A MICROSCOPIC EXAMINATION OF ORE FROM COPPER QUEEN AND MARBLE BAY MINES TEXADA ISLAND

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This report is submitted in partial fulfillment of the requirements of the course in Geology 409, at the University of British Columbia.

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INTRODUCTION

The laboratory work on which this report is based was done as part of the course in Geology 409 during the spring term of 1950 at the University of British Columbia. Some of the polished sections examined had been prepared for previous work and were merely repolished, and others were prepared especially for this problem from samples of ore from the Marble Bay and Copper Queen mines.

I am indebted to Dr. H.V.Warren and Dr. R.M. Thompson for advice and assistance in this work, and to Dr. Thompson particularly for an x-ray determination of one of the minerals of the linnaeite group which was found in these ores.

MARBLE BAY AND COPPER QUEEN MINES

The Marble Bay Mine and the Copper Queen Mine are situated on the north end of Texada Island within less than a mile of each other and close to similar copper deposits of the Cornell Mine and the Little Billy Mine. The deposits are of the contact-metamorphic type lying in the Marble Bay Limestone which is contained within volcanics of the Texada Formation of Upper Triassic or Lower Jurassic age. The ore is a high grade copper ore composed of bornite and chalcopyrite and carrying appreciable values of gold and silver.

Ore was first produced from the Marble Bay Mine in 1899, and the mine was continuously operated until 1921, by which time it had reached the seventeenth level more than 1500 feet below the surface and 1450 feet below sea level. The composition of the ore remained essentially the same as mining proceeded downward, but the ore became less abundant, and the bodies of ore discovered on the seventeenth level were not sufficiently large to bear the cost of mining. During the life of the mine several large and rich ore bodies were discovered, but much of the profits had to be spent in development work in order to find new ore bodies.

The Copper Queen Mine was opened a year or two before the Marble Bay Mine, but it has operated only sporadically, and mining has not gone beyond a depth of about five hundred feet. The mineralogy of the ore does not appear to differ greatly from that of the Marble Bay Mine, and reports do not indicate that the ore was of a lower grade. The less successful history of this mine may be explained by the erratic nature of the ore bodies. A good deal of both development work and luck would be needed to assure a steady supply of ore, and one or other of these was apparently lacking at the Copper Queen Mine.

PREVIOUS WORK

The geology and mineralogy of Texada Island were described by R.G. McConnell of the Geological Survey of Canada in 1914.[1] Information regarding the history of the two mines is contained in the Annual Reports of the Minister of Mines of British Columbia.[2] The Marble Bay Mine was studied in considerable detail by Victor Dolmage of the Geological Survey of Canada in 1921.[3]

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

2 Minister of Mines Province of British Columbia, Annual Report, Victoria, B.C.

3 Victor Dolmage, 'The Marble Bay Mine, Texada Island, British Columbia', Economic Geology, Lancaster, Pa., The Economic Geology Publishing Company, Vol 16, No.6, p 372, Sept.-Oct. 1921.

MINERALOGY

The following metallic minerals were observed in polished sections of ore from the Marble Bay and the Copper Queen mines: bornite, chalcopyrite, chalcocite, molybdenite, pyrite, pyrrhotite, magnetite, covellite, sphalerite, hessite, wehrlite, and linnaeite(?). In addition Dolmage reported argentite, tetrahedrite, galena, dyscrasite(?), calaverite(?), silver, gold, and electrum.

Bornite Reports of the Minister of Mines indicate that bornite is the most important mineral in both mines. It was present in all the sections studied except those made from a unique type of ore consisting of chalcopyrite, pyrite, pyrrhotite, and magnetite which was evidently found in two small bodies in the mine. In many of the sections bornite was associated with chalcopyrits but the relationship between the two minerals was not generally evident. In some places the granular texture seems to indicate a fairly complete exsolution of bornite from chalcopyrite (Fig. 1). In many cases the bornite has been invaded by minute veinlets of chalcocite or covellite, or contains fine blebs of exsolved chalcopyrite all of which can only be observed under very high power. Under medium power these are not visible and cause the bornite to apparently vary in color from place to place.

Chalcopyrite was observed in most of the sections which were studied. It was always associated with bornite

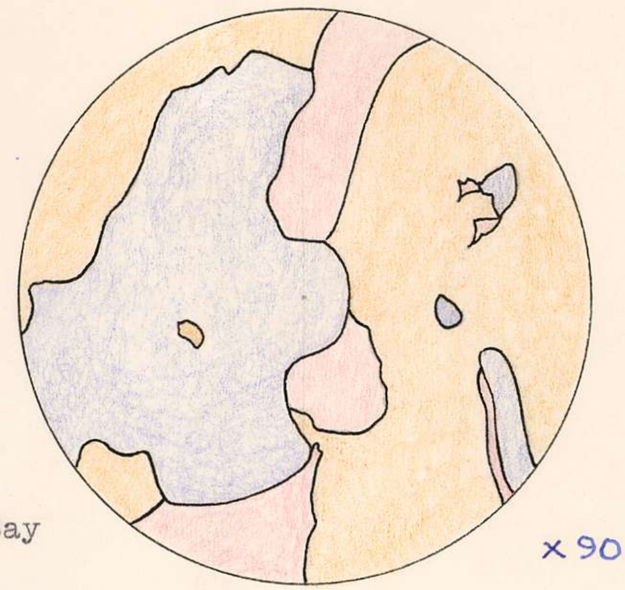


Fig. 1 Granular relationship between bornite (pink), Chalcopyrite (yellow) and chalcocite (blue).

except in sections made from the special type of ore mentioned above. In a number of places exsolution of chalcopyrite along the planes of bornite could be seen. In some cases this texture could only be observed with high magnification, but in others the exsolution was much coarser (Fig.2).

Chalcocite is present in a number os sections of ore from both mines and is always associated with bornite. In most places the texture is not clearly indicative of either exsolution or replacement, but in some places a fine network of chalcocite can be clearly seen invading and replacing the bornite.

Molybdentite was observed in chalcopyrite in sections of Marble Bay ore. It occurs as lath-like crystals some of which appear to have been crumpled. It was not seen

Size, mutual relations

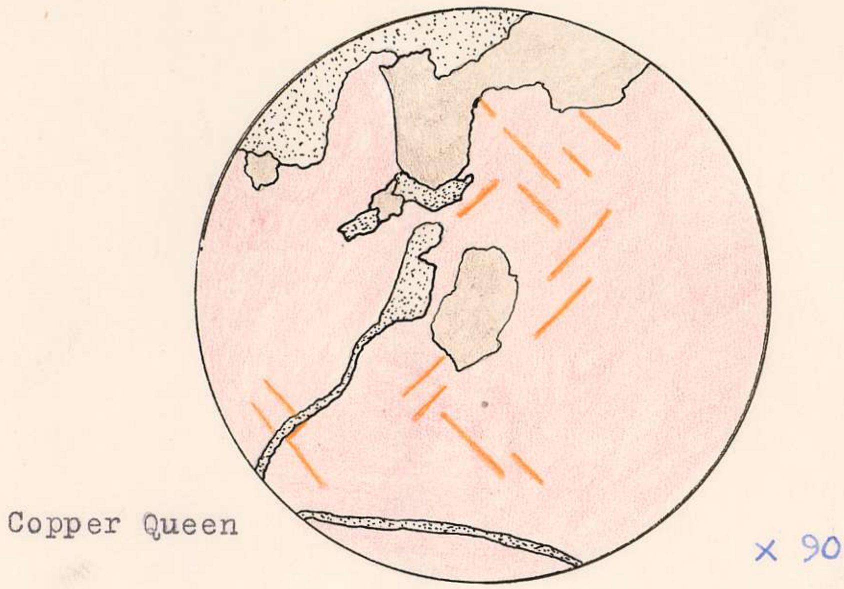


Fig. 2 Exsolution of chalcopyrite (yellow) in bornite (pink) associated with sphalerite (brown) and gangue (stippled).

in the ore from the Copper Queen or in the ore from the Marble Bay composed largely of chalcopyrite, pyrite, pyrrhotite and magnetite.

Pyrite was observed only in sections of the chalcopyrite, pyrite, pyrrhotite, magnetite ore, in which it occurs as small corroded crystals.

Pyrrhotite occurs only in the special type of ore mentioned above. Irregular grain boundaries between pyrrhotite and chalcopyrite suggest that they were deposited simultaneously.

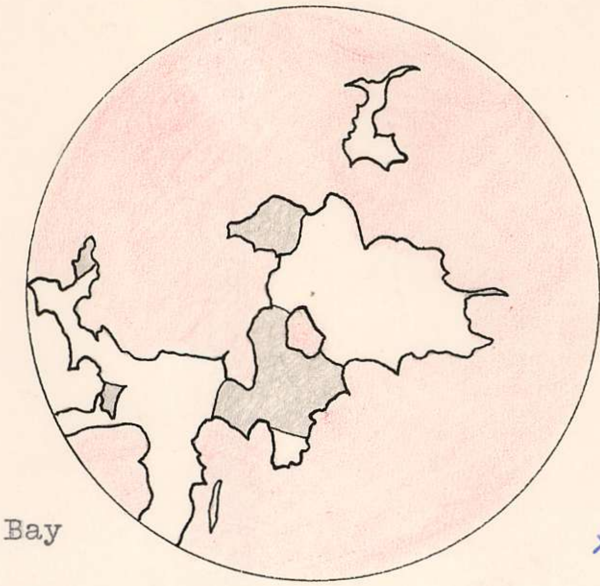
Magnetite was observed only in the ore mentioned above, and occurs as radiating finger-like formations extending into the chalcopyrite.

Covellite was observed in many sections always with bornite. Commonly it occurs as veinlets apparently replacing bornite and chalcocite along weak fractures, but avoiding chalcopyrite where the fracture ran into that mineral. It was also observed under high magnification as a very fine network replacing bornite.

Sphalerite was observed in a few places in small quantities associated with bornite. Dolmage noted that it appeared to be more abundant where chalcopyrite was plentiful.

Hessite and Wehrlite had previously been identified by x-ray patterns in sections of ore from the Marble Bay mine. They often appeared together in the manner shown in Figure 3. The blebs of hessite and wehrlite which occur in special type of ore from the Marble Bay mine are much larger and more conspicuous than any that could be found elsewhere in sections from the Copper Queen or Marble Bay ores. A number of small blebs which could not be positively identified as hessite or wehrlite were observed throughout the sections. The relationship of these minerals to those with which they are associated is not made clear by their textures.

Linnaeite was tentatively identified from an x-ray pattern by Dr. Thompson. It occurs as small crystals almost always showing some crystal faces. The color is white with a pitted surface, and it tarnishes creamy or slightly tan colored. It was observed in almost every section, always in contact with bornite and usually completely surrounded by



Marble Bay

x 90

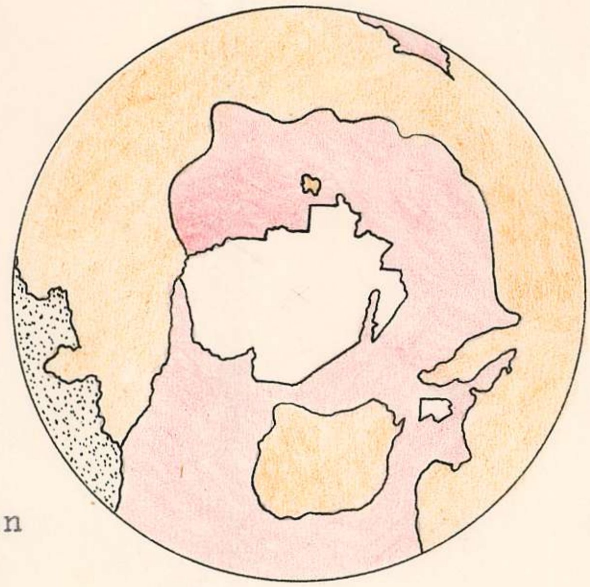
Fig. 3 Hessite (grey) and wehrlite (white) in pyrrhotite (pink).

it, even when the section consisted largely of chalcopyrite. What appeared to be linnaeite was also observed in sections of the chalcopyrite, pyrite, pyrrhotite, magnetite ore from the Marble Bay mine. The corroded appearance of most of the crystals of linnaeite, and the apparent common orientation of fragments of what may originally have been a single crystal (Fig. 4), suggests that the linnaeite was being replaced by or absorbed into the bornite.

Smith found tetrahedrite in Little Billy.

Argentite, tetrahedrite, and galena were reported by Dolmage in the Marble Bay ore in minute quantities, but were not identified in the sections studied for this report. Dolmage also tentatively identified dyscrasite and calaverite in small quantities.

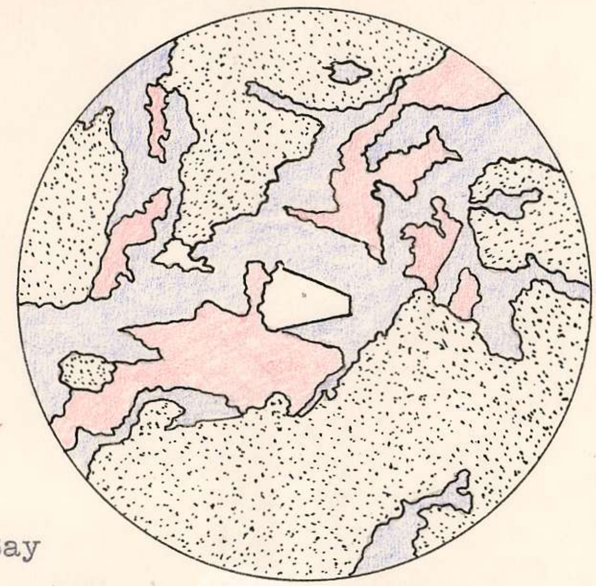
Native silver is mentioned in all reports of these mines. Dolmage says, 'native silver was found in the ore



Copper Queen

x90

Fig. 4 Linnaeite (?) (white) in bornite (pink) associated with chalcopyrite (yellow) and gangue (stippled). Note apparently parallel crystal faces on the two crystals suggesting common orientation.



Marble Bay

x90

Fig. 5 Linnaeite (?) (white) in bornite (pink) and chalcocite (blue) associated with gangue (stippled).

of all levels and appears to be as plentiful on the lower as on the upper levels'. McConnell mentions that it occurs in thin scales and small rounded nuggets with bornite. It is first mentioned in the Report of the Minister of Mines for 1913 as occuring in minor quantities. It is therefore surprising that no native silver was identified in the sections studied for this report. A possible explanation for this, of course, is that by chanse the sections which were studied did not contain the usual silver. A second possible explanation is that in the cases referred to, some other mineral was mistaken for silver. Wehrlite, because of its silver white color seems to be the most likely one. The etch tests for silver and wehrlite are only distinctly different for HNO_3 and $HgCl_2$, and even these might not be distinctive because the reagent would probably be in contact with adjoining minerals. However, the anisotropic character of the wehrlite should have distinguished it, and except in sections sections made from the special Marble Bay ore, wehrlite was not observed in the manner and association of the native silver described by Dolmage. It therefore does not seem possible to draw any definite conclusions regarding native silver in these ores.

<u>Native gold</u> and <u>electrum</u> were reported by Dolmage in many polished sections of bornite ore. Small irregular masses of what appeared to be gold was observed in bornite ore from both mines, but they were too minute to be positively identified. A few larger pieces proved to be

chalcopyrite, apparently exsolution blebs in the bornite.

TEMPERATURE OF DEPOSITION

The presence of magnetite, pyrrhotite, molybdenite, bornite, chalcocite, and a telluride in the ores suggests that there was a wide range in the temperature of deposition. The presence of exsolution laths of chalcopyrite in bornite in many places suggests that the temperature dropped sufficeintly rapidly to prevent complete diffusion of the chalcopyrite to the grain boundaries. The lack of zoning of minerals within the mines suggests that the temperature was dropping uniformly in all parts of the mineralized zone, rather than that there was a steep temperature gradient from one part of the ore zone to another.

The textures of the linnaeite grains in bornite may be significant. Solid solution of linnaeite in bornite has been inferred from unmixing textures by Edwards.[4] In the sections which were studied, the linnaeite appears to be being dissolved by the bornite rather than exsolved from it. If slow cooling allowed complete exsolution of linnaeite from the bornite in euhedral or subhedral grains, and this were followed by a change in conditions,(probably a rise in

4 A.B. Edwards, Textures of the Ore Minerals and Their Significance, Melbourne, Australasian Institute of Mining and Metallurgy, 1947, p 73.

temperature) to cause partial solution of the linnaeite and then more rapid cooling to prevent exsolution, the textures which are observed might be produced. Such a sequence could account for the absence of crystals of linnaeite in the chalcopyrite if linnaeite is much more soluble in bornite than in chalcopyrite. It would be difficult to understand why the linnaeite should be observed everywhere in bornite and not in chalcopyrite if the linnaeite were an early formed mineral which was being replaced by bornite. A sequence of slow cooling followed by reheating and rapid cooling might also account for the presence of a granular texture of bornite and chalcopyrite in most places, possibly indicating complete exsolution, and laths of chalcopyrite in bornite in other places, suggesting rapid cooling and incomplete exsolution. Though such a sequence may be suggested, the evidence is not very strong, and in this case, a quantitative examination of solid solution diagrams of bornite-chalcopyrite, bornite-linnaeite, and chalcopyrite-linnaeite, cannot be made, to indicate whether the reactions might take place.

SUPERGENE ENRICHMENT

Dolmage presents three alternatives regarding enrichment of the ore. Either all the chalcocite, covellite, and native silver are primary, or surface solutions have circulated through the ore in its present submarine position, or the deposits were enriched by surface solutions and later depressed to their present position. Of these three possibilities he favours enrichment followed by depression to their present level. For several reasons it appears to the write that a hypogene source of chalcocite, covellive and native silver, if it is present, is more likely.

The iron sulphides pyrite and pyrrhotite which could react with ground waters to produce the solutions which could carry copper in solutions to enrich the ore, are present only in one type of ore consisting of pyrite, pyrrhotite, chalcopyrite and magnetite, and this ore is reported only in two small bodies in the Marble Bay mine. If an upper portion of the ore markedly different in composition and containing the necessary quantities of iron sulphides had been present and subsequently removed by glacial action, solutions descending from it would have probably caused a zoning of the ore and would certainly have reacted with the limestone wall rock to deposit considerable amounts of copper carbonates. Since there is apparently no zoning of the ore, and since no copper carbonates are reported or were observed, it seems possible that the chalcocite and covellite were deposited by hypogene solutions. The covellite is found mainly along weak fractures in the bornite and so was probably deposited late and at a relatively low temperature. The chalcocite was probably deposited somewhat earlier and at a higher temperature, or it may have been subject to reheating after deposition, causing it to go partly into solution in the bornite.