Mineralographic Study of the "Maid of Erin" Copper Property Ore - Rainy Hollow, B.C.

Kenneth M. Dawson Nov. 20/63

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Mineralographic Study of the
"Maid of Erin" Copper Property
Haines - Alaska Cutoff
Rainy Hollow B.C.

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UBC Mineralography Report

Megascopic

Description of Hand Specimens

There were 24 hand specimens studied in the tray. These were classified into three groups as follows:

① Predominantly metallic minerals - 13 samples
② Non-metallic minerals - 3 samples
③ Mixture of metallic and non metallic - 8 samples

1. Metallic Minerals

All samples showed a predominance of massive bornite with covellite alteration. One sample showed several patches of chalcocite intimately associated with the bornite.

Another sample showed several grains of sphalerite about 1/4" diameter with good cleavage. It was of the darker, iron-rich type.

All the metallic samples had small (1-3 mm) euhedral yellow-green garnets disseminated fairly evenly throughout the metallic matrix.

A little calcite was seen in the form of small rhombic cleavage fragments surrounding the garnet.

A small amount of quartz was seen in disseminated anhedral grains of 2-5 mm diam.

Alteration in the form of covellite, malachite and a little azurite was noted on all specimens. Four samples had a soft, earthy limonitic alteration of yellow brown to grey-brown colour, possibly a copper salt.

Average composition of 13 samples

Bornite	50%
Garnet	25%
Chalcocite	15%
Sphalerite	8%
Calcite	1%
Quartz	1%

2. Non-metallic Hand Samples

The three samples in this group were almost uniform in composition. The predominant mineral was massive, buff-coloured garnet with fine twinning lamellae. Slender radiating prisms of pinkish brown tourmaline cut through the garnet. Some small anhedral grains of quartz were disseminated in the garnet in small amount. A few small grains of calcite surrounding smaller grains of chalcopyrite were seen in two of the specimens. One sample showed a little malachite stain around a zone of tourmaline prisms.

Average composition of 3 samples:

Garnet	80%
Tourmaline	15%
Quartz	5%
Calcite	< 1%
Chalcopyrite	< 1%

3. Mixture of Metallic & Non-Metallic Minerals

The bornite specimens all showed a coarse-grained, well-crystallized texture, with a larger variety of non-metallic gangue minerals than seen in other samples. One specimen was a homogeneous equigranular rock composed of calcite, bornite and sphalerite. The calcite had been replaced by bornite and sphalerite, then recrystallized into euhedral xls of 2-5 mm. The bornite was disseminated in fine grained blebs of 2-5 mm size some of which were connected. A little dark coloured sphalerite was seen also. Malachite and azurite stain was present.

The other six specimens were fairly uniform in texture and composition. Massive white quartz with massive light green vesuvianite intermixed formed the groundmass. Zoned, and randomly-distributed large tetragonal prisms (½ inch) of green vesuvianite with massive bornite veinlets and masses around them were the most striking feature of these samples. Radiating prisms of pink tourmaline cut through the groundmass.

Specimen K442 had a matrix of light green to white vesuvianite in circular areas of slender radiating prisms. Bornite veinlets cut through this matrix. The thin section showed the fibrous aggregate nature of the groundmass of vesuvianite. Optical properties noted were parallel extinction, high + relief, low birefringence (first order gray), length-fast orientation and a uniaxial interference figure. It was first thought to be zoisite but the association of skarn minerals indicated it was vesuvianite.

~~average~~ Small euhedral green garnets were scattered throughout the well-crystallized portions of these samples.

<u>Average composition of 8 samples:</u>

Vesuvianite	45%
Quartz	20%
Tourmaline	15%
Bornite	10%
Chalcocite	3%
Calcite	7%
Garnet	3%
Sphalerite	1%

Description of Metallic Minerals

1. Bornite   This was the principal metallic mineral in the samples. Bornite was seen in large, fine grained masses with minor amounts of exsolved chalcocite, as striking myrmekitic intergrowths with chalcocite and wittichenite, and as exsolved grains in sphalerite and chalcopyrite. It was a pinkish-brown colour which tarnished purplish-pt blue rather quickly. Its low hardness and isotropism were conclusive factors in its identification.

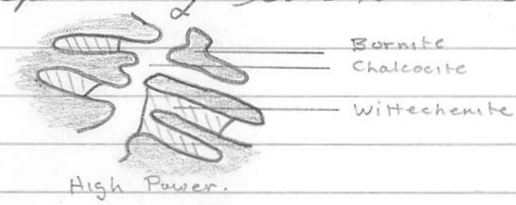
2. Chalcocite   This mineral was second to bornite in abundance in the samples. It was not readily visible in the hand specimens but was seen to occur with the bornite in every polished section. Its commonest ~~mode of~~ texture was myrmekitic exsolution from bornite in fine, sub-oriented lamellae. It also occurred alone in fairly large grains, and as minute blebs and rounded inclusions in bornite, sphalerite and chalcopyrite. Its colour was white to bluish-white, tarnishing a light blue. It was very soft (B) and sectile. Anisotropism was moderate and etch tests were conclusive.

3. Sphalerite   The sphalerite was of irregular distribution in the ore, and was not seen in all the sections. It was first thought to be tetrahedrite but further tests disproved this identification. The sphalerite was grey in colour and fairly hard with respect to the copper minerals above. It had a poor polish and a rather mottled surface. A reddish-brown internal reflection was seen under the carbon-arc light, and it was isotropic under reflected

light. Etch tests and microchem tests were conclusive. The sphalerite had a rough, slightly convex boundary with the bornite and had inclusions of chalcocite in an emulsion texture.

4. Chalcopyrite Only one section showed chalcopyrite associated with bornite. The chalcopyrite seemed to be replacing the bornite and had inclusions of chalcocite. Veinlets of chalcopyrite cut into the bornite. No association of chalco and sphalerite were seen. Hardness, colour, isotropism and confirmatory etch tests identified this mineral.

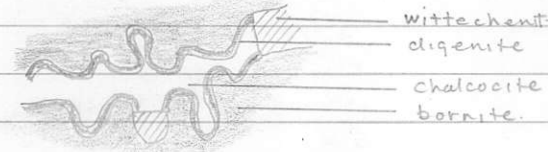
5. Wittechenite $3Cu_2S . Bi_2S_3$ This rare copper mineral was not readily identified. It occurred almost exclusively in the zones of fine myrmekitic bornite / chalcocite intergrowth apparently replacing the small lamellae of chalcocite.



The wittechenite was pale creamy white, the same hardness as chalcocite and moderately anisotropic. The fine grain size and intimate association with other soft minerals prevented the removal of material for microchem tests. Etch tests were confirmatory.

6. Digenite $4Cu_2S . CuS$. This mineral was observed in three of the sections. It surrounded bornite lamellae in a very thin rim texture, and was apparently replacing the ~~chalcocite~~ bornite. Its occurrence was restricted to bornite / chalcocite boundaries, and was seen almost exclusively in zones

of fine myrmekitic intergrowth.



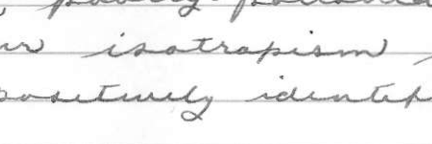
High Power

The texture of the digenite appeared granular but detailed examination was difficult due to the fine size of the digenite rim. It was a deep blue colour and isotropic, differing from chalcocite. Etch tests and hardness gave the same results as for chalcocite.

7. Pyrite A few isolated cubes and massive grains of pyrite were seen in randomly distributed fashion in the minerals. The small-sized grains had a high relief and a granular, poorly-polished surface. The hardness colour isotropism and roughly cubic shape positively identified the pyrite.

8. Covellite Thin films of covellite alteration were seen on many of the chalcocite grains in one section. The very high anisotropism with fiery orange colours, and the deep blue colour of the mineral were sufficient proof of identity.

9. Unidentified Bismuth Mineral This grey isotropic mineral was only seen under high power as tiny veinlets in, and rims around the Wittichenite. It term-



inated sharply at the wittichenite / chalcocite boundary and its intimate association with the wittichenite led to the belief it was a bismuth mineral. No etch tests or microchem tests could be made due to the small size of the grains.

Physical, Chemical, and Optical Properties.

Mineral	Hardness	Colour	Etch Tests	Optics and Other Properties
Bornite $5Cu_2S.Fe_2S_3$	B^+ less than chalcopyrite.	pinkish-brown to orange. tarnishes purple-violet	HNO_3 stains yellow-brown + eff. KCN-brown $FeCl_3$-orange Cu microchem test.	Isotropic. Exsolution texture may be due to rapid cooling. Chalcocite is oriented in xllographic planes of host.
Chalcocite Cu_2S	B softer than bornite	bluish-white to white Tarnishes blue.	HNO_3 stains blue. KCN - black $FeCl_3$ - blue Cu microchem test.	Moderate anisotropism - pinkish white to blue-grey. Blue streaks due to polish, tarnish. Replaced by wittechenite, digenite.
Sphalerite ZnS	C harder than chalcopyrite	grey	Zn microchem test positive.	Isotropic. Yellowish-to reddish-brown int. refl. Poor polish.
Chalcopyrite $Cu_2S.Fe_2S_3$	C	Brass-yellow	HNO_3 slow tarnish. Aq. regia-slow, brown differential stain Cu microchem test.	Weakly anisotropic. May exsolve from sphalerite. May be formed together with chalcocite by the disintegration of bornite.
Wittechenite $3Cu_2S.Bi_2S_3$	B same as chalcocite.	creamy white	Aq. regia fumes stain. HNO_3 - slow eff.	Moderate anisotropism - light to dark grey. Smooth polish. Straight boundaries with chalcocite.
Digenite $4Cu_2S.CuS$	B (chalcocite)	Dark blue	same as chalcocite	Isotropic. Fine granular rim replacing chalcocite.
Pyrite FeS_2	F	yellowish-white	—	Poor polish. Granular surface. High relief. Isotropic. Cubic form.
Covellite CuS	B	Dark blue	—	Very high anisotropism - fiery orange - brown

Abundance of Primary Metallic Minerals

An average of 10 wood-mounted polished sections, 6 plasticine mounts and 13 hand samples was taken, giving the following composition:

Bornite	56 %
Chalcocite	22 %
Sphalerite	15 %
Chalcopyrite	3 %
Wittichenite	2 %
Digenite	1 %
Pyrite	1 %
Bismuth mineral	< 1 %

Only one alteration mineral, covellite, was seen in polished section, but other supergene copper minerals were seen in the hand specimens. The minerals formed by alteration were:

- Covellite
- Malachite
- Azurite
- Limonitic copper salt (?)

No estimate of abundance was made.

Textures and Pargenetic Sequence

The earliest-formed minerals were non-metallic minerals: garnet and vesuvianite, then tourmaline and quartz in that order. Bornite veinlets cut through the vesuvianite and quartz, and massive bornite surrounds the garnet and tourmaline in hand specimens. Calcite is either earlier than the bornite or contemporaneous. One hand specimen indicates simultaneous crystallization by the texture, but the calcite later was recrystallized.

The bornite/chalcocite boundary relation is almost always a myrmekitic intergrowth. This could be a pseudoeutectic texture from exsolution after simultaneous deposition, or a replacement texture. Some boundary relations between bornite/chalcocite seem to indicate replacement of the chalcocite by the finger-like projections of the bornite into the chalcocite, but the rounded nature of the lamellae and the equivalent lamellae of chalcocite into bornite cause some uncertainty about the replacement relationships. The boundaries between the two minerals are essentially smooth curves. Inclusions of chalcocite in the bornite are randomly distributed, and of a rounded, oval or sub-oval shape indicating contemporaneous deposition and/or exsolution, rather than replacement. A certain degree of replacement is believed to have occurred, ie bornite replacing chalcocite or chalcocite replacing bornite, but contemporaneous deposition of the two minerals predominates.

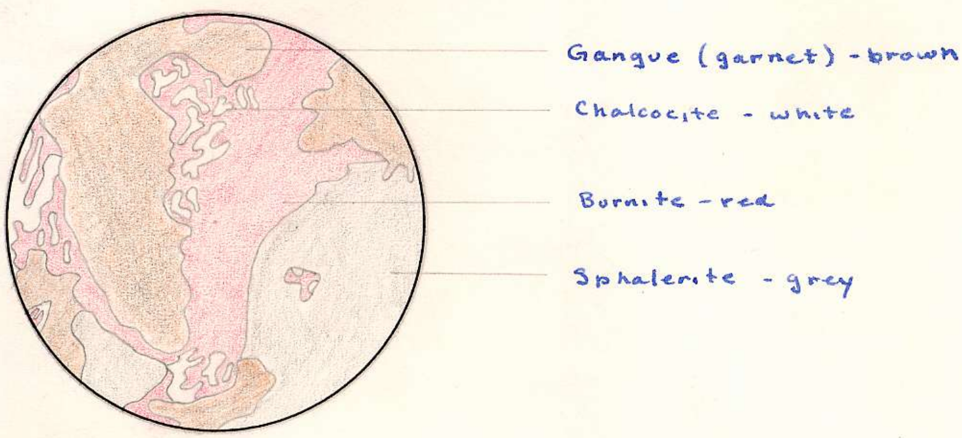
The Wittichenite appears to have selectively replaced the chalcocite in the zones of myrmekitic intergrowth. It always forms a smooth boundary with the chalcocite, but with a convex surface towards the chalcocite or, as in some cases, rounded projections into it. Some small exsolved inclusions of chalcocite in bornite show partial replacement by Wittichenite, with the above boundary relationships. The Wittichenite has not replaced the bornite in any samples, although it is in direct contact with it.

One interesting feature of the Wittichenite is the unidentified mineral seen associated with it in most of its occurrences. The mineral is believed to be a bismuth mineral because of its association with Wittichenite alone. In section 4, it appears primary, ~~(since)~~ because it forms myrmekitic intergrowths with bornite and chalcocite, and has inclusions of bornite, chalcocite and Wittichenite. As it was with the bornite/chalcocite relationship, this may be either a primary pseudoeutectic texture or a replacement texture. However, the bismuth mineral shows definite replacement texture in the Wittichenite, with long, vein-like projections cutting the Wittichenite but terminating at the Wittichenite/chalcocite boundary. It also shows a rim texture inclosing the Wittichenite. The "primary texture" exhibited in the myrmekitic bismuth intergrowth may be a complete replacement of the Wittichenite which had itself replaced chalcocite, or it may be a replacement of the chalcocite and bornite, along with the Wittichenite.

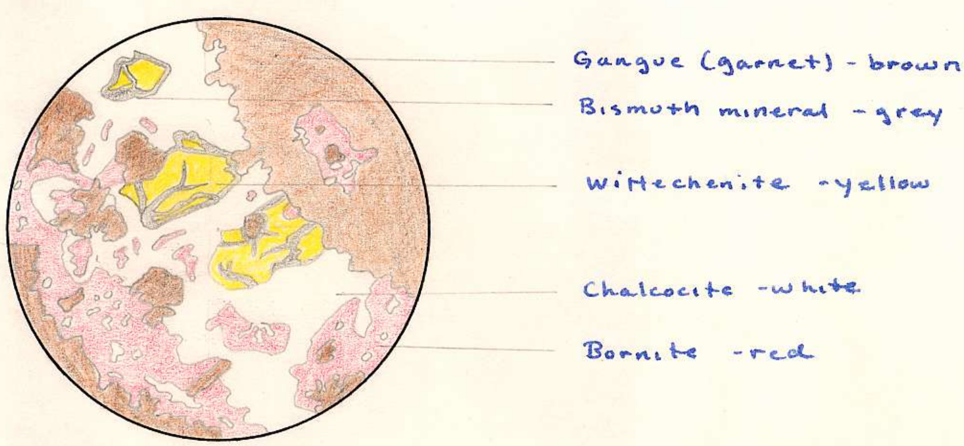
In several sections, a narrow dark blue rim of digenite was seen at the boundary of the bornite/chalcocite. It was first thought to be simply an alteration of the chalcocite to the isotropic forms, but closer examination showed isolated lamellae of bornite in chalcocite which had partly or wholly altered to digenite. This alteration replaces the chalcocite to the extent that the rims of digenite on opposite sides of narrow chalcocite lamellae will meet. It was noted that the digenite alteration occurred exclusively at the boundary between bornite and chalcocite. Sometimes the bornite was replaced (wholly altered lamellae) and sometimes the chalcocite was replaced (rims of digenite inside enclosed lamellae of chalcocite). Digenite did not occur at the chalcocite / Wittichenite boundary, the Wittichenite apparently replacing the digenite in the process of replacing the chalcocite.

Sphalerite was observed to be in contact with 5 other minerals: bornite, chalcocite, wittichenite, digenite and pyrite. In general it had rounded, convex or smooth boundaries with these minerals. In polished section 8, sphalerite is seen to cut across chalcocite, bornite and digenite, and project into Wittichenite, indicating replacement of all these minerals. Section 8 also showed inclusions of chalcocite in the sphalerite in an emulsion texture. Similar textures were seen in other sections. This exsolved chalcocite was obviously of a later stage than the primary chalcocite. Section 6 shows sphalerite replacing bornite and also exsolving bornite in a small rounded inclusion. Like the chalcocite mentioned above, this bornite is of a later stage than the primary bornite.

Polished Section 4
Med. Power



Polished Section 6
Med. Power

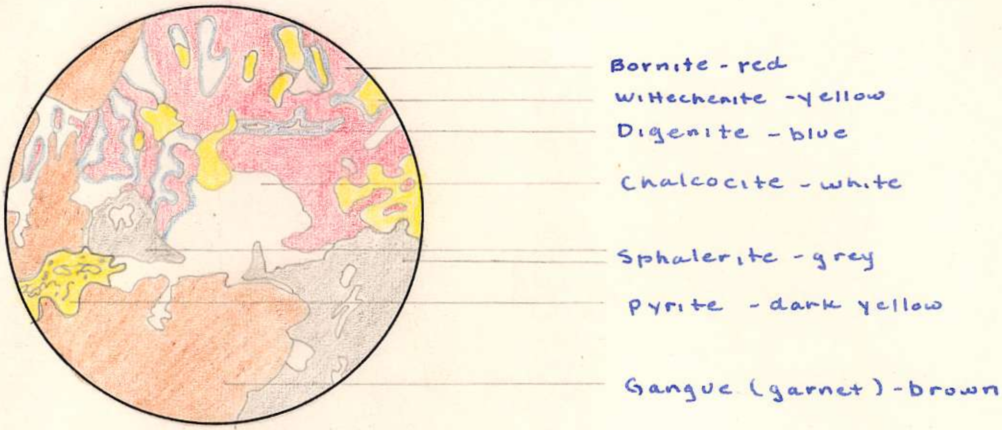


Polished Section 7
High Power

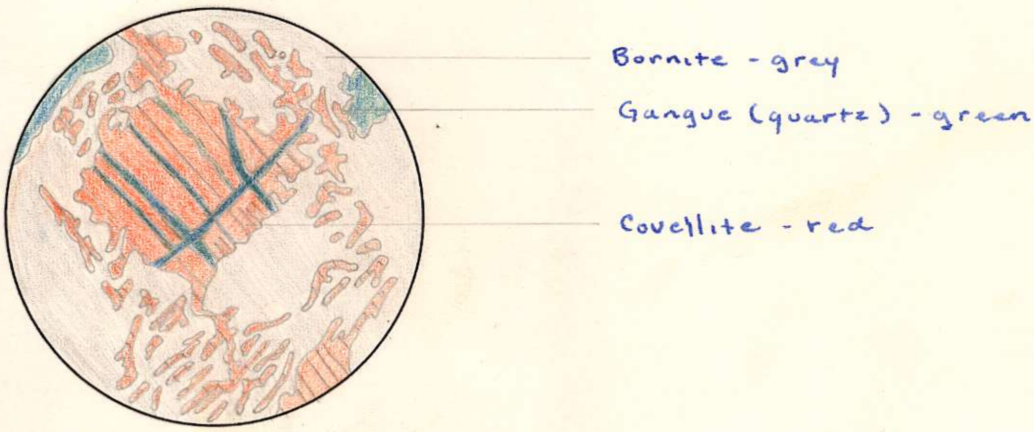
An interesting texture seen in this small inclusion, and in similar inclusions elsewhere, was the bornite altering to chalcocite in two small areas.

Chalcopyrite was seen only in one polished section, mount III, and boundary relations with only three minerals: bornite chalcocite and pyrite, were observed. Hence the true paragenetic relationships between chalcopyrite and all the minerals later than chalcocite, with the exception of pyrite, could not be determined. The chalcopyrite had fairly regular boundaries with the bornite and chalcocite, except for a few prominent veinlets of chalcopyrite cutting those two minerals. Replacement was evident by examination under high power which showed a serrated boundary between chalcopyrite and bornite with the cusps into the bornite. Convex boundaries and small projections were seen from chalcopyrite to bornite and from chalcopyrite to chalcocite. Very small inclusions of chalcocite were seen in a roughly defined zone within the chalcopyrite near the boundary with bornite. This emulsion texture was evidence of a late stage of chalcocite exsolved from the chalcopyrite.

The last mineral to crystallize was pyrite. It was seen in only three sections, and then as minute, isolated grains. In section 8, it was seen to replace ~~chalcopyrite~~ chalcocite, bornite and sphalerite and in mount III it replaced chalcopyrite. The pyrite commonly occurred in cubic grains standing in high relief and cutting across the other metallic minerals.



Polished Section 8
High Power



Plasticine Mount II
X-Nicols, High Power

Plasticine Mount III
High Power

Covellite was seen as an alteration film on chalcocite in plasticine mount II. The alteration film was too thick to be removed by buffing. The section was unique in that it was the only chalcocite which showed cleavage. A large grain of chalcocite was surrounded by smaller graphic or myrmekitic grains of chalcocite, all of which were optically continuous with the large grain and also showed continuous cleavage with it. The replacing mineral was bornite. Covellite had selectively replaced the chalcocite. Quartz gangue penetrated the chalcocite along cleavage planes and also cut across the cleavage. It appears that silicification took place before bornite replacement since the quartz terminated abruptly at the chalcocite/bornite boundary.

Nature of Mineral Deposit

The gangue minerals present were typical of a skarn deposit: garnet, tourmaline, vesuvianite and calcite. Some minor silicification was present also. The metallic minerals were deposited later and showed replacement textures indicative of metasomatic replacement. The common sulfides present; bornite, sphalerite, chalcocite and chalcopyrite, were hypogene minerals in the mesothermal temperature range. All evidence indicates a contact metasomatic or skarn-type deposit.

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Paragenetic Sequence