more valuable for its content of platinum metals, particularly palladium. The precious metal (gold, silver, palladium) content is of greater value than the copper at present.

History

The ore body of the Salt Chuck mine was discovered in 1904. It was first called the Goodro mine, a part of the Joker group of claims. Work on surface pits was begun the next year. In 1907 the deposit had been developed by surface pits, an open cut 70 feet long, and a tunnel 125 feet long, which cut the deposit 90 feet below the surface and 90 feet from the portal. In 1909, a wharf, ore bins and about 4000 feet of tram were constructed and shipment was begun. The ore was taken out of the Salt Chuck on barges at high tide and loaded on vessels at the head of Kasaan Bay.

After a winter shutdown operations were resumed in the spring of 1910. A 100 foot winze was sunk from the face of the haulage tunnel and drifts were driven east and west. The winze was in ore for 45 feet.

In 1911 only assessment work was done. Throughout the following years and until 1917 when the palladium was discovered very little or no work was done. In 1919 sixteen men were
PLATE IV

Aa. View showing mill and cook house at the Salt Chuck mine.

B. Sawmill of the Salt Chuck mine.
employed and a new lower haulage tunnel 1225 feet long was completed. It is used to tram the ore to the mill which was built just prior to the completion of the tunnel.

Operations were carried on sporadically until 1942 when due to labor, transportation and equipment shortages the mine was forced to close.

At present the mill has a 300 ton capacity. Power is supplied by a 10 inch stream of water under a head of 179 feet. This water is piped from a 31-acre lake which is located about three-fourths of a mile northwest of the mill. This creates some 220 horsepower. Additional power is provided by diesel engines.

Mineralogy and Occurrence

The ore crops out at the location of the glory hole, as shown in Plate III at an elevation of 400 feet, upon a knoll rising from one of the ridges characteristic of this highly glaciated area. Many other surface outcrops can be found nearby, particularly to the westward toward the Rush and Brown mine, but the general surface configuration of the mineralized zone cannot be determined, owing in part to the dense vegetation of the surrounding area, but particularly to the irregular distribution of the mineralization. The zone of most intense mineralization appears to be about 300 feet wide extending in a direction N.75°W.

The deposit occurs in a region of coarse-grained pyroxenite, but several differentiates are noticeable in the mine, especially
gabbroic and gabbro-pegmatitic phases.

The ore minerals consist of copper sulfides, distributed in grains and patches as ore shoots in the pyroxenite. Bornite is the principal copper mineral, but smaller amounts of chalcopyrite also occur in places. Alteration products of the bornite and chalcopyrite are present as chalcocite, covellite, malachite, azurite and chrysocolla. Cuprite is also present probably as an alteration product of native copper which occurs in small quantities in several portions of the mine. Gold, silver, platinum and palladium are also present.

The metallic content of the Salt Chuck ore is shown in the following table of analyses by Campbell (2).

<table>
<thead>
<tr>
<th>METALLIC CONTENT OF SALT CHUCK ORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper in percent, other metals in ounces per ton</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Copper</th>
<th>Gold</th>
<th>Silver</th>
<th>Pt-Pd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glory-Hole</td>
<td>1.92</td>
<td>0.07</td>
<td>0.17</td>
<td>0.41</td>
</tr>
<tr>
<td>150-foot level</td>
<td>1.08</td>
<td>0.07</td>
<td>0.24</td>
<td>0.18</td>
</tr>
<tr>
<td>Bottom of winze</td>
<td>1.42</td>
<td>0.05</td>
<td>0.24</td>
<td>0.17</td>
</tr>
<tr>
<td>Averages of ore analyses</td>
<td>1.427</td>
<td>0.063</td>
<td>0.217</td>
<td>0.253</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Copper</th>
<th>Gold</th>
<th>Silver</th>
<th>Pt-Pd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabbro</td>
<td>.06</td>
<td>.01</td>
<td>.10</td>
<td>.01</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>27.66</td>
<td>.11</td>
<td>2.03</td>
<td>1.01</td>
</tr>
</tbody>
</table>

By comparing the analyses of the country rock and the chalcopyrite, several inferences can be drawn. The chalcopyrite appears to contain larger percentages of the silver and platinum metals.
than it does of the gold, thus indicating the presence of a certain percentage of free gold in the country rock. The ratio of gold to silver to platinum metals in the chalcopyrite is 1 to 19 to 9, whereas in the averages of the ore analyses it is 1 to 3 to 4. The higher ratio of platinum metals to gold in the chalcopyrite analysis can be interpreted as evidence that more of the platinum metals are associated with the copper minerals than occur free in the country rock. The ratio of palladium to platinum is about 50 to 1.

Genesis

The genesis and localization of this deposit presents some puzzling features. The country rock is mainly pyroxenite, but contains some gabbroic phases. At the west end of the glory hole a basic dike, four feet thick, cuts through the pyroxenite showing it to be the latter. The ore is later than the dike as a chalcopyrite-bornite ore shoot cuts across it.

The country rock is highly fractured, but with no apparent system. There are no large displacements but the general trend of the zone of fracturing and faulting appears to be approximately N.75° W.

On first examination the bornite appears to be a segregation from the intrusive mass. The minerals do not appear to follow the more pronounced fracture planes as would be expected of an ore deposited by circulating solutions. The ore occurs in shoots which
appear to be independent of fractures, some of it in massive country rock at considerable distance from any apparent opening. Mertie (5) states that free gold has been observed which was drawn out and elongated by faulting subsequent to its deposition, showing that at least some of the fracturing movements occurred after the deposition of the ore. However, some of the copper ores, particularly the chalcopyrite, lie along apparent fractures showing clearly that they entered the rock and were deposited subsequent to fracturing. Where bornite occurs in massive unfractured pyroxenite, the rock forming minerals are altered, chiefly to epidote and some chloritic material. The amount of ore present seems to be proportional to the degree of alteration. Mertie (5) states that under the microscope the country rock contains many minute cracks, adequate for circulating ore carrying solutions, and the ore itself shows that it has entered the rock in this manner. Hence, it appears that the disseminated particles of bornite in the country rock are the result of metasomatic processes.

The presence of chalcocite, covellite, native copper, etc., point to enrichment, due to the action of meteoric waters working downward from the surface. Native copper and chalcocite have been observed about 200 feet below the surface showing that enrichment has occurred at least to that depth. Enrichment has taken place on a very small scale, but even this small amount is rather remarkable for southeastern Alaska, for it has generally
PLATE V

A. Portal of the Sawmill Tunnel.

B. Glory hole of the Salt Chuck mine.
been believed that in this region the recent glaciation has
removed the zone of oxidation and practically all of the
secondary sulfide zone. The native copper occurs as thin sheets
and flakes along fracture planes in highly altered country
rock and in gouge seams. The covellite is present as a re-
placement of primary sulfide minerals. This leads to the
conclusion that the ore will be of lower tenor with depth,
but this factor will not affect the economic importance as
the percentage of secondary sulfides appear to be relatively
small.

RUSH AND BROWN MINE

The Rush and Brown mine, about one half of a mile west
of the head of Lake Ellen consists of two distinct types of
ore bodies; one a contact-metamorphic deposit of copper-
bearing magnetite, and the other a fault zone deposit with
chalcopyrite as the chief ore mineral. Plate VI shows the
relationship of the two ore bodies.

History

The Iron Cliff claim of the Rush and Brown group contains
the magnetite deposit which was found about 1903 by use of a dip
needle. In 1904 the property was prospected by long trenches and
open cuts and a 25-foot shaft was sunk on the ore body. Ore was
mined almost continuously from 1906 to 1923 from both deposits
which were connected by a crosscut, first by the Alaska Copper
Company which leased the mine to provide ore for its smelter at Coppermount on the southwestern side of Prince of Wales Island, and later by U. S. Rush, the owner. Throughout most of the time the mine was operated, difficulty was experienced in finding a satisfactory smelter to handle the ore. This, coupled with the slump in copper prices, was the reason for suspending operations in 1923.

According to the records of the United States Geological Survey, the mine has yielded a total of 42,743 tons of ore, all of which was shipped directly to the smelter without concentrations. This tonnage provided gold worth $136,820.00, silver worth $31,495.00 and $706,109.00 in copper values.

In 1929 the Solar Development Company, a subsidiary of the Consolidated Mining and Smelting Company of Canada, took an option on the mine and is reported to have shipped only a small amount of ore. They unwatered the mine and took some 120 samples. Upon the basis of these samples, they began driving a tunnel from a point 1350 feet east of the shaft. This tunnel known as the Sawmill Tunnel was designed to connect with the workings approximately on the 280 foot level. They drove the tunnel some 1290 feet when work was once again halted due to a slump in copper prices. The property is now under lease to Montana Lease, by the Alaska Gold and Metals Company, the present holders.

Plans of the present operators call for the completion of the
Plan and Section of the Rush and Brown Mine

Showing the relationship of the two ore bodies
Sawmill Tunnel, unwatering and sinking 100 feet below the lowest level which is now the 500-foot level.

Mineralogy and Occurrence

The Rush and Brown mine consists of two distinctly different types of ore bodies: one a contact metamorphic deposit, consisting essentially of cupriferous magnetite, the other a sulfide-bearing vein deposit in a shear zone.

Magnetite Ore Body

The magnetite ore body at the Rush and Brown mine is quite similar to the many magnetite deposits which occur abundantly over the whole of the Kasaan Peninsula. The deposit lies in contact rock between diorite and greenstone. The ore comprises an east-west trending lense which stands practically vertical. It is exposed in a glory hole which has been mined out for 160 feet in length, 40 to 50 feet in width, and 100 feet deep. Several drifts expose ore to a depth of 140 feet, for a distance of about 200 feet and show widths ranging from 50 feet at the west end to 125 feet at the east end.

Magnetite and skarn consisting mainly of garnet, epidote, calcite, diopside and hornblende replaced brecciated greenstone and clastic rocks which contain a few remnants of what appears originally to have been limestone. The sulfide minerals were deposited in a network of minute fractures throughout the magnetite. The chief sulfides contained in the magnetite are
chalcopyrite, pyrite and some pyrrhotite, but they are so scattered that it is difficult to select ore of a commercial tenor. There is a small body of this ore remaining on the north side of the east end of the glory hole which is exposed by former workings, showing a small tonnage of magnetite containing an estimated 1 to 1.5 percent of sulfide minerals. This body extends along its strike for a distance of 90 feet and is 20 feet wide at its western end. There is no indication of this body on the surface which is about 35 feet above or on the 200-foot level, 120 feet below.

_Sulfide Vein Deposit_

The sulfide-bearing vein deposit of the Rush and Brown mine crops out 150 feet northwest of the glory hole. At the surface the strike of the vein is N.60°E, and the dip is about 60°S.E. The dip decreases with depth to about 55° at the 200-foot level and about 30° on the 500-foot level. A fault trending N.20°W., known as Murphy's Slip, joins the vein southwest of the shaft, and west of the fault the strike of the vein is about N.35°E. On the lower levels the strike swings to the east and is nearly east-west in places on the 400 and 500-foot levels.

The deposit is a replacement in a shear zone occurring in the metamorphic rock. In places the mineralized zone is 1/4 feet in width. The sulfide ore consists chiefly of pyrite, chalcopyrite and pyrrhotite, occurring in lenses and reticulating veinlets. The ore shoots are mainly lenticular tabular bodies.
of massive sulfides. A massive chalcopyrite body with a thickness of 14 feet was encountered in one place. Segregations of pyrite and pyrrhotite are also present. Molybdenite has been found in minor quantities.

In addition to copper, the ore bodies carry important quantities of gold and minor amounts of silver. Some small lenses of magnetite have also been encountered in the shear zone.

The gangue consists of crushed country rock, rather than gangue minerals. The two walls of the shear zone evidently represent the outer limits of movements as they are highly slickensided and the crushed and sheared material ends abruptly against them. The ground outside the limits of shearing is firm and hard. There does not appear to have been any movement along the vein subsequent to mineralization but cross faulting, generally with a north strike, is quite common. Murphy's Slip is an example of this cross faulting. It intersects the vein on the 200-foot level and offsets it 25 feet. This fault was followed for over 450 feet on this level but no mineralization of importance was encountered.

Localization of ore minerals apparently follows no definite pattern. The higher grade ore occurs more commonly nearer to the hanging wall than to the foot wall. The transition from high to low grade ore is generally sharp with no apparent regard to structure.
Values of silver are roughly proportional to the percentage of copper but the gold shows no apparent link to the copper content. A few representative analyses of samples taken by the Solar Development Company are shown in the table below.

**TABLE II**

**ANALYSES OF SAMPLES TAKEN AT THE RUSH AND BROWN MINE**

By the Solar Development Company

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Width of Vein</th>
<th>Percent Cu</th>
<th>oz. Ag</th>
<th>oz. Au</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>2 1/2</td>
<td>3.90</td>
<td>1.02</td>
<td>.26</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>6.72</td>
<td>1.45</td>
<td>.19</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>16.24</td>
<td>2.80</td>
<td>.26</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>5.36</td>
<td>.97</td>
<td>.27</td>
</tr>
<tr>
<td>35</td>
<td>3</td>
<td>5.98</td>
<td>1.25</td>
<td>.19</td>
</tr>
<tr>
<td>39</td>
<td>3 1/2</td>
<td>.90</td>
<td>.31</td>
<td>.03</td>
</tr>
<tr>
<td>43</td>
<td>3 1/2</td>
<td>1.00</td>
<td>.19</td>
<td>.05</td>
</tr>
<tr>
<td>47</td>
<td>3</td>
<td>7.02</td>
<td>1.24</td>
<td>.26</td>
</tr>
<tr>
<td>63</td>
<td>4</td>
<td>5.02</td>
<td>.81</td>
<td>.09</td>
</tr>
<tr>
<td>87</td>
<td>4 1/2</td>
<td>5.50</td>
<td>1.14</td>
<td>.30</td>
</tr>
<tr>
<td>88</td>
<td>5</td>
<td>11.18</td>
<td>1.42</td>
<td>.16</td>
</tr>
<tr>
<td>110</td>
<td>2 1/2</td>
<td>22.88</td>
<td>3.55</td>
<td>.09</td>
</tr>
<tr>
<td>127</td>
<td>4</td>
<td>1.64</td>
<td>.40</td>
<td>.08</td>
</tr>
</tbody>
</table>

**Genesis**

The two separated and different types of deposits of the Rush and Brown mine appear to be related genetically to the same agency-the intrusive diorite. This assumption is based principally on the fact that isolated outliers of cupriferous magnetite of the same character as the large contact magnetite deposit are found leading off of the shear zone vein deposit. The locale immediately adjacent to the contact, apparently was more conducive to magnetite deposition, hence, the comparatively
large deposit of that material there.

Following the intrusion of the dioritic igneous rock, the magnetite was undoubtedly the first mineral of the sequence. The sulfides were later as evidenced by the fact that these minerals fill minute cracks and fissures in the magnetite ore body, as well as the magnetite outliers of the shear zone and the shear zone itself. A still later period of mineralization, but of much lesser extent, deposited similar sulfide minerals in fissures and fractures which occurred subsequent to the first period of deposition. These late fractures which cut the magnetite body, all strike nearly north, usually slightly to the west, and have a steep dip—usually more than 70°. Some of these are slightly mineralized with sulfide material and calcite. Pyrrhotite is quite prevalent throughout this period of mineralization. Other fractures appear to have been filled with extremely basic rock forming minerals, resulting in the lamprophyric dikes which have been mentioned before.

There are no supergene minerals present at either deposit. It is possible that due to climatic conditions these were never formed. However, it is more likely that the zone of enrichment has been removed by recent glaciation which was quite intense in all of southeastern Alaska.

OTHER DEPOSITS

There are several other known deposits in the immediate area
on which a small amount of work has been done. These are all very similar to those deposits already described.

Approximately a mile south of the Rush and Brown mine is an outcropping, known as the Venus Prospect. The area is largely covered with glacial drift and alluvium, but metamorphics, probably the same as those in the vicinity of the Rush and Brown mine can be found close by. Also there are some beds of intensely altered conglomerate, interstratified with banded slates and graywackes.

The deposit is a vein of pyrrhotite with sphalerite, pyrite and chalcopyrite. Quartz and calcite are the gangue minerals. The vein strikes N.85° E. and dips steeply to the south. The vein as exposed by trenching is 250 feet long and averages 2½ feet wide.

A prospect tunnel, approximately 200 feet in length, has been driven on a fault which strikes N.10° E. and dips 80° to the east in the igneous rock about one quarter of a mile, southwest of the Salt Chuck mine. This fault is about four feet wide with both the hanging and foot walls highly slickensided. The metallization is a concentration of the bornite which is disseminated throughout the pyroxenite in the vicinity of the Salt Chuck mine. A few oxidation products, principally malachite can be seen along the walls and back of the adit. A marked similarity of the deposit of the Salt Chuck mine is obvious.
Two prospects about three-fourths of a mile southeast of the Salt Chuck mine are also concentrations of disseminated bornite, similar to the deposit of that mine.