T H E M A I D O F E R I N

A Problem in Mineralography

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

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Introduction

The Maid of Erin Group consists of fourteen crown-granted claims, four full, and two fractional claims. They are located at an elevation of 3500 feet on the southwest slope of Mineral Mountain in the extreme northwest corner of British Columbia.

First located in 1903, the property has experienced several periods of development. At present, title is held by St. Eugene Mining Corporation, Limited, Suite 401-5, 402 W. Pender St., Vancouver, B. C.

A severe physical environment coupled with transportation problems place unfortunate burdens on the property. Latitude and altitude may combine to restrict surface work until as late as August. Prospecting is restricted to about three and one-half months a year. Access is now afforded by the Haines Road which passes within four miles of the property.

The regional physiographic picture is one of glacially-scoured uplands, smooth profiled drift-filled valleys, and mountains modified by glaciers into deep cirques, sharp peaks, and serrate ridges. Drainage is via the Klehini and O'Connor Rivers to the Lynn Canal and Gulf of Alaska, respectively. Forest cover is limited to "buckbrush" and willows, with spruce and hemlock in the Klehini valley.

General Geology

The geology of the area reflects the setting in the Coast Mountains. Permo-carboniferous sediments and Mesozoic volcanics are cut by Mesozoic intrusions.

The Rainy Hollow Camp, of which the Maid of Erin is the main property, occurs in Permo-carboniferous sediments. Originally limestones, argillites, and quartzites, these have been metamorphosed to a marble, argillite, quartzite, gneiss and schist suite with skarns. Metamorphism appears to be related to nearby large granodiorite and quartz diorite bodies. The marble is important because where altered to skarn, it may contain replacement deposits of economic interest.

In the vicinity of Rainy Hollow, Permo-carboniferous rocks are in a northward-plunging asymmetrical syncline.

Ore-Deposits

Lode-deposits of the Rainy Hollow area are replacement deposits in skarn. These consist of:

(1) bornite-chalcocite deposits which carry silver,

(2) galena-sphalerite deposits,

(3) pyrrhotite-sphalerite-chalcopyrite deposits.

At the Maid of Erin, which is in the (1) group, developed ore-bodies are all close to the skarn-quartzite or skarn-marble contacts. They are highly irregular, sometimes lenticular. Mineral assemblages indicate fairly high temperatures. Undoubtedly there has been a great deal of erosion since emplacement of the granitic bodies.

Mineralogy of the Maid of Erin Group

The main economic values of the Maid of Erin are in copper, with less significant silver and zinc. Shipments from 1911-1922, totaling 157 tons of hand-sorted ore, yielded 77,658 lbs. copper, 5,849 oz. Ag, and 6 oz. Au.

This report is based on examinations of fourteen polished-sections and various hand specimens from the collection of the Geology Department, University of British Columbia.

Metallic minerals identified in hand-specimens and polished sections with their approximate percentages are listed below:

- Bornite - Cu_5FeS_4 -- 60%
- Chalcocite - Cu_2S -- 20%
- Digenite - Cu_2S -- 6%
- Chalcopyrite - $CuFeS_2$ -- 10%
- Covellite - CuS -- 3%
- Wittichenite - $3Cu_2S \cdot Bi_2S_3$ -- 1%
- Sphalerite - ZnS -- 10%
- Arsenopyrite - FeAsS -- Tr. ?

lo mineral

<u>Bornite</u>

Bornite mineralization is ubiquitous but variable in amount and form. In polished section, color varies from light-pink through cream-pink to mauve; anisotropism, from slight to negative. The lightest-colored bodies have a complex, very fine crystallographic texture developed by the exsolution of other copper minerals. Notable features of many of the specimens examined were peculiar mottled patterns of cream-pink in reddish bornite. Check

<u>Chalcocite</u>

Chalcocite is also everywhere abundant. Color is light grey-bluish to grey; anisotropism is weak; pleochroism, grey to blue. KCN stains dark blue. HNO_3 effervesces and brings out parallel cleavage. $FeCl_3$ stains blue and brings out cleavage.

<u>Digenite</u>

Digenite, or "blue chalcocite", is the isotropic, blue form of chalcocite. It occurs much the same as the ordinary form and can easily be confused in ordinary reflected light with covellite, with which it is commonly associated. Distinguished from the very weakly anisotropic chalcocite in being negative to $FeCl_3$ and staining slightly darker with KCN; readily from covellite by isotropism, less prominent cleavage.

Chalcopyrite

Chalcopyrite is weakly anisotropic to isotropic; if pleochroic, in grey to blue-grey. In general, reagents are not of significant value in confirming its entity. Has no relief with bornite and wittichenite. Color varies with specimens but generally pale yellow, often creamy. In places, exhibits broad lamellar twins. Occurs massively or as various forms in other minerals.

Covellite

Covellite is a deep-blue strongly anisotropic mineral which shows good basal cleavage. Four extinctions per revolution with fiery red-orange to white anisotropism are diagnostic. KCN stains black. Occurs in almost every section but generally in small amounts.

Wittichenite

Wittichenite is a weakly anisotropic very pale blue or grey mineral which, in this case, is usually negative to all reagents except HNO_3. The latter produces an easily removed brown stain. Relief is less than bornite; pleochroism, from grey to cream, if decernable. Occurs in chalcocite, and, it seems, invariably in contact with bornite or chalcopyrite. The significance, if any, of this last observation is doubtful.

Sphalerite

Sphalerite is of the iron-rich variety and has almost no internal reflection. In a few sections the mineral is abundant, in others, lacking. Distinguished by its isotropism, bright grey color, and good polish. Contains small inclusions of chalcopyrite.

<u>Arsenopyrite</u>

Arsenopyrite was found in two small, partly corroded, diamond-shaped crystals. Identification was based on white color, good polish, euhedral crystal outlines, extreme hardness, and positive Fe^{++} and As^{+++} microchemical tests.

Owing to the complete lack of silver minerals, it must be assumed that chalcocite, which can carry up to 60 oz. per ton, has the silver values.

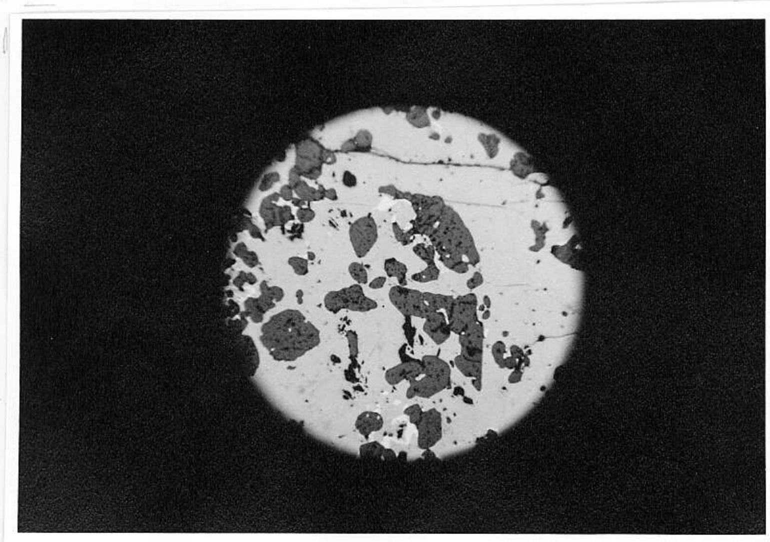
Gangue minerals, typical of contact metamorphic deposits, include andradite garnet, epidote-zoisite-clinozoisite members, vesuvianite, diopside, marble, dolomite?, and wollastonite. Corroded and isolated crystals and masses indicate that gangue minerals preceeded the metallics. Many of the silicates show extremely good crystal development, in contrast to the nondescript sulfides. Particularly noted are the euhedral epidote members and vesuvianite.

The succession of events was:

1. over-all thermal metamorphism by the rising granitic mass
2. a high temperature and pressure metasomatic phase whereby dilute vapors emanating from the granitics passed into the confining rocks.

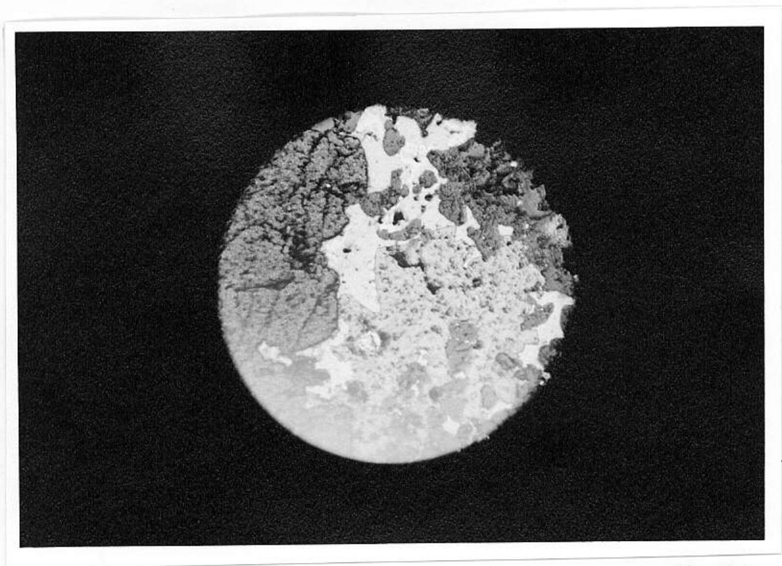
Ore formation was connected with the latter phase.

Photographs 1 and 2 illustrate the relations between gangue and sulfide minerals.



X 24

Photograph 1. Showing association of ore with gangue (dark).



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Photograph 2. Showing corroded gangue (darkest), sphalerite (grey) and bornite, with minor chalcocite (white).

The paragenesis is suggested in Fig. 1, a Van de Veer diagram.

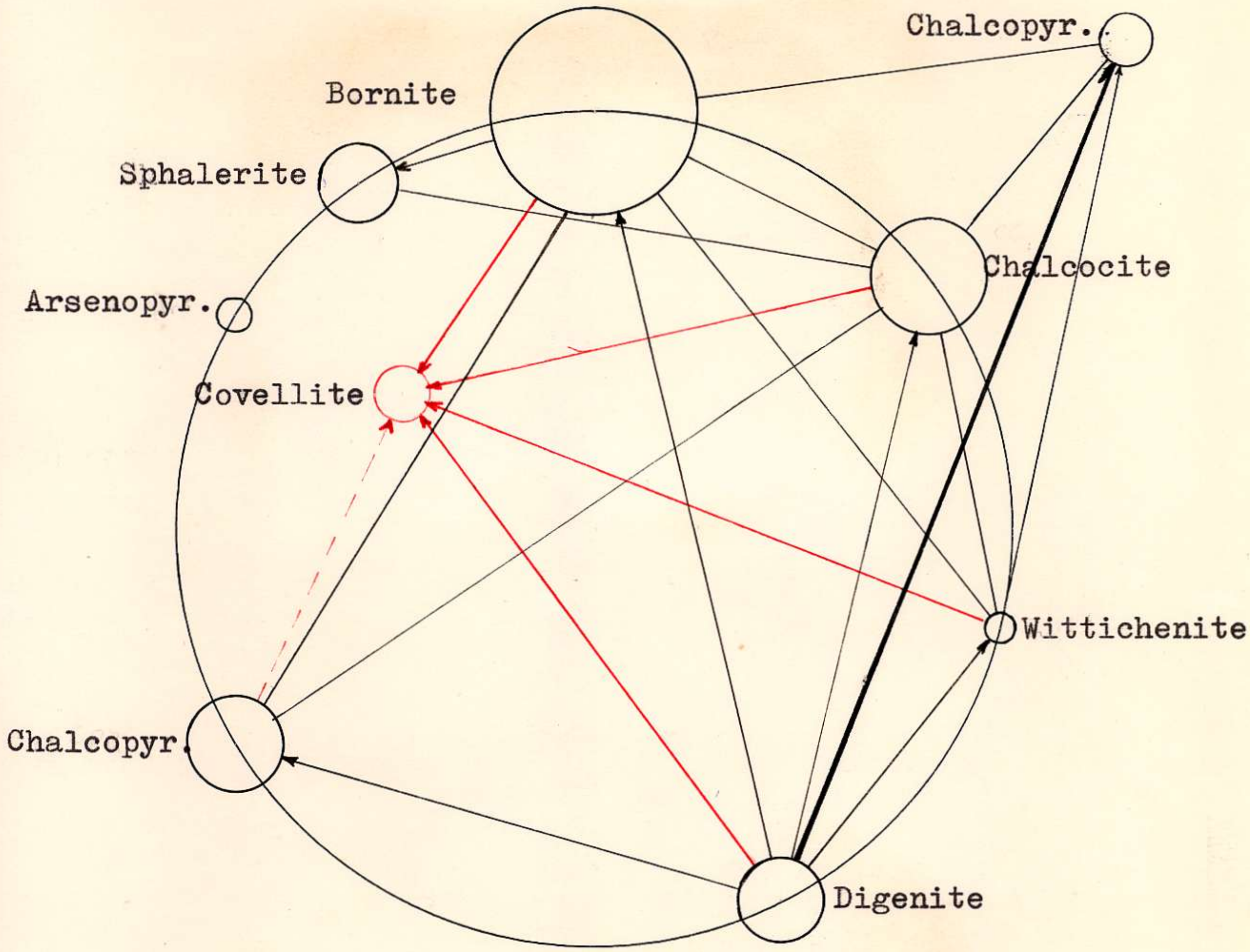
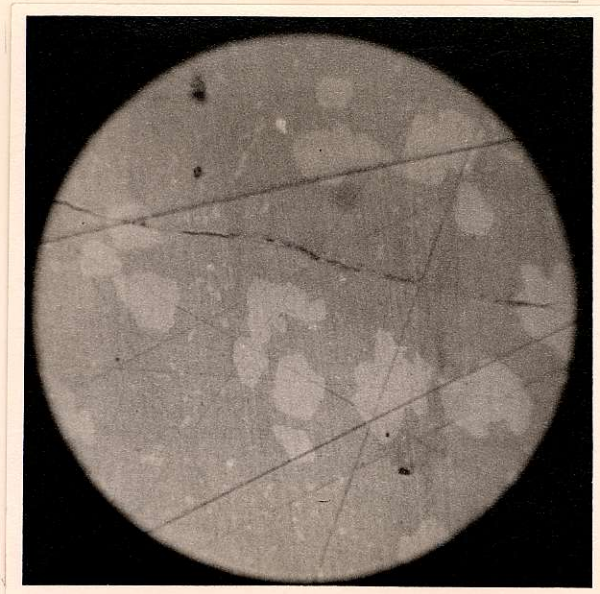


Figure 1. Van de Veer Diagram

Textures of Ore Minerals

There are numerous interesting textures in the polished sections.

Some bornite has a peculiar blotchy appearance as illustrated in Photograph 3. The mauve bornite has irregular bodies of reddish-orange mineral. There is no optical evidence that it is not a variety of bornite, nor has alteration to covellite differed in any way in one from the other.



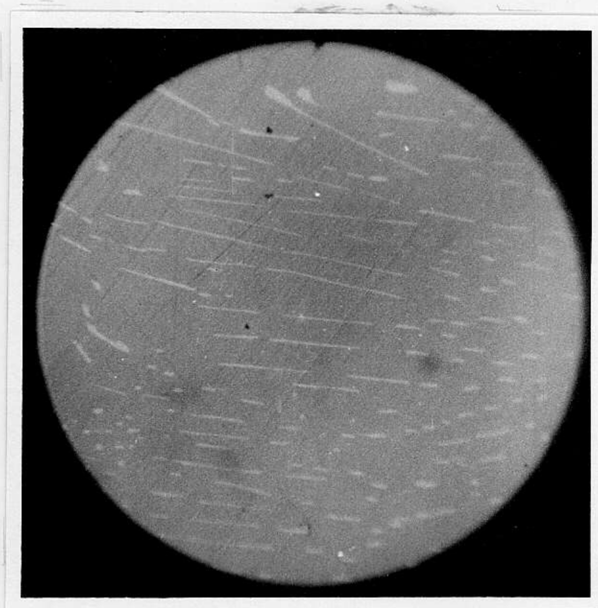
X 300

Photograph 3. Showing "island" texture in bornite. Veinlet of covellite.

Chalcopyrite has irregularly exsolved from bornite. Exsolution has followed crystallographic directions giving various patterns. These are common in bornite. Temperature is suggested by the evidence given by Schwartz (13).

Schwartz cites experiments indicating that chalcopyrite and bornite readily dissolve in one another at temperatures greater than 475°C and that unless cooling is very rapid, the solid solution will break down into a crystallographic intergrowth. Photograph 4 and Figure 2 illustrate patterns.

Figure 2.
Chalcopyrite in bornite



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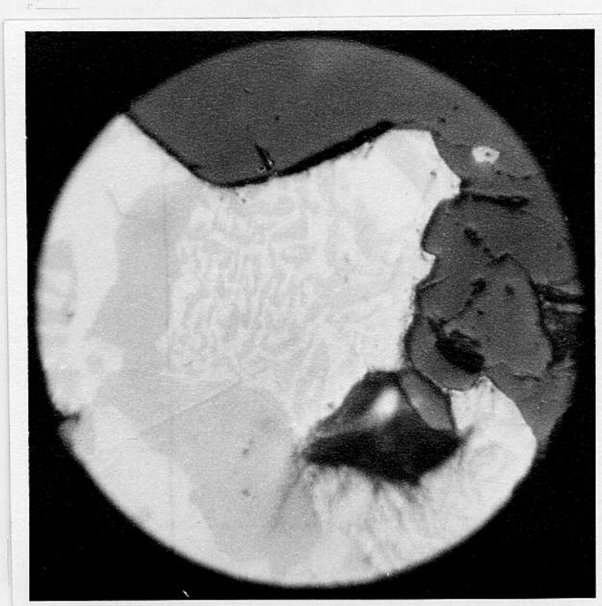
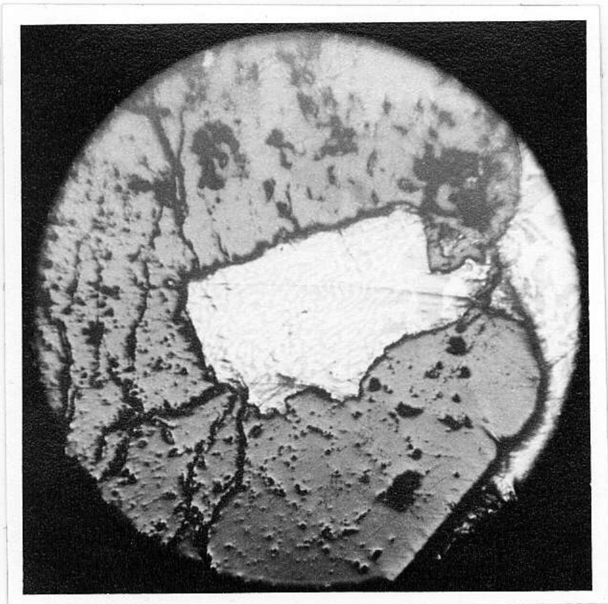
Photograph 4. Showing chalcopyrite needles along {111} plane of bornite.

With regard to other camps, there has been much discussion of the significance of the rather common bornite-chalcocite intergrowths. Photographs 5 and 6 illustrate these textures.



X 300

Photograph 5. Bornite in chalcocite.



X 100

Photograph 6. Myrmekitic Bornite in Chalcocite.

Graphic intergrowths such as those illustrated have been explained in three ways:

(1) Bornite-chalcocite formed simultaneously,

(2) Chalcocite is a replacement of bornite,

(3) Bornite is a replacement of chalcocite.

A. F. Rogers (11) believes in the second of these, stating that:

(1) bornite is directly replaced by chalcocite,

(2) late hypogene chalcopyrite may result from the breakdown of bornite,

(3) klaprothite (wittichenite) is intermediate in age between bornite and chalcocite.

He substantiates his statements by reporting his observations of these intergrowths in ores from five mining camps.

Schwartz (12) catalogues the following contact relations:

(1) graphic intergrowths,

(2) sub-graphic intergrowths,

(3) lattice or grating textures,

(4) ice-cake structures,

(5) mutual boundaries.

All these can, by the way, be found in Maid of Erin ore. Schwartz also lists the interpretations of graphic intergrowths as suggested by eminent mineralogists:

(1) crystallization at the eutectic point (Laney),

(2) replacement (Rogers),

(3) non-eutectic due to excesses of both (Whitehead),

(4) supergene action (Schwartz).

Whitehead, (17), an early investigator of this phenomenon, claimed to have found abundant evidence that graphic intergrowths form by replacement of bornite by chalcocite. He rejects eutectic intergrowths because in places in the same ore, both minerals are in excess. This latter point can be substantiated using Maid of Erin ore.

In specimens from the Maid of Erin no conclusive evidence was found that chalcocite was not contemporaneous with both the bornite and the wittichenite.

Digenite appears to replace all earlier copper minerals. Figure 3 illustrates relations between digenite and chalcopyrite and bornite. The continuity between large masses of digenite in chalcopyrite is maintained by a minute veinlet across the bornite, indicating a preference for replacement in chalcopyrite rather than bornite. This appears to be generally true, the digenite having extensively replaced chalcopyrite exsolved from bornite. Digenite also appears to readily replace wittichenite blebs and needles in bornite.

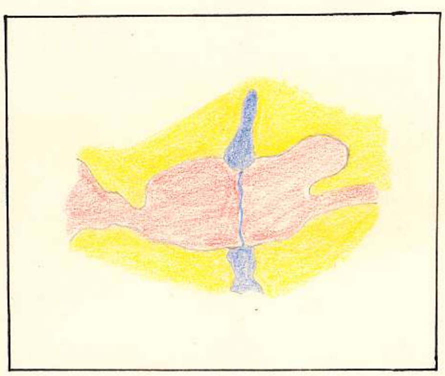
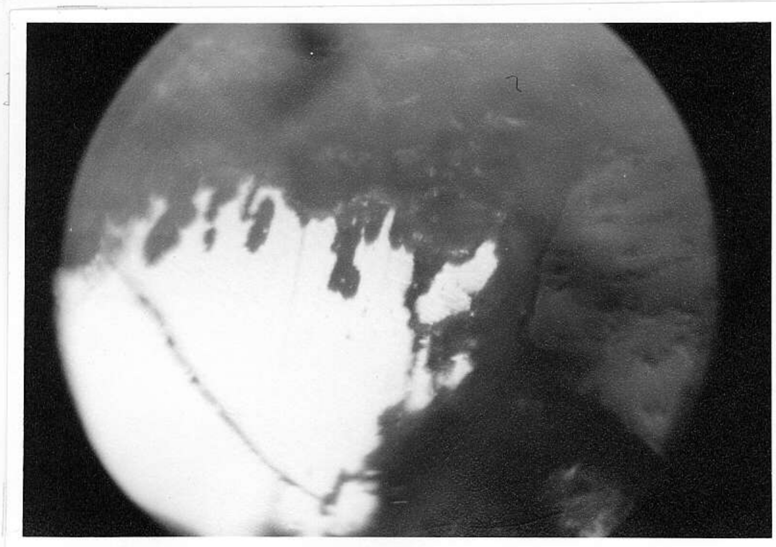


Figure 3.
Digenite in bornite and chalcopyrite.



Oil immersion - X 1000+

Photograph 7. Digenite (dark) replacing chalcocite. Veinlet of covellite.

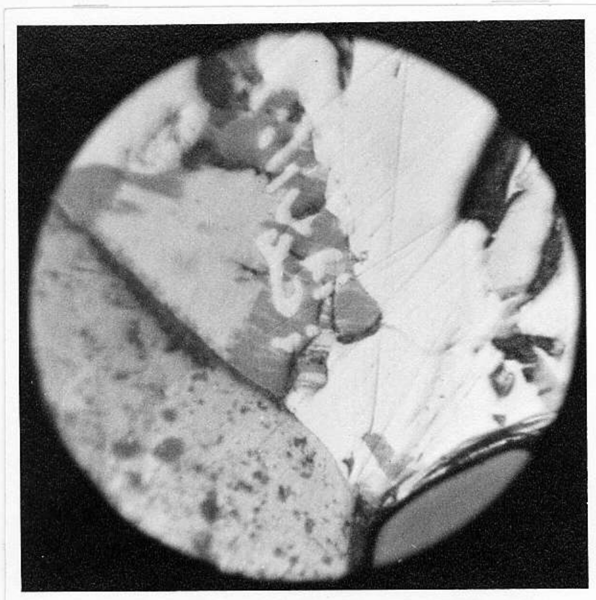
Photograph 7 shows advance of digenite as it replaces chalcocite along cleavages.

X 300

Photograph 8. Showing contact between sphalerite (dark grey) and bornite (light grey). Veinlet of covellite in bornite.

Photograph 8 illustrates typical contact relations between bornite and sphalerite. The acutely cusped contact is indicative of bornite younger than, and replacing, sphalerite.

Covellite is obviously a secondary member in the sulfide suite of minerals. Photographs 3, 7, 8, & 9 illustrate its occurrences; the first three as veinlets, the latter, replacing digenite and bornite. Commonly bornite is rimmed by a narrow discontinuous halo of covellite. Irregular bodies of covellite in bornite may be replacing wittichenite rather than the bornite. This is impossible to prove, but in many cases, small amounts of wittichenite remain with the covellite.



X 300

Photograph 9. Showing covellite (dark grey) in relation to digenite (light grey) and bornite (white).

Conclusions

What about the Cobalt?

The Maid of Erin is a "straight-forward" contact metamorphic property. The assemblage includes copper-iron sulphides, copper sulfides, and black sphalerite. Primary silver minerals are absent but silver values are nevertheless significant -- assays (reported by Watson (16)) running as high as 60 oz. silver per ton but average 23 oz. per ton. Chalcocite is a likely host for the silver.

The property is of academic interest to mineralogists in that it has a variety of unmixing and replacement textures. Most notable are the myrmekitic intergrowths of bornite and chalcocite.

Acknowledgements

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