Very few errors
1st Class.

9A

A MICROSCOPIC STUDY OF A SUITE
OF ORE FROM THE LITTLE BILLY MINE,
TEXADA ISLAND, BRITISH COLUMBIA

submitted by

K. C. Smith

as a partial requirement in

Geology 409

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ACKNOWLEDGEMENTS

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ABSTRACT

The ore body of the Little Billy Mine is a low-pyrite, possibly enriched, pyrometasomatic deposit of copper-gold-silver ore in a limestone skarn. The ore minerals, which are finely disseminated throughout the gangue, listed in order of abundance are: chalcopyrite, bornite, magnetite, molybdenite, sphalerite, pyrite, chalcocite, covellite,an unidentified mineral of the Linnaeite Group, tetrahedrite, wehrlite, hessite,electrum and gold.

The suggested order of deposition of the ore minerals is: (1) pyrite and the unknown mineral; (2) magnetite and molybdenite; (3) chalcopyrite,bornite, and sphalerite; (4) tetrahedrite, electrum, wehrlite, and hessite; (5) gold; and (6) chalcocite and covellite. Some of these stages may have occurred simultaneously.

The important copper minerals are bornite and chalcopyrite, the silver values are carried by hessite, wehrlite, electrum, and possibly tetrahedrite, and the gold values are due to native gold and electrum. The copper minerals are but little altered, and though disseminated, occur in masses large enough to suggest that a high grade copper concentrate could be secured by fine grinding and flotation.

A MICROSCOPIC STUDY OF A SUITE OF ORE FROM THE LITTLE BILLY MINE, TEXADA ISLAND, BRITISH COLUMBIA

OBJECT AND LIMITATIONS OF THE REPORT

The object of this report is to describe the mineralogy and paragenesis of the ore from the Little Billy Mine, Texada Island, British Columbia. The report is based on the microscopic study of a suite of ore collected from the Little Billy Mine by John Deleen in 1946, and at present available at the University of British Columbia.

As the writer is not familiar with the mine, and as the specimens available are not in all cases clearly labelled, no attempt has been made to distinguish between various specimens from different parts of the mine, and the suite of specimens is considered as representing only one deposit. Furthermore, as no thin sections of the ore have been prepared or studied by the writer, the postulated paragenesis is based mainly on the textural relationship of the opaque minerals.

The ore of the Little Billy Mine is finely disseminated, a fact which makes the determination of minerals and paragenesis uncertain. Free use has been made of the reports by Dolmage (1921), Deleen (1946), and Carter (1948).

The method of study outlined by Short (1940) was used for the determination of the ore minerals. Two minerals that occurred in grains so small as to make microchemical methods unsatisfactory were identified by Dr. Thompson by means of their X-ray patterns.

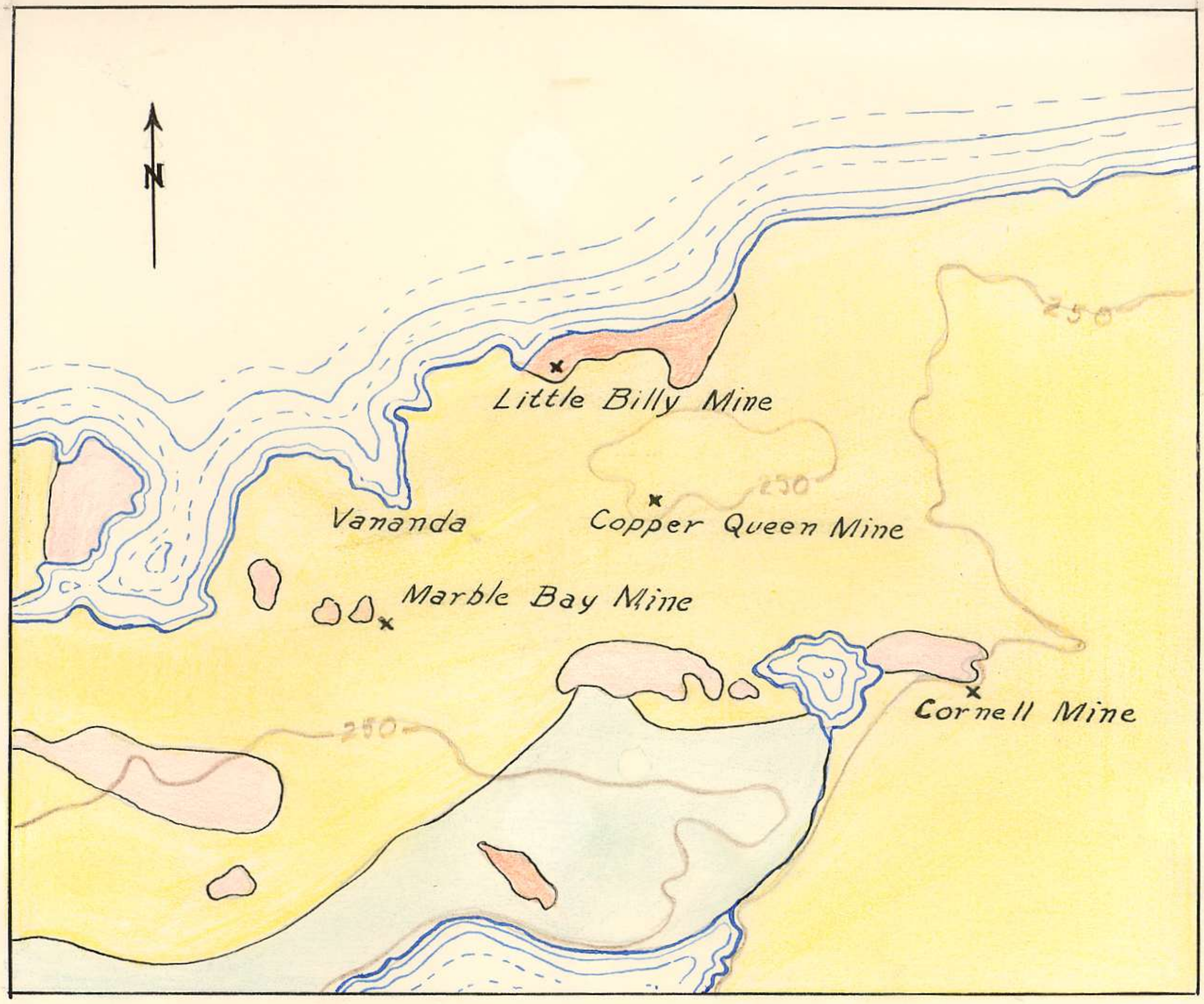
INTRODUCTION

Location and Accessibility

The Little Billy is one of a small group of mines located near Vananda on the northern part of Texada Island, which lies in the Strait of Georgia that separates Vancouver Island from the mainland of British Columbia (see map, page 3). The mine is less than a mile by road from Vananda which is serviced from Vancouver by the Union Steamship Company.

History

The history of the Little Billy Mine is closely associated with that of the other copper mines of northern Texada Island, and has been outlined by Dolmage, Deleen, and others. Low grade copper deposits were known to occur in the northern part of the island as early as 1886. The ore body of the Marble Bay Mine was discovered in 1897, and was worked continuously until 1924, yielding $25,000,000 in copper, gold and silver. The Little Billy, Copper Queen, and Cornell properties, also discovered in 1897, were developed by the Vananda Copper and Gold Company which



MAP SHOWING THE OUTCROP GEOLOGY IN THE VICINITY OF THE LITTLE BILLY MINE, TEXADA ISLAND, B.C.

Scale: 1" = 2000'

LEGEND

JURASSIC OR CRETACEOUS	Diorite, Diorite Porphyrite
JURASSIC OR CRETACEOUS	Quartz Diorite
LOWER JURASSIC (?)	Porphyrite
LOWER JURASSIC OR TRIASSIC	Marble Bay Limestone

Map and geology after Deleen

built a 50 ton smelter to treat the ore. Though these mines obtained the same minerals from the same type of deposit as did the Marble Bay Mine, the ore was not of the same quality or quantity, and they were worked by the company only until 1920, when they were abandoned.

These properties were purchased by the Industrial Metal Mining Company in 1943. Diamond drilling located a new ore body in the Little Billy Mine, which was the first to be dewatered. In 1944 the Little Billy, Cornell, and Copper Queen Mines were leased by Pioneer Gold Mines Limited, which company by 1946 had deepened the shaft of the Little Billy by 200 feet and begun development of the 480 level. The property has evidently changed hands again, for according to Carter (1948, p.2), Sheep Creek Gold Mines were building a small mill at the Little Billy Mine in 1948.

Previous Work

The mineral deposits and geology of Texada Island have received considerable attention, and Deleen (1946) has compiled a comprehensive bibliography. The Summary Reports of the Geological Survey of Canada and the Reports of the Minister of Mines for British Columbia contain numerous references to Texada Island. Brewer (1905), McConnell (1914), and Dolmage (1921) have made valuable contributions to an understanding of the geology and mineral deposits of the island. To the writer's knowledge, the most recent studies of the mineralogy of the Little Billy Mine have been made by Deleen (1946) and Carter (1948). Neither of these reports have been published.

General Geology

Virtually all of Texada Island is underlain by the Texada formation, a thick series of volcanics belonging to the Vancouver Group. The formation is over 3000 feet thick and consists of a variety of superimposed, medium to basic volcanic flows. It does not outcrop in the immediate vicinity of the Little Billy Mine and is not shown on the map (page 3). Apparently intercalated with these volcanics is a formation of limestone, 1500 feet thick, known as the Marble Bay Limestone, which is of lower Jurassic or Triassic age. This formation extends across the northern part of the island in a belt from 1 to 2 miles wide and contains the ore bodies of the Marble Bay, Cornell, Copper Queen, and Little Billy Mines. It is exceedingly pure and has been recrystallized into fine-grained, light grey marble.

The intrusives which cut the Marble Bay Limestone can be divided into three types: (1) a lower Jurassic porphyrite, (2) a Jurassic or Cretaceous quartz diorite, and (3) a Jurassic or Cretaceous diorite and diorite porphyrite. The quartz diorite outcrops at the Little Billy Mine, at Priest Lake one mile to the south, and has been intersected at the bottom of the Marble Bay Mine (Map, page 3). Dolmage (1921, p.387) suggests that these intrusions which he terms granodiorite, are parts of the same plutonic body and are the source of the ore.

Faulting on a small scale has occurred both before and after emplacement of the ore. The post-ore faulting is of little consequence and resulted in only slight displacements, but the pre-ore faulting provided fissures which exerted a major control on the deposition of the ore.

MINERALOGY

Megascopic Study

The hand specimens available for study consisted o~~d~~f picked samples collected by Deleen from various parts of the mine and from the dump. They range from 5 to 75 percent metallics in a skarn gangue. The metallic minerals identifiable with the aid of a hand lens and needle are listed in order of abundance:

Chalcopyrite
Bornite
Magnetite
Molybdenite
Pyrite

The chalcopyrite, bornite, and magnetite are disseminated throughout the gangue, usually finely disseminated, although some irregular areas of massive chalcopyrite exceed 2 inches in their maximum dimensions. The magnetite apparently occurs in less than half the specimens, but where visible is usually present in considerable amounts. These specimens undoubtedly represent the type of which Deleen calls Bornite-Magnetite ore. The molybdenite occur~~r~~s as small areas of massive or platy aggregates within the gangue, apparently never in contact with the other metallics. The pyrite, which is surprisingly scarce, occurs as pyritohedral crystals up to $\frac{1}{2}$ of an inch to a side.

Typical skarn minerals comprise the gangue. A tentative identification by means of hand lens and needle showed these minerals, listed in order of abundance, to be:

Calcite

Garnet

Wollastonite

Epidote

Quartz

Serpentine

Sericite

Doubtless a thin-section analysis of the specimens would indicate the presence of others.

Microscopic Study

The ore minerals identified under the microscope and listed in order of abundance are:

Chalcopyrite

Bornite

Magnetite

Molybdenite

Sphalerite

Pyrite

Chalcocite

Covellite

Unknown (Linnaeite group)

Tetrahedrite

Wehrlite (?)

Hessite

Electrum

Gold

Chalcopyrite ($CuFeS_2$)

The chalcopyrite appears as irregular masses replacing the gangue and is present in varying amounts in nearly all sections studied. It often contains exsolution blebs of sphalerite which themselves sometimes show exsolution blebs and stars of chalcopyrite (Figs. 2 and 5). It is apparently contemporaneous with bornite as well, but a few sections show long narrow veins of chalcopyrite in bornite (fig. 8).

Bornite (Cu_5FeS_4)

The bornite is next to the chalcopyrite in abundance and from an economic viewpoint is undoubtedly the most important copper mineral. It occurs as irregular masses, varying in maximum dimension from 20 to 1000 microns, disseminated throughout the gangue. In most sections it appears to be contemporaneous with the chalcopyrite and often contains small blebs of exsolved chalcopyrite, but in some cases, as noted above, it has apparently preceded the chalco-pyrite (fig. 8). The bornite and chalcopyrite both replace and are replaced by gangue. According to Deleen all the gangue minerals except serpentine and late calcite and quartz precede the bornite.

Magnetite ($FeO.Fe_2O_3$)

The magnetite occurs as euhedral and anhedral crystals, up to 200 microns in diameter, disseminated throughout the gangue. It is entirely absent in many of the sections but in some, such as section 55, it comprises over 40 percent of the ore. In the polished sections its relationship to bornite and chalcopyrite suggests contemporaienity but it is also associated with pyrite, suggesting that it has preceded the bornite and chalcopyrite.

Molybdenite (MoS_2)

The molybdenite occurs as small, finely lamellated, tabular fragments, as irregular grains up to 10 millimeters across, and as narrow laths, up to 1000 microns long, ? comprised of bent, lamellated crystals. It is associated with the gangue in several sections but was seen to have a mutual boundary with the other metallics in only one instance, in section 59, where the molybdenite extends from the gangue into chalcopyrite. The age relationship of the two minerals is not clear. From its distribution throughout the mine, its relationship to the various gangue minerals, and its association with pyrite, Deleen has suggested that ~~it~~ the molybdenite probably preceded the chalcopyrite and bornite, but this is not evident from a study of the polished sections alone.

Sphalerite (ZnS)

Sphalerite occurs in minor amounts and comprises less than one percent of the ore minerals. It is present as small irregular masses within and bordering the chalcopyrite (figs. 2 and 5), suggesting that these minerals are of the same age.

Pyrite(FeS_2)

The pyrite, which is an uncommon mineral in the deposit, is present in only 5 or 6 sections. It occurs as corroded cubes up to 20 millimeters to a side and as irregular masses of the same order of size. There appears to be two generations of pyrite, and in some cases, such as in the "high pyrite" section, a definite contact can be seen between the cubic crystals and the massive pyrite which replaces them. Although the etch reactions of both types of pyrite are identical the two generations can be distinguished when in contact with one another from the fact that the cubic crystals take a somewhat better polish than the younger irregular masses. The powder of the massive variety was X-rayed by Dr. Thompson to confirm its identification as pyrite. Both generations of pyrite appear to be earlier than the other sulphides. Bornite and chalcopyrite tend to surround and replace the pyrite, which contains hexagonal quartz crystals. The pyrite is veined by gangue bearing chalcopyrite and sphalerite (fig. 6).

Chalcocite (Cu_2S)

Chalcocite is not abundant. It is usually intimately associated with the bornite, and was not observed in the chalcopyrite. Although chalcocite occurs in abundance in the nearby Marble Bay Mine, and according to Carter (1948,p.7) is present in that deposit as large, irregular, massive areas up to two millimeters long, in the Little Billy suite it usually occurs in such small areas as to make positive identification difficult. Deleen (1946, p. 13) has reported chalcocite occurring as irregular boundaries and veins replacing the bornite. The writer noticed chalcocite (?) as irregular blebs, usually less than 30 but occasionally up to 100 microns in diameter, associated with the bornite in such a manner that the age relationship was not apparent. Also, in some sections, and particularly in section 55, the bornite contains an extremely fine network of veins of a blue mineral which may be chalcocite. These may be the veins of chalcocite referred to by Deleen.

This network of veins is so delicate as to be clearly discernable only under high-power magnification with an oil immersion lens, and it appears impossible to conclude whether the mineral is chalcocite or covellite. Dolmage (1921,p. 381), reporting blue chalcocite from the Marble Bay Mine, suggests that it may be a mixture of the two sulphides, and Edwards (1947,p. 74) reports that chalcocite and covellite are stable as a solid solution system at temperatures below 75 degrees centigrade.

Could it be digenite?

Covellite (CuS)

The covellite is sparsely scattered throughout the bornite as small veins or rosettes of small plates along hair cracks (fig. 1), or gangue boundaries. It is obviously younger than the bornite, but whether it is of supergene or hypogene origin remains an open question which will be discussed briefly under paragenesis.

Unknown Mineral

An unknown mineral, which is present in masses too small to be identified by microchemical tests, occurs within the bornite of many of the sections and is best seen in section 64. Well developed cubic crystals, up to 50 microns across, havebeen partially replaced by bornite, and it is apparent that this unknown mineral has preceded the bornite. The mineral is light grey, isotropic, somewhat harder than bornite, brittle, and exhibits cubic cleavage.

It is apparently negative to all etch reagents but, as in no cases was an area larger than a drop of reagent available, the microchemical tests are inconclusive. From the X-ray pattern of its powder Dr. Thompson was able to place it as belonging to the Linnaeite Group. The mineral was observed only in association with bornite (fig. 4) and was never seen to occur in chalcopyrite.

Tetrahedrite ($5Cu_2S \cdot 2(Cu,Fe)S \cdot 2Sb_2S_3$)

Deleen (1946, p. 15) reports tetrahedrite occurring as scattered, irregular blebs, less than 70 microns in diameter, within the bornite. The writer was able to observe this mineral in only one section (section 55), in which it occured as irregular masses, up to 300 microns across, within the bornite. Although the mineral exhibited a red streak under crossed nicols the etch reactions were anomalous and the X-ray pattern of the powder was necessary to identify the mineral conclusively as tetrahedrite. The mutual boundary contact between the tetrahedrite and the bornite seems to indicate simultaneous deposition, but the evidence is inconclusive.

Ag by microchem?

Wehrlite (?) (Bi_3Te_2 approx.)

Thompson (1949, p.370) reports wehrlite as occurring at the Little Billy Mine and Deleen (1946, p.15) reports wehrlite occurring as anhedral to subhedral masses, usually over 70 microns in diameter, in bornite and chalcopyrite of the Little Billy suite. The writer was not able to make positive identification of this mineral but small, anhedral, circular to sub-circular crystals, generally less than

70 microns in diameter, of a mineral resembling wehrlite were observed within the bornite and, less commonly, the chalcopyrite of several sections. These grains were too small to make microchemical tests reliable and appeared isotropic under high-power magnification. However, from their resemblance to authenticated samples of wehrlite from the Marble Bay Mine, and their association with hessite (fig. 7) they were, on the advice of Dr. Thompson, tentatively identified as wehrlite. Deleen(1946, p.15) reports the wehrlite from the Little Billy Mine to contain more than 2 percent silver and regards it as the main silver mineral. The age relationship of the wehrlite to the bornite and chalcopyrite is not clearly indicated, but simultaneous deposition seems likely.

Hessite (Ag_2Te)

Hessite occurs in extremely small amounts as partial rims around the blebs of wehrlite within the bornite and chalcopyrite (fig. 7). The wehrlite often occurs independently of the hessite but the hessite was never observed except in contact with the wehrlite. As the hessite was never seen to occur in masses greater than 30 microns maximum dimension conclusive identification was not possible, but the fact that the general appearance, the etch reactions, and the polarization colors indicated hessite, combined with the fact that hessite is known to occur in Little Billy ore associated with bornite, chalcopyrite, and hessite (Deleen, 1946,p.15; and Thompson, 1949, p.355). strongly suggests that this mineral is hessite. Undoubtedly some of the silver values of the Little Billy ore are derived from this source. It is apparently contemporaneous with the wehrlite.

Electrum (Ag,Au)

A single minute, anhedral grain of an extremely bright, soft, silver-white mineral was observed in section 64, associated with bornite near a gangue contact. Dr. Thompson obtained a gold pattern from an X-ray of this grain, and this fact, combined with its physical properties, served to identify the mineral as electrum.

Gold (Au)

Deleen (1946, p.16) reports the presence of a single grain of gold, associated with wehrlite and hessite, in a gangue-filled fracture in pyrite. The writer observed a single subhedral grain of gold, approximately 50 microns across, associated with an unknown mineral resembling wehrlite, occurring in gangue which is apparently replacing bornite (fig. 3), in a section representative of 0.25 oz. Au ore. The gold appears to be later then the bornite.

PARAGENESIS

Deleen (1946) has suggested that the formation of the Little Billy ore deposit occurred in a sequence of events as listed below:

(1) The formation of the skarn minerals at the contact of the diorite and limestone. Diopside, epidote, and quartz were first formed, followed by the development of grossularite, andradite, and white calcite. This phase

ended with the deposition of pyrite, magnetite and molybdenite.

(2) The partial replacement of the epidote, diopside, and grossularite by wollastonite. A small amount of quartz and calcite were deposited with the wollastonite.

(3) The general replacement of the wollastonite, diopside and garnet by bornite, chalcopyrite, and tellurides. A small amount of quartz was apparently deposited with the sulphides. Gold and silver were apparently deposited a little later than the sulphides.

(4) A general crushing of the silicates and sulphides. Quartz, calcite, and serpentine filled the fractures resulting from this movement.

These conclusions are in general agreement with the paragenesis proposed by Dolmage (1921) for the nearby Marble Bay Mine. Dolmage also divided the mineralization into four periods: first, the garnet-wollastonite-pyroxene period; second, the chalcopyrite-bornite period; third, the calcite-zoisite period; and fourth, the serpentine-native silver-chalcocite-covellite period. Dolmage suggested three alternatives for the origin of the minerals deposited during the last period which are uniformly distributed over a vertical range of 1500 feet to a great depth below sea level: (1) all the native silver, covellite, chalcocite, and serpentine are primary; (2) surface enriching solutions have circulated through the ore in its present submarine position; or (3) the deposits were enriched and later depressed to their present position during a preglacial period. He considers the latter most probable.

Unfortunately, the present writer has had no occasion to examine any properties on Texada Island and in postulating a paragenesis for the Little Billy deposit is forced to rely to a large extent on previous reports. Microscopic examination of polished sections indicates that the ore minerals were deposited in the following order:

(1) The pyrite and the unknown mineral of the Linnaeite Group were deposited early. The pyrite and unidentified mineral are never in contact, and their age relationship is unknown, but both definitely precede the bornite. The unknown mineral is partially replaced by bornite, the only mineral with which it is in contact. The pyrite is generally surrounded by gangue, often encloses hexagonal crystals of quartz, is veined by gangue carrying chalcopyrite, bornite, and sphalerite, and when in contact with bornite or chalcopyrite is corroded by these minerals. Possibly two generations of pyrite are present as massive pyrite appears to replace cubes of the same mineral, but the evidence cited is applicable to both types of pyrite.

(2) The magnetite and molybdenite are of an indefinite age. They do not occur in contact with the pyrite and their contacts with the copper minerals offer little indication as to their age.

(3) The chalcopyrite, bornite, and sphalerite are much the same age and definitely post-pyrite. Exsolution textures show chalcopyrite to be contemporaneous with both bornite and sphalerite, and though chalcopyrite occasionally veins bornite(fig. 8) evidence of simultaneous deposition is more common.

(4) The tetrahedrite,electrum, wehrlite, and

hessite appear to be of the same general age as the bornite and chalcopyrite.

(5) The gold occurs in gangue that is apparently replacing bornite and may have been deposited somewhat later than the main copper minerals. If the mineral associated with it (fig.3) is indeed wehrlite, then the wehrlite and hessite may be post-bornite.

(6) The covellite, and perhaps the chalcocite, were apparently the last minerals to be deposited. The covellite veins and replaces bornite (fig.1) and is conceivably supergene. The chalcocite, where it occurs as irregular blebs in the bornite, exhibits mutual boundaries which are inconclusive criterion for paragenesis, but if the blue mineral accurring within the bornite as a fine network of veins is also chalcocite, then the chalcocite can be regarded as post-bornite and of the same general age as the covellite.

CLASSIFICATION OF THE DEPOSIT

The gangue minerals are all of the contact metamorphic type. The bulk of the ore minerals are of hypogene origin and indicate a wide temperature range. The indicated paragenesis agrees very well with the sequence of deposition listed by Edwards (1947, p.114) for hydrothermal and pyrometasomatic deposits. Of the minerals present that are listed in Edwards' generalized sequence (magnetite, molybdenite, pyrite, chalcopyrite, sphalerite, bornite, tetrahedrite, and tellurides) only pyrite is out of place, and this can not be considered unusual. The covellite, and perhaps some or all of the chalcocite, is most likely secondary. Dolmage (1921, pp387-392) has discussed the origin of these minerals at length and has put forward a tenable, though inconclusive, argument for supergene origin. Deleen (1946), on the other hand, maintains that they are hypogene. On this problem, which appears insoluble by mineralographic methods alone, the writer does not care to hazard an opinion.

The low pyrite content, the absence of arsenic and, except for minor amounts of tetrahedrite, of antimony minerals is worthy of note.

The deposit may be described as low-pyrite, possibly enriched, pyrometasomatic deposit of copper-gold-silver ore in a limestone skarn.

ECONOMIC SIGNIFICANCE

Deleen(1946) has investigated the Little Billy ore with a view to the economic importance of the deposit and has employed assays, particle sizes, trace elements, graphs, gangue associations, and a first-hand knowledge of the mine as well as a microscopic study of the ore minerals. He has attributed the gold values to native gold, and the silver values to native silver, wehrlite (apparently containing over 2 percent silver), and hessite.

The writer was unable to identify any native silver, and is forced to attribute the silver values to the hessite, the electrum, and, on the strength of Deleen's assays, the wehrlite. Tetrahedrite was observed in only one section, but in masses considerably larger than reported by Deleen. This tetrahedrite, which was not assayed, may carry some silver values.

Gold was seen to occur in only two sections, once as a small grain of native gold in gangue, and once as a small bleb of electrum in bornite. The association of Electrum with bornite, which is a cyanicide, would complicate the recovery problem.

The chalcocite and covellite are of little economic importance as they occur in only minor amounts. Neither the molybdenite nor the sphalerite appear to occur in sufficient quantity to warrant extraction, as separation of molybdenite from gangue, and of sphalerite from chalcopyrite would require a grind of-400 Mesh.

The main copper minerals are bornite and chalcopyrite. As these minerals are in the main unaltered, and for the greater part occur as masses exceeding 200 microns across, a good recovery could evidently be obtained by employing a medium grind and a flotation process. As some of the bornite occurs as finely disseminated particles in gangue, and as much of the chalcopyrite is spotted with small blebs of sphalerite, a richer, cleaner coneentrate could probably be obtained by employing a very fine grind, but whether the added recovery would warrent the added expense of a finer grind is an open question.

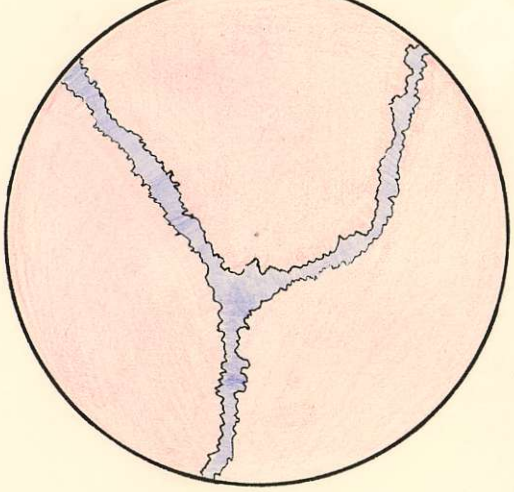
CONCLUSIONS

The Little Billy ore comprises finely disseminated metallics in a skarn gangue. The metallic minerals, listed in order of abundance are: chalcopyrite, bornite, magnetite, molybdenite, sphalerite, pyrite, chalcocite, covellite, an unidentified mineral of the Linnaeite Group, tetrahedrite, wehrlite(?), hessite, electrum, and gold.

The suggested order of deposition of the ore minerals is: (1) pyrite and the unknown mineral; (2) magnetite and molybdenite; (3) chalcopyrite, bornite and sphalerite; (4) tetrahedrite, electrum, wehrlite and hessite; (5) gold; and (6) chalcocite and covellite.

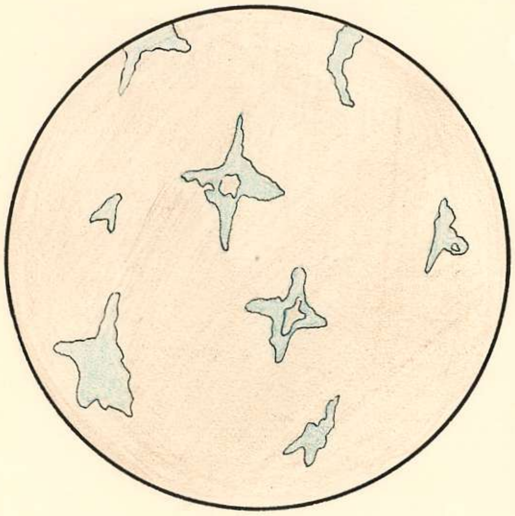
The deposit may be described as a low-pyrite, possibly enriched, pyrometasomatic deposit of copper-gold-silver ore in a limestone skarn.

The silver values are carried by hessite, wehrlite, electrum, and possibly tetrahedrite. The gold values are carried by native gold and electrum. The main copper minerals are bornite and chalcopyrite, the covellite and chalcocite occurring in such small amounts as to be of little economic importance.



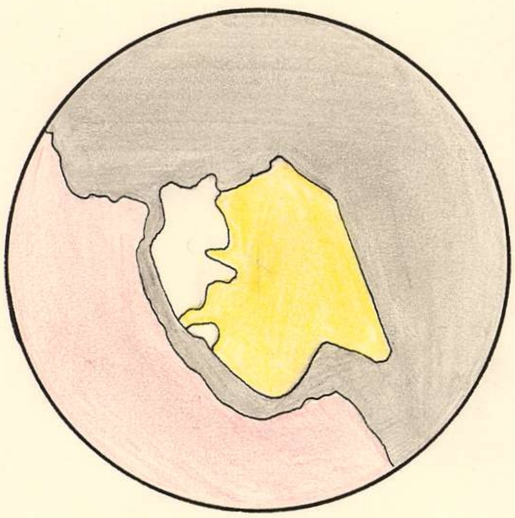
Covellite (blue) veining bornite (pink). x 600.

FIGURE 1



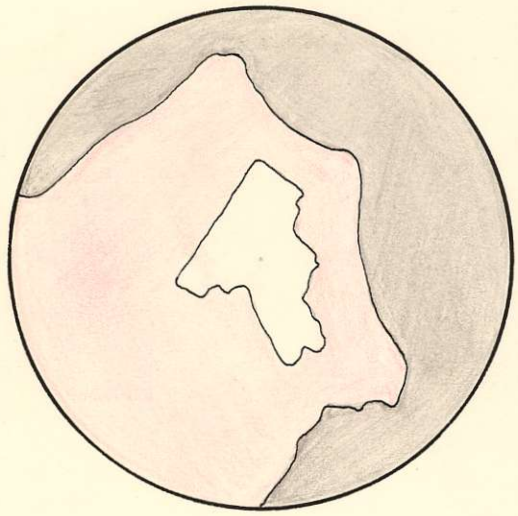
Exsolution stars of chalcopyrite (green) in sphalerite (brown). x 360.

FIGURE 2



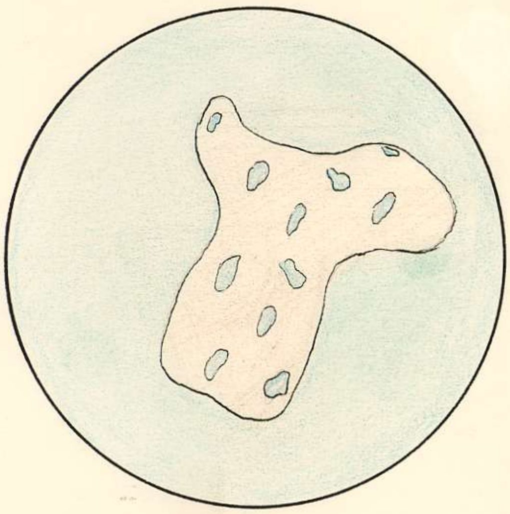
Gold (yellow), closely associated with unknown mineral (white), in gangue (black). Pink is bornite. x 1000.

FIGURE 3



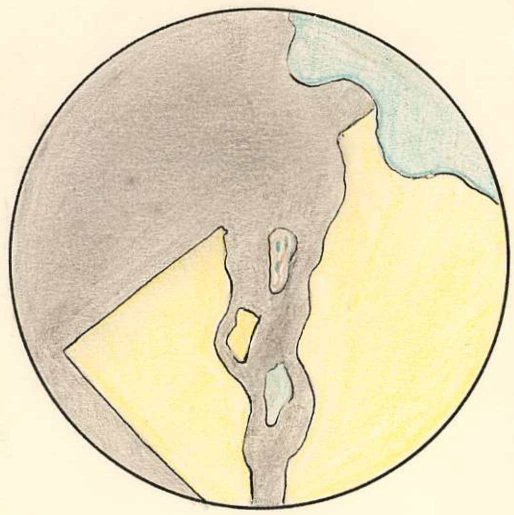
Unknown mineral of the linnaeite group (white) being replaced by bornite (pink). Black is gangue. x 600.

FIGURE 4



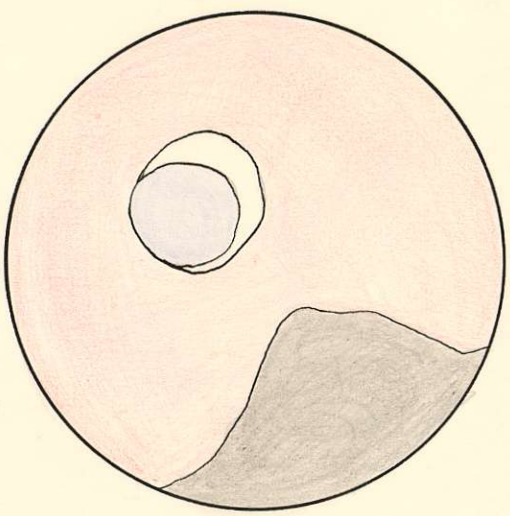
Exsolution blebs of chalcopyrite (green) in sphalerite (brown)in a groundmass of chalcopyrite. x 360.

FIGURE 5



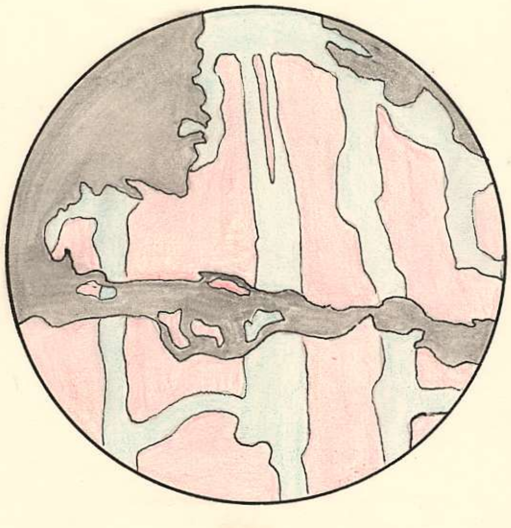
Pyrite (yellow) veined by gangue (black), which itself is being replaced by chalcopyrite (green) and sphalerite (brown). x 250.

FIGURE 6



Partial rim of hessite (white) around wehrlite (blue) in bornite (pink). Black is gangue. x 760.

FIGURE 7



Chalcopyrite (green) replacing bornite (pink), both fractured and replaced by gangue (black). x 450.

FIGURE 8

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