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A MICROSCOPIC STUDY OF THE COPPER ORES OF TEXADA ISLAND, BRITISH COLUMBIA

submitted by

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as a partial requirement in

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ACKNOWLEDGMENTS

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ILLUSTRATIONS

ABSTRACT

The ores from the Little Billy, Copper Queen, and Marble Bay Mines examined microscopically shows the following minerals to be present in order of abundance: chalcopyrite, bornite, chalcocite, molybdenite, sphalerite, pyrite, an unknown mineral, and covellite. The particle size of the minerals varied from massive areas of chalcopyrite down to small crystals of the unknown mineral only 20 microns across.

The paragenesis of the ore is as follows. The pyrite was deposited first with gangue, followed by the unidentified white crystal and sphalerite. A deposition of chalcopyrite then occurred, followed by a mixture of bornite and chalcopyrite, in turn followed by a third deposition of chalcopyrite. Finally there was a deposition of molybdenite.

From an investigation of the particle size, the recovery of copper by flotation appears to present no problems, except in the cleaning of the copper concentrate of small amounts of sphalerite and molybdenite.

A MICROSCOPIC STUDY OF THE COPPER ORES OF TEXADA ISLAND

General Purpose of Study

1. To determine the minerals present.

2. To study the relationship of the minerals to one another, with special relation, if possible, to their relationship with gold.

Introduction

The specimens of ore studied were from the Marble Bay, Copper Queen, and Little Billy Mines on Texada Island, Vancouver Mining Division.

The ore bodies of these three mines have all proven to be moderately small but unusually rich. Their lengths vary from a few feet up to 220 feet, the widths from 10 to 50 feet, and the vertical dimension usually greater. These ore bodies are very irregular enclosing masses of barren limestone.

Location and Accessibility

The Marble Bay, Copper Queen, and Little Billy Mines are near the northern end of Texada Island in the Gulf of Georgia. The Copper Queen and Little Billy Mines being less than a mile southeast of Marble Bay.

These mines may be reached by car from Vananda, which is about a mile north of Marble Bay. Vananda is serviced from Vancouver by Union Steam Ships.

History

Copper was known to occur in the marbles of Northern Texada Island as early as 1886, but not until 1897 was a shaft sunk on the Marble Bay property. By 1899 the shaft had reached a depth of 140 feet and was continued in 1901 to a depth of 200 feet. Development continued steadly until 1921 when the seventeenth level was reached, where only small deposits of copper were found. The Little Billy and Copper Queen Mines have not been developed to such a depth.

Interest in these mines has been revived in the last few years, and at the present time Sheep Creek Gold Mines are building a mill at the Little Billy Mine.

General Geology

The rock formations of Northern Texada Island consist of: (1) a thick series of volcanics called the Texada Formation; (2) a thick Marble Bay Limestone of lower Jurassic or upper Triassic age; and (3) the granodiorite and quartz-diorite intrusions of the Coast Range Batholith of upper Jurassic age.

The Texada Formation is a part of the Vancouver Volcanics which form a greater part of the Vancouver Group. The Texada formation is several thousand feet thick and underlies virtually the whole of Texada Island.

The Marble Bay Limestone is the formation containing the ore bodies of the Marble Bay, Copper Queen, and Little Billy Mines. The formation occupies a belt from one to two miles wide and eight miles long, extending across the northern end of the island in a northwesterly direction, and is approximately 1500 feet thick.

The intrusion rock at the Little Billy and in the bottom of the Marble Bay Mine is a typically plutonic rock consisting essentially of quartz, plagioclase, and varying amounts of orthoclase, hornblende, augite, and biotite. It is generally considered that the ore found in the Little Billy and nearby mines was formed by solutions emanating from the magma which formed these intrusions.

Faulting on a small scale occured both before and after mineralization. The faulting after mineralization is unimportant, while that preceeding mineralization has an important bearing on the formation of the ore bodies, the largest and richest ore being found in the largest fault.

Procedure of Study

1. Verification of the previously determined paragenesis by V. Dolmage (1921) of the Marble Bay Mine.

2. Investigation to determine if the paragenesis is similiar for all three mines.

3. A study of the mode of occurance of gold and silver in view of the recent interest in the property shown by Sheep Creek Gold Mines Limited.

Megascopic Study

The metallic minerals recognized under the hand lens (X 12) are, in order of abundance:-

Chalcopyrite

Bornite

Molybdenite

Pyrite

The quantity of sulphides present in these specimens varied from 10% to almost 100% sulphides..

The Characteristics of the ore are:

1. The Marble Bay samples were nearly solid sulphides, but no developed crystal forms could be seen.

2. The Copper Queen specimen was over 50% sulphides but finely disseminated with no visible cyrstal forms.

3. In the Little Billy suite one specimen showed well developed pyrite crystals of pyritohedral form measuring

Dolmage, V.; The Marble Bay Mine, Texada Island, British Columbia, Economic Geology, vol 16, 1921, p. 372.

five to ten millimetres across. Another specimen showed massive to scaly molybdenite. The sulphides in the remaining specimens from this suite were finely disseminated.

Microscopic Study

Summary of Mineralogy

The Minerals found in order of ahundance are:

Chalcopyrite
Bornite
Chalcocite
Molybdenite
Sphalerite
Pyrite
Unknown Mineral
Covellite

A summary of the mineralogy is as follows:

1. Chalcopyrite: The chalcopyrite occurs principally as large massive areas showing no crystal outline. The chalcopyrite is closely associated with bornite, usually with mutual boundries between the two and the bornite containing exsolved bornite, as in plates 1 and 2, and figures 8 and 10. Often in the same sections, however, the chalcopyrite is replacing the bornite as shown in figure 10 and in other sections the bornite is replacing chalcopyrite as shown in figure 8.

2. Bornite: The bornite in all sections occurs with chalcopyrite and in most sections contains exsolved chalcopyrite.

3. Chalcocite: The chalcocite is always associated with bornite, with the chalcocite replacing the bornite, but never with chalcopyrite. The chalcocite examined was nearly white instead of bluish grey and is negative to the etch reagents.

4. Molybdenite: The molybdenite, more commonly associated with the chalcopyrite than with the bornite, usually occurs as small finely lamellated tabular fragments as seen in figures 3 and 11.

5. Sphalerite: The sphalerite occurs in chalcopyrite as unsupported neculei, often replaced partly by chalcopyrite.

6. Pyrite: Pyrite is a minor mineral only a few corroded crystals being found. In all sections examined the pyrite did not border any large amount of the copper minerals but occurred entirely surrounded by gangue. This is shown in figures 4, 5 and 11.

7. Unknown Mineral: The unknown mineral occurs as small equiaxed crystals, about 50 microns in diameter, surrounded by bornite and chalcopyrite.

8. Covellite: The covellite occurs in thin very irregular bands replacing bornite along thin cracks. This is shown in figure 6.

Detailed Mineralogy of Sections Examined

Section 1

Marble Bay Mine

1300 level

Metallics occupy over 90% of the total area of the section.

Assays:
- Au = 0.04 oz per ton
- Ag = 27.2 oz per ton
- Cu = 58.0%

Minerals present, in order of abundance are:
- Bornite = 55%
- Chalcocite = 35%
- Chalcopyrite = less than 1%

Fabric: The bornite and chalcocite in this specimen show no crystal forms but occur in massive areas. This structure is shown in figure 1.

1. Bornite, Chalcocite: These minerals occur in large, irregular, massive areas up to several millimetres long.

2. Chalcopyrite: The small amount of chalcopyrite present is not with the mass of the copper sulphides but occurs with bornite as small crystals, about 40 microns in diameter, in gangue. This is shown in figure 2.

Mutual Relationship of Minerals Present:

No true veining of the metallics is seen in this section but an examination of figure 1 indicates that the gangue which now occurs as unsupported neculei made up the original rock. This gangue was then broken up and bornite entered. After the deposition of the bornite, chalcocite began to replace it as shown by the fingering of the chalcocite into the bornite. After this deposition the deposite was again fractured and more gangue entered.

Section 2

Marble Bay Mine

Stock Set

Metallics occupy approximately 85% of the total area of the section.

Assays:

Au = 0.02 oz per ton
Ag = 2.2 oz per ton
Cu = 28.2%

Minerals present in order of abundance are:

Chalcopyrite = 80%
Bornite = 3%
Molybdenite = 3%
Sphalerite = 2%
Unknown Mineral = 3 small crystals

Fabric: Massive chalcopyrite makes up the background mass of this section, the gangue occurring in particles approximately a millimeter in diameter, the bornite, sphalerite, molybdenite, and unidentified crystals occuring in small particles.

1. Chalcopyrite: The chalcopyrite is as large massive areas, several millimeters long.

2. Bornite: The bornite occurs in small irregular crystals varying in size from about 20 microns to 400 microns. The bornite usually has smooth boundries with the chalcopyrite but some crystals have a ragged outline and contain exsolved chalcopyrite. This is shown in plates 1 and 2.

3. Molybdenite: The molybdenite occurs in small lath-like shapes varying from 40 to 90 microns thick and 500 to 1000 microns long. These laths have smooth boundries and cut all other minerals, as shown in figure 3.

4. Sphalerite: The sphalerite usually occurs bordering on bornite with smooth boundries between the two but often with ragged boundries between the sphalerite and chalcopyrite. This

is shown in plate 1. The size of the sphalerite particles varies from 20 microns and less to about 100 microns.

5. <u>Unknown Mineral</u>: The unidentified crystals are equiaxed and about 50 microns in diameter. They occur in bornite and have sharp regular grain boundries. The properties of these crystals are:

Color = white

Hardness = C

Weakly anisotropic, displaying a grey violet to dirty purple color.
Negative to all etch reagents.

<u>Mutual Relationship of Minerals Present</u>:

The sphalerite and bornite have smooth boundries, both minerals encroaching the chalcopyrite, the bornite containing exsolved chalcopyrite. The molybdenite veins all the minerals and gangue in the section.

Section 3

Copper Queen

Stock Set

Metallics occupy approximately 80% of the total area of the section.

Assays:

Au = 0.04 oz per ton
Ag = 14.0 oz per ton
Cu = 36.4%

Minerals present in order of abundance are:

Chalcopyrite = 60%
Bornite = 20%
Pyrite = less than 1%
Covellite = less than 1%
Unknown Mineral = less than 1%

Fabric: Massive chalcopyrite makes up the mass of this section the bornite occuring in massive particles up to 1000 microns across. The gangue is badly broken, appearing usually as unsupported neculei.

1. Chalcopyrite: The chalcopyrite is as large massive areas.

2. Bornite: The bornite occurs in small irregular crystals varying in size from about 20 microns up to 400 microns. The bornite shows no exsolved chalcopyrite and has smooth boundries with the chalcopyrite.

3. Pyrite: The pyrite occurs as a few irregular crystals in badly broken quartz. The pyrite crystals are about 300 microns in diameter.

4. Covellite: The covellite occurs as thin, very irregular bands replacing chalcopyrite and especially bornite along cracks through the copper minerals. These bands, shown in figure 6, are about 30 microns in width.

Unknown Mineral: The unknown mineral occurs as small crystals 50 to 100 microns in diameter surrounded by bornite and chalcopyrite. This is shown in plate 3.

Mutual Relationship of Minerals Present:

The pyrite has fractured boundries and is surrounded principally by gangue. The copper minerals have mutual boundries and vein into the gangue.

Section 4

Little Billy Mine

High Pyrite

Metallics occupy approximately 45% of the total area of the section.

Assays:

Au = 0.16 oz. per ton
Ag = 8.4 oz. per ton
Cu = 14.9%

Minerals present in order of abundance are:

Chalcopyrite = 25%
Pyrite = 20%

Fabric: The pyrite occurs as large regular crystals, while the chalcopyrite occurs as large irregular masses as in section 2.

1. Pyrite: The pyrite occurs in large regular crystals, 5 millimeters square. These cubes are badly cracked and veined with gangue, as shown in figures 4 and 5.

2. Chalcopyrite: The chalcopyrite occurs in large irregular areas as in section 2.

Mutual Relationship of Minerals Present:

The large crystals of pyrite have been badly cracked and these cracks filled with gangue before the deposition of the chalcopyrite. Almost nowhere does the chalcopyrite border the pyrite, the gangue veining the pyrite and the chalcopyrite replacing the gangue. This is shown in figure 4.

In the one place where the pyrite does join the chalcopyrite the gangue again veins the pyrite but not the chalcopyrite. This is shown in figure 5.

Section 5

Little Billy Mine

High Molybdenite

Metallics occupy approximately 20% of the total area of the section.

Assays:

Au = 0.02 oz per ton
Ag = 0.5 oz per ton
Cu = trace

Minerals present in order of abundance are:

Molybdenite = 20%
Bornite = less than 1%
Chalcopyrite = less than 1%

Fabric: The gangue is fractured and in large grains, among which occur the molybdenite.

1. Molybdenite: The molybdenite occurs as irregular grains from 30 microns up to a quarter of an inch across, as seen in figure 7.

2. Bornite: The bornite occurs as small crystals, 40 to 100 microns in diameter, with sharp smooth boundries, entirely surrounded by quartz. Some of the bornite crystals are cut by the chalcopyrite as seen in plate 4.

3. Chalcopyrite: The chalcopyrite occurs either cutting the bornite or as small crystals, from 5 to 40 microns in diameter, in quartz.

Mutual Relationship of Minerals Present:

The chalcopyrite and bornite occur as neculei for the quartz, the bornite being present before the chalcopyrite. The molybdenite does not bound the copper minerals but occurs in badly fractured gangue.

Section 6

Little Billy Mine

High Bornite

Metallics occupy approximately 55% of the total area of the section.

Assays:

Au = 0.65 oz per ton
Ag = 6.5 oz per ton
Cu = 22.4%

Minerals present in order of abundance are:

Chalcopyrite = 25%
Bornite = 20%

Fabric: The sulphide minerals are coarsely disseminated throughout the gangue.

1. Chalcopyrite: The chalcopyrite occurs as large irregular masses, filling fractures in the gangue.

2. Bornite: The bornite occurs as large irregular masses about 200 to 300 microns in length, often containing exsolved chalcopyrite. A typical sketch of this section is shown in figure 8.

Mutual Relationship of Minerals Present:

The chalcopyrite and bornite have mutual boundries both veining into the gangue and containing unsupported neculei of gangue.

Section 7

Little Billy Mine

High Chalcopyrite

Metallics occupy approximately 85% of the total area of the section.

Assays:

Au = 0.02 oz per ton
Ag = 15.7 oz per ton
Cu = 30.5%

Minerals present in order of abundance are:

Chalcopyrite = 70%
Bornite = 15%
Covellite = less than 1%
Unknown Mineral = less than 1%

Fabric: Massive chalcopyrite makes up the background mass of the section, the gangue being present as unsupported neculei and the bornite as small irregular particles.

1. Chalcopyrite: The chalcopyrite is as large massive areas several millimeters long.

2. Bornite: The bornite occurs in small irregular crystals from about five microns up to an eighth of an inch across. The bornite has smooth boundries with the chalcopyrite, as shown in figure 9, and under high magnification shows exsolved chalcopyrite, shown in figure 10.

3. Covellite: A very small amount of covellite occurs, as in section 3, along hair cracks through the bornite.

4. Unknown Mineral: The unidentified crystals are equiaxed and about 20 microns in diameter, have sharp boundries, and occur in chalcopyrite and bornite.

Mutual Relationship of Minerals Present:

The bornite, containing exsolved chalcopyrite, has mutual boundries with the chalcopyrite. The gangue appears as unsupported neculei.

Section 8

Little Billy Mine

Molybdenite

Metallics occupy approximately 2% of the total area of the section.
Minerals present in order of abundance are:
Pyrite = 1%
Molybdenite = 1%

Fabric: The mass of gangue is fractured and the edges are eroded away.

1. Pyrite: The pyrite occurs in the gangue as regular rectangular crystals from 20 to 1000 microns in diameter. The edges of the grains are eroded.

2. Molybdenite: The molybdenite occurs in long thin grains, 100 microns wide and up to 2 mm long, cutting across the fractured gangue. This is shown in figure 11.

Mutual Relationship of Minerals Present:

In general, throughout the sample the pyrite is eroded and does not occur with the molybdenite, which is not fractured but cuts across fractured gangue.

Section 9

Little Billy Mine

600 R.S.

Metallics occupy approximately 3% of the total area of the section.
Assays:
Au = 0.25 oz per ton
Minerals present in order of abundance are:
Chalcopyrite = 2%
Bornite = less than 1%
White Mineral = less than 1%

Fabric: The sulphide particles are as unsupported neculei throughout the gangue. No gold was found even under 650 magnification.

1. Chalcopyrite: The chalcopyrite occurs as unsupported neculei from a few microns up to 700 microns long.

2. Bornite: The bornite occurs as small unsupported crystals often with the chalcopyrite. No exsolution was seen in this section.

3. Unknown Mineral: The unknown mineral occurs as small grains in bornite and chalcopyrite.

Mutual Relationship of Minerals Present:

All three minerals occur together as unsupported neculei. The boundries between the chalcopyrite and bornite are smooth, while the boundries of the unknown mineral are very sharp. A general view of this section is shown in figure 12.

Paragenesis

Convincing veining or replacement relationships of the copper minerals are lacking in the sections examined. On the other hand there exists good veining relationships for the molybdenite and some of the gangue, widespread evidence of encroachment of the sphalerite by the copper minerals, and exsolution of chalcopyrite in the bornite. The paragenis is determined largely upon this criteria.

The order of deposition of the minerals is as follows:

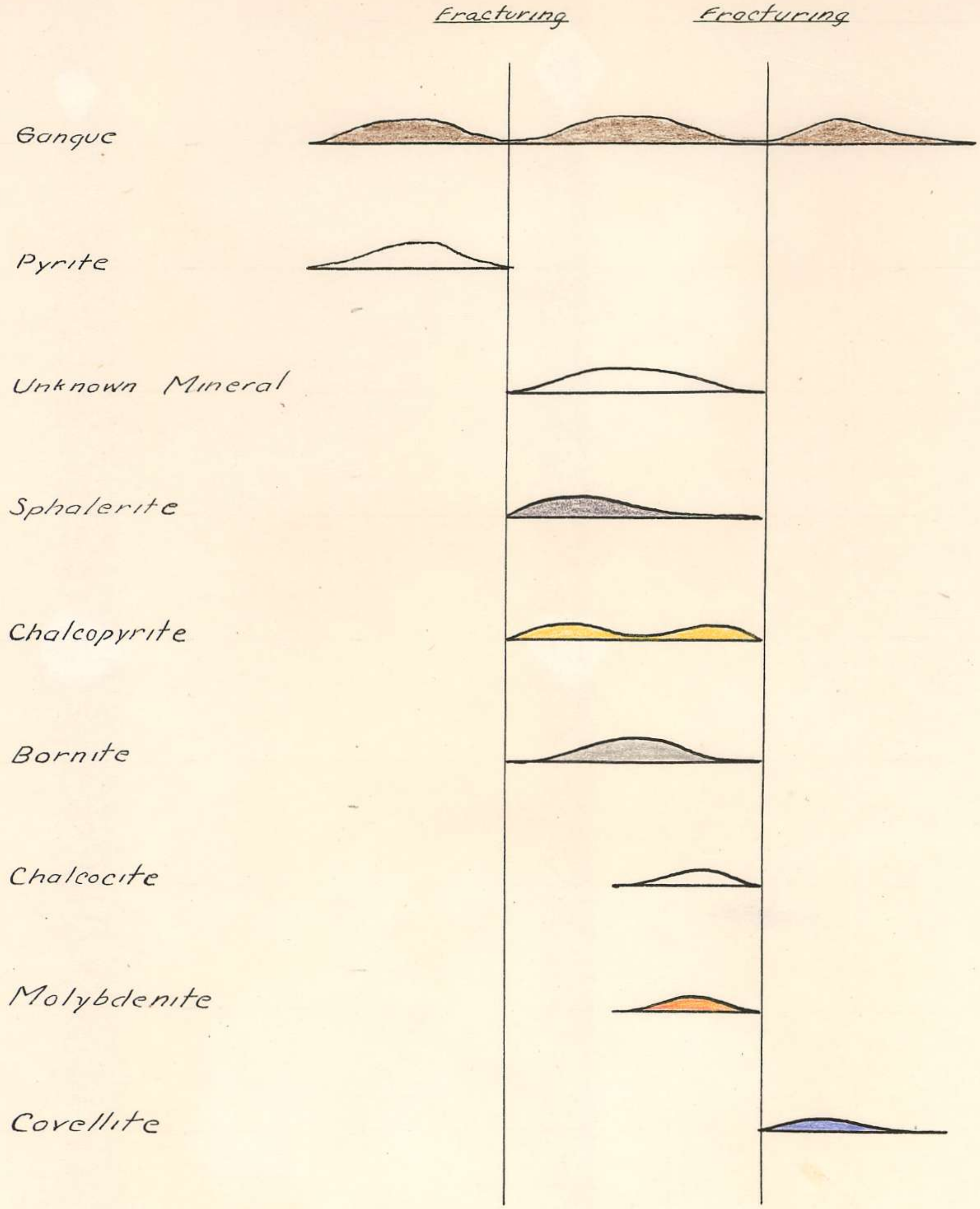
1. These is evidence that pyrite was the earliest mineral, since gangue fills fractures in the pyrite, see figures 4 and 5, but all other minerals vein into gangue or contain gangue as unsupported neculei, see figure 1, 6 and 8.

Gangue entered about the same time as the pyrite and before the copper minerals as seen by the numerous unsupported neculei in the copper minerals. See figures 1, 4, 7 and 8.

2. The age of the unidentified white crystals is difficult to determine, but by their unsupported neculei they appear to have deposited just before the bornite, since the bornite surrounds these crystals as seen in plate 3.

3. Sphalerite appears to be the next mineral deposited, since it occurs as unsupported neculei in the chalcopyrite and bornite, and shows no exsolution of chalcopyrite which is usually present when the two are deposited together.

4. Chalcopyrite is the next mineral deposited as it is being



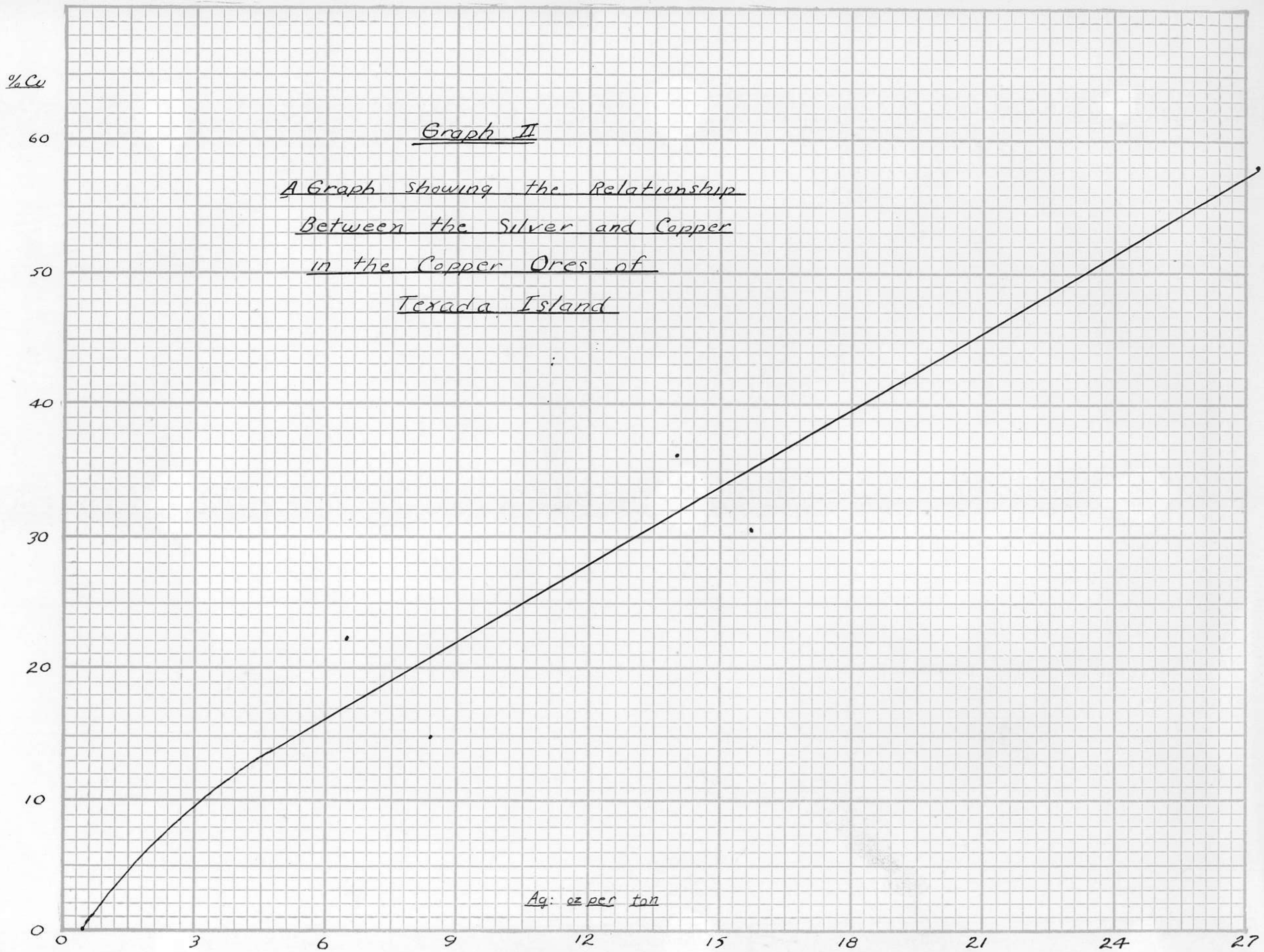
GRAPH I

PARAGENESIS of the COPPER ORES of TEXADA ISLAND replaced by bornite in some sections,as seen in plate 1. The chalcopyrite was then followed closely by a deposition of bornite and chalcopyrite together as is seen by the numerous sections showing exsolved chalcopyrite in the bornite. There then followed a further deposition of chalcopyrite as seen in plate 4 where it cuts bornite. After the deposition of these primary copper minerals the bornite was partly replaced by chalcocite as shown in figure 1, probably by solutions from the magma dissolving out the iron, since it is unlikely that the replacement could be by surface solutions since section one is from the 1300 level of the Marble Bay Mine, about 1050 feet below sea level. After the deposition of the copper minerals the deposit was fractured and there was another deposition of gangue, as seen in figure 1.

5. Molybdenite was definitely the last primary mineral deposited, since it cuts all other minerals as seen in figure 3.

6. Late in their life the bornite and chalcopyrite were oxidized along minute cracks to covellite as seen in figure 6.

The above age relations are summarized in graph 1.


Graph II
A Graph Showing the Relationship Between the Silver and Copper in the Copper Ores of Texada Island
% Cu
60
50
40
30
20
10
0
0
3
6
9
12
15
18
21
24
27
Ag: oz per ton

Economic Significance

The specimens studied all showed the copper minerals occurring in massive particles several hundred microns across and relatively unoxidized or unaltered indicating that a high recovery by flotation should be possible at a relatively coarse grind. An examination of the sphalerite and molybdenite, however, indicates that to either recover these minerals or separate them from the copper concentrate a grind to about 20 microns is needed for the sphalerite and a grind to about 50 microns is required for the molybdenite. Thus it is likely that much of the sphalerite and molybdenite will go into the copper concentrate lowering its grade.

The precious metals cannot be recovered by cyanidation because of the cyanicides, especially bornite, present.

Because of the absence of free gold or silver minerals in the sections examined no definite relationship between the precious metals and any of the minerals, metallic or gangue, could be determined. An examination of a graph between the copper and silver, however, see graph 2, indicates that the silver follows the copper. Unfortunately the gangue was so disseminated through the specimens having the higher assays that not sufficient of the sulphide could be cleaned for a silver assay.

The gold appears to follow no noticable trend in the small number of specimens examined, but on milling it is found that the gold follows the copper.

Conclusions

The metallics present in paragenetic order are:

Pyrite
Unidentified white crystals
Sphaterite, chalcopyrite, bornite, chalcocite
Molybdenite
Covellite

The exsolution of the chalcopyrite in the bornite rather than the sphalerite is a notable feature of this ore.

The ore solutions which formed these deposits were evidently of an unusual composition. The great preponderance of low iron minerals such as bornite and chalcocite and the absence of pyrite in any amount, pyrrhotite, and magnetite affords an interesting comparison with the huge deposits of magnetite found only four miles distant in the same formations.

This study gives a paragenesis similiar to that developed by Dr. Dolmage in 1921. Moreover this study also shows the great similarity between the ores from the three mines studied, indicating that all three mines were mineralized from the same magma.

Classification of Deposit

The sulphides present except for the covellite are all of hypogene origin. An indication of the very active history of this deposit is illustrated by the following facts:

1. The low temperature pyrite was the first sulphide mineral deposited.

2. The medium temperature sphalerite and copper sulphides were deposited next.

3. Finally the high temperature molybdenite was the last sulphide deposited.

4. The badly fractured gangue and sulphides.

Thus, in view of the limited data available the deposit may be classified as having passed from the epethermal to hypothermal type.

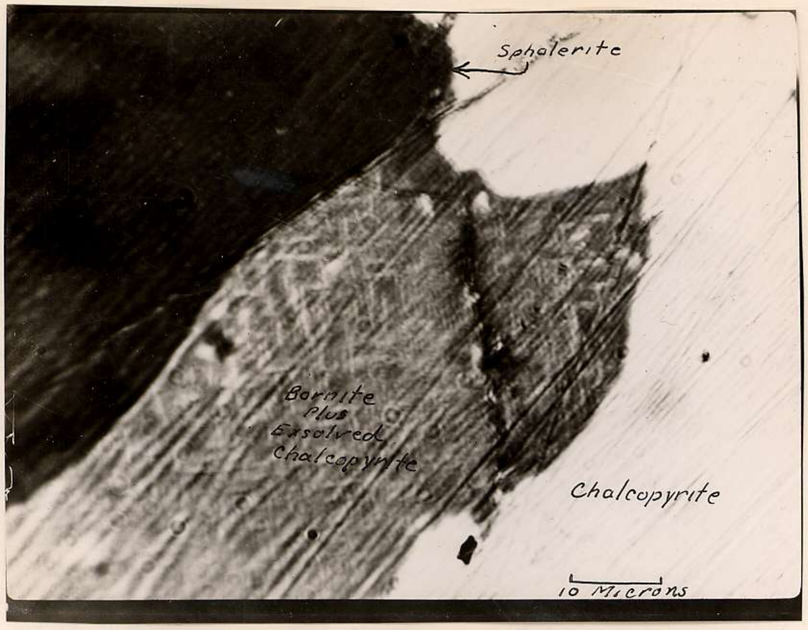


Plate I Section II 1200X

Note Exsolved Chalcopyrite in Bornite

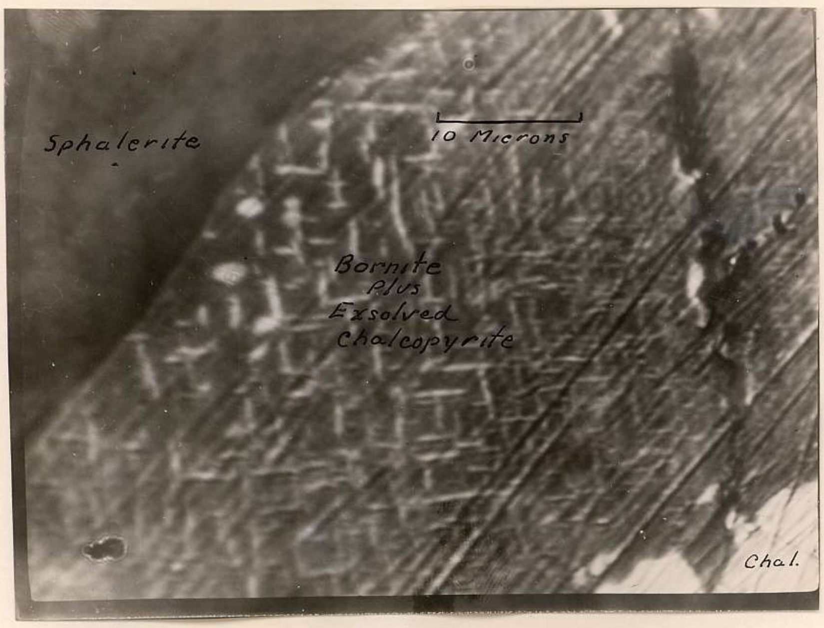


Plate II Section II 1900X

Note Exsolved Chalcopyrite in Bornite

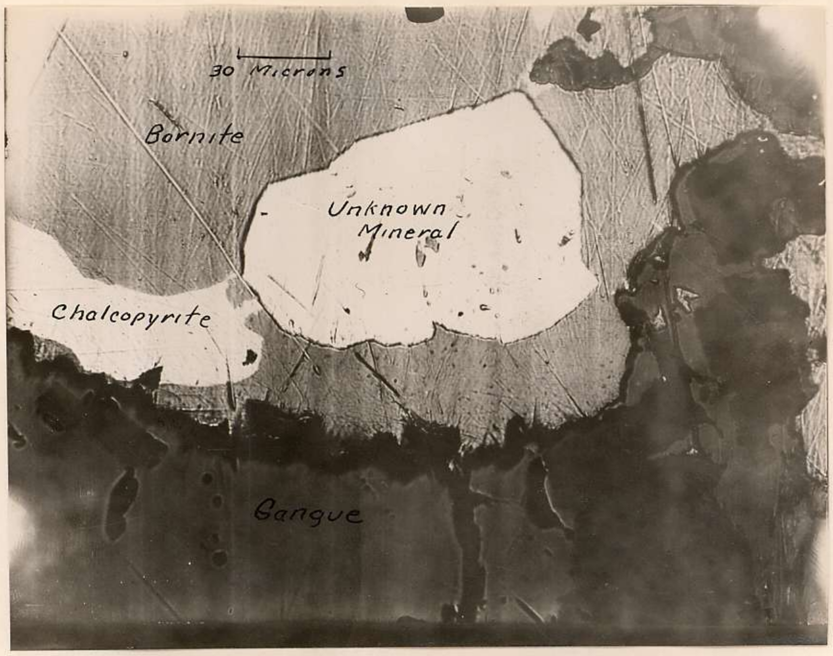


Plate III Section III 400 X

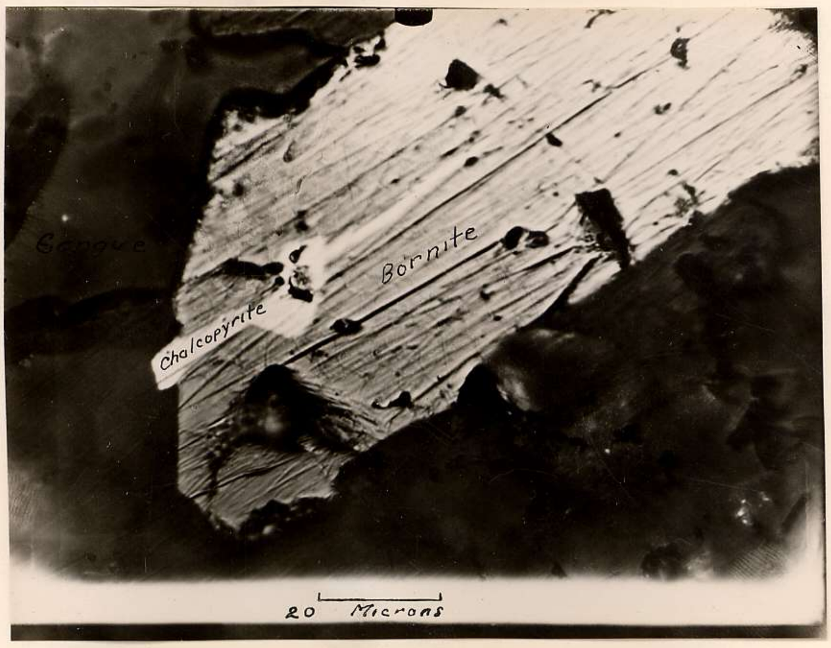
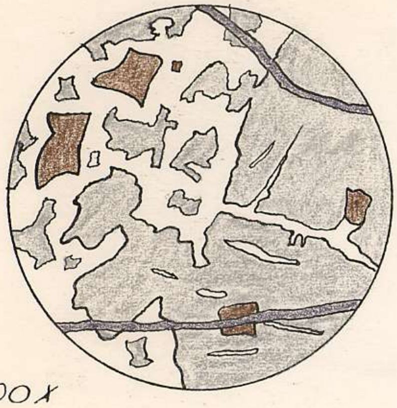


Plate IV Section V 810 X

Fig. I
Section I



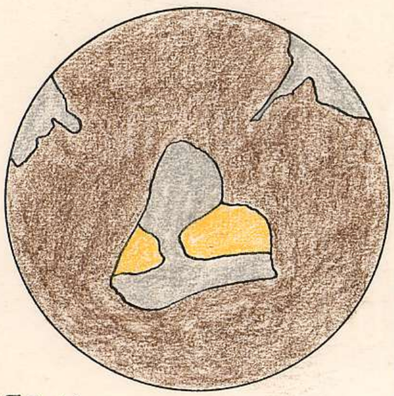
- Chalcocite
- Bornite
- Old Gangue
- New Gangue

Chalcocite replacing bornite

100X

200 Mesh 74 Microns

Fig. II
Section I



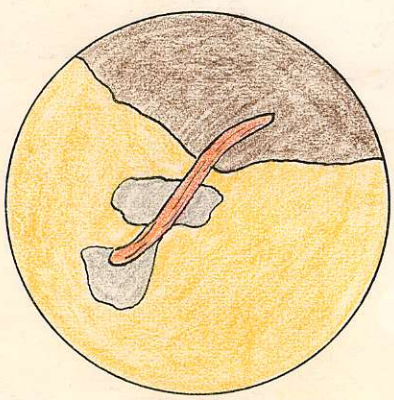
- Chalcopyrite
- Bornite
- Gangue

Chalcopyrite and bornite showing mutual boundries

450 X

200 Mesh

Fig. III
Section II



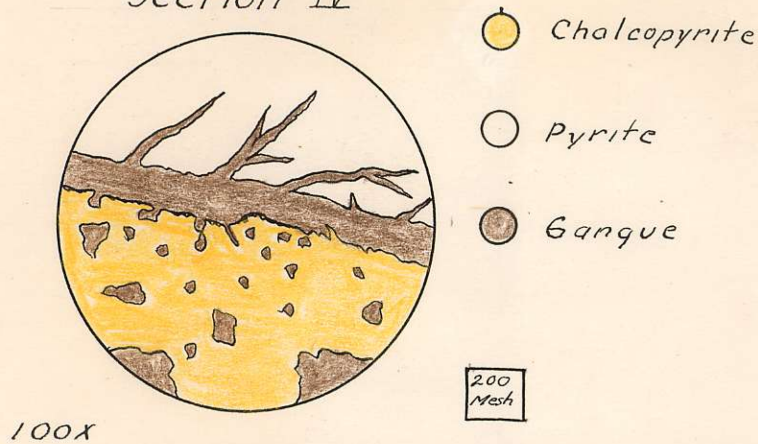
- Chalcopyrite
- Bornite
- Molybdenite
- Gangue

Molybdenite cutting bornite, chalcopyrite and gangue

200 Mesh

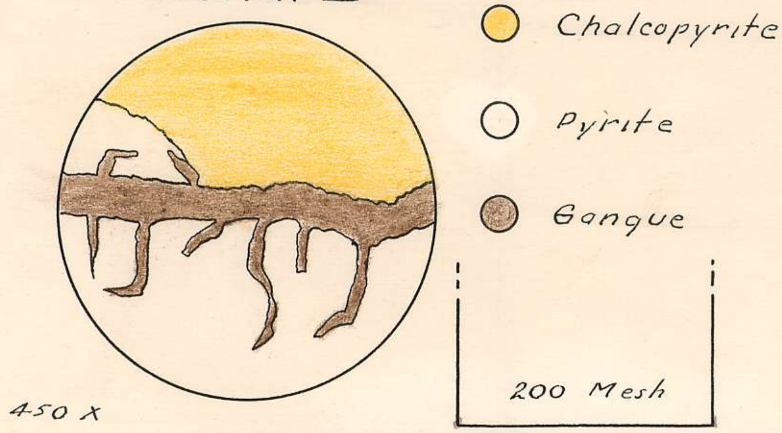
100 X

Fig. IV
Section IV



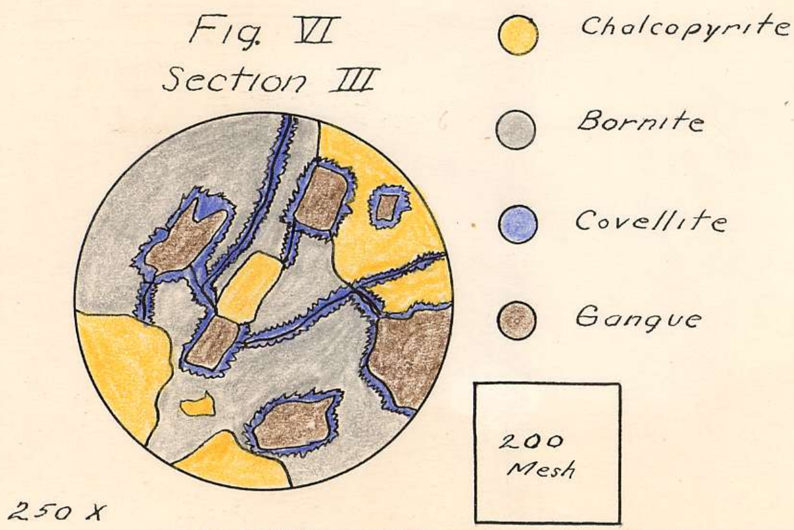
Gangue veining pyrite

Fig. V
Section IV



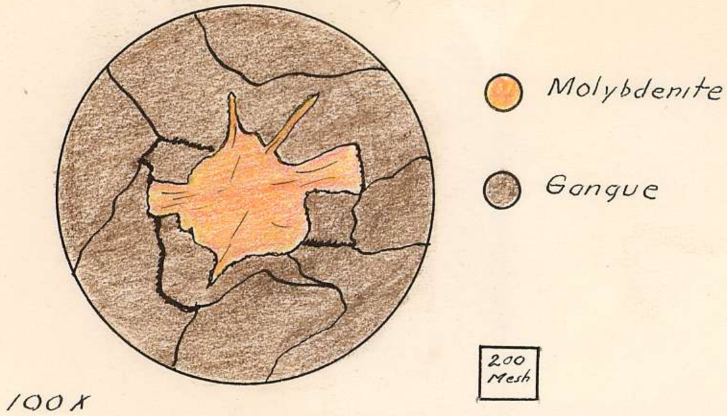
Gangue veining pyrite

Fig. VI
Section III



Covellite replacing bornite

Fig. VII
Section V



Molybdenite in gangue

Fig. VIII
Section VI

Bornite containing exsolved chalcopyrite

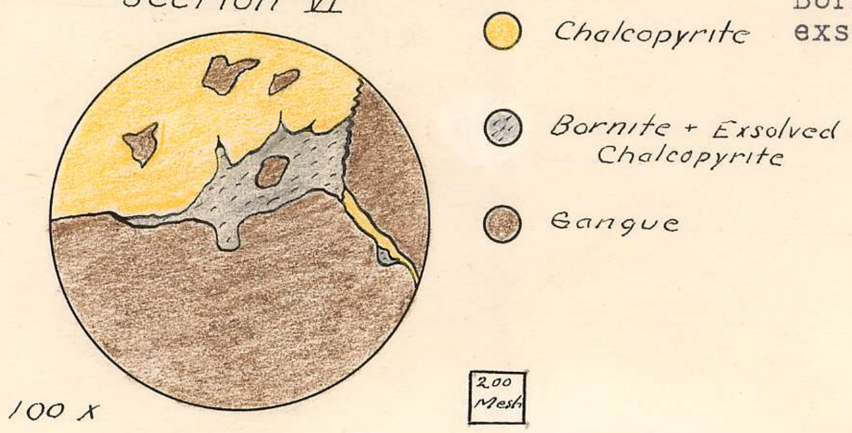


Fig. IX
Section VII

Bornite and chalcopyrite showing mutual grain boundries

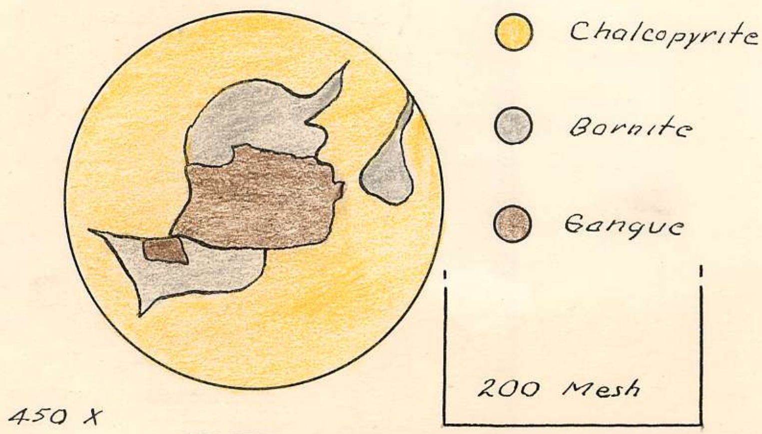
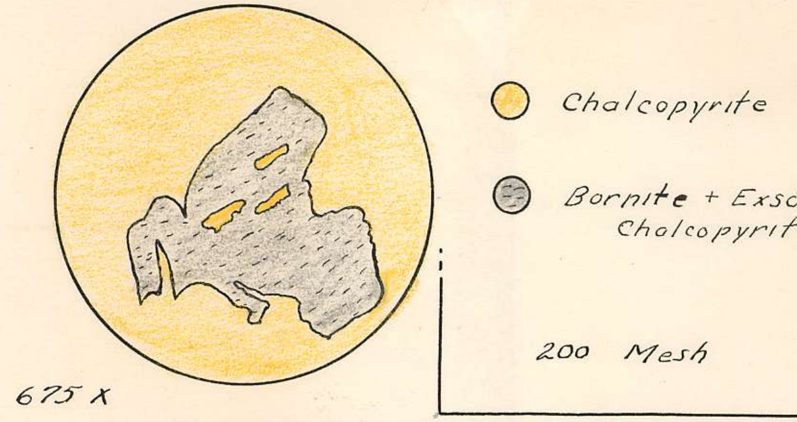
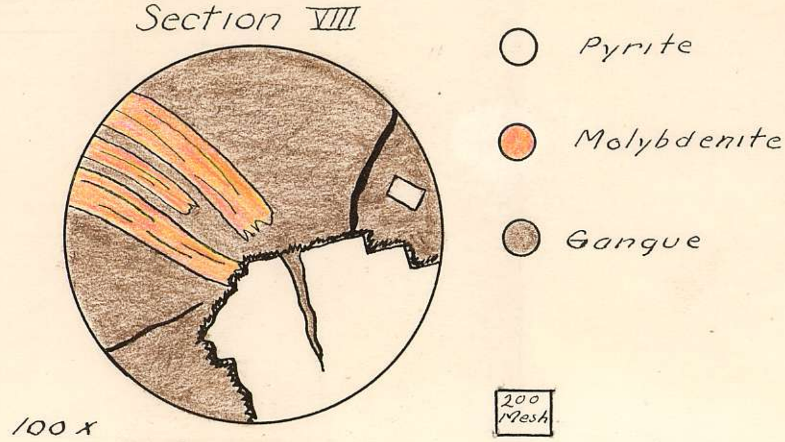


Fig. X
Section VII



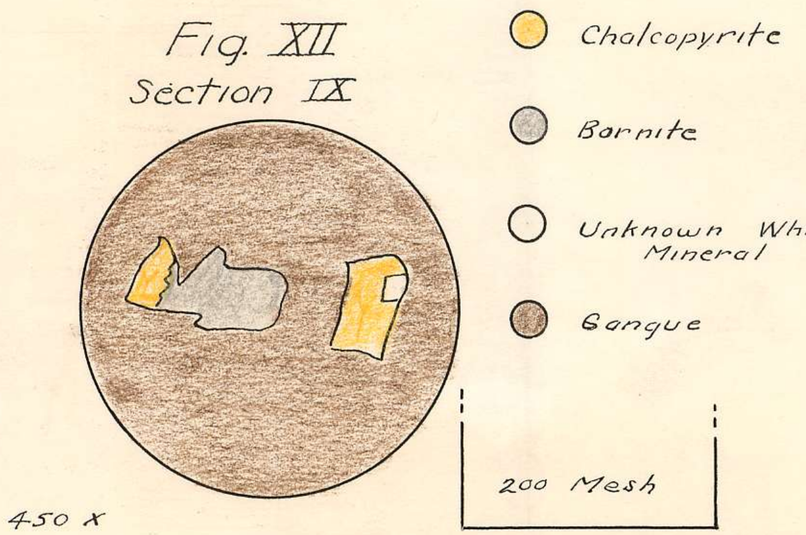
Bornite containing exsolved chalcopyrite

Fig. XI
Section VIII



Pyrite veined by gangue in turn veined by molybdenite

Fig. XII
Section IX



Bornite, chalcopyrite and unknown mineral occurring in gangue

Bibliography

Dolmage, V.; The Marble Bay Mine, Texada Island, British Columbia, Economic Geology, vol 16, 1921.

McConnell, R. G.; Texada Island, B. C., Memoir 58, Canada Department of Mines, Geological Survey, 1914.

Brewer, W. M.; The Origin of Bornite Ores on Texada Island, Journal of the Canadian Mining Institute, vol 7, 1905.

Short, M. N.; Microscopic Determination of the Ore Minerals, United States Government Printing Office, 1940.